People's Democratic Republic of Algeria
Ministry of Higher Education and Scientific Research

Superior school of management
Tlemcen

Department of management
Option: management and enterprise's strategy

Dissertation submitted for the fulfillment of the requirements for the degree of master

THEME

The role of Lean Six Sigma in the optimization of a seaport process

case study: port company DjenDjen

Presented by: Amani Laouar
On the 23rd of July 2019

Comity of debate:

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Academic year: 2018/2019

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Dedication

To my father Hassane who has always been there for me.

To my mother Lamia who has always shown kindness and courage.

To my sister Hana and Nermine and to my little brother Wassim who always gives me the positive energy that pushes me and encourages me to give the best of me.

to my grandmothers whom I cherish particularly.

To my deceased grandparents who are always present in my heart and in my memory.

To my family who have always shown a lot of kindness and love.

To my friends who have always believed in me and shared my follies.

To my ESM and the preparatory school of Annaba teachers.

And to all the dear ones who have marked my life at some point

I love You.

Thanks

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I would also like to thank Mr. ouali Fares, Manager of Port DjenDjen, for trusting me, and for having shown a particular interest in my research theme.

Above all, I want to thank my parents, sisters, and my little brother for their dedication and unconditional support in all stages of my life, this is, I hope, only the beginning of a long series of victories. that I will dedicate to them proudly every time.

Finally, I thank all those who have contributed, directly or indirectly, to the realization of this modest work.

SUMMARY

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ABREVIATIONS

GE: General Electric.

LSS: Lean Six Sigma.

DMAIC: Design, Measure, Analyze, Improve, Control.

TPS: Toyota Production System.

JIT: Just In Time.

CTQ: Critical To Quality.

DPMO: Defect Per Million Opportunities.

DFSS: Deign For Six Sigma.

DMAIDV: Define, Measure, Analyze, Improve, Develop, Validate.

FMEA: Failure Modes and Effects Analysis.

FMECA: Failure Mode, Effects and Criticality Analysis.

VSM: Value Stream Map.

VOC: Voice Of Customer.

SIPOC: Supplier, Input, Process, Output, Customer.

PCJ: port company DjenDjen.

NVA: Non-Value Added.

VAO: Value Added Off-loader.

TEU: Twenty Foot Equivalent.

RP: Replacement Piece.

UNCTAD: United Nation Conference of Trade And Development.

LIST OF SYMBOLS

σ Greek symbol for sigma

X Process or system inputs

Y Process or system outputs

General Introduction

Introduction to general topic

The instability of the global economy, and the evolution of the market requirements, has made organizations increasingly vulnerable to change. Faced with growth objectives, these organizations are inclined to opt for management mechanisms aimed at predicting and managing changes in order to assure their performance.

Mastering performance is therefore the challenge of any organization aiming sustainability. To remain competitive, the managerial practices of these organizations are punctuated by the evolution of the market, they continually integrate new managerial approaches in their management mode and it is a process management based on customer satisfaction that these organizations prefer adopting to master their processes and control their growth.

To achieve this goal, the company's offer must satisfy at the same time 03 constraints: quality, speed, costs. In the traditional conception of management, the pursuit of these three objectives at the same time was a real dilemma, because the optimization of one of these constraints is done at the risk of the others: we cannot increase the quality nor increase the speed of our processes without accumulating more costs and vice versa, modern management has demonstrated through the Lean Six Sigma method, that the meeting of these three objectives is finally possible and the chance of their pursuit all at the same time multiplies and allows achieving performance.

The LSS best application and the one we will be applying consists in the process called DMAIC (Define, Measure, Analyze, Improve and Control) (Pzydek & Keller, 2010)

Background of the study

The Lean Six Sigma approach, methodology of process optimization emerging from the industry, is becoming popular after giving significant results in large multinationals.

The constraints of economic globalization, has given new impetus to international trade based largely on maritime transport, which in 2015 represented 80% of world trade according to WTO, it is therefore very important for any country wishing to strengthen its economy to invest in its port infrastructure. Algeria has seven commercial ports of different capacities, we are interested in the performance of the last port built after independence, the port of DjenDjen.

The latter, following the fluctuation of the regulations published by the public authorities, saw its performance strongly impacted since 2017, and despite the investments made, the activity of the PCJ is marked by a decrease in traffic resulting in a drop-in turnover.

Faced with this situation, the port company DjenDjen (PCJ) is engaged in a quest for better control of its costs and sources of revenue. It is therefore with an optimization perspective that the PCJ intends to deal with this situation. it is forced to invest more in the satisfaction of its customers in order to preserve and increase its market share.

Although previous work had been performed in relation to handling process, no improving work had been done on the entire process.

The theme choice

There are a variety of subjective and objective motivations and reasons behind the choice of the research topic that can be summarized in:

Personal inclination and interest for management Field and its different approaches, theories and strategies.

The lean six sigma method was first born in the industry but it has proven recently its success in the service sector making significant results and improvements, so we wanted to confirm this and check the possibility of applying it in a service company ourselves.

In our journey searching for a company for our practical internship we were surprised that we could not find any Algerian company using Lean Six Sigma, despite its success, LSS is still unknown in the majority of the Algeria companies, what motivated us even more to try to implement it in an Algerian company.

The enterprise choice

The genesis of the idea of applying the Lean Six Sigma method in the optimization of the seaport DjenDjen process was done because of the 3rd year practical internship in this latter, where we made the following finding:

- Pursuit of one of the objectives cost-quality-delays is done only to the detriment of the other, which contradicts the very principle of the management which stipulates to drive the port activity with all its aspects towards the achievement of its objectives while optimizing this triple constraint.
- With the legislative instability concerning the import-export activity that Algeria has been experiencing since 2017, it’s very important for seaport companies to master and improve its processes without recourse to investment.

This justifies the choice of DjenDjen our study case company, as well as why the application of the LSS method within it will help us to highlight the contributions of Lean Six Sigma to seaports.

Previous studies

Due to the importance of the subject, it has been addressed in many local and foreign thesis, what have helped us greatly in our research:

foreign studies:

Simona Rakuša thesis monitored by dr. **Branko Ilič** in 2016 under the title of "Business Process Improvement using Lean Six Sigma: An Example of Improving the Onboarding Process".

In the University Of Ljubljana Faculty Of Social Sciences, Slovenia. This thesis promotes the idea of making data-driven decisions also in services. Its primary research question is:

- Can Lean Six Sigma methods also be used in services? And, if so, how?

Simona Rakuša thesis aim is to prove the statement that Lean Six Sigma is not only applicable for use in manufacturing but is also a great methodology for use in services.

Main finding:

✓ the Lean Six Sigma method offers appropriate tools for business process improvements also in the area of services

lessons:

✓ optimization projects might in some cases be connected with employees' fears,

✓ the gap between self-perception about our services and the perception of others. Thus, it is essential to ask our customers, be they external or internal, of their opinion on the current process and to involve them in process improvement projects.

✓ We should keep the flexibility and use common sense when adjusting Lean Six Sigma to an organizational environment and to the people involved in a project.

✓ Lean Six Sigma project is the strong support and commitment of the top management and department managers of the departments to which the projects apply.

✓ we have to ensure that enough resources are available, with this applying to the project manager and to the team members. In the event we are lacking resources for the project its quality can become questionable.

Main recommendation for company:

✓ consider the changing needs of newcomers arising from demographic changes and to use technology to facilitate onboarding.

Yang Bin Master's thesis monitored by **Gerald.Q** and **Bogumila.R** in 2015, under the title of "Using Six Sigma Methodology to improve the performance of the Shipment Test".

In School of Information and Communication Technology Department of Communication Systems Sweden. This thesis will give:

- an explicit explanation of the Six Sigma methodology, and the use of this methodology to solve the issue of providing high performance shipment testing.

Findings:

- ✓ Applying Six Sigma in shipment test had a positive effect and improved the test performance (in terms of finishing testing on time) and increased delivery quality.
- ✓ A new business model was defined in order to reduce the Differ–Days leading to an improvement to 93.33% of on time delivery.
- ✓ In the end of this thesis a set of proposals for improvements and control of the improved process is provided in order to ensure sustainable improved performance results, 93% test campaigns were finished on time in 09AXE and project goal was fulfilled.

David Woo, Holly Wong bachelor's thesis monitored by **Viliam Makis** in 2007, under the title of "An application of Lean Six Sigma to improve the assembly operations at a wireless mobile manufacturing company".

In the University of Toronto, Department of Mechanical and Industrial Engineering, Canada. This thesis goal is to acquire extensive knowledge on the approach and apply it to improve the quality of an assembly operation process of a wireless mobile manufacturing company facility, so the research aims at:

-Familiarizing ourselves with the Lean Six Sigma methodology.

- Completing critical analyses of two published case studies of Lean Six Sigma application.

-Implementing the Lean Six Sigma methodology in improving the assembly operations at the wireless mobile manufacturing company.

Findings:

- ✓ In the end of the project the authors were able to accomplish all the three pre-mentioned goals.

Local studies:

IHDENE Sabrina master's thesis monitored by **Pr. Kherbachi**. H in 2017 under the title of "The conditions for setting up LEAN Management _Case: General SPA Packing".

In the university of Abderrahmane. Mira, Faculty of Economic Sciences, Bejaia. This thesis focuses on the adoption of LEAN Management by the "General Emballage Spa" who used this approach to modernize their management method, the primary research questions:

- What are the conditions for setting up the LEAN Management approach?
- What are the factors that drive companies to adopt a LEAN approach?
- The goal of our work is to better understand LEAN Management's approach, which is important within organizations. It is also a question of determining the conditions of setting up within the company "Générale Emballage Spa"

Main findings:

✓ As part of " General Emballage Spa ", the Lean approach has improved the production process

✓ the follow-up and the control and the motivation of the personnel, are the main conditions to carry out a LEAN Management approach.

Thiziri Ait Yahiatene master's thesis monitored by **F. Haddad** in 2015 under the title of "Application test of the Lean method Six Sigma in a construction project. Case Study: ENC Division, Sonatrach. Pilot project: SBF Elghar project".

In the School of High Commercials Studies**,** Algiers. This thesis focuses on the contribution of lean six sigma implementation in the project management field in general and SBR Elghar project in particular, the primary research question is:

- What are the contributions of the Lean Six Sigma method for the management field project?

Main findings:

✓ the approach of Lean Six Sigma and that of the project management are in perfect adequacy

✓ Lean Six Sigma has significant contributions to the field of project management

✓ Lean Six Sigma contributes to the optimization of the triple constraint of project management scope, schedule and cost.

Amel Bouridan master's thesis in 2015 titled by "An attempt to implement a lean management model in port company to improve its efficiency study case: port of DjenDjen".

In the **School of High Commercials Studies,** Algiers this thesis focuses on Lean tools and techniques, as well as critical success factors and challenges of Lean management implementation in general and in lean implementation in seaport company DjenDjen in particular, the primary research question is:

- What are the appropriate lean tools and techniques that can be applied in port company in order to improve the unloading work process?

Main findings:

✓ The study answer to its main objective which is the recommendation of Lean tools and techniques based on current unloading state, and suggest: VSM, 5S as some lean practices that might be applied successfully in the near future, in order to unload vessels more efficiently when it arrives and manage material more efficiently while we store cargos.

Problem statement

The research regarding how Lean Six Sigma could be used to improve the current handling processing process and reduce handling container ships process cycle time was chosen.

We therefore opted for the Lean Six Sigma methodology, specifically for its DMAIC (Define, Measure, Analyze, Innovate or Improve, Control) approach to see if it is possible for the PCJ to optimize its key processes and achieve significant performance results despite the current conjecture and without resorting to investment, our main research question is:

"How does the Lean Six Sigma methodology contribute to the optimization of a port process to achieve significant performance results?"

Research questions

From this main question arise other underlying issues:

-Is this new methodology from the industry applicable to the tertiary sector, specifically to port companies?

-Does the Lean Six Sigma methodology answer the current performance concerns of DjenDjen?

-Does Lean Six Sigma have significant contributions to the optimization of a seaport process?

-What are the improvements recommended by this methodology?

Hypothesis

Answers to these questions can be made by confirming or reversing following hypotheses:

H1: Lean Six Sigma methodology has proven itself in several organizations and especially in services, its implementation in a port company is so possible.

H2: PCJ faces increased national and international competition and is currently facing an unexpected decline in activity, it is therefore the time to improve the port performance by opting for effective optimization measures, and the Lean Six Sigma methodology presents itself as a solution to this situation.

H3: By definition Lean Six Sigma contributes to the reduction of variability and wastes in the processes, so it has considerable inputs for optimizing a port delivery process.

Significance of the study

This study is significant to the DjenDjen port, the other Algerian and international seaports, and future researchers.

The DjenDjen seaport that was studied will benefit from this study because it will provide process improvement recommendations, that can be implemented to reduce the process cycle time, running the process in the best possible way and allow the company to maintain superior customer satisfaction.

Since the company is classified as a seaport company, the entire seaports will benefit from this study by utilizing the work that was done as guidance to develop and implement recommendations to improve their process.

Future researchers will benefit from this study as they will be able to use the provided information as a guide for further developing research about the utilization of Lean Six Sigma in business processes improvement.

The purpose of the study

The goal of this work is to better understand Lean Six Sigma Management approach, which is important within organizations.

Our research is motivated, academically, by the fact that this work will allow us to discover the fundamental concepts of LSS approach and its deployment challenges and to find the main tools of improvement associated with the Lean Six Sigma management.

On the managerial level, the adoption of the LSS approach by companies can determine their willingness to make continuous improvements to achieve performance and as such, our research may be relevant.

Another goal of this thesis is to present the Lean Six Sigma methodology in the context of the service business environment and demonstrate its practical use in a real-life example, helping the company to make its process more effective and efficient and relevance

This study will allow us to explore the application of Lean Six Sigma in DjenDjen seaport process. The process will be investigated to determine associated problems as well as the root causes of the problems. Then, the problem and their root causes will be used to make improvement recommendations.

Assumptions, limitations, and delimitations

The assumptions of the study are focused on the responsibles who were giving us information, documents … etc. and the seven consignees with whom we conducted an interview the study's assumption are as follows:

-The information and documents provided by responsibles will be honest.

-The consignee will focus while answering questions and will ask about anything that is unclear before providing a response.

The delimitations of this study are associated with my personal choices. The primary delimitation of this study is my choosing to make the focus of the case study on a single company and working on only one of its processes.

The limitations of this study are associated with the delimitations we mentioned above:

- The case study strategy limits the study because a case study only involves a chosen entity. The results of the case study are specific to the chosen entity. therefore, the results of the study cannot be generalized.
- Although the case study results are not able to be generalized, they could be applied to a similar entity. But additional research would have to be completed to determine whether or not findings from one study would be applicable to a similar organization or not.

Methodology

Our theme requires the use of several tools and research methods:

Documentary research: to identify the fundamental principles of Lean Six Sigma, DMAIC, process optimization and port activity.

Descriptive method: for observing and defining the studied process.

Deductive approach: at the beginning, we introduce our research a question, In the first part of the thesis we offer a theoretical background about the topic. While performing the improvement project in the empirical part to confirm our research question.

In the empirical part, for two months period we gathered data, we describe and explain the findings using visual aids (e.g. tables, figures …etc.) To collect the data we used observational, and interview techniques.

Analytical method: for choosing the process, asking the questions "Why?", "What?" and "How" to obtain a better and deeper understanding of the process, identifying process problem and its roots, designing a new process through recommendations and testing their impact.

Comparative method: for proposing improvements to the business inspired by other projects.

In our research we combine quantitative and qualitative data elements:

Qualitative: through interviews with the PCJ clients (Voice of customers), structured self-observation (Activity structure analysis). Organizing process description maps (e.g. SIPOC, swim lane).

Quantitative: through the use of information gathered from observations, interviews and reported data in order to analyze existing problems in the process and to obtain the performance level in the case study.

The structure of the study

In order to best answer our problem as well as the questions asked, we have structured our work in four chapters, each split into two sections.

The first chapter will be devoted to the presentation of the theoretical foundations of the Lean Six Sigma hybrid, so we will discuss in the first section the history of both lean and six sigma and their fusion, in the second section we will present some of the concepts related to the two Lean and Six Sigma methods, the general context and theorical frame of this methodology .

The second chapter will be about lean six sigma in practice, we will discuss the fundamental implementation principles and aspects of Lean Six Sigma and we will explain later, the DMAIC steps (the one we will be applying in our case study) in details in the second section.

In the third chapter titled concepts related to process optimization and generalities on port activity, we will discuss in the first section the concepts related to process optimization, and the second section will be devoted to the presentation of the port activity and the measurement of ports performance according to the United Nations Conference on Trade and Development -UNCTAD- report.

The fourth chapter will focus on the study case, so the first section will discuss the presentation of the host company, in the second we will make an implementation attempt to study the contribution of Lean Six Sigma on one of the port processes through the application of the DMAIC approach.

In the end, our work will end with a conclusion, in which we will summarize the results of our research.

Chapter 1: the hybrid Lean Six Sigma.

Chapter introduction

Companies are always seeking optimum results which they will only get by making their processes the most efficient they can be and assuring quality, so they are constantly looking for and developing methods and tools to make this happen.

This chapter is dedicated to the presentation of the most popular tool that delivers both efficient operations and consistent quality standards in the industry sector "The Lean Six Sigma - LSS", this latter will be divided into three sections as follows:

- The first section will talk about the history and evolution of lean six sigma.
- The second section looks at the mind set of LSS.
- The third and last section will talk more about the approach objectives, goal and principals.

1.1. Section one: The history of lean six sigma

Lean Six Sigma, as its name applies, is the combination of lean and six sigma the two most powerful business improvement tools developed over the past 100 years to understand lean six sigma approach, it's important to understand first how did every concept appeared, developed and how they came together.

This section is dedicated to the presentation of the evolution of this approach. it will be divided into three sections as follows:

- The first sub-section will deal with the history of lean.
- The second sub-section looks at the history of six sigma.
- Finally, the third and last sub-section will examine the integration of lean principles with Six Sigma methodology as a coherent approach to achieve efficiency.

1.1.1. The history of lean

Even if the word "Lean" was not necessarily used to designate the practice we know today but the existing literature on the concept of Lean tells us that Lean thinking goes back to more than 100 years, in this subsection we will be highlighting the major phases of the Lean evolution.

The history of contemporary Lean is marked mainly by the efforts of three major industries, so we will approach these three actors in the chronological order of their intervention.

Table 1-1. The history of production

Craft manufacturing Taylor	**Mass manufacturing Ford**	**Lean manufacturing**
Combination of man and machine	Mass production, achieved through specialization of equipment and labor	The Toyota production system
- Tailored - Quality according to craftsman skill - High cost and prices - Long delivery times - Low volume	- Low customized - Good quality - Dramatic cost reduction - Delivery time reduction - High volume	- Optimization of all resources - Focusing on the elimination of waste to ensure complete customer satisfaction - Low costs - High flexibility - Low volume per type, high total volume

Source: *Adopted by Thorstsen.A,2016 (Thortsen.A, 2006)* ***in*** *(Amel.B, AN ATTEMPT TO IMPLEMENT A LEAN MANAGEMENT MODEL IN PORT COMPANY TO IMPROVE ITS EFFICIENCY master's thesis, 2015, p. 5)**.***

1.1.1.1. Taylor's theory

Taylor's theory states, that production efficiency can be greatly enhanced by closely watching individual workers, in order to find and eliminate wasted Time and motion in the operation. Management could identify the one best Way to do a job, determine the correct productivity level, and set a pay rate based on that level (A.Thorsten, 2006, p. 14).

Taylor encouraged workers to suggest improvements and made management Responsible for careful analysis of these suggested methods, whenever it was found to be superior to the old, he wanted it to be adopted as the Standard for the whole establishment (Chase, Aquilano, & Jacobs, 2018) in (Amel.B, AN ATTEMPT TO IMPLEMENT A LEAN MANAGEMENT MODEL IN PORT COMPANY TO IMPROVE ITS EFFICIENCY master's thesis, 2015, p. 6).

This shows clearly that even Taylor recognized the importance of workers for effective changes.

1.1.1.2. Fordism

Starting about 1910, Ford and his right-hand-man, Charles E. Sorensen, fashioned the first comprehensive Manufacturing Strategy. They took all the elements of a manufacturing system: people, machines, tooling, and products- and arranged them in a continuous system for manufacturing the Model T automobile. Ford was so incredibly successful. he quickly became one of the world's richest men and put the world on wheels. Ford is considered by many to be the first practitioner of Just in Time and Lean Manufacturing.

Ford's success inspired many others to copy his methods. But most of those who copied did not understand the fundamentals. Ford assembly lines were often employed for products and processes that were unsuitable for them.

It is doubtful that Henry Ford himself fully understood what he had done and why it was so successful (Strategos Inc, 2018, p. 2).

1.1.1.3. The Toyota production system

Established in April of 1950, Toyota Motor sales Company launched a business during an era that should have resulted in failure, This was post-World War II in Japan. The country was attempting to recover from the devastating effects, In an effort to create economic growth, the country began to manufacture inexpensive consumer goods, classified by the rest of the world as junk that earned the Japanese people a reputation for shoddy workmanship.

The management at Toyota, however, understood that in order to gain recognition in the global marketplace they would need to provide a high-quality product at a competitive price (figure 1-1: the TPS house). They also recognized that in order to accomplish this, they would need to do more with less. This realization sparked the birth of the Toyota Production System (TPS), which today is more commonly known as Lean Manufacturing.

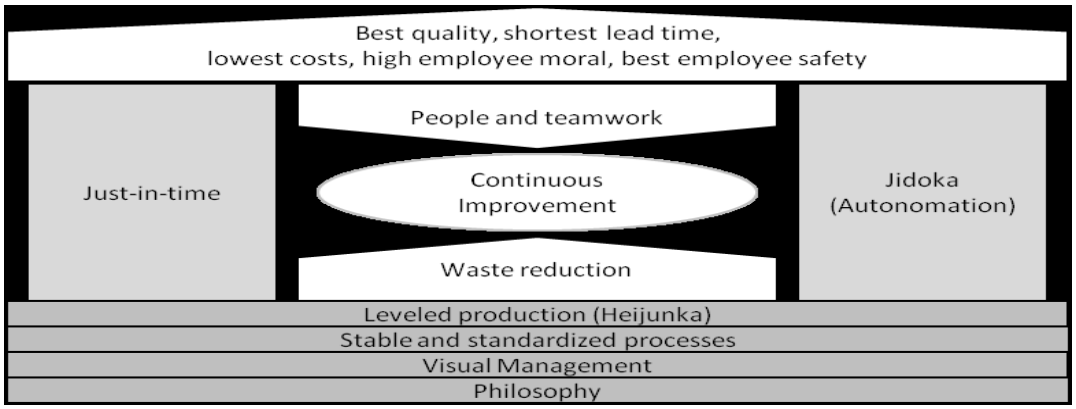
The basic underlying concept of TPS was to eliminate any operations that did not add value to the company's product or service from the standpoint of the final customer. The management at Toyota implemented this concept in every operation throughout their plant. They eliminated or minimized the need for their assemblers to walk, bend, reach, or turn. They implemented devices that eliminated mistakes or brought attention to mistakes before they became defects. They reduced inventories by providing the parts to the assembly lines "just in time" instead of stockpiling huge quantities of parts "just in case" they were needed to complete an order. By eliminating delays and the constraints that caused these delays, TPS assured the continuous flow of the product from the beginning to the end of the process. Toyota's leaders eliminated the need to transport parts to different areas of the manufacturing floor and streamlined operations so that each step provided only what was needed when it

was needed in the quantity it was needed every time it was needed. They developed new procedures for changing over from one product to another, which minimized machine downtime. The employees practiced these procedures so they could execute them correctly and safely in the least amount of time. In addition to implementing efficiency improvements, they also kept a close eye on quality by implementing statistical process control methods and empowering employees to react to problems. All employees who worked in the plant had the authority to stop the production line if they spotted a defect. This action would summon the immediate attention of management and engineering to quickly eliminate the problem and get the line back to producing defect-free products. Implementing these concepts allowed Toyota to provide a quality product at a competitive price.

The Toyota Corolla gained popularity in the United States during the 1973 OPEC oil embargo. Americans purchased the Corolla because it offered an alternative to the gas-guzzling American cars, but quickly noticed that the Corolla was also extremely reliable, less prone to breakdown, and subject to few, if any, defects.

Although it was fuel efficiency that initially prompted people to purchase the Toyota, it was the auto maker's attention to quality that kept customers coming back and caused them to spread the world. Today, the Toyota Corolla is the best –selling automobile in the world. Toyota Motor Sales Company is the second –largest automobile manufacturer in the world and is slowly nudging General Motors out of the number one position, which it has held since 1931 (Zidel, 2006, p. 2) .

Figure 1-1 The TPS house



Source: Adopted by Christian (CHRISTIAN.F, 2010) in (Amel.B, AN ATTEMPT TO IMPLEMENT A LEAN MANAGEMENT MODEL IN PORT COMPANY TO IMPROVE ITS EFFICIENCY master's thesis, 2015, p. 6)

The overall goal of TPS, as visualized by the roof in Figure 1-1, is to produce quality products at the lowest costs and with short lead time. Toyota puts a high emphasize on their employees' safety, which trumps any other goal.

1.1.2. The history of six sigma

Now, that we have a good idea about the evolution of lean, we will discuss the six sigma history in this sub-section

Six Sigma is a recognizable evolution of TQM. It is the result of the revolution of methods and approaches for quality and efficiency improvement. it can be seen as the accumulation of principles and practices developed in management statistics and quality engineering, all of which matured significantly over the course of the twentieth century.

The Six Sigma approach was first developed in the late 1980s within a mass manufacturing environment in Motorola by Mikel harry as they struggled to meet demanding quality targets on complex manufactured products. and become widely known when General Electric adopted it in the mid-90s when, arguably, it evolved from being a process improvement methodology to a broader, companywide philosophy. Both companies still consider Six Sigma as the basis for their on-going strategic improvement approach. Since the 1980s Six Sigma has become one of the most popular improvement initiatives. widely implemented around the world in a wide range of sectors (by companies such as Boeing, DuPont, Toshiba, Seagate, Allied Signal, Kodak, Honeywell, Texas Instruments, Sony, Bombardier, Lockheed Martin) that all declared considerable financial savings (knowles.G, 2011, p. 12).

Six Sigma has undergone a considerable evolution since the early manifestations. Initially it was a quality measurement approach based on statistical principles. Then it transformed to a disciplined processes improvement technique (based on reducing variation within the system with the help of a number of statistical tools) (knowles.G, 2011, p. 12).

Through the years, hundreds of organizations have indicated their interest in making Six Sigma their management philosophy of choice.

Figure 1-2 The integration of six sigma in businesses through the years

Source : adopted by Bounazef. D,2012 (Bounazef.D, 2012) according to (Singha.A, 2006)

nowadays, Six Sigma is not used exclusively in manufacturing as it was, large and small companies apply it in different fields such as service, transactions or software industry.

1.1.3. The appearance of lean six sigma as one tool

In this sub-section we will be talking about the how Lean and Six Sigma became one.

It was published for the first time in 2002 in the book of Michael George "Lean Six Sigma: Combining Six Sigma Quality with Lean Speed" (Demetrescoux, 2015), but in fact the LSS is the result of a long history of the industry Manufacturing. the evolution of Lean and Six Sigma has gone through several stages, until the appearance of the hybrid concept Lean Six Sigma as we know today.

1.1.3.1. How the lean concept and the six sigma tool were combined?

Combining Lean manufacturing and Six Sigma principles began in the 90's, and has quickly taken hold by many companies. There are many examples of industrial companies implementing a combined effort of Lean and Six Sigma.

An early example, starting in 1997 was by an aircraft-engine-controls firm, BAE Systems Controls, in Fort Wayne, Indiana. They blended Lean-manufacturing principles with Six Sigma quality tools. Their LSS strategy was according to Sheridan's, "designed to increase velocity, eliminate waste, minimize process variation, and secure its future in the evolving aerospace market" (sheridan.J, 2000).

BAE started with implementing Lean initiatives and then identified a synergy between Lean and the Six Sigma quality program that had been launched while the company was a part of General Electric. BAE Systems Controls implemented the following Lean initiatives:

1) Kaizen events, 2) takt-time-driven one-piece-flow product cells,

3) Kanban pull system and point-of-use storage bins on the plant floor,

4) Lean production cells, 5) mistake proofing, 6) use of a multi-skilled workforce.

As part of the Six Sigma program, they implemented statistical methods and team leadership with the use of Black Belts. The primary focus of BAE's Six Sigma program was to reduce variation within their processes (Furterer, 2004).

To blend Lean and Six Sigma, they incorporated the Six Sigma Black Belts within the Kaizen teams. The Black Belts used the statistical techniques to help solve problems. They found that the Six Sigma tools helped to generate the data needed to justify major improvements, such as equipment upgrades.

Another early innovator combining Lean and Six Sigma was Maytag Corporation. It implemented Lean Sigma in 1999. They designed a new production line using the concepts of Lean and Six Sigma (Dubai Quality Group, 2003).

Maytag reduced utilized floor space to one third of that used by Maytag's other product lines. Maytag also cut production costs by 55%. Their Lean sigma effort helped Maytag to achieve savings worth millions of dollars (Dubai Quality Group, 2003).

TBM Consulting Group implemented their LSS methodology at Pease Industries. (Smith & Adams, 2001). The basic approach included first implementing Lean principles. The consultants established one-piece flow, eliminated waste and redeployed operators no longer needed on the line. Once the hidden factory or waste was exposed, they implemented Six Sigma principles to reduce variation and improve quality. Lean Sigma has saved Pease Industries over a million dollars a year in scrap and manpower reductions. In another Lean Sigma implementation, The Lean six sigma improvement process of Measure, Analyze, Improve and Control (MAIC) was used to implement LSS project. The typical MAIC project timeline consisted of 1) a Measure phase including a four to five day Kaizen event, 2) Analyze and Improve phase with a 5 day Kaizen event, and 3) a Control phase with a 30 day follow up. The improvement process also includes a few weeks between each phase for data collection and testing. Some of the successful Lean Sigma implementations that TBM was part of achieved significant results, including capital reduction of 20 to 30% per year, productivity improvement of 15 to 20% per year, and quality improvement of 50% per year.

In other case studies reported in the literature by Bonnie Smith the approach to Lean Sigma depends on the problem to be solved. In a Lean Sigma implementation with a playground equipment manufacturer the company had implemented Lean techniques and then implemented Six Sigma when a problem arose that needed Six Sigma Quality techniques. Another TBM Consulting Group Lean Sigma implementation with a commercial refrigeration equipment manufacturer used the best of Lean and Six Sigma (B.smith, 2003).

Goyal presents how Lean Six Sigma was implemented in a company that converted paper documents to electronic copies.

The company first improved the consistency of the product quality through the application of Six Sigma quality tools. They used a modified DMAIC improvement process. They first performed a Define and Measure phase. Brainstorming was used to identify over 30 problems. They then separated the problems into two categories and then prioritized the problems using a weighted voting consensus system. A second brainstorming session further defined the problems. They then collected data to measure the problem. The second phase performed was the Analyze phase. They flowcharted the process and identified the value added and non-value added activities. Principles of Lean manufacturing were introduced during the Analyze phase including:

1) zero waiting time, 2) zero inventory, 3) scheduling using pull techniques, 4) reducing batch sizes, 5) line balancing.

They used Pareto Analysis within the Lean solutions. They performed an Idea Generation phase to develop an implementation plan. They performed a pilot test of the new process, and then implemented the change and checked the result. To control the processes, they implemented control charts (a Six Sigma technique) and standard operating procedures (a Lean tool). The Lean Six Sigma implementation reduced the error rate by 98% when converting paper documents to electronic copies, increased productivity over 50%, reduced costs, improved quality, and improved the ability to handle peaks of input data within customer specified turnaround limits (Goyal, 2002).

1.1.3.2. Summary diagram of the hybrid concept lean six sigma

As we saw, the evolution of Lean and Six Sigma has gone through several steps, until the appearance of Lean Six Sigma, the following table do not take in consideration the unofficial use of lean six sigma but it summarizes the biggest phases:

Table 1-2 The origin of lean six sigma

Six sigma	Lean
15ème siècle: The introduction of lines assembly in the shipbuilding Venetian	1875: Taylor has observed the methods of work to study time of operations (Time study) and standardize tasks
1910: H.Ford introduced the continuous assembly line	1924: Swewhart has introduced the concept of control cards in the Bell laboratories
1937: K.Toyoda, The instigator of the GST philosophy (Toyota Production System), this philosophy was formalized in 1954	1945: K.Ishikawa.Crosby and J.Jureny , E.deming , Introduction of the mastery process statistics and the total quality (total quality management)
1990: J.Krafick explains the Lean concept manufacturing	1986: Bill Smith Calvin wasintroduced the concept of process quality of "Six Sigma"
1999: J.womarck has introduces the notion of Lean Manufacturing	
M.GEORGE 2002 1st publication dealing with LSS concept	

Source : Adopted by Demestrescoux (Demetrescoux, 2015)

1.2. Section two: lean six sigma mindset

Now, that we know the origin of this approach, also that we deduced from the companies past experiences mentioned in the first section, that it delivers optimum results through efficient operations and consistent quality.

we will try to dig more into the concept and understand how he is defined nowadays, to understand Lean Six Sigma I find it is better to first have a hint on the related concepts that we might find while talking about LSS. Then, I think we should understand separately the lean and the six sigma. So, this section will be presented as following:

- The main concepts related to lean six sigma in the first sub-section.
- Theoretical frame of Lean in the second subsection.
- Theoretical frame of six sigma the third subsection.
- Theorical frame of lean six sigma.

1.2.1. The main concepts related to lean six sigma

Some related concepts to lean six sigma that we will be using through our work will be defined in this subsection.

1.2.1.1. Definition of quality

"The totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs" (ISO 9000, 2005).

Quality In manufacturing

a measure of excellence or a state of being free from defects, deficiencies and significant variations. It is brought about by strict and consistent commitment to certain standards that achieve uniformity of a product in order to satisfy specific customer or user requirements (Business Dictionary website, 2019).

Quality in services

An assessment of how well a delivered service conforms to the client's expectations. Service business operators often assess the service quality provided to their customers in order to improve their service, to quickly identify problems, and to better assess client satisfaction (business dictionary web site, 2019).

1.2.1.2. Definition of total quality management

TQM stands for total quality management. A core definition of total quality management (TQM) describes a management approach to long-term success through customer satisfaction. In a TQM effort, all members of an organization participate in

improving processes, products, services, and the culture in which they work (ASQ web site, 2019).

The 8 principles of total quality management (ASQ web site, 2019):

1. Customer-focused: The customer ultimately determines the level of quality. No matter what an organization does the customer determines whether the efforts were worthwhile.
2. Total employee involvement: All employees participate in working toward common goals
3. Process-centered A fundamental part of TQM is a focus on process thinking. A process is a series of steps that take inputs from suppliers (internal or external) and transforms them into outputs that are delivered to customers (internal or external). The steps required to carry out the process are defined, and performance measures are continuously monitored in order to detect unexpected variation.
4. Integrated system: Although an organization may consist of many different functional specialties often organized into vertically structured departments, it is the horizontal processes interconnecting these functions that are the focus of TQM.
5. Strategic and systematic approach: A critical part of the management of quality is the strategic and systematic approach to achieving an organization's vision, mission, and goals.
6. Continual improvement: Continual improvement drives an organization to be both analytical and creative in finding ways to become more competitive and more effective at meeting stakeholder expectations.
7. Fact-based decision making: TQM requires that an organization continually collect and analyze data in order to improve decision making accuracy, achieve consensus, and allow prediction based on past history.
8. Communications: During times of organizational change, as well as part of day-to-day operation, effective communications plays a large part in maintaining morale and in motivating employees at all levels.

1.2.1.3. Definition of customer satisfaction

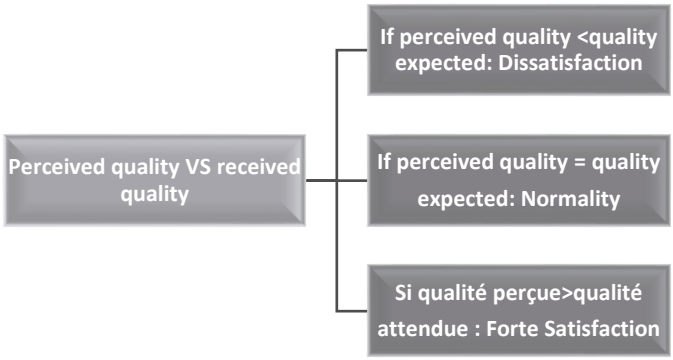
Satisfying the customer is no longer an easy task to accomplish, he has become more informed, more independent, and he has a lot of products to choose from as a result the customer's requirement are constantly evolving (Giordano, 2006, p. 29).

According to Giordano "Satisfaction is the result of the client's difference in appreciation between what he perceives and what he expects,

In other words (Giordano, 2006, p. 29):

"Satisfaction or dissatisfaction = expected quality - perceived quality"

Figure 1-3 Paradigm of the expectation's confrontation



Source : *adopted by Giordano,2006 (GIORANDO, 2006, p. 29).*

1.2.1.4. Definition of waste

It includes any activity that does not add value beside the minimum equipment's, parts and employees, which are needed for the business (Becheno.J, 2004).

1.2.1.5. Definition of risk

"effect of uncertainty on objectives" and an effect is a positive or negative deviation from what is expected (iso 31000, 2009).

1.2.2. Theoretical frame of Lean

In this sub-section we will try to give some definitions and characteristics of the lean concept.

1.2.2.1. Definitions

In English literature, "Lean" means skinny. leaning a thing means reducing its fats.

In economics, a company's fats are the operations that do not add value from customer's point of view, so leaning organizations is getting rid of worthless operations in their processes (cambridge dictionary, 2019).

In their book "Lean Thinking" Womack and Jones explain that Lean is the observation of an operational system through a prism that reveals the value, the flows, the potential to pull the flows and strive for perfection (James.P & Daniel.T, 2003)

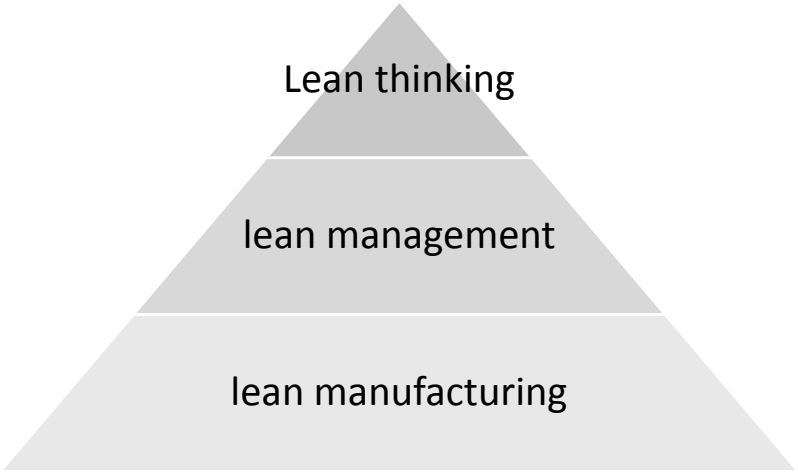
1.2.2.2. Lean management in service sector

Lean in service sector is essential to add value to customers by providing services with higher quality and speed the process by using fewer, but right resources. There is a need to analyze the non-value added activities to reduce the cost and complexity. Employees should identify the waste and hidden costs caused in different steps of processes, which might involve reorganization of companies by less capacity, material and people to perform the work more

efficiently. Also, organizations should focus on value added activities from customers' perspective. In this way, they will understand better the customers' needs and how much they are willing to pay to increase quality of service (Amel.B, AN ATTEMPT TO IMPLEMENT A LEAN MANAGEMENT MODEL IN PORT COMPANY TO IMPROVE ITS EFFICIENCY master's thesis, 2015).

1.2.2.3. Lean levels

Figure 1-4 The lean concept can be broken down into 03 levels



Source: Amel.B,2015. (Amel.B, AN ATTEMPT TO IMPLEMENT A LEAN MANAGEMENT MODEL IN PORT COMPANY TO IMPROVE ITS EFFICIENCY master's thesis, 2015)

1.2.2.3.1. Lean thinking

is a business methodology that aims to provide a new way to think about how to organize human activities to deliver more benefits to society and value to individuals while eliminating waste (James.P & Daniel.T, 2003).

1.2.2.3.2. Lean management

According to Thomas:

*"*Lean management is a system designed for companies committed to leading the lean production revolution. It is a strategy for managing constant change. Lean management depends on a humanistic approach, an unshakable confidence in the inherent creative spirit residing in each worker, and a firm commitment to promoting their well-being" (Thomas , Jackson, & Karen, 1996, p. 15).

1.2.2.3.3. Lean manufacturing

Lean manufacturing, also known as lean production, is a methodology that focuses on minimizing waste within manufacturing systems while simultaneously maximizing productivity (TechTarget website, 2019).

1.2.2.4. Lean major measures:

In order to know if a process is lean or not, we calculate:

1.2.2.4.1. Cycle time:

The period required to complete one cycle of an operation. or to complete a function, job, or task from start to finish. Cycle time is used in differentiating total duration of a process from its run time (businessdictionary website, 2019).

1.2.2.4.2. Value creation time:

Value creation time: This is the part of the time cycle during which the work activities actually transform the product so that the customer wants to pay (Summers.D, 2010, p. 3).

1.2.2.4.3. Lead Time:

Is the time it takes for a piece to unfold throughout the process from beginning to end (Summers.D, 2010).

1.2.2.4.4. Inventory turns:

Number of times a firm's investment in inventory is recouped during an accounting period. Normally a high number indicates a greater sales efficiency and a lower risk of loss through un-saleable stock. However, an inventory turnover that is out of proportion to industry norms may suggest losses due to shortages, and poor customer-service. The preferred method of computing inventory turnover is to compare the cost of sales (also called Cost Of Goods Sold or COGS) to average inventory (Cost of sales ÷ Average inventory). Another method, which compares net sales revenue to the inventory (Net sales revenue ÷ Inventory) is also used but it introduces the distortion of sales markup that is not documented in the inventory records (businessdictionary website, 2019).

1.2.2.5. Lean principals

The five Lean principles were developed by Womack and Jones in their book ‘The Machine that Changed the World’:

1. “Specify value from the point of view of the customer”, to do so it is important to know first who the customer is: “the final customer, next process, next company along the supply chain, or the customer’s customer” (Bechino.J & Holweg, 2009, p. 18).
2. “The Value Stream” this refers to the sequence of processes from raw materials to the final customer, or from the product to its market launch. The supply chain (if possible) should be viewed and analyzed. After all, it is supply chains that compete, not companies. Focus should be on the product or customer, not the machine, department, or process step. Value streams are created by grouping similar products together in a company. The grouping of the products should depend on the company but could be centered on the characteristics,

demand, and process routings. The value stream should allow for unhindered material, information, and people flow. the material flow focuses on the flow of materials from raw to final product, the information flow focuses on the communication flow of customer requirements and orders within a supply chain, and people flow focuses on how people are able to move within and around the processes (Becheno.J, 2004, p. 54) (McCullum, Roggenhofer, & Drew, 2004, p. 36).

3. The third principle is Flow. Batch and queue processes should be avoided or continuously reduced so that there is a smooth and quick flow of information, products, and services. "Flow requires much preparation activity. But the most important thing is vision" (Bechino.J & Holweg, 2009, p. 19). When looking through the point of view of an entire supply chain, it makes sense for activities to be organized in a way that allows for uninterrupted flow of work at the rate of demand pull from the customer. Disruptions to the supply chain flow affect the supply chain throughput, capacity, and cycle time and it ultimately "adds little value that the customers appreciate". (Trent, 2006, p. 16).

4. "Pull" means short-term response to the customer's rate of demand, and not over producing". Pull is especially useful in cases when it is difficult for a company to maintain continuous flow at a part of the value stream. For example, there may be a painting process in a value stream that is required to paint parts in batches of different colors. If these parts are required by several downstream assembly lines then it would be impossible to maintain a continuous flow for each line. Instead a Kanban system can be set up. A predefined number of boxes of parts are painted and stored. Every time a box part is taken by an assembly line, a Kanban card that was attached to the box is returned to the painting process. When a certain number of Kanban cards have accumulated, the paint processes changes over to replace the parts (Bechino.J & Holweg, 2009, p. 19).

5. "Perfection" Having worked consecutively through the previous four principles. a company would now be able to see that perfection within the company processes is now possible. This not only means a defect free company – but also means "delivering exactly what the customer wants, exactly when, at a fair price and with minimum waste" (Bechino.J & Holweg, 2009, p. 19).

1.2.2.6. Lean and wastes:

The notion of waste includes all sources of non-value activities that generate additional costs without adding value to customers, so wastes can be defined as a loss or a non-value-creating action.

If Lean is considered as a hunter for wastes and delays, then this hunt, hence the need to locate the activities who are generating value and those who are not.

1.2.2.6.1. VAC, NVA and VAO

Lean analyzes the activities of a process and classifies them into three categories which are (Chassend.E, Cheffontaines.C, & Fermy.O, 2010, p. 3):

VAC: Customer value added: activities that bring value to the customer (CVA: Customer value added).

NVA: Non added value or pure waste: these are activities that do not bring value for the customer (NVA: Non value added).

VAO: refers to activities that add value to the organization and other stakeholders, also called necessary waste because they do not bring value to the customer (BVA: business value added)

1.2.2.6.2. Muda, Muri and Mura

Muda, Muri, and Mura are Japanese words that were often used by Toyota during their development of Lean. Muda means waste (explained before), muri means overburden, and Mura means unevenness.

These three concepts allow for a more complete understanding of Lean. "Variation in the order arrival rate and variation in the capacity is unevenness (Mura). Capacity is directly linked with overburden (Muri). … Mura and Muri lead to Muda" (Bechino.J & Holweg, 2009, p. 6)

- **Muri (The overburdening of workers and machines is a waste)**

Workers want to be able to enjoy their working life, and they should be willing to be a part of the improvement of company processes. The quality of work life should be enjoyable. ergonomics such as lighting, temperature, and comfort should be as work friendly as possible. Also, emphasis on safety in the work place is key. Workers should not be overburdened with work as this could result in stress and/or injury. Overburden leads to less efficient and low-quality work done.

Likewise, machines can be pushed beyond their limits causing them to break down. Overburdening people and machines at the same time could result in accumulation of queues, which in turn would result in missing targets. (Bechino.J & Holweg, 2009, p. 6).

- **Mura (unevenness or inconsistency)**

it is impossible to achieve a fast-uninterrupted flow of production, information, or other company processes, when there is variation in demand. In other words, achieving full Mura is impossible. However, there are ways of avoiding the increase of unevenness, as well

as ways of making the entire production process more even. Ways of avoiding the increase of unevenness includes avoiding company policies such as end of month reporting and quantity discounts. Ways of making the production process more even includes, "encouraging both suppliers and customers to order and produce more evenly – often to mutual advantage". (Bechino.J & Holweg, 2009, p. 7).

Bicheno and Holweg explain in their book "The essential guide to lean transformation" that Mura may be the root cause of the wastes that occur in a company (Bechino.J & Holweg, 2009, p. 6).

- **Muda (the result of Muri and Mura)**

is any activity or process that does not add value, a physical waste of your time, resources and ultimately your money. These wastes were categorized by Taiichi Ohno within the Toyota production system, they are (leanmanufacturingtools website, 2019):

Transport: the movement of product between operations, and locations.

Inventory: the work in progress (WIP) and stocks of finished goods and raw materials that a company holds.

Motion: the physical movement of a person or machine whilst conducting an operation.

Waiting: the act of waiting for a machine to finish, for product to arrive, or any other cause.

Overproduction: Over producing product beyond what the customer has ordered.

Over-processing: conducting operations beyond those that customer requires.

Defects: product rejects and rework within your processes.

To this list of the original seven wastes most people also add the following.

Talent: failing to utilize the skills and knowledge of all of your employees.

Resources: failing to turn off lights and unused machines.

By-Products: not making use of by-products of your process.

Many "lean" initiatives fail to see past the elimination of Muda and believe that the point of Lean is to just eliminate waste. This leads to implementations that initially appear to save money but quickly fall apart and revert as problems such as customer demand fluctuations and supplier problems occur. They have failed to tackle the other forms of waste identified by Toyota.

1.2.2.6.3. Remove Muda, Mura and Muri

Lean is about the removal of waste. but not just Muda (non-value adding steps), it is about removing Mura and Muri too. In fact, by concentrating on solving Mura and Muri you

prevent the creation of Muda, By working on Just in Time (JIT) principles with Heijunka, Kanban and other techniques you enable production smoothing and flow. removing the causes of Mura, unevenness. The other lean tools such as 5S and TPM help you to remove other causes of overburden removing Muri, overburden.

You should first concentrate on ensuring that your Mura is removed and creating a level predictable flow. this in turn highlights the Muri (unreasonableness) within your system which can then be eliminated. By following this route, you will often eliminate the vast majority of Muda that is present within your system.

Muda, Mura and Muri can be eliminated or significantly reduced if you implement the various lean tools and principles. But don't just rush in to try and highlight and remove the Muda in the hope of making a quick impression on your boss. it will be a short-lived success as without tackling the other MS Mura and Muri you will find the other wastes of Muda returning to haunt you (leanmanufacturingtools website, 2019).

1.2.2.7. the fields of application of lean

Given the ease of its use and its massive benefits, lean management break into many fields giving us several operational versions, such as (TAMSSAOUET & MECHOUAR, 2004, p. 24):

Lean Manufacturing: Aim for the rationalization of the productive resources of the company.

Lean Logistics: Its purpose is to optimize the supply chain of the company (wastes in terms of delays in receiving and delivering goods, unnecessary transport).

Lean Warehousing: Concerns the management and organization of stocks by reducing any type of waste.

The Lean Office: Who aims to reduce the slowness of administrative processes.

We can also find Lean Innovation, Lean Development, or continuous improvement of the immaterial flow.

1.2.2.8. Lean limits

The great success of Lean has made it widely adapted in different sectors, different environments as well, so Lean has become an approach universally recognized. Only practitioners and academics of Lean draw attention to the constraints of its use.

Indeed, there is a great disparity between Lean theory and its actual application in the field, often related to cultural differences, resistance from staff, which leads to the abandonment of the actions implemented. So, the success of applying a good lean philosophy is highly dependent on the cultural context, as well as on the interest of the methodology and

the risk of the miss use of its concepts and the non-mastery of its practices (Layonnet.B, 2015, p. 195).

1.2.3. Theorical frame of six sigma:

Lean is therefore a safe source for organizations that wish to improve their management, but its philosophy in the face of various economic and cultural contexts is questioned (Layonnet.B, 2015, p. 195). This explains the use of other methodologies such as Six Sigma, focusing more on the technical aspect of the organization.

This sub-section will deal with the presentation of the theoretical concepts related to the Six sigma method:

1.2.3.1. Definitions:

In statistics, the Greek letter sigma "σ" is used to designate the standard deviation. In the "Six Sigma" method, it represents a unit of measure for the variation of a process. There are therefore several levels of sigma including the "Six" which correspond to the level of perfection to achieve.

According to George (Geaorge.M, 2002, p. 9)Six Sigma isn't just an "improvement methodology." It:

- A System of management to achieve lasting business leadership and top performance applied to benefit the business and its customers, associates, and shareholders.
- A Measure to define the capability of any process.
- A Goal for improvement that reaches near-perfection.

Six Sigma is a rigorous, targeted and very effective method in the implementation principles and techniques of quality, it's main aim is a performance without error (Pzydek & Keller, 2010, p. 15)

Six Sigma is a method of improving the quality of products and services provided to consumers, in this method we need to focus on what the customer really wants, not what we think he wants. Another must is to be able to determine the critical characteristics for quality (CTQ) characteristics in order to set a target.

1.2.3.2. Six sigma in service sector:

Although six sigma has garnered much deserved attention and recognition in the manufacturing sector, its applications in the service industry are not yet well documented. Experts agree that the most common reason service-oriented organizations stay away from six sigma is that they see it as a manufacturing solution, But the truth is that Six sigma can be used in services organizations for example to reduce the costs of poor quality so that a more consistent process for service delivery may be achieved (George.M, Lean Six Sigma

for Service: How to Use Lean Speed and Six Sigma Quality to Improve Services and Transactions, 2003) and (Jiju Antony, Frenie Jiju Antony , & Maneesh Kumar, 2007).

Another important reason for the introduction of the six-sigma strategy in service companies is that customers of today feel "process variability" in the delivery of the service provided and not just on "process average or mean" so the objective of a six-sigma strategy is to reduce "process variability" around the acceptable target service performance (Jiju Antony, Frenie Jiju Antony , & Maneesh Kumar, 2007).

Table 1-3 Examples of six sigma use in service organizations

Service	Problem example	Outcome
Healthcare	Increase radiology throughput and decrease cost per radiology procedure in a hospital	Significant improvement in radiology throughput and reduction in cost per radiology procedure
Banking	High number of flaws in customer-facing processes	Reduced flaws in all customer-facing processes
Miscellaneous	Poor delivery performance in a logistics company	Reduced the number of delayed deliveries
Utility services	High contract complaints resulted in customer, dissatisfaction and high costs.	Reduce the number of complaints.
Financial services	Problems in accounts receivables within an accounting department	Improve cash flow

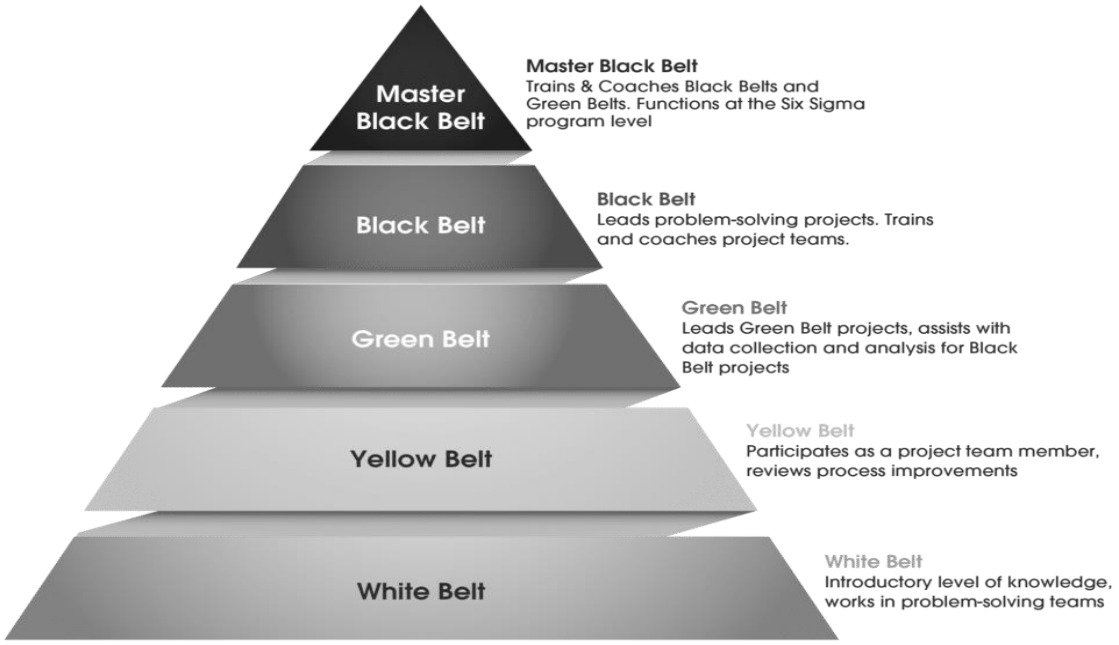
Source: made by the author according to (Jiju Antony, Frenie Jiju Antony , & Maneesh Kumar, 2007)

1.2.3.3. Six sigma infrastructure levels:

Understanding six sigma levels can be confusing. But the most important thing is to know that levels of six sigma are referred to by colored belts, each colored belt represents a level in the hierarchy of six sigma infrastructure.

Companies recognize Six Sigma certification as a proof that an individual has the knowledge and training to enhance, reduce or eliminate unnecessary costs and streamline business processes that help propel future growth, Unlike the rigorous standards set forth by the Project Management Institute for PMP certification requirements, there are no prerequisites to becoming Six Sigma Certified. To receive Six Sigma Certification, one must follow a hierarchical process (sixsigmacamp website, 2019).

Figure 1-5 Six sigma belts



Source: six sigma camp website https://www.sixsigmacamp.com/six-sigma-belt-levels/ consulted on June 2019 (sixsigmacamp website, 2019).

So, Six Sigma implementations and roles may vary, here is a basic guide to who does what (ASQ web site, 2019):

Master Black Belt: Trains and coaches Black Belts and Green Belts. Functions more at the Six Sigma program level by developing key metrics and the strategic direction. Acts as an organization's Six Sigma technologist and internal consultant.

Black Belt: Leads problem-solving projects. Trains and coaches project teams.

Green Belt: Leads green belt projects, assists with data collection and analysis for Black Belt projects. Leads Green Belt projects or teams.

Yellow Belt: Participates as a project team member. Reviews process improvements that support the project.

White Belt: Can work on local problem-solving teams that support overall projects, but may not be part of a Six Sigma project team. Understands basic Six Sigma concepts from an awareness perspective.

In some companies we might find Brown Belt it is not recognized by most organizations or accrediting agencies:

Brown Belt: as a person who has their Green Belt and has passed the Black Belt certification exam, but hasn't completed a second Six Sigma project.

In addition, each project needs organizational support. Six Sigma executives and champions set the direction for selecting and deploying projects. They ensure, at a high level, that projects succeed, add value, and fit within the organizational plan.

Champions: Translate the company's vision, mission, goals and metrics to create an organizational deployment plan and identify individual projects. Identify resources and remove roadblocks.

Executives: Provide overall alignment by establishing the strategic focus of the Six Sigma program within the context of the organization's culture and vision.

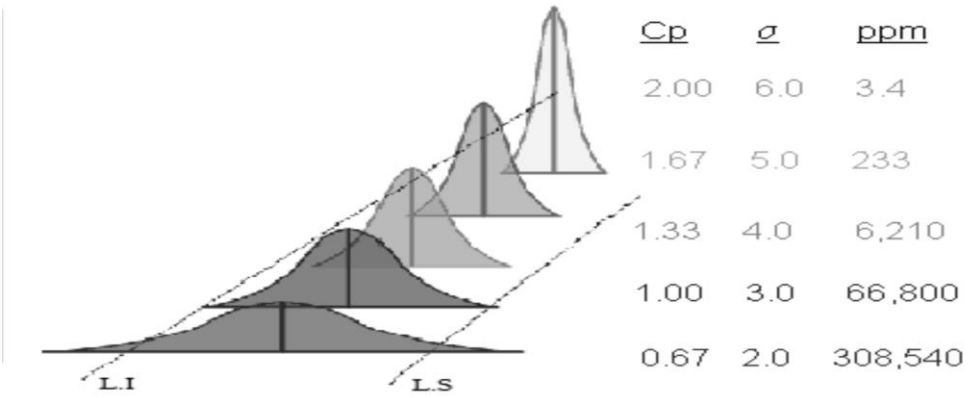
1.2.3.4. The sigma major measures

The six sigma level is measured as follow

DPMO and sigma level

The Greek letter "sigma" in probability refers to the standard deviation of a normal law (represented graphically by a Gauss curve), it is originally a statistical unit of measure that defines the variability or dispersion of data. By extension, the higher the "sigma" of a process, the more the outgoing elements of the process (products or services) satisfy the needs of the customer, and the more the defects of this process are rare (HAMILTON, 2009, p. 54)

Figure 1-6 Gauss curve in the different levels of sigma



Source : adopted by (George.M, Rowlands.D, & Kastle.B, What is Lean Six Sigma?, 2004, p. 39)

As we see, the sigma value ranges from 1 to six and the reason behind the name of "Six Sigma" is that the value 6 of sigma is the goal. So, all the challenge of this approach is to succeed in converging to the smallest number of defects possible, which corresponds to 3, 4 defects per million25 (George.M, Rowlands.D, & Kastle.B, What is Lean Six Sigma?, 2004)

DPMO is calculated using this formula (WILEY, 2001, p. 18):

$$DPMO = \frac{Defetcs}{Oppurtunities \times Number\ of\ units} \times 1\ 000\ 000$$

While,

- **The unit:** The article produced or the service delivery object.

- **The defects:** Any event that does not meet the customer's requirements.

- **The opportunity:** The opportunity that a defect occurs.

Figure 1-7 Sigma levels and their yield

Sigma Level	Defects per Million Opportunity	Yield
6	3.4	99.9997%
5	233	99.977%
4	6 210	99.379%
3	66 807	93.32%
2	308 537	62.2%
1	690 000	31%

Source: made by the author according to. (Geaorge.M, 2002)

The "per million opportunities" (DPMO) aspect of the Six Sigma metric is critical because it allows you to compare the capability of widely different processes. The Sigma metric makes sure that simpler processes, which have fewer steps and fewer chances for something to go wrong, aren't given an advantage over more complex processes. (Having 20 errors in a four-step process is a higher rate of defects that having 50 errors in a forty-step process) (Geaorge.M, 2002).

1.2.3.5. Six sigma principals:

The five six sigma principles according to Craig, Neil, Bruce (Craig.G, Neil.D, & William.B, 2005):

1. "It begins with one simple Equation", every activity in organizations can be represented by a simple function $Y = F(x_1, x_2, \dots, x_i) + \varepsilon$, six sigma operation also can be represented by this formula while:

Y: is the outcome, the result that the company desire or need.

X represent the inputs, factors or pieces that are needed to create the outcome, we can have several inputs ($x_1, x_2, \dots, x_i$).

F: is the function, the way or the process by which inputs are transformed into the outcome.

ε: is the presence of error, the uncertainty in depending upon the x_i and the transformation function to actually create the desired outcome, also called the variation.

2. "Determine the cause" it's in our nature that we always look for causes, if good things happen, you want to know how to make them happen again, and if bad things happen, you just as surely want to know how to prevent them next time.

Cause and effect: All outcomes are the result of the inputs and the process that acts on them, plus error that create variation, regardless of complexity, literally every result has one or more causes. The more you can identify causes and understand them, the better your opportunity to change it for the better, in six sigma knowing the X, the function and the uncertainty means you know what caused the outcome Y.

This is a better way: every organization tries its best to consistently improve its performance and boost its efficiency, to make this a reality companies change their way of work consistently, they are always looking for optimum combinations of inputs, processes and variation with the best outcome, and they never stop because there is always a better way.

Beware superstitious delusions (that is, correlation doesn't imply causation): the more you understand the cause-effect relationships between inputs and outputs, the better you can predict , determine and control the result, not confusing cause- effect with correlation is so important in businesses, just because two events happened together does not mean that one has caused the other , for example a company decided to ramps up its production after a great month because they think this indicates an economic expansion but after a while they discover that they were wrong and increased sales are correlated to something else .

3. "Variation happens" in general, variation- in time, process, specification or costs - is undesirable, it creates uncertainty in the ability of producing or offering a desired outcome. but in the hand, we have to admit that it is inevitable and we need to learn how to minimize it and how to deal with when it occurs, reduction of the unwanted variations is the key to achieving the six-sigma goal (I'm going to talk more about variations next).

4. "Thou shalt measure" it might seems impossible and a lot of unnecessary work to measure all your inputs and outputs, you would prefer to think that somethings are just unmeasurable and everything is okay even if you are not measuring , but for long term its going to be much more difficult to try to achieve goals without data.

Mind the x_s and y_s: measuring both inputs and outputs is what gives you the profile of how your process -function f- is playing out relative to a goal. measurement begins with the x_s then y_s extends to the to understand the causes.

The answer begins with the data: some inputs and outputs are easy to measure because of their nature, that allows us to have some numerically quantifiable measures. Other variables are not easy to measure, because of their non countable nature or because they might need lot of time efforts or cost a lot. in these cases, measurement instruments need to be specifically designed, like a survey question that ranks responses, this will make the qualitative data much more quantitative in nature.

The bottom line of measurement: taking measurements is the key to quantify the relationship between inputs, outputs and error in a given system, process, or operational model. And even when numbers are not available, we can create estimates numbers in accordance with sound practice.

5. "The power of leverage" in six sigma terms, leverage is the ability to apply critical few x_s that have the largest impact on your desired Y.

The vital few versus the vital many: also known by pareto rule or 20-80 rule where 20% of inputs in any system accounts for 80 percent of the influence on that system. That means in a process we can say that a few key variables are the cause of most performance problems and defects ,that means by only controlling few variables you can make a big difference in your production or work on general and you will not waste your time effort and money on putting attention to all variables .

Finding the better way: in six sigma, structured tools help you brainstorm the possible causes of performance problems or operational issues as well as the behavior of y of concern. Analytical tools enlighten you as to which x_s are the critical one that you should focus on to impact Y.

After understanding numerically how x_s interact and impact the Y you can implement countermeasures – different X related actions that ultimately improve the y – and use the same data framework to take new measurement in order to test the impact of the countermeasures you applied .these what we call data-oriented baseline against which to prove the new way of doing business is truly a better way.

1.2.3.6. Six sigma and variation:

As its mentioned before "the reduction of the unwanted variations is the key to achieving the six-sigma goal" (Craig.G, Neil.D, & William.B, 2005), so it's clearly important to understand the relation between six sigma and variations.

The source of defects is almost always linked to variation in some form: variation in materials, procedures, process conditions, etc. (As you'll see, Lean Six Sigma expands the scope of variation to include time: missed deadlines, variability in lead times, and so on.) That's why the fundamental thesis of Six Sigma is that variation is evil because a high level of variation means customers will not get what they want— with all that that implies for retention, marketing efficiency and revenue growth (Geaorge.M, 2002, p. 24).

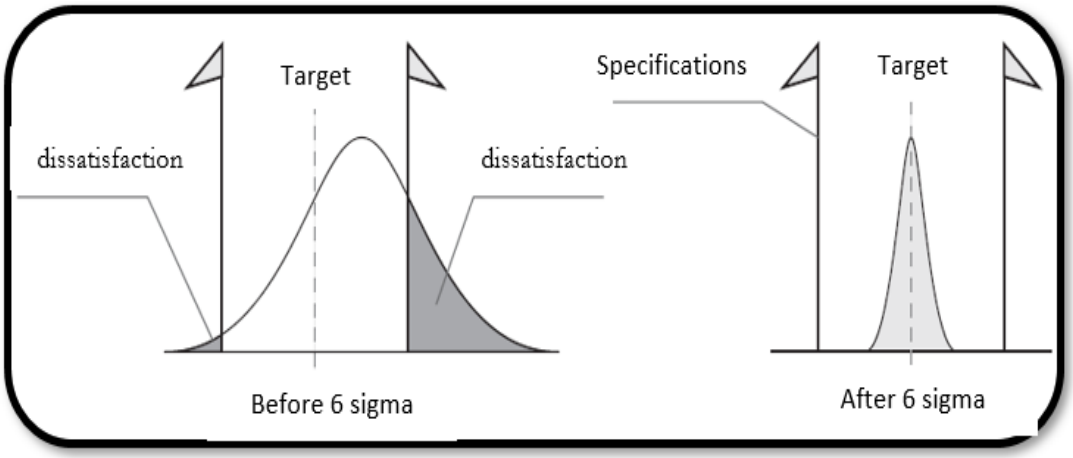
The Six Sigma method finds an application for all types of variability, the initial goal of the approach is to reduce the variability of a process observed in one of the data of its outputs, and also works on improving the quality of products and services by treating the root causes and the real sources of problems (Pillet.M, 2013, p. 10).

After the application of the method, the process must be able to manufacture non-discarded products, this will help with optimizing the cost of the products, which lead directly to the improvement of company's productivity. (Aouadi.H, 2016)

So, six sigma main objective is a good quality output, in six sigma method good quality is not about controlling the products to make sure of their conformity but of working on the processes so that only products conforming to the requirements of the customer are realized this is only obtained by reducing the variability of the processes, which finds its origin, in particular, in (Aouadi.H, 2016):

- Variability on materials.
- Variabilities in procedures.
- Variability in the conditions in which the process evolves…

Figure 1-8 The variation of sigma and the client satisfaction



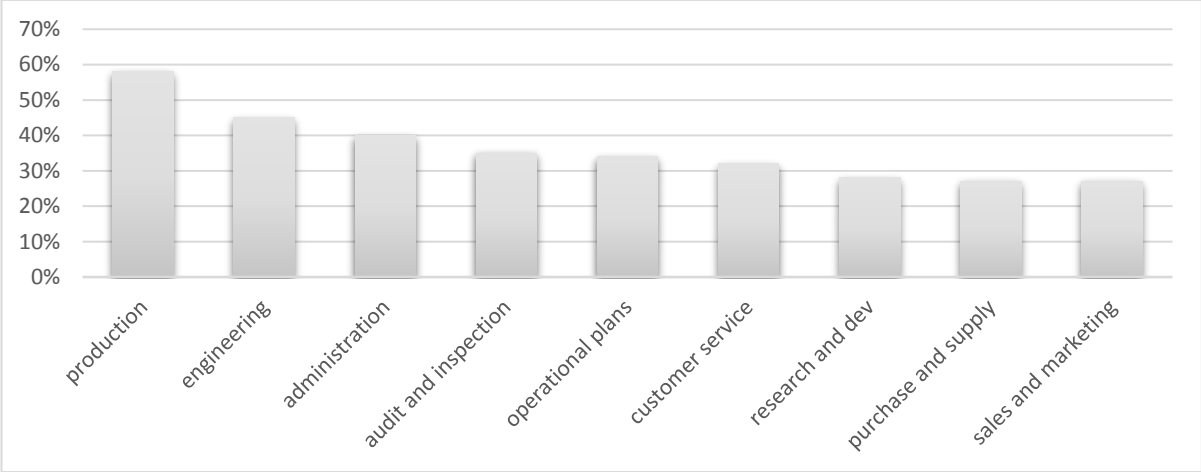
Source: made by the author according to (Aouadi.H, 2016)

1.2.3.7. The fields of application of six sigma

As the Six Sigma method offers measurable and unmeasurable gains that are significant enough for the company that sets up Six Sigma programs on identified problems within one or more of its processes, applying the Six method Sigma today touches all sectors of all functional areas.

A survey conducted by Quality Digest shows that Six Sigma programs started to spread since 2008 across few functional sectors as shown in the following figure:

Figure 1-9 Distribution of Six Sigma projects on functional fields in 2008



Source: made by the author according to (Dusharme, 2008)

nowadays, six sigma is a fundamental tool in the total quality management approach in all the companies who are after of processes excellence (Dusharme, 2008).

1.2.3.8. Six sigma limits

In the spirit of Six Sigma, we work on the processes in order to reduce their variability, but we must admit that as soon as we are confronted with a complex system, the stability of the result of the process necessarily passes by the variability of the process, indeed the variability in this case is synonymous with flexibility, which can be manifested in different ways (versatility of teams, use of resources according to needs...etc)

Also, Six Sigma does not take into account the sources of waste that may exist during the execution of the tasks, which could lead to more costs and thus sacrifice the profitability of the company for quality improvement purposes.

In addition, timing optimization is not displayed as one of the primary goals of Six Sigma, which could compromise its key focus, customer satisfaction.

1.2.4. Theorical frame of lean six sigma

After defining the lean and six sigma separately, in this sub-section we will be developing their combination theorical frame.

1.2.4.1. Definitions

According to George (George.M, Lean Six Sigma for Service: How to Use Lean Speed and Six Sigma Quality to Improve Services and Transactions, 2003) : "Lean Six Sigma is an overall improvement approach that is characterized by the achievement of the objectives of the company and the satisfaction of the customer's needs".

Some people have described Lean Six Sigma as "doing quality quickly," which may seem counter-intuitive at first. Intuition tells us that the faster we go, the more mistakes we make. If that were the case, trying to speed up a process would only result in lower quality. But Lean Six Sigma works not by speeding up the workers or the machines, but by reducing unneeded wait time between value-add steps.

Lean Six Sigma is the fusion of two complementary approaches working on the optimization of processes by focusing on quality, costs and process deadlines.

By mastering the operational risk, the LSS makes it possible to link the two notions of productivity (Lean) and quality (Six Sigma) at the same time in order to allow a more complete intervention on the whole system of the company (Geaorge.M, 2002, p. 45).

Indeed, the synergistic effect of the LSS has been more effective compared to the application of Lean and six sigma separately (Geaorge.M, 2002, p. 18):

- Lean cannot bring a process under statistical control
- Six Sigma alone cannot dramatically improve process speed or reduce invested capital

1.2.4.2. Lean six sigma in service sector

As we mentioned before, both Lean and Six Sigma started in the industry sector. So, organizations in this sector have somehow acquired a "historical maturity" which favors the deployment of such approaches.

Indeed, notions of measurement, performance, inventory management or still return on investment and steering are relatively anchored in the industrial environment. But we can say that these notions are still unevenly used in the services sector. Of this view, the establishment of Lean Six Sigma in services seems to be a challenge.

Yet, services where wastes vary and the complexity is a big problem generating considerable costs, represent a sector in which the use of Lean Six Sigma can result in significant savings. It is for these reasons that service companies are very interested in setting up programs inspired by Lean Six Sigma.

With the hope of simplifying the flows of administrative procedures, reduce deadlines, eliminate unnecessary tasks that do not add value to the customer.

Some of the difficulties that project teams are going to confront each other are quite characteristic of the services. So, it is often necessary to strengthen - even to establish- a culture of measurement and management in the sector of services, which is theoretically a prerequisite of projects, and which becomes in this case a resultant of the projects.

Moreover, it is not uncommon for organizations in this sector develop more and more personalized offers, "Tailored" for their customers, but increasingly complex to be managed by the employees. Lean Six Sigma projects in this case seek to reduce this complexity, with for the dual purpose of facilitating the work of employees while respecting the needs of customers.

Finally, if in industry the machines represent only a source of considerable variability is more (Nicolas.V, 2009, p. 15).

the human factor that is at the heart of many processes' services. This reality implies that the dimension of questioning practices and habits, and the inevitable resistance to it must be given special attention in this sector.

1.2.4.3. Lean six sigma infrastructure levels

The LSS methodology is using a 'belt' concept to identify roles and individual levels of experience and knowledge (Allan.G, 2014)

Lean six sigma follows a bit the six-sigma infrastructure to better spread its culture, it uses of the six sigma colored belts methodology to make an extra organizational support for lean by identifying roles and individual levels of experience and knowledge.

Lean Six Sigma usually begins at the top levels of a company with executive training and planning. Implementing Lean Six Sigma through various positions include (Lee, February 2013):

- Champions: An executive level manager who has the responsibility for managing and guiding Lean Six Sigma efforts.
- Black Belts: Employees who receive a minimum of 4 to 5 weeks of training on leadership and problem solving.
- Master Black Belts: Those who receive advanced training in more sophisticated problem-solving techniques.
- CEO & executives: One who determines whether the organization will adopt Lean Six Sigma.
- Business unit managers: Managers working closely with the Champions.

- Line managers/process owners: the people who own the processes that will be improved by Lean Six Sigma. They are responsible for authorizing changes in the process procedures.
- Green Belts/Yellow Belts/White Belts Team members: Those can be anyone in the organization who receives some level of awareness education or skill training.

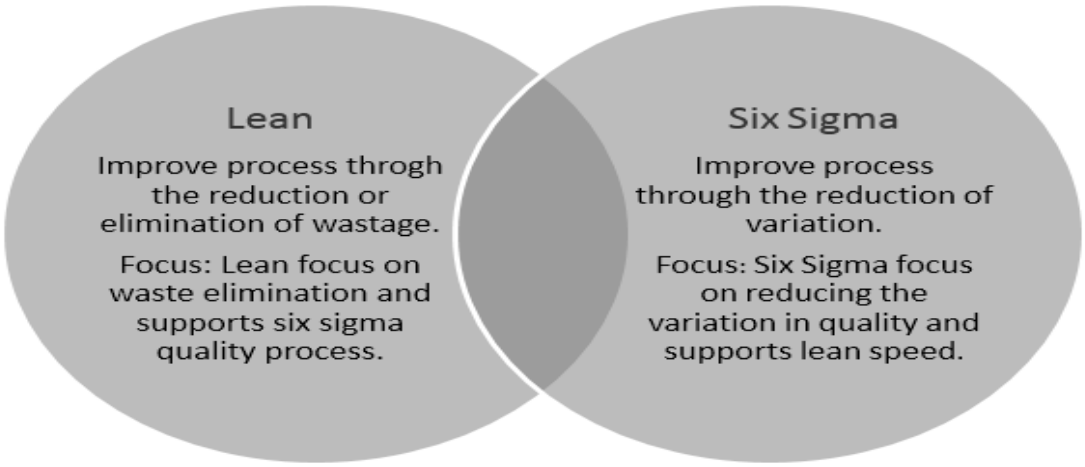
1.2.4.4. Why and where the combination of lean and six sigma is highly recommended (Geaorge.M, 2002, p. 40)?

Six Sigma does not directly address process speed and so the lack of improvement in lead time in companies applying Six Sigma methods alone is understandable, Lean methods alone aren't the answer either: Many of the firms who have shown little improvement in inventory turns have in fact attempted to apply Lean methods.

It appears that, while many of people at these companies understand Lean, they just aren't effective in implementing it across the corporation at a rapid rate. The past companies' experience shows that improvement across the corporation as a whole remains slow without the Six Sigma cultural infrastructure. An executive whose company is making rapid progress.

If a company started with Six Sigma… it might spend a long period trying to reduce lead time, only to realize it was reinventing Lean! In other words, no matter where you start—with Lean or with Six Sigma—you'll be driven to invent or learn the other half of the equation if you want to achieve high quality, high speed, and low cost.

Figure 1-10Lean and six sigma combination



Source: adopted by educba website https://www.educba.com/principles-of-lean-six-sigma. Consulted on June 2019 (educba website, 2019)

According to figure 1_10 Six Sigma focuses more on quality than speed. The methods known as "Lean" are better at eliminating wastes and speed than on improving quality,

combining the two makes Lean Six Sigma a powerful improvement tool that leads to dramatic fast improvements across the corporation, and indeed this combination is in fact a pre-requisite to deliver efficiency.

Lean six sigma can be and its already applied in any company of any size operating in any sector, as long as its operational processes are well defined.

“While the fundamental principle of Six Sigma is to take an organization to an improved level of Sigma capability through the rigorous application of statistical tools and techniques, Lean production has a role in eliminating waste and non-valued added activities across the entire supply chain” (Antony.J, 2011).

1.2.4.5. Lean six sigma principal laws

The Lean Six Sigma concept is based on five principles (laws) that make its application effective, some authors starts from zero to 4 laws (sixsigma basics, 2019) but they are the same as those who consider them as 5 laws (George.M, Rowlands.D, & Kastle.B, What is Lean Six Sigma?, 2004, p. 22)

Law n ° 1 - the law of the market: "the needs of the customer define the quality and are the highest priority of the improvement".

Law n ° 2 - the law of flexibility: "the speed of any process is proportional to its flexibility (that is, the ease with which people can move from one task to another. other ".

Law n ° 3 - the law of concentration: "pareto law 20% of the activities within a process cause 80% of the problems and delays".

Law n ° 4 - the Law of Speed "Little Law": "the speed of any process is inversely proportional to the amount of work in progress".

Law No. 5 - the law of complexity and cost: "the complexity of a service offer or product usually adds more costs and work in progress than do quality problems (low sigma) or slow (contrary to Lean) ".

1.2.4.6. Lean six sigma foundation

The foundation of Lean Six Sigma centers on (George.M, Rowlands.D, & Kastle.B, What is Lean Six Sigma?, 2004, p. 25):

1. Delighting customers, delivering higher quality service in less time (with speed and quality). Developing a focus on customers means more than just doing a survey now and then. It means developing awareness about customer needs that shape most of the work we do every day.
2. Improve processes by eliminating variation in quality (defects) and focus on how raise the speed of work flow through the process

Improving processes include:

- Documenting how work gets done (the steps that comprise the process)
- Examining the flow of work between people or workstations.
- Giving people the knowledge and methods needed to constantly improve work.

3. Team work

the skills of collaboration:

a- Listening skills, b- Brainstorming and discussion, c-organizing ideas, d- decision making

Additional skills for effective teams:

a-Set goals b- assign accountability c- Handle conflict

d- Pay attention to how decisions are made e- Make sure effective meetings,

f- Foster continuous learning g- Collaborate with other groups.

4. Decisions are based on data.

You need data and facts because they will save you a lot of trouble and prevent a lot of wasted dollars and time. Having data can make a huge difference in the decisions we make every day on the job and are particularly important in improvement projects. A lack of available data limits knowing how long, or on average, or how long it takes you to handle work items, which brings about customer satisfaction and/or dissatisfaction.

Kinds of data to collect:

a. Customer satisfaction (a result measure) Data gathered through surveys or interviews on what customers think about your product or service.

b. Financial outcomes (a result measure) What impact the quality and/or problems have on revenue, expenses, costs, etc.

c. Speed/lead time (result or process measure) Data on how fast (or slow) your process is. "Lead time" is how long it takes for any individual work item to make it all the way from the beginning to the end of the process.

d. Quality/defects (result or process measure) How many errors are made, whether the product or service has flaws that affect the customer, etc.

1.2.4.7. Key success factors of LSS

For a Lean Six Sigma approach to succeed, it is necessary that the project of its implementation be framed, the following elements constitute the key factors of success of the establishment of the LSS (Pascart.E, 2009, p. 113):

- The support of senior management is essential.
- The involvement of the entire company.

- Setting up the necessary organization (Black Belts, Green Belts).
- Communication needs to be adapted and structured.
- The control of the method by the team through training on the method.
- Choosing the right tools for the company.

Chapter conclusion

Lean six sigma is one of the best tools that can be applied as continuous quality improvement. This chapter gives a brief explication of the evolution of the hybrid lean six sigma, it highlights the fact that lean six sigma is not a simple tool that can be used only in manufacturing. Rather it is a fully integrated management and approach that can be applied in service companies and any other type of companies, leading to great results and making them more efficient than ever, in the second chapter will be talking about how to use lean six sigma in the best way according to the multiple reads and researches we did .

Chapter 2: Lean six sigma in practice, a game of reducing variability and wastes.

Chapter introduction

After defining the concept of Lean Six Sigma and studying its mindset, it's time to focus on how it works in the real business world.

The purpose of this chapter is to explain the implementing project of Lean Six Sigma in general and the method chosen in this work DMAIC.

- In the first section we will explain how to implement the lean six sigma project in the best possible way we will talk about the LSS culture and its importance then we will bring to the table some of the most famous implementation methodologies.
- The second section will be about the deployment of Lean Six Sigma following the DMAICS approach which will be explained in detail.

2.1. Section one: How to better implement lean six sigma

"Culture eats strategy for breakfast" _Peter Drucker, is especially true for Lean Six Sigma success we will be talking more about

- Lean six sigma culture and how to introduce it to the company in the first sub-section,
- In the second subsection, we will try to highlight some implementation challenges we judge the most common.
- In the third sub-section, we will be talking about DFSS, DMAIC and DMAIV approaches in order to choose the one that fits better our project.

2.1.1. The Lean Six sigma culture

Many organizations focus broadly on providing their employees with Lean Six Sigma training. While broad-based Lean Six Sigma training is important, it is only the beginning. Training must be reinforced by a company culture that nurtures a Lean Six Sigma outlook and prevents employees from returning to their old and less-effective ways.

Companies need to have a culture that supports the best the implementation of LSS and if they don't, no worries, culture can be changed (six sigma daily, 2019), and this is what we will be describing in this sub-section.

Improve Company Culture with Change Management (six sigma daily, 2019) **:**Change management can help solidify a new culture in individuals and organizations. Consider these four steps of change management can be used to instill Lean Six Sigma culture into an organization.

2.1.1.1. Create Awareness and Desire

This process starts at the top, as executive management communicates the benefits of using LSS methodology, down through the organization. This can provide four important benefits:

Projects are better able to stay on time and budget.

Management can support LSS projects by allocating the proper resources.

Management's support for LSS projects can decrease resistance from employees and other stakeholders.

Employee productivity may be less impacted by the change.

2.1.1.2. Practice, Practice, Practice

Once employees' hearts and minds are prepared for a cultural shift, it is time to put Lean Six Sigma into practice. Fortunately, Lean Six Sigma training can be adapted to the abilities and needs of every member of the organization. The more employees who receive certification, education and training the better established Lean Six Sigma becomes in the culture.

2.1.1.3. Expect the Unexpected

Following your change management plan is critical for creating a climate where Lean Six Sigma culture can thrive. However, change agents may encounter hidden obstacles that threaten to derail change, such as strongly held traditions or an attachment to outdated practices. Managing change means being prepared for the unexpected.

2.1.1.4. Be Liberal with Rewards

You get more of what you reward. Companies that bestow generous rewards on the employees who support a Six Sigma culture will in turn be rewarded with more support for the culture.

2.1.2. The common challenges

The implementation of any new method, approach or culture in any enterprise is a challenge, in this sub-section we will be talking more about this challenge and especially the LSS implementation challenges.

Executives, experts and employees have been singing the praises of the LSS continuous process improvement methodology for years. Organizations that implement this methodology have improved their products, services and processes. The ability to reduce defects has helped them to increase productivity, customer satisfaction and profitability.

What is mentioned less frequently are the obstacles that stand in the way of implementing Lean Six Sigma. No discussion of Lean Six Sigma execution is complete

without addressing the hurdles that organizations face in implementing LSS and how to overcome them (Jared.M, 2013).

Here are a few common roadblocks in successfully implementing LSS in an organization, and how to eradicate them (Jared.M, 2013):

Lack of Leadership Commitment

A true test of a company's commitment in deploying LSS comes when management decides which employees will be dedicated to the project. Using whoever is available instead of dedicating top talent to LSS project efforts puts the project on uncertain footing and reduces the odds of its success. A successful LSS project requires leaders who are willing to dedicate resources of time, talent and money to the project.

Reassigning top performers from their current work to deploy LSS projects is a short-term sacrifice, but can unlock the benefits of LSS over the long term.

Incomplete Understanding of LSS Methodologies

In their eagerness to reap the benefits of deploying the LSS methodology, some organizations rush in before they have a firm grasp of what successful LSS implementation requires. This can occur when companies implement LSS simply to keep up with the competition, or to impress shareholders by being able to use continuous process improvement terminology in company documentation. Organizations that deploy LSS as only a cosmetic change, or implement it without the resources it requires, are only inviting failure.

Companies can overcome this obstacle by committing fully to the process and employing and supporting LSS experts to ensure that the company is deploying the methodology and not just using the terminology. These experts also keep the project focused on core operations where they can make the most difference, not just on the simple changes and the low hanging fruit.

Poor Execution

Even under the expert guidance of project Champions and Master Black Belts, LSS quality improvement projects can go awry if they are not properly executed. Poor execution happens when process improvements are not aligned with the organization's goals, when the project is based on reactively solving problems instead of meeting strategic objectives or when the quality improvement project focuses on the output of the process instead of the inputs.

When companies understand that LSS methodologies are not intended to operate in a vacuum but that they work best when aligned with the goals and objectives of the organization, they are more likely to stay on target.

Organizations that find they are not getting the productivity gains or financial savings they anticipated from employing LSS methodology are not disappointed because the methodology is ineffective. The most likely source of their disappointment is that the projects lack effective leadership and are managed inefficiently. When leadership is committed to applying the LSS methodology, assigns top talent to project teams, puts the project through a formal selection and review process, and provides the required resources, the odds of LSS success increase dramatically.

2.1.3. Lean six sigma implementation approaches

In this sub-section we will be presenting three famous ways to implement the LSS, each of which responds to a specific need:

The DFSS

(Design for Six Sigma) for the design of new processes, projects, or innovative products (Frechet.C, 2005).

DFSS Foundations (Peter.K, 2015):

1- Customer-oriented design.

2- Systematic and creative design.

3- Robust performance and prevention philosophy.

The DMADV

(Define, measure, analyze, develop, validate), it is a step aimed at improving the business through the design of new processes or products, this approach can be considered as a derivative of the DFSS since it meets the same need (Frechet.C, 2005).the five inter – connected phases of DMADV are elaborated as follows (Abhishek.V, 2008):

DEFINE - This phase encompasses the definition of the goals of the design activity, per the customer's demands and in consistency with the company strategy and goals.

MEASURE - In this phase, the customer's needs or the Critical to Quality requirements from the customer's perspective, are measured from customer input. These metrics are translated to project goals. The product capability, risk assessment and the capability of the production process are also measured.

ANALYZE - This phase consists of the analysis of innovative concepts and alternatives (benchmarking) for the feasibility of aligning them to the customer

requirements, DMAIC's analyze phase consists primarily of data analysis while it deals with the research and selection of concepts that provide the best value to the customer.

DESIGN - The Design phase involves the design of the product, process or service. The design is optimized and its effectiveness in meeting the customer requirements is validated using simulation, prototype testing, DOE etc.

VERIFY – This final phase involves the verification of the design to adapt to the real – world environment, before it enters full production.

DMAIC

Most of DMAIC projects go through a sequence of activities know as Define, Measure, Analyze, Improve and Control (DMAIC). it is almost the same as DMAIV, but this latter as we mentioned before is used to design new processes, unlike the DMAIC used for solving already existing process problems, in order to make them more efficient.

2.2. Section two: DMAIC approach and its tools

Since our work focuses on an already existing key process, the approach that we will be adopting is the DMAIC and we will be developing it more in this section in order to make it easier for us to apply DMAIC in our case study this section will be divided into two sub-sections:

- the first sub-section will be talking more about DMAIC concept and how as a six sigma method can be combined with the lean principles.
- In the second sub-section we will be explaining in details each of the 5 steps of DMAIC.

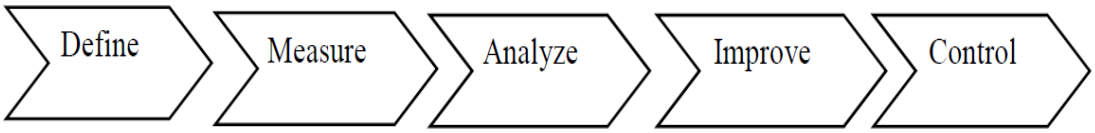
2.2.1. What is DMAIC?

In this sub-section we will be giving a brief definition of DMAIC, why it can be used as an LSS framework and its 5 steps.

2.2.1.1. DMAIC definition

DMAIC resolves issues of defects or failures, deviation from a target, wastes, excess cost or time, and deterioration. DMAIC identifies key requirements, deliverables, tasks, and standard tools for a project team to utilize when tackling a problem (Frechet.C, 2005, p. 13).

Figure 2-1The DMAIC steps



What is the problem?	What data is available?	What are the root causes of the problem?	Do we have the right solutions?	What do we recommend?
What is the scope?	Is the data accurate?	Have the root causes been verified?	How will we verify the solutions work?	Is there support for our suggestion?
What key metric is important?	How should we stratify the data?	Where should we focus our efforts?	Have the solutions been piloted?	What is our plan to implement?
Who are the stakeholders?	What graphs should we make?	What clues have we uncovered?	Have we reduced variation?	Are result sustainable?

Source: Dale et al. (2007) (Dale.B, Wiele.T, & J.Iwaarden, 2007) in (Salaha Uddin.C, Zahed Hashem.M, Kumar.S, & Abdur.R, December 2007)

As we mentioned previously, DMAIC stands for the five steps of this method and we are going to explain every one of them briefly in the table below:

Table 2-1DMAIC execution

Project phase	Brief Description	Tools	Deliverables
Define	Define the framework activity and the improvement objectives	VOC, SIPOC, Swim Lane diagram, Gemba walk, Stakeholder Analysis.	Project charter.
Measure	Measure valid and reliable metrics in the process. Establishment of the data collection and measurement methods.	Preliminary Data Analysis, Initial result of DPMO, FMECA, VSM	Quantified actual process performance, Data Collection Plan
Analyze	Identifying the roots of the most	Ishikawa, process map	FMECA

	important causes of variability	analyzing, Pareto diagram, 5 whys	
Improve	Improve the system by developing, selecting, and implementing the best solutions.	Brainstorming, the 5S,Solution decision matrix.	Implementation plan.
Control	Control the new system		

Made by the author according to my multiple researches and reads (Abhishek.V, 2008), (Aouadi.H, 2016), (Bechino.J & Holweg, 2009) (Define-Measure-Analyze-Improve-Control-DMAIC)….

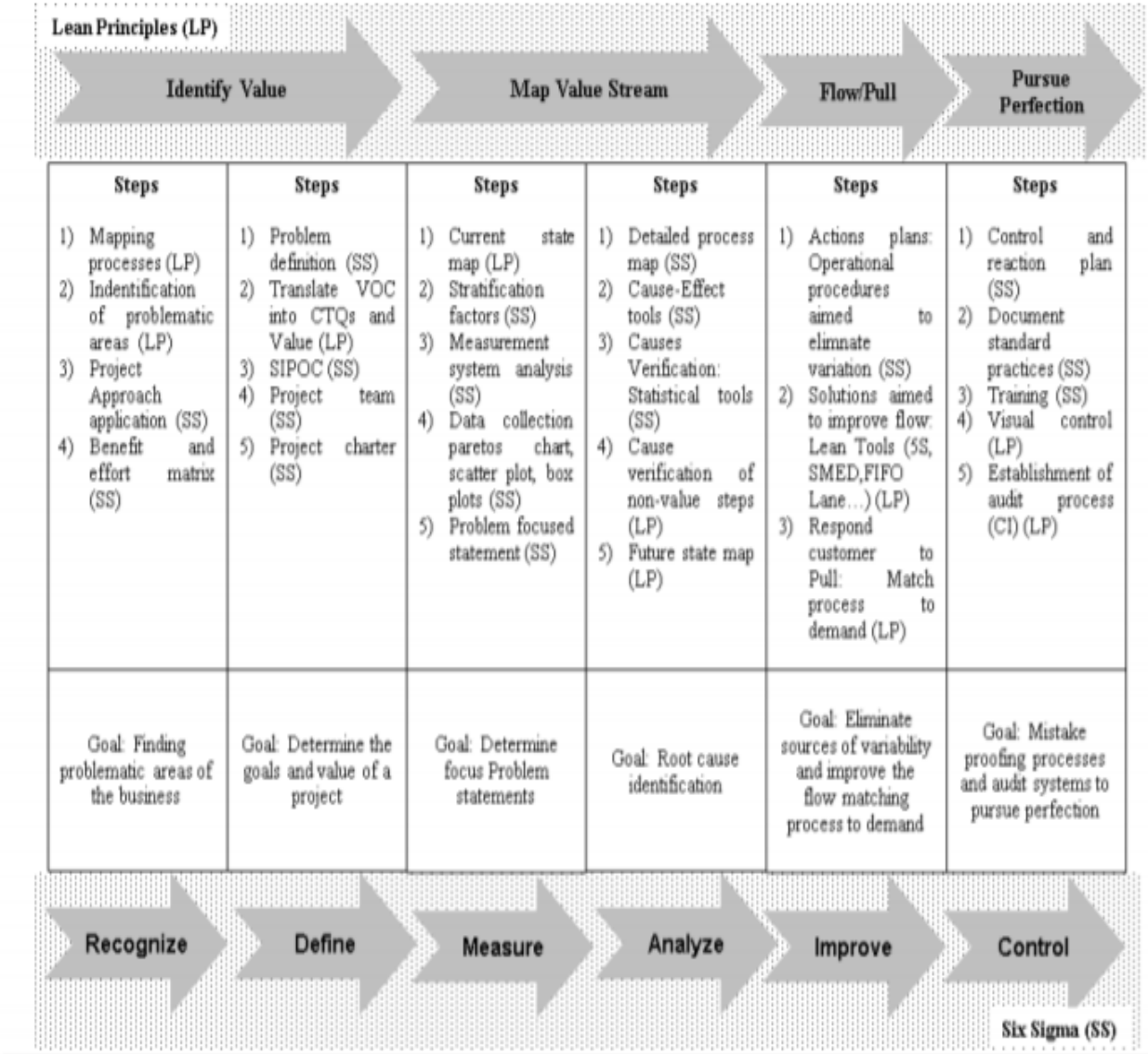
2.2.1.2. Combining six sigma DMAIC steps and lean principals

It is true that most of LSS projects uses six-sigma method and the most three famous ones "DFSS DMAIDV and DMAIC" mentioned in the previous title are six sigma methodologies, but some literatures offer a clear combination of both six sigma and lean methodologies.

Lean and Six Sigma are combined in only one initiative. Depending on the expected output, each tool is assigned to different phases. Although DMAIC is maintained as the framework for the inclusion of Lean and Six Sigma tools, the proposed approach presents an alternative framework related to the five Lean principles proposed by Womack and Jones in the classic book "Lean Thinking" (James.P & Daniel.T, 2003, p. 72):

- Identify Value
- Map Value Stream
- Create Flow
- Establish Pull
- Pursue Perfection

Figure 2-2 Proposed Lean Six Sigma Framework



Source: adapted by marcos, B. et al (Marcos.B, Cinthia.P, & Edwin.D, july 2016).

2.2.2. The 5 phases of DMAIC approach

For each phase of the five phases, we will be giving, in this sub-section, the goal, the implementation procedure, the deliverables and some recommended tools that can make the phase implementation easier.

2.2.2.1. Define phase

What is the definition of the problem from customer point of view?

2.2.2.1.1. the goal of Define

Any LSS project starts with the definition of the project framework, as well as the definition of the improvement objective that we want to achieve by the implementation of this project, this can be done in two sub-phases (Pillet.M, 2013, p. 28):

The predefinition of the project: in which we must collect and define:

- The real problem, the one process with a significant gap between expected and measured performance.
- The real customer, in other words, a customer motivated by minimizing the gap.
- The goals of the implementation of LSS project in the process
- Significant gains justifying the time and energy that will be invested.
- The necessary and available resources to achieve.
- The limited scope guaranteeing a duration of action between 6 months and 1 year
- the involved actors in every step of the project implementation.

the second sub-phase:

2.2.2.1.2. The implementation of the phase

The beginning of this phase is marked by a kick-off meeting during which the problem is mentioned, a first version of the project charter is presented. the preliminary chart project is studied and structured using different tools such as VOIC, SIPOC, Swim Lane diagram, Gemba walk, Stakeholder Analysis. Once the project chapter is validated by committee responsible for steering the mission it is considered as the deliverable of the define step and the starting point of the measure step (Sankar.S & Natarajan.V, 2011).

2.2.2.1.3. The deliverables of define step

"chart project"

This document created at the beginning of the project serves to synthesize the information collected, and includes the following points (Terhi.v, 2015):

1- The business case: This is a macro and qualitative description of the problem that will be dealt with during the DMAIC process.

2- Problem statement (The definition of the problem or problematics of the project): Consists of a brief presentation of the project and its importance for the organization, as well as an initial estimate of the cost of nonequality to be solved throughout the DMAIC process.

3- Goal statements (The objectives of the project): These are the expected outputs of the project, these objectives must be SMART (specific, measurable, achievable, realistic and temporal)

4- The scope of the project: It is a matter of defining the scope of the project (organization, process, product) in order to solve the previously identified problem as the risk of being confronted with wider and difficult to solve problems in the project as initially defined.

5- Expected benefits of the project: The objectives set in terms of productivity, lead time, quality etc. must be translated into financial benefits and related to the project costs.

6- The project team: the LSS projects are carried out in teams, so a team must be composed of 6 to 8 people having a mastery of the subject treated by the project and must include the necessary members referred to previously in section 2 as lean six sigma infrastructure.

2.2.2.1.4. The recommended tools and methods

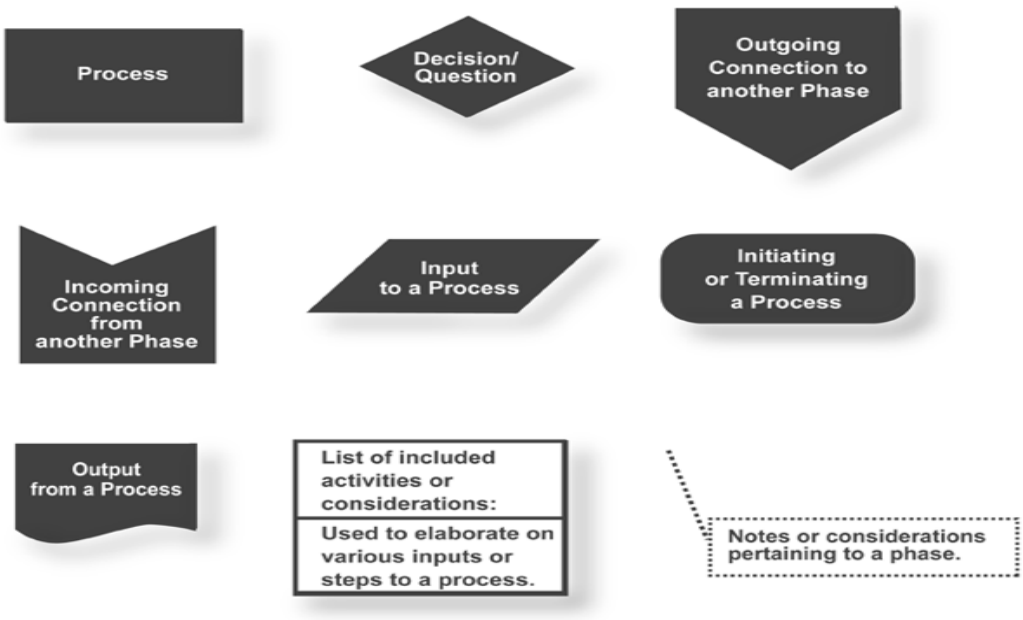
Several tools can be mobilized during this phase to provide the expected deliverable:

VOC: The "voice of the customer" is the process used to capture and describe the stated and unstated needs requirements or feedbacks of the customer. The voice of the customer can be captured in a variety of ways: Direct discussion or interviews, surveys, focus groups, customer specifications, observation, warranty data, field reports, complaint logs, etc (Jhon.A, 2016).

SIPOC: is the acronym of supplier input process output customer, SIPOC diagram is a tool used by a team to identify all relevant elements of a process improvement project before work begins. It helps define a complex project that may not be well scoped, it also makes it possible to identify the various actors and their relations around the process, the supplier customer relationship is thus schematized (kerri.S, 2019). SIPOC allows us to know the real customers of the process.

Swim Lane diagram: documents all the steps or the activities of a process. The swim lanes can represent many categories of information such as the involved actors, the stage of the process in which the activity takes place or any other information considered important and need to be communicated, this tool uses multiple shapes with significant meaning (niatex website, 2019).

Figure 2-3 Key shapes



Source: made by the author according to (Moira.C & Susan.F, 2019)

Gemba walk: (real place walk) is defined as the action of going to the unit or work area to see the actual process, understanding the work, and learning the process by asking questions. It is about getting a working understanding of the process, looking for waste, and identifying opportunities for improvement (Health PEI , 2019).

Stakeholder Analysis: Stakeholder Analysis is an important technique for stakeholder identification and analyzing their needs. It is used to identify all key (primary and secondary) stakeholders who have a vested interest in the issues with which the lean six sigma project is concerned (project-management website, 2019)

CTQ: critical to quality it allows the transformation of the customer needs into a requirement of performance, and establishing performance indicators (isixsigma website, 2018).

2.2.2.2. Measure phase

What are the process and performance current metrics? and how to pursue their changes and patterns?

2.2.2.2.1. the goal of measure

measure is the success key of lean six sigma, this step helps to collect reliable data (inputs and outputs of the process and variations), to better understand the process, and pinpoint the sources of failure to target them, so any decisions made will be based on real accurate data (George.M, Rowlands.D, & Kastle.B, What is Lean Six Sigma?, 2004).

2.2.2.2.2. The implementation of the phase

This phase goes through different stages (George.M, Rowlands.D, & Kastle.B, What is Lean Six Sigma?, 2004, p. 92):

- Defining the data collection plan.
- The observation of processes and the collection of the current data using different tools and technics
- The quantitative and qualitative data processing.
- Mapping the process more precisely using tools.

2.2.2.2.3. The deliverables of the measure step

"data collection plan":

is a detailed document. It describes the exact steps as well as the sequence that needs to be followed in gathering the data for the given Lean Six Sigma project (Azzabi, 2010).

"Quantified current process performance"

The quantitative or qualitative collected data that best describes the current state of the treated process otherwise said the starting point state (Antony.J, 2011).

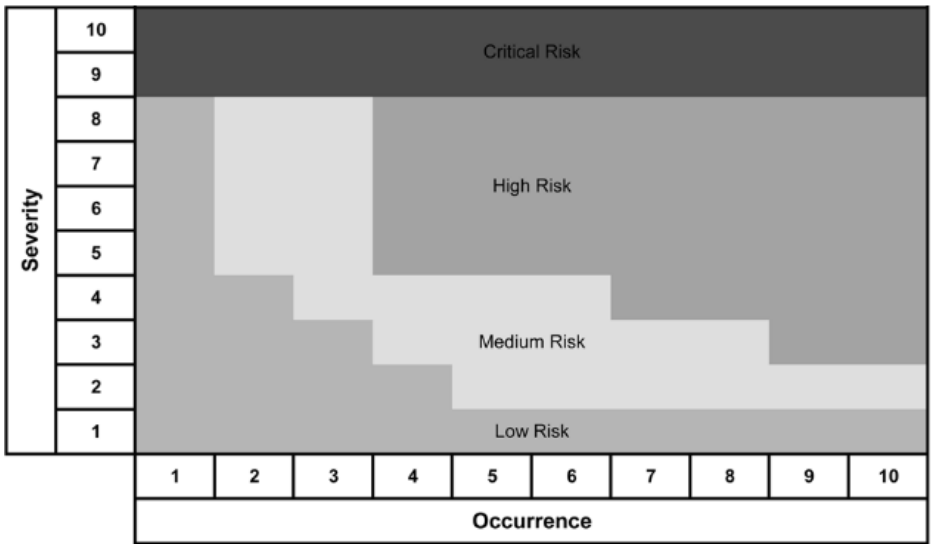
2.2.2.2.4. The recommended tools and methods:

FMEA (quality one website, 2019): an acronym for failure mode and effect analysis, Failure modes are the ways in which a process can fail. Effects are the ways that these failures can lead to waste, defects or harmful outcomes for the customer, originally it is a risk management tool and its role are to identify potential problems that may occur in the manufacturing, assembly and design processes. Basically, it helps detect errors or failures that may affect a product's quality.

But it was made clear in many literatures that if a product or process doesn't work as it should, we can use this method to prioritize the root cause of failure by sorting them from the highest to lowest through an RPN risk analysis. The RPN (risk priority number) helps estimate the likelihood of failure, its severity and the effectiveness of corrective actions. It is calculated by multiplying these three variables

The information provided by this method helps determine the impact of the failure (error) on products or processes. Furthermore, FMEA experts rank each failure based on its impact and its probability of occurrence. Businesses can use this data to develop better products by improving their design and key features.

Figure 2-4 FMEA Criticality Matrix



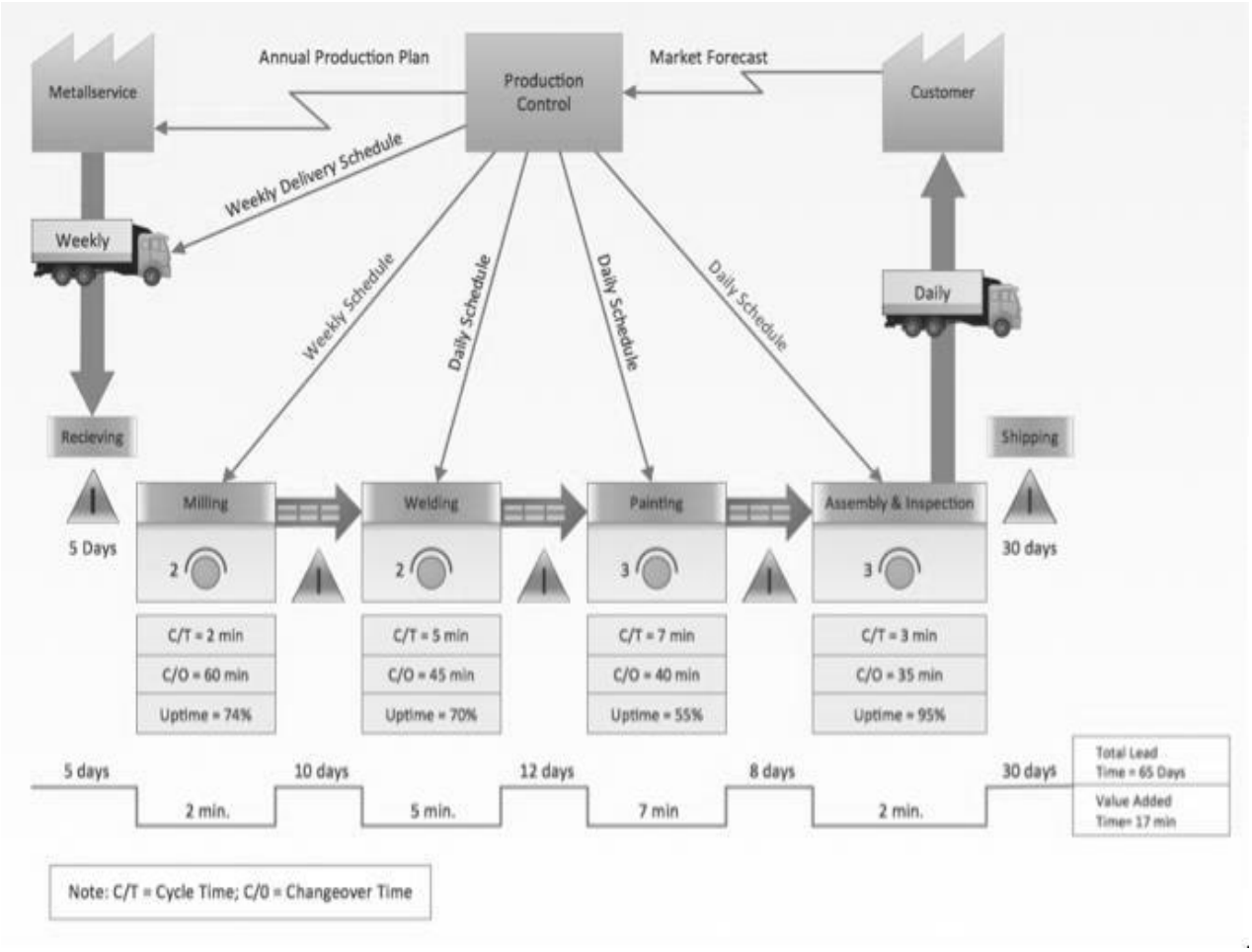
Source: adopted by Quality one website: https://quality-one.com/fmea consulted on June 2019 (quality one website, 2019).

Preliminary Data Analysis: The objectives of preliminary data analysis are to edit the data to prepare it for further analysis, describe the key features of the data, and summarize the results (Karim.M, Blischke.W, & Prabhakar.D, 2011).

Initial result of DPMO: the initial sigma level should be measured in order to compare with after the application of lean six sigma and to be able follow the improvement of the sigma level.

VSM (Rother.M & Shook.J, 1999)**:** is a method for visualizing and analyzing the current state and designing a future state for the series of events that take a product or service from its beginning through to the customer with reduced lean wastes as compared to current map. A value stream focuses on areas of a firm that add value to a product or service, whereas a value chain refers to all of the activities within a company.

Figure 2-5 Example of VSM



Source: adopted by. (YAHIATENE.B & Thiziri.A, 2015)in (Agilea, 2014)

The time in VSM

The Lead Time: Called also flow time, it is the time of execution of the global process, for example the time between the design of a product and its production, or between ordering a product and receiving it (cambridge dictionary website, 2019).

Cycle time: measures the amount of time it takes to produce a product. Cycle time includes process time, inspection time, move time, and wait time. All of these processes are part of producing one product. Inspection time, move time, and wait time are considered to be non-value adding time processes. Inspecting a computer for flaws or moving it to the loading berth does not improve the computer. In other words, these processes don't add value to the product (myaccountingcourse website, 2019).

Value Added Time: is the working time spent on production tasks that transform the product and add usefulness to it (myaccountingcourse website, 2019).

2.2.2.3. Analyze phase

What are the root causes?

2.2.2.3.1. The goal of Analyze

This step is where you make sense of all the information and data collected in Measure and use that data to confirm the root cause of the problem and the source of delays, waste, or poor quality.

Finding patterns in the data will allow to find clues to the real causes, and identify the most critical process factors to control. (George.M, Rowlands.D, & Kastle.B, What is Lean Six Sigma?, 2004).

2.2.2.3.2. The implementation of the phase

This phase is implemented as follow (George.M, Rowlands.D, & Kastle.B, What is Lean Six Sigma?, 2004):

- Reformulate the problem.
- identify all the possible root causes on the base of the data collected in the measure phase and using different tools and methods.
- prioritize the root causes that need to be tackled first by tools as pareto or by establishing significant relationship between the causes using data analysis.

2.2.2.3.3. The deliverables of analyze step

In this phase the delivered documents vary according to the used tools and methods, every tool delivers a different document.

but it's better to gather all the information in one document. So, after identifying and prioritizing cause roots using FMEA, Ishikawa …etc, we might use the FMECA matrix to synthetize this phase outcomes

FMECA: stands for "failure mode, criticality effects analysis», Compared to FMEA, this method looks at causes of the problem in more detail and yields more accurate results. When done right, it helps identify those errors with the highest criticality number based on their likelihood and severity, and recommend some actions (quality one website, 2019).

Figure 2-6 FMEAC matrix

Potential

Failure Mode and Effects Analysis

(Design FMEA)

__System
__Subsystems
__Component
Model Year / Vehicle(s):
Core Team:
Design Responsibility:
Key Date:
FMEA Number:
Prepared by:
FMEA Date (Orig.):
(Rev.):

Item / Function	Requirements	Potential Failure Mode	Potential Effects of Failure	SEV	CLASS	Potential Causes / Mechanisms of Failure	Current Design Controls Prevention	OCC	Current Design Controls Detection	DET	RPN	Recommended Actions	Responsibility & Target Completion Date	Action Results				
														Actions Taken	SEV	OCC	DET	RPN

Source: Quality one website: https://quality-one.com/fmea consulted on June 2019, (quality one website, 2019)

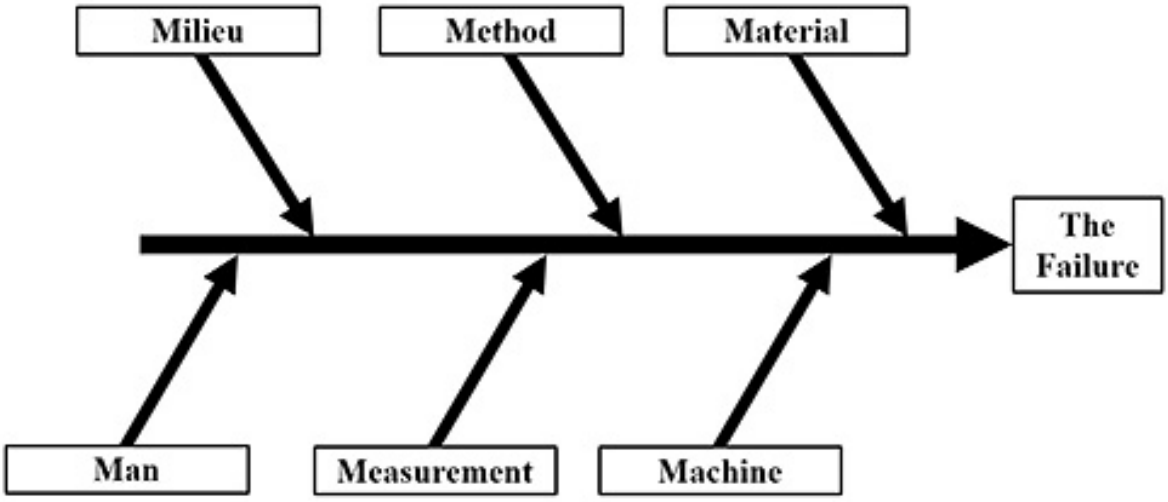
2.2.2.3.4. The recommended tools and methods

This phase of Lean Six Sigma methodology is loaded with tools to help spot the problems in the production process, as well as their root causes and to check if they are the true causes of the defects:

Process map analyzing: This tool uses a workflow diagram to capture the steps of a production process. The entire process is illustrated including inputs into the process, tasks performed, decisions required and outputs. The rigor demanded to record the production process on the page forces the project team to think through how the production process currently operates. A complete process map also gives the project team the chance to visualize potential changes in the process (Matthew.B, 2019).

Ishikawa Diagram: also called fishbone diagram for its distinctive shape, it is a Cause and Effect Diagram, this graphical tool helps the team identify the cause of the problem, not just the symptoms. The problem is stated at the right side of the diagram. The project team works to the left by filling in and examining potential causes of problems according to six categories equipment, materials, process, environment, people, management (Matthew.B, 2019).

Figure 2-7 Ishikawa diagram



Source: https://www.qualitydigest.com/inside/lean-article/worksheet-ishikawa-diagrams-033016.html consulted on June 2019, (Matthew.B, 2019)

Pareto law: law of the vital few, a graphical analysis tool that allows to prioritize the problems according to the number of occurrences and their impact, the principal of pareto states that 80% of the effects come from 20% of the causes.

The 5 Whys: is a simple but powerful tool for cutting quickly through the outward symptoms of a problem to reveal its underlying causes, so that you can deal with it once and for all, the 5 Whys uses "counter-measures," rather than "solutions." A counter-measure is an action or set of actions that seeks to prevent the problem from arising again, while a solution may just seek to deal with the symptom. As such, counter-measures are more robust, and will more likely prevent the problem from recurring (mindtools website, 2019).

After the identification of the causes we can test to determine if it is the true cause of the problem using (statisticshow to website, 2019):

Regression Analysis: This tool helps estimate the impact variables in a process have on each other and on the final product. It allows the project team to measure how well the theory fits the data.

ANOVA: This statistical technique tests three or more groups of data. It starts with a null hypothesis stating there is no significant difference between the groups. It then tests variation between the groups of data and variation within the groups of data. A high variation between groups of data indicates a possible root cause.

Chi Square: The Chi Square tests whether the difference between the expected and observed results is significant. This tool can determine whether differences in the expected and observed results are due to chance or there is an independent cause.

2.2.2.4. Improve phase

What are the best corrective measures and where they should be applied to increase the customer satisfaction level?

2.2.2.4.1. The goal of improve

on the identified root causes in the prior step, directly address the cause with an improvement. Brainstorm potential solutions, prioritize them based on customer requirements, make a selection, and test to see if the solution resolves the problem (Define-Measure-Analyze-Improve-Control-DMAIC).

2.2.2.4.2. The implementation of the phase

It can be broken down into four steps:

- coming up with feasible solutions for the problem and countermeasures of the root causes that can lead to the elimination of the problem and then looking for appropriate procedures to implement the solutions found.
- testing the chosen solution, and statistically proving the improvement made.
- before definitively validating the implementation plan for the solution, a risk study must be carried out.
- writing the plan of the implementation of the solution.

2.2.2.4.3. The deliverable of improve phase

The most important document delivered in this phase is:

Implementation plan: it describes how the information system will be deployed, installed and transitioned into an operational system. The plan contains an overview of the solution, a brief description of the major tasks involved in its implementation, the overall resources needed to support the implementation effort (such as hardware, software. facilities, materials, and personnel), and any side-specific implementation requirements (implementation plan, 2019).

2.2.2.4.4. The recommended tools and methods

Brainstorming: it is a process designed to obtain the maximum number of ideas relating to a specific area of interest, brainstorming can maximize the ability to generate solutions from different angles and different point of views by giving the chance to different people (brainstorming website, 2019).

Solution decision matrix: (Pugh matrix) is a decision-making model used to evaluate various alternatives using criteria for example, a company has five alternative processes to the one it's using, and it wants to know if any of the five is better or not.

It is also used when only one solution is possible, only one product can be brought to market, has only sufficient financing for one solution or where the optimal alternative is required, and you are deciding on the basis of multiple criteria (decision-making-confidence website, 2019).

The 5S: it is a system for organizing spaces so work can be performed efficiently, effectively, and safely. This system focuses on putting everything where it belongs and keeping the workplace clean, which makes it easier for people to do their jobs without wasting time or risking injury (5today, 2019).

The term 5S comes from five Japanese words (5today, 2019):

Seiri, Seiton, Seiso, Seiketsu, Shitsuke

In English, these words are often translated to:

Sort, Set in Order, Shine, Standardize, Sustain.

Each S represents one part of a five-step process that can improve the overall function of a business.

2.2.2.5. Control phase

What controls should be implemented to sustain this improvement?

2.2.2.5.1. The goal of control

Its first goal is to follow the activity by ensuring the implementation of settled recommendations made in improve phase, the second goal it makes sure that any gains your team makes will last. That means creating procedures and work aids that will help people do their jobs differently from now on by reacting quickly to future problems, and share the learning, the last goal is the documentation of the process improvements achieved after implementing the solutions (Define-Measure-Analyze-Improve-Control-DMAIC, p. 15)

2.2.2.5.2. The implementation of the phase

This phase is implemented as follow according to George (George.M, Rowlands.D, & Kastle.B, What is Lean Six Sigma?, 2004) in (Amel.B, AN ATTEMPT TO IMPLEMENT A LEAN MANAGEMENT MODEL IN PORT COMPANY TO IMPROVE ITS EFFICIENCY master's thesis, 2015)

- Document new and improved procedures.
- Train everyone.
- Establish procedures to follow vital signs.
- Entrust the ongoing management of the process to its manager.
- Finalize project documentation.

2.2.2.5.3. The deliverable of control phase

In this phase all the documents related to the process in question should be updated from process maps to procedures checklists. The better their final documentation, the easier it is for process participants to adopt the new way of doing things, other documents should be written like:

Monitoring and response plan (goleansixsigma website, 2019)**:**

A Monitoring Plan is a data collection plan for checking the ongoing health of the improved process. It lists the measure, the targets for each measure, how each measure will be checked, how and who will check the measures. It sets the stage for the Response Plan.

The Response Plan establishes a threshold or trigger level for each measure in the Monitoring Plan. When the process performance goes beyond a trigger level, the Response Plan details immediate and long-term actions that will help the process return to and maintain the desired performance.

Figure 2-8 Example of Monitoring and response plan

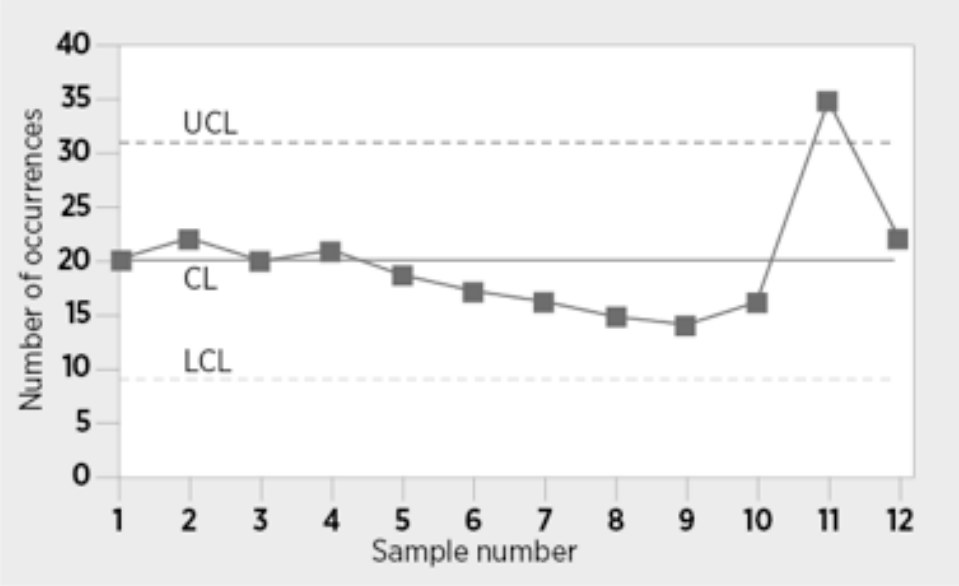
Monitoring Plan						Response Plan		
Name of the Measure	Input, Process or Output?	What is the Target?	Method of Data Capture	Checking Frequency	Person Responsible	Upper/Lower Trigger Point	Who Will Respond?	Reaction Plan
O1: Order Lead Time	*O*	*less than 16 minutes for cold food; Less than 20 minutes for hot food*	*Time stamp, in and out*	*Daily*	*Server*	*Over 18 minutes for cold food; Over 22 minutes for hot food*	*Manager*	*Observe the process to see why it's taking longer. Make the corrections. Are the orders still being processed in FIFO order? Are Servers turning orders into the kitchen immediately after taking them? Are we stocked at point of use through peak hours?*

Source: adopted by goleansixsigma website https://goleansixsigma.com/monitoring-plan/ consulted on June 2019 (goleansixsigma website, 2019).

2.2.2.5.4. The recommended tools and methods

Control chart: is a powerful tool for monitoring and controlling a process, it is used in the field of the quality since it allows to visualize the behavior of a characteristic through the time and locate the exact moment of occurrence of a variation in the process which helps to determine the exact cause behind this variation (Frechet.C, 2005).

Figure 2-9Example of control chart



Source: ASQ website https://asq.org/quality-resources/control-chart consulted on June 2019 (ASQ website, 2019)

Chapter conclusion

The LSS methodology is therefore based on the DMAIC approach in the case of missions or projects aimed at optimizing the performance of a process. The steps of the DMAIC approach make it possible to concretize the reflection of the Lean Six Sigma hybrid, notably through the use of several descriptive and analytical tools designed for a better knowledge and analysis of the processes, which brings us to the subject treated in the 3rd chapter, process performance through optimization

Chapter 3: Concepts related to process optimization and generalities on port activity.

Chapter introduction

Process optimization is the other option beside the investment offered to organizations aiming at the improvement of their performance.

Thus, companies looking for optimization have developed a transversal vision of their process concretized through the adoption of the process approach as a management mode.

Ports companies are not an exception, process optimization is at the heart of their concerns, which are confronted with a demand drawn by several actors and at the same time constrained to provide a more satisfactory, more competitive offer in a complicated economic environment.

In order to present this notion of optimization in the port, we organized our chapter as follows:

- Section one is about process optimization.
- Section two is highlighting generalities on port activity and performance.

3.1. Section one: Process optimization

The undeniable existence of interactions between the units of the same organization and the creation of horizontal flows within it, justifies the increasing use of management by process.

The process approach includes establishing the organization's processes to operate as an integrated and complete system (ISO.international organization of standarization, 2019, p. 1), the approach process is a strategy that allows having a clearer overall vision on the organization's workflows, allows the identification of the sequence of key activities that create value which make it easier to work on them, in our case we are aiming the optimization of processes it is defined as the last step of the process approach, so:

- In the first sub-section we will be dissecting the notion of the process.
- In the second sub-section we will be talking about the process optimization.

3.1.1. The notion process

before talking about the optimization of a process we need first learning in this sub-section about the different aspects of the term process.

3.1.1.1. Definition

The word process comes from the combination of two Latin words. "Pro" which means "forward" and "cessus" which means "to go", so, the word process means: "Go forward", it refers to progression (dicolatin website, 2019).

The concept of process management was first introduced in the 2000 version of the international standard ISO 9001, as following:

" set of interrelated or interacting activities that use inputs to deliver an intended result"

To better understand this definition, ISO 9001: 2000 adds the following notes:

NOTE 1: The input elements of a process are usually the output elements of other processes.

NOTE 2: An organization's processes are usually planned and implemented under controlled conditions to add value.

NOTE 3: When the conformity of the resulting product cannot be immediately or economically verified, the process is often referred to as a special process.

Cantt defined a process as a set of operations or activities carried out by actors with means and according to references for a purpose (Cattan.M, 2010, p. 6).

3.1.1.2. Process characteristics

-A process is a series of actions or steps toward achieving a particular end. A business process or a sub-process can be described based on the following characteristics (Kaufman Global, 2018):

scope: Starting point and end point for the series of steps.

purpose: Overall objective or reason why the process is performed.

steps: Actions performed by operators.

sequence: Order in which steps are performed.

operators: Individuals that perform the steps.

outcome: A specific result, product or state.

customer: Next process, requestor, or end-user of the outcome.

Also, a process (Cattan.M, 2010, p. 10) :

- May include activities performed by different departments, different entities.

-Is transversal and as such uses different trades.

-It "consumes" data (input), "provides" data (output), and generating added value by the control of these data.

-It interacts with its environment, so different parameters exert an influence on its structure and functioning: economic environment, social environment, technological environment.

3.1.1.3. Process vs procedure (Pearson.S, 2018)

A process is a series of related tasks or methods that together turn inputs into outputs.

A procedure is a prescribed way of undertaking a process or part of a process.

At a glance, the two might seem confusing, as they both refer to the same activities being carried out. So, to make it easier, you can look at the difference between a process and a procedure as "what" versus "how."

A process consists of three elements:

- An input (materials or information)
- A process with its sub-processes
- An output

A procedure, on the other hand, describes:

- Who is responsible for each part of the process.
- When each part of the process occurs.
- The specifications applicable to each part of the process.

Considering the differences between the two terms, it shouldn't be too surprising that there are different ways to document them. For a process, a simple workflow diagram would do. Procedures, on the other hand, would be explained through a physical or electronic document (To complete the process, do X, Y, and Z). Unlike processes, a procedure doesn't have to be a workflow – a set of simple guidelines could suffice.

3.1.1.4. Typology of processes (BSI Group, 2018)

Organizations must define the number and types of processes required to fulfill their business objectives. Although the results will be unique to each organization, it is still possible to identify typical processes, such as:

Processes related to the management of an organization: They include processes related to strategic planning, policy setting, goal setting, and communication.

Resource Management Process: They include all the processes that provides necessary resources to achieve the quality objectives and desired results of the organization.

Operating process: They include all processes that provide the desired results of the organization.

Process of measurement analysis and improvement: They include process designed to measure and collect data for the purpose of analysis of performance and improvement of efficiency and profitability.

3.1.1.5. Processes formalization and optimization objectives (Cattan.M, 2010, p. 5)

An action on the processes aims at different objectives:

• better take in consideration the expectations of beneficiaries to improve the services provided.

• enable the different actors to get involved in the operation of the process,

• clarify the roles and responsibilities of all the actors, define the necessary margins of maneuver and coherence, simplify the interfaces between entities.

• transform or create a new process to meet new expectations.

• reduce the costs, the delays of a process, increase its performance against defined indicators.

• better react to risks.

• aim for certification through the establishment of a quality system.

• support the implementation of a management software.

3.1.2. Process optimization

In this sub-section we will be explaining the process optimization, which is a complex task. The optimization challenge is twofold, it is about improving quality and productivity at the same time by increasing the volume of processed flows and reducing the used resources, two objectives that seem contradictory and which are necessary to ensure the continuity in a highly competitive environment where investment is not enough, where we must always improve and optimize.

3.1.2.1. Definitions

Optimization: "Optimize is to make something as perfect, effective or functional as possible" (TRENDT.R, 2008, p. 10).

Process optimization: consists in adjusting processes to optimize a set of specific parameters under certain constraints, the visible objectives are the minimization of inputs and the maximization of the outputs in the most efficient way (web.spi website, 2019).

Successful process optimization is based on choosing the right approach. there are several optimization approaches and techniques such as the Lean Six Sigma DMAIC in the second chapter.

3.1.2.2. The basic principles of process optimization

Process optimization approaches follow certain basic principles to achieve significant results (Cattan.M, 2010, p. 7):

- **characterize the scope covered by the process**

the failure of processes optimization approaches is often explained by a poor framing of the perimeter of the different processes. It is therefore necessary to define precisely the fields covered by each process, in terms of activities, productions and also actors.

- **Identify the interfaces**

It is often at the interfaces between processes or between entities within the same process that the main areas of potential improvement are located. It is therefore necessary to identify them as best as possible, from a common point of view to the different actors involved.

- **Only work on key or critical processes**

Process work needs to be framed strategically and aimed only at improving performance, it is therefore not a question of working on all the processes, but only on some that could appear priority according to different criteria:

• strong dysfunctions,

• dissatisfaction of beneficiaries or emergence of new expectations,

• evolution of the service strategy…

- **Prioritize a participatory approach**

The most effective process optimization approaches are those that involve the process actors in it. The pilot is responsible for setting and controlling the terms of the participatory plan, A discussion with the process actors of its characterization is essential it is good to involve even the beneficiaries. Finally, it is important to anticipate the possible resistance to change of actors (optimizing a process often means modifying routine practices and turning more towards the beneficiaries what can lead to resistance).

- **Be ready for emergency by keep the formalization the most flexible**

The formalization of processes should not create a rigid system in which each actor would simply observe the procedure paper. On the contrary, this system must be open, to allow and even to favor the initiatives of the actors, but it should be noted that the degree of formalization of a process varies according to the skills of the actors who make it work. In general, the higher the skills, the less strict the formalization.

3.1.2.3. Process optimization approach

There are several optimization approaches, the one we will be presenting has been established for services, it takes the sequence of essential steps of project optimization and can be adapted to the specificities of any project. It consists of eight steps as follow (grandsorganismes, 2019):

3.1.2.3.1. Mapping processes

It is very useful to have an overall vision of the process that we are aiming its optimization, a tracking of all the major processes of an organization can be done in the form of a diagram (grandsorganismes, 2019, p. 9).

3.1.2.3.2. Choose the key processes

It is not always a question of optimization of all the processes, different criteria can thus help to choose the processes on which optimization work and lead to greater results (grandsorganismes, 2019, pp. 9-10):

• serious dysfunctions,

• dissatisfaction of beneficiaries or emergence of new expectations,

• evolution of the service strategy that places certain processes ahead of others,

• development of new approaches (ARTT, skills management ...) that can have a strong impact on certain processes,

• introduction of new IT tools, including integrated management software,

• launch of a service commitment approach (to commit to a beneficiary, it is imperative to master the related processes) ...

3.1.2.3.3. Characterize a process

It's is done by answering the following questions (grandsorganismes, 2019, p. 10):

• what is the purpose of the process?

• who is the beneficiary or beneficiary system of the process?

• what is (are) the service (s) or product (s) provided?

• What are the beneficiaries' requirements in this service / product?

• What indicators are used to measure compliance with these requirements and, more generally, the performance of the process?

• which actors are directly involved in the process?

• What are the main means used?

• What are the input elements of the process? (these are sometimes the triggers)

• who are the suppliers of these elements and the process requirements in this these suppliers?

• What are the indicators that measure compliance with these requirements?

3.1.2.3.4. Describe a process

It is a question of carrying out an overall description of the process with the summary presentation of the activities and their managers.

The main steps of the process can then be identified, the main control points and the current indicators as well (grandsorganismes, 2019, p. 11).

3.1.2.3.5. Diagnose a process and its context to define the optimization objectives

This diagnosis is based on the precise identification of the main facts of the operation of the process and its context. These facts can for example relate to:

- Internal dysfunctions in the process,
- The non-qualities noted,
- The frequency of the anomalies,
- The dissatisfaction of the beneficiaries,
- The evolution of indicators (cost, delay, etc.),
- Time spent on making all or some parts of the process,
- The emergence of new expectations of beneficiaries ...

Once the diagnosis is made, it means translating it into clearly formulated objectives aimed at optimizing the process (grandsorganismes, 2019, p. 12).

3.1.2.3.6. Choose the degree of optimization: improve or redesign, according to objectives and performance indicators

Depending on the objectives identified from the previous diagnosis, it is a question of deciding what actions to take. These can vary widely in two dimensions (grandsorganismes, 2019, p. 12):

An improvement action: is to take over the existing process to act on some of its factors.

A redesign action: does not start from the existing process. It is only based on the targeted performance levels and available means and resources to design a brand new process.

3.1.2.3.7. Optimize the process

Depending on the objectives previously identified, it is a question of deciding the optimization actions to be implemented, actions that will lead to a more or less strong modification of the process (grandsorganismes, 2019, p. 13).

3.2. Section two: Generalities on port activity and performance

In this section, we will be introducing the fundamental principles of the maritime trade

- In the first sub-section, we will be defining some of the fundamental notions related to port activity,
- Then, we will pass to the measures of the performance of this activity as established by UNCTAD, in the second subsection.

3.2.1. Related notions to port activity

In this sub-section we will be talking about all the aspects of port companies and their activity, and is the end of this sub-section we will be talking about the port performance to make a good understanding basis to better understand the second sub-section.

The port can be defined as a natural or artificial shelter designed for ships for the loading and unloading of cargo and passengers. It is therefore an infrastructure and superstructure designed to treat port flows (Abdi.M, 2012, p. 103).

The port is therefore a complex set occupying a privileged place, not only in the region where it represents a driving force of development, but also on the national and the international level.

3.2.1.1. The port mission (Bouyaali.H, 2013, p. 25)

Due to its geographical location, and according to the international maritime community the port mission can be summed up in three points:

- Development through foreign and domestic trade thanks to the traffic of goods at competitive prices.
- The promotion of industrialization.
- Contribution to the development of the economic and territorial area to better integrate the related economic and social activity.

3.2.1.2. Ports typology

Ports can be classified according to nature, localization, statute, activity and generation.

3.2.1.2.1. Ports by nature (Bouyaali.H, 2013)

Ports can be classified by their nature in two categories follow:

Natural ports: They are protected by a natural site: bay, peninsula, cape, island. This type of port generally benefits from channel dredging to allow ships with a large draft to borrow them.

Artificial ports: They are fully protected by fabricated structures.

3.2.1.2.2. Ports by localization (Benchick.A, 2017, p. 4)

Ports can be classified by their localization as follow:

maritime ports: located on the coast of a sea or an ocean with a seafront. These ports need a good protection against waves and wind because of their exposure. This is the case of the port of DjenDjen on which we conducted our study.

Lacustrine ports: Located on the edge of a lake, lake ports include small marinas, but also ports of commerce.

Fluvial ports: Or inland ports, located on the edge of a river, a river or a river canal, they are often laid out on a backwater, some river ports are created artificially by digging the earth to create pools accessible from the river.

Dry Ports: Is a terminal connected by a road or by a railway to a seaport, used as a transshipment center for maritime cargoes to inland destinations.

3.2.1.2.3. Ports by their management mode (Bouyaali.H, 2013, p. 41)

Ports can be classified by their management mode in two categories:

Public ports: They are managed directly or indirectly by the public sector.

Private ports: They are managed by private companies.

3.2.1.2.4. According to their activity (Bouyaali.H, 2013, p. 27)

Knowing that a single port often combines several activities, we distinguish:

Commercial ports: These are used to accommodate merchant ships.

Fishing ports: They generally have small dimensions, their infrastructure simpler than that of commercial ports: some quays, a refueling station, and a way to sell the fish.

Marinas: They are located near the center of cities, for tourist and practical, serve to welcome pleasure, leisure and competition boats.

Military ports: Accommodate warships.

3.2.1.2.5. According to generation

This classification was first adopted by UNCTAD they classify the ports into four generations according to their commercial politics and their implication in the universal economy.

3.2.1.3. Port activities

The activity of the port can be according to its economic nature organized in three categories:

3.2.1.3.1. Public service activities

Security and safety in the land and sea boundaries of the port area.

3.2.1.3.2. Commercial activities (djen-djen port website, 2019)

in addition of the public service, the port offers other commercial services such as:

- **Pilotage service:** the assistance given to the ship's captain by the authorized personnel (pilot) of the port company, at the entry and the exit of the ports.
- **Towing Service:** consists of the assistance (pushing, pulling) provided to ships during entering and leaving the port.
- **Mooring service**: mooring and undocking of ships.
- **Handling service:** the loading / unloading of goods and the placing and picking up of goods on land or in the warehouses. Port handling operations are carried out under a contract.
- **Service of acconage:** the reception, the pointing and the recognition on the ground of the goods shipped or unloaded as well as their guarding until their boarding or delivery to the recipient.

3.2.1.4. **The main actors involved in the port delivery process (Khyar.M & Zerouklane.N, 2008, p. 18)**

Because of its complexity, maritime transport requires the intervention of specific actors whose mission is to ensure the routing of goods from their supplier to their consignee. These maritime operators, have very varied and related functions, we will classify them as follows:

3.2.1.4.1. Carrier (sea side)

It takes care of the transportation of the goods by sea from one place to another, whether it is the owner of the vessels (shipowner) or not, (charterer of the ship): distinguishes three types of charter:

Trip charter: It consists in renting a ship to transport the goods from one point to another on tramping lines (request).

Time charter: This is a hiring a ship with its team, where the charterer only takes care of the commercial aspect. while the conduct and the technical aspects of the ship are taken care of by its forwarder.

Bareboat Chartering: In this type of charter, the charterer takes charge of the commercial and technical management of the vessel.

3.2.1.4.2. Loader (land side)

Refers to the owner of the cargo of a ship, or a part of it, the importer or exporter role:

- Preparing the goods.
- Prospecting a ship.
- Moving the goods.
- Moving the goods to the port of shipment.

3.2.1.4.3. Handler

The handling activity consists in loading and unloading the goods by the use of a workforce called dockers and equipment.

3.2.1.4.4. Mooring service provider

Assistance operation for mooring ships upon their arrival, departure or also their movement.

3.2.1.4.5. The forwarder

Ensures the passage of the goods on the port, his role toward his client is summarized in the following points:

- Inform and advise the customer on the organization of the transport
- Inform him about customs formalities
- Receive the goods

3.2.1.4.6. Customs

Control goods passing through the port and keeps statistics on foreign trade, so customs verify the declarations and the collection of duties and taxes on the goods transition.

3.2.1.4.7. The consignee

In the ports where it is not installed, the shipowner will entrust all his tasks to a shipping agent called: consignee, it is the representative of the shipowner at the port. he deals with the administrative formalities as well as all the needs of the ship before its arrival, during his stay at the port (tugs, pilot, repairs, relations with the maritime administration), the need of the workforce (medical examination... etc.) and the management of the cargo, its role consists in:

- Prepare the ship's stopover according to the state (expected date of arrival of the ship at the port)
- Notify the receivers of the arrival date of the goods
- Introduce the customs manifest.

3.2.1.4.8. The consolidator

It is an intermediary between the shipper and the shipping company, he regroups the goods with the same areas of origin and destination in load units (a container for example), in order facilitate the delivery and transportation activity.

3.2.1.4.9. Refueling companies

A refueler is a small boat equipped to refuel the other boats. it can refuel them where they are moored or in full navigation.

3.2.1.4.10. Banks and insurance companies

Their role is to promote the maritime commerce of goods

- The services offered by the bank consists in the identification of the transaction as well as its physical and financial follow-up.
- The insurance companies insure and indemnify their customers on the risks associated with the cargo and the activity of the ship.

3.2.1.5. The performance of the port activity

A data that measures the effectiveness and / or efficiency of all or a part of a process or system (real or simulated), against a standard, a plan or a specific objective (Marrion.G, 2013, p. 152).

Gilbert positions the performance at the center of a triangle, grouping three major notions, each of which expresses a precise notion, so, the performance of a company is mainly defined by its ability to achieve its objectives (efficiency), by opting for the best option (efficiency) and in adequation with the beneficiaries real requirement(relevance) (Gilbert, 1980)

These three notions can be defined as follows:

Relevance: according to OECD / DAC (The Organization for Economic Co-operation and Development's-Development Assistance Committee) the relevance of a project can be defined as its ability to achieve the objectives assigned to it. Measuring the relevance of a project is therefore tantamount to measuring its risks of failure by an evaluation.

Effectiveness: is the way to obtain by means of the planned actions, the expected results in a process of improvement (Login.P & Deneth.H, 2005, p. 152).

The effectiveness can be measured by the following formula (Voyer.P, 2006, p. 113):

$$Effectiveness = \frac{obtained\ result}{planned\ objectives}$$

Efficiency: it's about "getting results by minimizing the cost of resources and processes"

Efficiency can be measured by the following formula (Voyer.P, 2006, p. 110):

$$Efficiency = \frac{results\ (outputs)}{resources\ (inputs)}$$

3.2.2. Measurement of Port Performance

To make the implementation measure phase in our case well-founded and easy we won't be measuring the performance triple, instead we will be following the UNCAD measurement sets. So, in this sub-section we will be talking more how to really evaluate and calculate the port performance according to UNCTAD.

Ports are essentially service providers, in particular for ships (shipowners, charterers or consignees), goods (receivers of goods, exporters or importers) and inland transport (such as loaders). The degree of satisfaction that is obtained on the basis of the pre-set standards will indicate the level of port performance achieved (UNCTAD, 1987, p. 1), so the notion of yield is relative to the recipients of the service whether they are ships, cargos or internal transportation and

UNCTAD indicates that a port can offer very satisfactory services to vessel operators and at the same time leave something to be desired from the point of view of the loader or the inland transport operators. in this case we are talking the quality of provided services despite the established standards meant to standardize this concept, however, it should be noted that a failure in a service extends to all services offered by the port.

3.2.2.1. Performance measurement series according to UNCTAD

As a result, the performance of ports cannot be assessed on the basis of a single value or measure in fact a meaningful evaluation of a port's efficiency will require sets of measurements relating to (UNCTAD, 1987, p. 1):

-The duration of the ship stay in port.

- The quality of service provided to inland transport vehicles during their passage through the port.

- the quality of the cargo handling.

3.2.2.2. Relationship between the three series of measures (UNCTAD, 1987)

The fact that these three sets of performance measures are closely interdependent, in addition to the various performance level of each.

It is therefore not relevant to consider them in isolation, nevertheless we will focus on two measures because of their particular importance and the primary interest they represent to the main users of the ports, (the vessel operators).

3.2.2.3. Port performance measures (UNCTAD, 1987)

The three series:

3.2.2.3.1. First series of measurements (Time spent by the ship at port)

We have with and without decomposition:

Without time decomposition: This first series has three measures:

a- Ship productivity: this is the most important measure. it is provided by the total time spent in port by a given ship on a given call (Usually expressed in hours)

b- Total turn-round time of a given vessel at a given call: the cargo tonnage to be handled during the call

c- Total turn-round time

d- at the port in the light of the cargo composition (traditionally divided into main classes which are: bulk liquids, bulk solids, various conventional, containerized goods.)

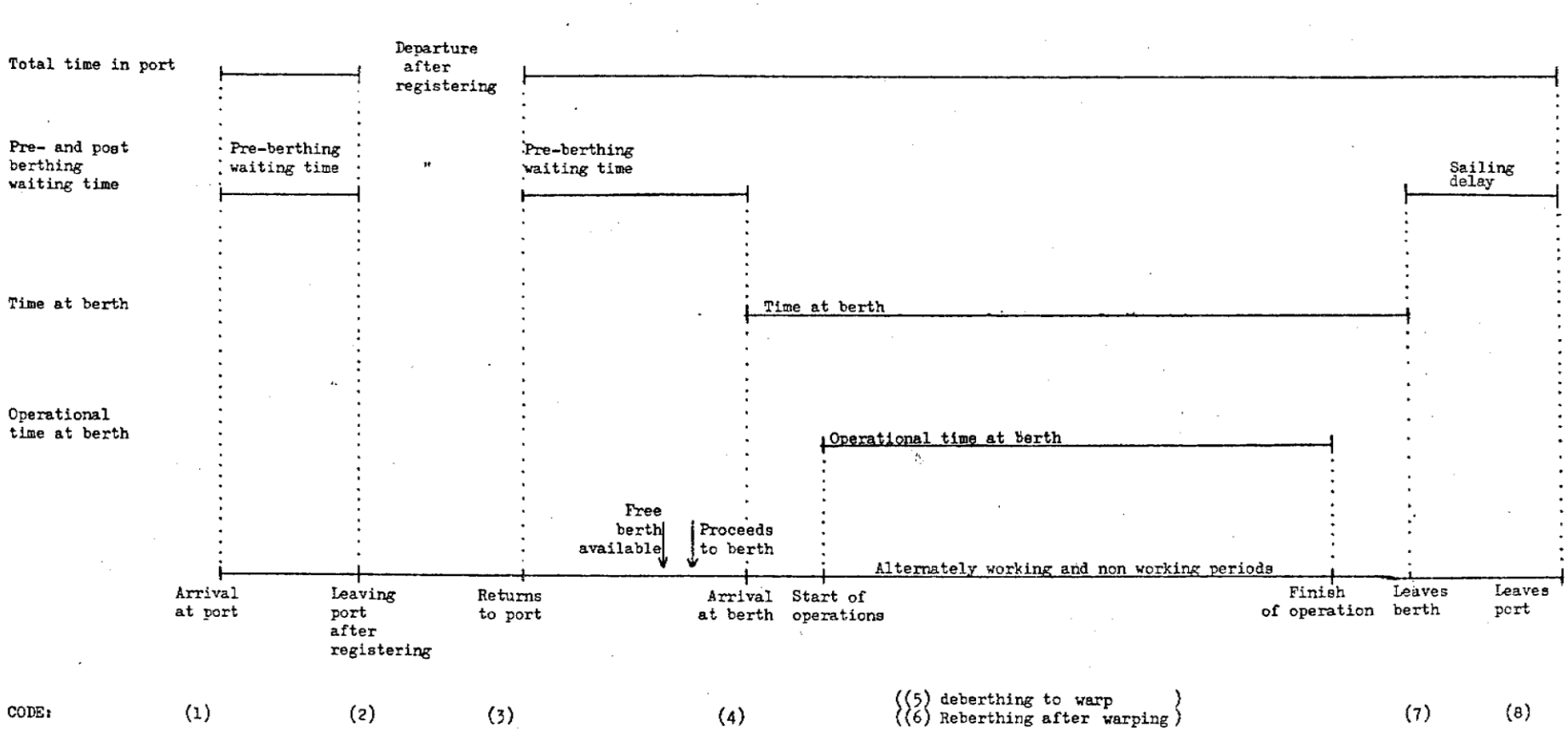
With time decomposition:

It is possible to improve the total productivity of the ship at port as shown in Figure 3-1, by reducing some of its periods, at least two of these periods require special emphasis, "ships waiting time for a berth "and" time spent at the berth ". In our practical case we are interested in the second period.

These two measures are particularly crucial in port characterized by a slow congestion and latent, it means where ships must regularly wait before berthing, because all the adequate service points are already occupied.

In conclusion, the measurements of time spent in port by the ship are essential indicators of the quality of the services offered to the main users, it should be noted that identical values can be interpreted differently by the various operators of the ship according to their priority need, and that their judgment of the quality of services can therefore vary considerably.

Figure 3-1 Break down of ship's time in port



Source: adopted by UNCTAD, monograph report on port management. 1987 (UNCTAD, 1987, p. 3)

3.2.2.3.2. second series of measurements (The indicators of occupation of the berth)

The berth occupation indicates the utilization rate of these positions for a given period of time (one week, one month, one year) based on an actual occupancy value calculated in hours or days.

Overall rates of berth occupation are very significant indicators, but they do not inform directly on the direct causes of the weakness or the importance of its occupation, nor on its "productive" value.

It is therefore necessary to divide the total time available at the post into periods:

-The period in which the position is occupied but without actual work.

-The period in which the position is occupied and in actual work.

-The period when the position is occupied but not in service.

3.2.2.3.3. Third series of measurement (performance measures for cargo-handling on board and on shore)

The essential period “time at berth” is basically constituted by alternative working and non-working periods during which cargo-handling takes place.as a result the performance of the cargo-handling operation will to alarge extent determine the quality of service to the ship and consequently deserves special analysis. To effectively measure the cargo-handling performance, two groups are required namely:

Indicators of output,

Indicators of productivity,

Indicator of output: provide information on the total quantity of work done in a particular period or on the tonnage handled in a stated time. the most commonly used indicators are:

Berth throughput. Ship output. Gang output.

The latter two values also represent the work efficiency and productivity, the most used one is gang output.

- **Berth throughput** measures the total tonnage of cargo handled at a berth in a stated period expressed on a weekly monthly or annual basis. berth throughput does not provide information about the efficiency of the activity. moreover, this measure is only significant if we mention the types of goods handled, the handling techniques used (crane, special equipment, machinery for handling containers), the route followed (direct or indirect) and the units of measurement used (ton-weight, ton-freight, congestion barrel). It is essentially a unit of measurement of the "activity" of an installation.

➢ **Ship output** give an accurate indication of the cargo handling operations quality,

The most commonly used measures are:

-Tonnage handled per hour and per ship.

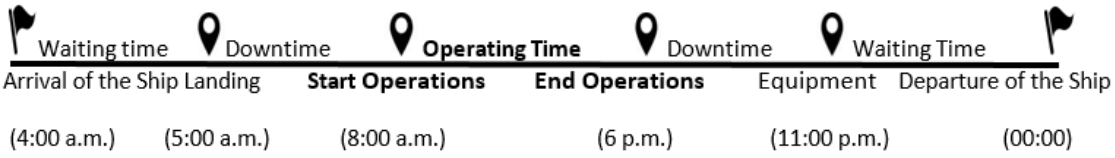
-Tonnage handled per hour spent at the berth.

-Tonnage handled per hour spent in the port.

Significant differences between these values indicate a considerable loss of time for the ship at berth or in port.

Example to illustrate the importance of the comparison between the three measures (UNCTAD, 1987, p. 13):

Figure 3-2 Distribution of the time that the ship spent in the port



source: made by the author according to (UNCTAD, 1987)

The three indicators:

Tonnage handled per ship working hour	Tonnage handled per hour spent at Berth	Tonnage handled per hour spent in the port	Yield per day (calculated by the operator)
$\frac{\mathbf{1000\ T}}{\mathbf{10\ H}}$	$\frac{1000\ T}{18\ H}$	$\frac{1000\ T}{20\ H}$	$\frac{1000\ T \times 24H}{20\ H}$
100 T/H	**55 T/H**	**50 T/H**	**50 T/H**

source: made by the author according to (UNCTAD, 1987)

The difference between these three values reveals a large wasted time at the Berth when the vessel is not being operated.

Nevertheless, these measures do not make it possible to specify the cause of this important dead time.

➢ **Gang output** this is the average quantity (in tons) of cargo handled by a team in a certain time interval, normally an hour, so it is the most revealing value of team performance. Although they must also be supplemented by explanatory data on factors such as the composition of the

teams, the cargo handled, the ship's configuration, and many other elements before any valid conclusions are drawn.

Chapter conclusion

There are many actors between clients and stakeholders in the maritime trade and their requirements may differ considerably, also the provided services variety is large. however, port performance is essentially based on the notion of time, a key factor of competitiveness, this explains the fact that all port companies monitor it and aim its optimization lead times and yields.

Chapter 4: Lean Six Sigma in DjenDjen seaport.

Chapter introduction

In order to put into practice our theoretical knowledge on Lean Six Sigma methodology, we completed our internship within a service delivery company, more specifically a port company "Port Company of DjenDjen".

Through this chapter, we will try to apply the Lean Six Sigma methodology to one of the key processes of the PCJ, by highlighting the steps of the DMAIC method in order to optimize our process. Thus, this chapter is divided to two sections:

- The first section provides a general presentation of the host company" DjenDjen".
- In the second section we will be Applying Lean Six Sigma on the chosen process.

4.1. Section one: The presentation of DjenDjen

The port of DjenDjen is the last port built in Algeria after its independence, it is considered as the most important port in the Mediterranean in terms of space, water depth (18,2 m) and capacity, and in this section, we will be introducing more of its characteristics in three sub-sections:

- General presentation in the first sub-section.
- The organizational structure in the second sub-section.
- DjenDjen activity in the third sub-section.

4.1.1. General presentation

In this sub-section we will be giving some general information about DjenDjen port company.

Headquarter address: BP N°87 Achouat -Taher- Jijel/Algeria.

Legal status: joint-stock company (spa), managed by the SGP SOGEPORTS / Management Company of State Holdings of Algerian Ports.

Shareholder: Port Management Company << SOGEPORTS >>.

Capital: 1,040,000,000 D

This port was built on an area of 104 ha, and its annual capacity is estimated about 4 000 000 tones.

The port of DjenDjen was realized as part of an integrated development program making it a support infrastructure to the iron and steel complex of BELLARA alongside with other achievements: a power plant, an airport, and the east west highway.

railway track: The Railway track of the port connected to the national network through a freight station at 1500 m from the port of capacity of 8 million tons / year, the port is connected to the industrial area of Bellara by rails too.

4.1.1.1. The port history

The port company of Jijel was created by the decree n ° 84-173 of July 21st, 1984 following the restructuring of the company of Bejaïa, it had for missions to manage the port of Jijel as well as the ports of fishing of Jijel and Ziama-Mansoruah. This port construction was decided in the 1970s, began in 1984 and ended in 1992. On 11/10/1989 the Jijel port company (PCJ) became an autonomous company in the form of a stock company (Djen-Djen website, 2019).

Table 4-1 Shareholder participation in 1989

Shareholder	participation
The service participation fund	40%
The electronic participation fund	30%
The fund of the participation various industries	30%
Total	**100%**

source: Djen-Djen website

After a few years, the company has undergone a statute change transforming the EP JIJEL into EP DJEN-DJEN whose only shareholder is the service participation fund.

4.1.1.2. Geographical position

the port of DjenDjen is one of the most efficient ports, located in the east of Algeria, it benefits from a strategic position less than 50 km from the sea route connecting the Suez Canal of the Strait of Gibraltar. It is located at (Djen-Djen website, 2019):

- Latitude: 36 51’N
- Longitude: 005 54’E
- 10 Kilometers from city center
- 350 Kilometers from Algiers
- 140 Kilometers from the city of Constantine
- 40 Kilometers from the industrial zone Bellara
- 900 Kilometers from Hassi Messaoud
- 04 Mooring boats

4.1.1.3. Vision, Missions et DjenDjen values

- **Vision**

Bring the port to the population through logistic.

Excellency in export.

- **Missions**

Contributing to the prosperity and development of our environment

Lead the development of the port of DjenDjen, build and manage new infrastructures and guarantee the reliability of services to contribute to the competitiveness of our customers, and contribute to the enrichment of the company.

- **Values**

Social responsibility and sustainable development.

Valorization of human capital.

The flourishing of man as a major vector of development.

Pride of belonging.

Win-win relationship with those interested.

4.1.1.4. DjenDjen infrastructure and superstructure

4.1.1.4.1. Infrastructure

Protection work:

Table 4-2 protection works

Western pier	**3000 m**
Eastern pier	**900 m**

Source: internal documents of DjenDjen

Berthing facilities:

Table 4-3 general cargo dock

Length	770 m
Width	200 m
Depth of water	-11 m

Source: internal documents of DjenDjen

Table 4-4 Multipurpose Dock/ RORO

Length	250 m
Width	300 m
Depth of water	-11 m
Area	7.5 ha

Source: internal documents of DjenDjen

Table 4-5 Ro/Ro Berths

Stern Ramps	03
Depth of water	-11 m
Area	09 ha

Source: internal documents of DjenDjen

Table 4-6Western Dock

Length	1060 m
Width	300 m
Depth of water	-18 m 20
Area	30 ha

Source: internal documents of DjenDjen

4.1.1.4.2. Superstructures

Table 4-7 Specialized installations

Object	Capacity
Bulk Cement Silos	12 000 T
Vegetable Oil Trunks	8 000 T
Bulk Grain Silo	280 000 T (in Progress)

Source: internal documents of DjenDjen

- **warehouses:**

Area = 600 m²

Table 4-8 Storage areas

Object	Capacity
Storage area inside the port	104 ha
Storage area outside the port	27 ha
Projected area for supply chain	350 ha

Source: internal documents of DjenDjen

- **Equipment:**

Cargo handling Equipment:

• Forklift trucks of different capacities (3MT- 38 MT)

• Fork-lifters provide spreaders for the container

• Cereals gantries of 250 tons / hour

• Mobile harbor cranes of 64 tons

• Telescopic cranes of 64 Tons

• Telescopic cranes of 60, 90 and 120 Tons

• RO/RO tractors of 40 Tons

• Shovel

• Shipper

• Retro- charger

• Bucket truck

• Tractors and semi-trailers

• Harbor frames

Naval equipment:

• 01 Voith Schneider tugs of 2750 CV

• 01 conventional tugs of 1700 CV

• 03 Piloting boats

• 04 Mooring boats

4.1.2. The organizational structure of the enterprise

In this sub-section we will be dealing with the organizational structure of the company, because, understanding how DjenDjen operates is essential to implement LSS project. the organizational structure gives us information about who is responsible of what and who handles what.

4.1.2.1. Human resources distribution

DjenDjen's company has undergone several changes in its organizational structure according to the evolution of its activity, in 2016 the organization of the company was done according to departments but in 2017 these were replaced by directions, so Heads of Department have been promoted and the majority of their positions remain vacant which justifies the decline in the number of masters, about executing employees the company hires them for a period of 6 to 36 months eventually renewable and due to the decline of the activity many contracts have not been renewed that is why one notices the decrease in the number of the employees of executions.

Table 4-9 Human resources distribution by category

Category	2016	2018	Evolution
Executives	98	107	9.2%
Masters	273	307	12.5%
Employees	1022	954	-6.7%
Total	1373	1368	15%

Source: human resources direction

Table 4-10 Human resources distribution by gender

Gender	number
Woman	76
Man	1292

Source: human resources direction

4.1.2.2. The company's directorates

(the organization chart of the company Appendix A)

DjenDjen is structured in seven directorates and each one of them include departments.

4.1.2.2.1. The general directorate

Headed by the general director whose mission is to design, coordinate and control the actions of the company.

In order to carry out his mission, the Director General is assisted by:

- The Deputy Director General.
- The Internal Audit and activities Control Department.
- The secretariat.

The internal audit and management control department: this department is directly attached to the general directorate and ensures these two functions: management control and internal audit. both functions are supervised by the same director.

As part of its audit activities, this department is primarily responsible for:

- organizing the working methods by updating all the regulations and procedures.
- Scheduling controls and checking methods according to the issues raised by the Directorate General.
- Conduct field work to identify any anomalies in the regulations and procedures in effect.

As part of these management control activities, this department is primarily responsible for:

- Developing and monitoring the company's budget.
- Conducting periodic analyzes regarding forecasts.

4.1.2.2.2. Operating directorate

This directorate is considered as the nerve of the whole enterprise, currently it is composed of department of loading and unloading (handling) and the commercial department.

The department of handling: Its mission is the treatment of the ships and the conservation, the reception and the delivery of the goods through:

- Ensuring the organization of all port operations.
- Ensuring optimal use of port spaces for labor and equipment.
- Assuring the fluidity of port traffic. by Coordinating, directing and controlling the activities of its structures.

The commercial service: This service has for mission:

- Marketing,
- Looking for traffic,
- The billing of services provided by the company,
- The management and operation of the company's facilities and installations.

4.1.2.2.3. The Human Resources Directorate:

It is currently composed of two departments:

Department of Personnel and Training: Among the tasks of the department:

- Assure the Management of the personnel administration.
- Maintain the central file of all staff.
- Follow the movement of staff with reference to management procedures.
- Ensure the application of labor laws and regulations.
- Analyze the training need of the company.
- Develop the recruitment plan.
- Manage the general affairs of the company.

Department of General Administration: This department is responsible for:

- The management of the material means necessary for the services functioning,
- Hygiene,
- Safety and occupational medicine.
- Documentation and preservation of the company's archives.
- Supplies (supply, spare parts).

4.1.2.2.4. The finance and accounting directorate

This department is currently composed of an accounting department and a finance department:

The accounting department: Its mission is:

- Prepare and implement accounting procedures.
- Control all accounting operations.
- Ensure compliance with the regulations in force.
- Keep the accounts up to date and ensure good bookkeeping.
- Making balance sheets of the company.

The finance department:

- Anticipate the financial policy elements of the company.
- Carrying out and monitoring the financing plan of the company.
- Design the management rules of the funds of the company.
- Develop and monitor the company's budget.
- Perform periodic analyzes against forecasts.

4.1.2.2.5. Research and Development directorate

It is currently organized into a statistics department and a communication office.

The statistics department: This department is responsible for drawing up the development plan proposals:

- Studying statistics and observed changes in traffic, handling, superstructures and infrastructure.
- Proposing accommodation and equipment adaptations.
- Promoting the port.
- setting up a database at the company.
- Techno-economic studies of the projects.
- Choices of equipment, installations and superstructures.

Computer and communication office: This office is in charge of the writing and the issue of the quarterly magazine of the company as well as the statistical yearbook. It is also responsible for establishing and implementing the company's IT plan:

- Determining IT needs and specifications and ensuring their implementation and operation.
- Determining the software and program needs of the company.
- Developing these programs and software or ordering them from suppliers.

4.1.2.2.6. work and handling directorate

This direction is composed of two departments:

The department of projects and works: This department is in charge of:

- Design ways to ensure the conservation of existing structures and buildings and the Construction of new structures.
- Organizing the work of the services on the basis of planning.
- Participating in the realization of project specifications.
- Ensuring the administrative, physical and financial management of the projects.

The department of handling: The head of this department is responsible for ensuring the conservation of equipment production, operation, transport and facilities.

4.1.2.2.7. The captaincy directorate

This direction is composed of two departments:

The Department of Navigation Assistance: Its mission is:

- To keep track of ships arriving in the harbor, out of port and at entry to optimize the use of berths.
- Coordinate and organize the piloting, mooring and towing operations by: Providing human and material resources necessary for the different operations of assistance.

Department of Maritime Police: The agents in this department:

- Ensure the respect of the regulation in control of police and security.
- Ensure good use of covered and uncovered storage areas.

4.1.3. DjenDjen activity

As any other port DjenDjen offers public and commercial services (review chapter3-section 2), to better highlight its activity we are analyzing in this sub-section the port traffic from 2003 to 2016 in tones per year.

4.1.3.1. Analyzing the port traffic

Table 4-11Retrospective of port traffic tone per year (2003/2016)

Year	Embarkation	Debarkation	Total
2003	1 602 351	1 581 043	21 308
2004	1 390 594	1 313 965	76 629
2005	1 379 378	1 344 809	34 569
2006	1 379 359	1 231 757	147 602
2007	1 362 939	1 231 595	131 344
2008	2 119 580	1 973 246	146 334
2009	2 166 272	2 156 456	9 816
2010	2 740 204	2 737 444	2 760
2011	3 065 629	2 982 729	82 900
2012	3 822 272	3 819 572	2 700
2013	3 865 509	3 835 511	29 998
2014	4 734 581	4 711 216	23 365
2015	4 736 307	4 725 732	10 575
2016	3 893 141	3 880 475	12 666

Source: the annual statistical review-2016 version.

Since our case study covers handling activities in the first half of 2018, we compared the port activity level between the first half of 2018 and that of the previous year.

Table 4-12 Evolution of merchandise traffic by product category

SECTIONS	Completion at the end of June 2017	Completion at the end of June 2018	Forecast at the end of June	Evolution 2017/ 2018 (%)	Achievement rate R18/P18 (%)
Agricultural products	**754,5**	**909,**	**71**	**21**	**127%**
- Wheat/barley/oats	552,6	830,	56	**50.**	**148%**
- Wood/ Plated	201,8	79,5	15	**-**	**52%**
- Paper	-	-	2,		
Foodstuffs	**47,70**	**59,7**	**40**		**149%**
- Vegetable oil	47,70	59,7	40		**149%**
- Sugar	-	-	-		
Ores and Prod. Met	**349,3**	**261,**	**45**	**-**	**57%**
- Concrete iron/ Wire machine	144,5	13,7	78	**-**	**18%**
- Steel reels	38,02	47,6	43	**25**	**111%**
- Tubes	145,6	164,	20	**13**	**81%**
- bracket / flat iron/frame/truss	20,98	5,86	12	**-**	**47%**
- Rails / Tole	225	-	-		
Steel biettes	-	29,9	12		**24%**
Minerals and Mat const.	**555,8**	**116,**	**34**	**-**	**34%**
- Cement	440,6	14,4	18	**-**	**8%**
- Clay/Sand/Felds path	65,12	71,4	64	**10**	**112%**
- Industrial salt	-	-	-		
- Marble	50,05	30,9	45	**-**	**68%**
- Clinker exports	-	-	50		**0%**
Chemicals	**9,070**	**5,62**	**15**		
- Sulfate/ Carbonate/Soda	9,070	5,62	15	**0%**	**0%**
Oil products	**49,77**	**30,9**	**35**	**-**	**88%**
- Bitumen	49,77	30,9	35	**-**	**88%**
Miscellaneous goods	**86,31**	**148,**	**18**	**72**	**82%**
- Various	74,57	49,3	85	**-**	**58%**
- Container	11,73	99,0	96	**744**	**103%**
Rolling stock	56,81	43,1	50	**-**	**86%**
- Vehicles and gear	56,81	43,1	50	**-**	**86%**
T O T A L	**1,909,**	**1,57**	**1,**	**-**	**86%**

Source: internal documents of the seaport.

4.2. Section two: Applying Lean Six Sigma

The purpose of this section is to demonstrate the contribution that the LSS methodology can make through its DMAIC approach in optimizing one of the key port delivery processes, without resorting to investment.

In this sense, our study was conducted according to the progress of the steps of the DMAIC approach, in which we will try in each phase to apply the reasoning conveyed by the LSS. As a first step, We will try to identify a process with value-added opportunities for the client of the PCJ (Define), then will measure the current performance of the selected process (Measure), after that, we will try to detect the optimization areas in our process (Analysis), once the improvement tracks are detected alongside the root causes of the identified problems, we will propose actions to improve the performance of the process (Improve). Finally, to ensure the implementation and follow-up of the proposals, control mechanisms will be proposed to ensure the continuation of the progress made (Control).

4.2.1. Define phase

The aim of this phase is to define the perimeter concerned by our study as well as the problematic treated throughout the DMAIC cycle. At the end of this phase, therefore, it will be necessary to establish the LSS project charter for the identified process.

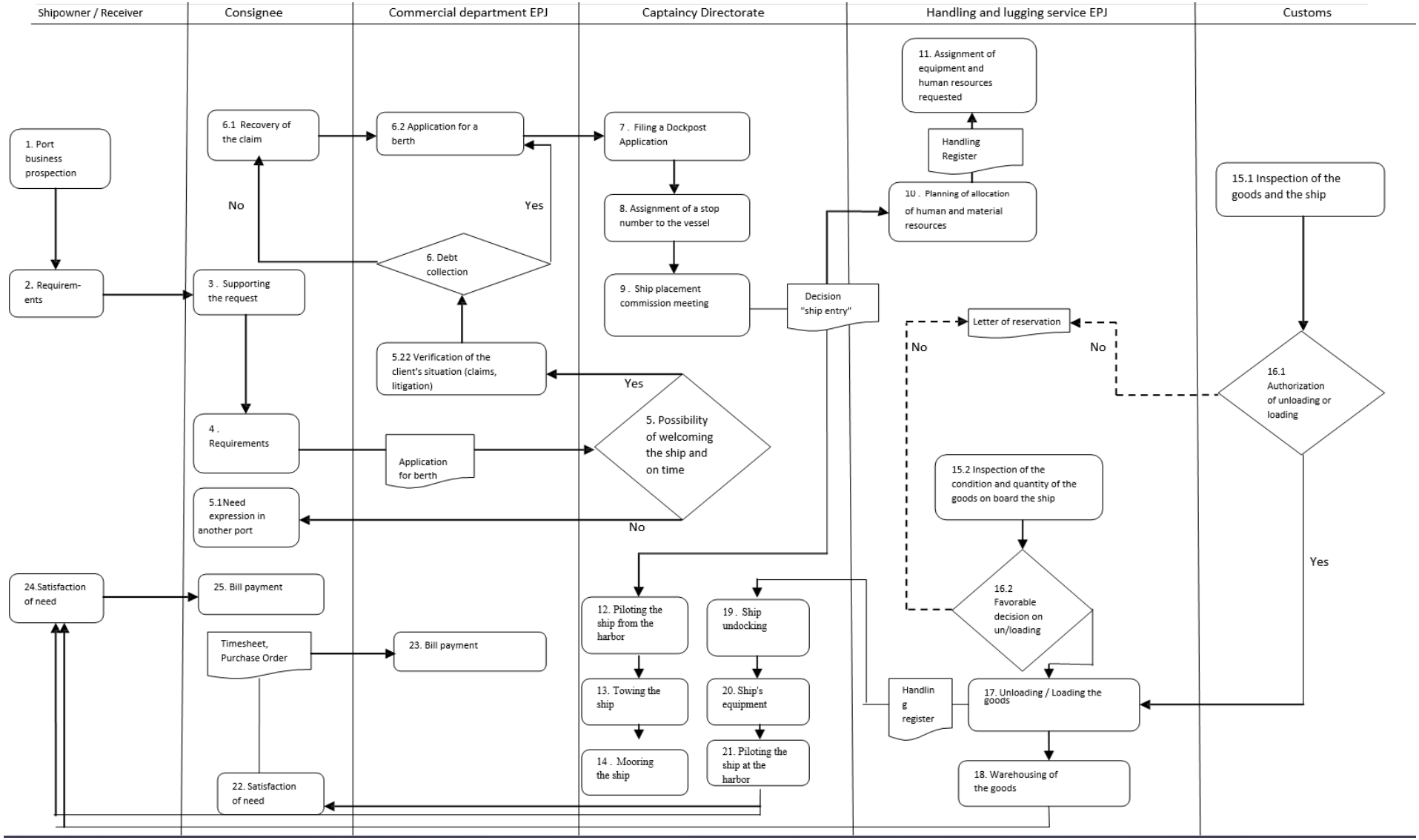
To do this, it will be a first step to trace the general process of delivery of the port in order to have a global view of the various stakeholders and the activities carried out by them and thus better identify the activities with high added value for the customer of the PCJ.

To retrace this process, we used one of the process mapping tools that is the Swim Lane.

4.2.1.1. The Swim Lane

Based on the internal procedures of the PCJ (Handling Procedure, Harbor Master's Procedure) and the information provided by PCJ’s staff and our field observations (Gemba Walk), we were able to trace the process of deliveries in the port. Formed based on the model explained in “ (BINTZ.D, 2009, p. 11)

Figure 4-1 Swim Lane of the port delivery process



From the Swim Lane, we have identified the various stakeholders throughout the port delivery process. from the expression of need expressed by the receiver or shipowner (process triggers) to the satisfaction of their needs.

Thus, the players involved in this process are: the ship owner, the freight receiver, the consignor, the PCJ captaincy directorate, the PCJ handling and docking department, the commercial department of PCJ and the customs.

It can be noted that the port delivery process involves several key players along the shipping supply chain, however, those players whose impact is considerable in the process do not necessarily have a direct trade agreement with the PCJ.

Indeed, it is the consignment company that presents itself in most cases as an intermediary between the stakeholders in the process.

4.2.1.2. SIPOC

In order to highlight the existing relationship (supplier-client) between the players in the process, we will map it using SIPOC in order to identify the real customer of the port on which will focus the optimization efforts

Figure 4-2 SIPOC of the port delivery process

From SIPOC we can notice that the triggering of the process although it emanates from the need expressed by the shipowner or final customer (Receiver) to the consignee, the port as a service delivery entity is included in the process only from from the consignee's need expression to the port, so the real customer of the port is the **consignee**.

4.2.1.3. VOC (Voice of Customer)

The customer of the PCJ once identified (the consignee), we will determine the voice of the customer, in other words its requirements and expectations, for this we conducted a series of interviews with 7 consignees operating during my internship at DjenDjen seaport.

Analysis of interviews

As a result of government decisions to rationalize expenditures due to the current economic conditions, port traffic has been heavily impacted. As for the port of DjenDjen, it is particularly affected by these decisions, especially given the consistency of goods imported by it: building materials, petroleum products, metallurgical products, vehicles, currently subject to import licensing.

For our part, I met during our stay at the PCJ a few consignees, whose operations are frequent through the port of DjenDjen. not having the opportunity to speak with many because of their occasional use of the PCJ.

Conduct of interviews:

The interviews took place during the month of April within the operating department, I talked with 7 consignees I met during the defining phase of the LSS project. For the questions refer to Appendix D the answers were as follows:

Answer 1

Consignee 1: "We are a private consignment company, our company was created following the liberalization of the market in 1996, we operate at the port of Djendjen through the EPJ since the year 2000."

Consignee 2: "We are a consignment company from Norway, we have been recording in Algeria since the year 2002 and we opened our agency in Jijel in 2010 following the Ministerial decision on the transfer of vehicles to the port of Djendjen . "

Consignee 3: "We are a private consignment company. we operate in the port of Djendjen since 2008."

Consignee 4: "We are a private consignment company. we operate through the port of Djendjen since its inception. "

Consignee 5: "We are a private consignment company, we operate at the port of Djendjen since its creation, we ensure the stopover of ships carrying various goods, including marble, bulk cement currently, containers sometimes."

Consignee 6: "We are specialized in the container, and we operate through the port of Djendjen since 2014, before we operated through the port of Bejaia, but since the decline in traffic in the port of Djendjen, we went to the latter at the request of our client. "

Consignee 7: "We are a private consignment company. we have been operating at the port of Djendjen since 2005."

Take away

From these answers we deduce that the PCJ has loyal customers in its portfolio whose seniority goes back more than ten years, on the other hand, we can notice that the PCJ was seen expand its market particularly following political decisions (ministerial decision on the transfer of vehicle traffic from Algiers to the ports of Djendjen and Ghazaouat), but also the current economic situation which has caused traffic to fall to the level of port of Djendejn and thus induced a decrease in stay in the harbor attracting new customers in search of time saving.

Answer 2

Consignee 1: "The use of this or another port may be recommended by the importer (receiver of the goods) himself, by the shipowner who wants to ensure a quick stopover, or even by the consignee himself who knows well ports and can thus recommend to the importer or the shipowner the appropriate port, so the choice of the port company can be conditioned by the contract which binds us with our client, importer, it is after his consent that we operate, because it can have requirements of proximity to the production sites in order to save in transport costs, or by the contract which links us with the shipowner, it depends. We are at the service of our customers, and a lot of our requirements come from their requirements. "

Consignee 2: "You have to know that the importation of vehicles is a big market, that's what pushed us to open an agency at Jijel level and therefore to request more frequently the benefits of the port of Djendjen. following the government's decision to rationalize spending through the reduction of imports, particularly that of vehicles. For this reason we settled in Jijel, our activity was strongly regressed at the port of DjenDjen, but remains that for the vehicle market we seek the services of the port of Djendjen obligatorily. "

Consignee 3: "At present, we are providing a stop for ships bringing in pipes on behalf of one of our clients whose exclusivity we have obtained. Our client, whose activity is the realization of large projects, is currently importing large quantities of pipes and has a strict just-in-time policy, which means that the port of Djendjen is the ideal port for the reception of ships. indeed, in addition to its draft, its warehousing capabilities allow our customer to apply its just-in-time policy. "

Consignee 4: "We provide a stopover for ships of different sizes, bringing various goods, usually transported in packages and containers. The port meets a multitude of criteria, which means that we use his services several times."

Consignee 5: "The use of the port of Djendjen may be justified in some cases by its proximity to the receivers of goods (importers) and in this case it is the importer himself who requires us to opt for the port of Djendjen to optimize the cost of transportation. In other cases, it is the shipowner who requires it, it depends on the contract and the nature of the relationship between the various stakeholders, as well as the characteristics of the cargo. In this trade it must be remembered that operations are governed by international laws between suppliers in the countries of origin, shipowners, charterers of the times, the customer who may be a private company or even the state. Transport terms and requirements differ from one situation to another and each situation is unique, we only perform sometimes, in other cases we are an important player, it depends on the contract we conclude. "

Consignee 6: "The use of the port of Djendjen is explained by the current economic situation which has meant that the length of stays in the harbor has decreased following the decline in traffic, it is besides our customer who after prospecting has made the demand. "

Consignee 7: "In general, we are solicited to ensure the stopover of large ships, lately we have brought ships bringing wheat, vehicles, pipes .It must be said that we are famous for that, which says big ship says big draft, so in a lot of times we opt for the port of DjenDjen. "

Take away

As a result of these responses, it can be deduced that although the consignee is the direct client of the PCJ, and in general he is the actor in the logistics chain who has direct contact with the various stakeholders in the delivery process. port, the choice of the port company does not necessarily depend on the consignee.

Firstly, we found that the choice of the port depended indirectly on the customer's requirements, so the choice of port is usually made indirectly either by the importer (Freight Receiver) or the Shipowner (owner of the vessel), and that these relations are rigorously governed by contracts specifying the requirements and expectations of each as well as by international regulations governing the activity of the various parties and delimiting the field of intervention and responsibility of each.

In a second step, the choice of the port company can be previously defined by the public authorities as in the case of the traffic of vehicles which was transferred from the port of Algiers to the port of Djendjen and Ghazaouat by a ministerial decision in 2009.

However, the consignee may in the absence of specific requirements by its customers or others choose the port that he considers adequate based on his experience in the field.

Answer 3

Consignee 1: "At the port of Djendjen, the stay in the harbor is short compared to the neighboring ports, which is a real advantage, we can also mention the large draft and the large storage areas."

Consignee 2: "In addition to the delay in the harbor, the solid land of the port of Djendjen is a very important advantage. it has a fairly large storage area, in general, there is no problem in this sense, which suits us a lot, especially knowing the nature of the goods transported by the ships we provide the stopover. The draft that can accommodate large vessels is also an advantage. "

Consignee 3: "The infrastructure of the port is a major asset and a very important advantage, its draft, its land full"

Consignee 4: "Solid ground wide enough, draft quite large compared to other port"

Consignee 5: "For our importing customers, it is the storage capacity of the port, it has a fairly large land, in addition to its geographical location quite advantageous compared to other wilayas, including through infrastructure road transport (railways, connection to the national transport network through penetrating Jijel-El Eulma). With regard to shipowners, it is the length of stay in the harbor that is not very long compared to other Algerian ports, in addition to the draft, which is quite important. "

Consignee 6: "This is the reason why our client has asked us to change port, the period of stay in harbor, fairly competitive with the port of Bejaia. Indeed this one has for requirements just in time to ensure the continuity of its activities. "

Consignee 7: "It's the draft I find, there are some ships that can only berth in Djendjen"

Take away

The consignees answers indicate that the greatest benefit of the PCJ is its infrastructure, as almost all responses were identical, with focus on berth draft, storage capacity. in particular its solid land of 104 ha, as well as its rather advantageous geographical situation recently reinforced by penetrating (Jijel -El-Eulma) allowing from now on to link the port to the national highway network and by the same the rest of the country and the others African countries.

The other great advantage of the port of Djendjen, acquired recently but at the expense of a strong activity, is the reduction of the period of stay in the roadstead which can be explained by the decrease of the traffic. This is due to the decisions of rationalization of the expenses which impacted the performance of the ports, particularly that of the PCJ, which was heavily dependent on the importation of vehicles, which is currently limited. It should be known that the traffic of the vehicles has been transferred from the port of Algiers to the ports of Ghazaouet

and DjenDjen in 2009, in addition to other goods namely: non-containerized goods, food products, wood and concrete round.

In sum, it can be concluded that the benefits identified mainly relate to the port's geographical location and its infrastructure (storage space, draft), as well as the improvement of the stopping times (new factor of attractiveness).

Answer 4

Consignee 1: "We can not really call them disadvantages, but it is true that these are criteria that are not directly in the interest of the consignee, for example: the option offered by the port of Djendjen to our customers, that is to say the receiver of the goods or importer to pay the operations of landing and loading of goods makes us lose a source of value "

"Also there is the price increase in the fourth shift (the double night) and on the holidays, many customers who opt for the payment of the costs of landing / boarding whose time requirement is not so important, reports this operation in the morning shift, evening or night (the regular hours), which causes a huge loss of time for us and the shipowner whose time requirement is extremely important"

Consignee 2: "The increase in prices during the double night shift whether for maritime operations, that is to say (steering, towing, mooring) or handling (loading / unloading), in addition to the situation of the port which makes it too exposed and which in this way can cause a serious safety problem for the ships, especially in the winter season, because the port is obliged especially in case of BMS to interrupt the operations, to make take the ships out of the harbor, return them again to continue the operations, so more marine operations in more time and therefore more costs. "

Consignee 3: "The possibility that the EPJ to the receivers (importer) to pay by themselves the costs of landing / boarding, greatly reduces our profit margin, given that in Djendjen we work largely with a As the only receiving customer, we are assured of our stopover by the port of Djendjen, only to be paid for the maritime operations.

"Another disadvantage is the lack of a dry harbor nearby. It is an infrastructure that the case where it would be available would improve the reception capacity of the port, the port has faced situations inducing a number of times a cessation of activities, until areas are available".

Consignee 4: "The option which offers the receivers the possibility to pay by themselves the invoice of the operations of handling is a great disadvantage in our case, because if the ship comprises the goods of 10 customers for example, in most cases the 10 customers will require that the invoice be broken down into 10 other invoices and in this case the, we will be remunerated only for the maritime services. "

Consignee 5: "The increase in prices during irregular shifts, also the option offered by the port to the receivers to pay the handling operations. "

Consignee 6: "The delay of stay at the berth is one of the major disadvantages at the port of Djendjen, indeed it is significantly higher than in the port of Bejaia, the storage space is not sufficient, but our client adapts. "

Consignee 7: the port is geographically too exposed, which does not allow the protection of ships in case of BMS and especially during the winter season.

Take away

With respect to the disadvantages of the port of Djendjen, the majority of responses focused on the PCJ's pricing policy and prices.

Indeed, almost all the consignees interviewed believe that the option offering importing customers the option of paying for handling operations instead of the consignee presents a loss of profit for them, because they are limited to the gains made by the operations. However, this modality is also applied by other Algerian ports such as the port of Algiers, which means that the port of Djendjen is no exception, which does not as much as a disadvantage, taking into account the fact that this method of payment which is mainly aimed at the interest of the end customer attracts new importers to the port who will thus seek the services of consignees operating through Djendjen.

In addition to the payment terms, the increase in prices during the fourth shift (shift of the double night) and during holidays poses a great problem for the consignees, indeed, in the case where the importing customer requires the consignee to postpone handling operations at regular shifts, the shipowner other customer of the consignee for whom the time factor is extremely important will deal with a huge loss of time, the port too, because the ship remains immobilized and the berth without any activity which results in underutilization of port infrastructure.

Answer 5

Consignee 1: "For any port, the decisive criterion of quality apart from the geographical acquis of course, remains the processing time of the ships. it is important to know that in our trade of consignee, the most important resource is the time, the faster we operate, the more we win, and the same goes for the port. Safety is also a criterion of quality, because it is necessary to ensure the good condition of the goods landed or shipped, otherwise it is a loss for the port and the consignee. the operations will not be remunerated and in most cases the costs will be shared with the port, the handling operations are the experience of the handlers and the quality of equipment used, and execution errors can cause losses priceless. "

Consignee 2: "The unloading time is very important, also the availability of a qualified human resource who knows how to handle the goods during unloading and embarkation, the availability of the storage areas and the organization of the latter which largely facilitates handling operations. "

Consignee 3: "The criteria of quality of services of a port are the flexibility in the handling of the goods, the speed of execution, adapted equipment, in summary, all which allows the operations to happen in the best conditions and to lower cost."

Consignee 4: "In maritime transport, the port's duration of call at the port level is a decisive criterion. You know, we meet the requirements of us customers. that is to say the clauses of contracts signed with importers and shipowners. In the world of transport, time is money, the more we make a quick stopover to our shipping customers, the more they will be able to carry out other operations in other ports. In the case of our receiving customers, this means will help ensure the availability of their merchandise at the right time, and in so doing, allow us to do more business in less time. "

Consignee 5: "The time of execution of the maritime operations and handling, the quality of the equipment and of course the security of the goods. "

Consignee 6: "The time of execution of the operations and the quality of the latter. By this I mean handling operations without incident, without damage whether for the container that is our property or for the goods inside the container. "

Consignee 7: "The capacity of the port to cope with difficult situations, especially by the harbor master when it comes to large ships also the time of treatment of ship is an advantage. "

Take away

Other than the geographic and infrastructure assets of the port, including the availability of storage areas. For the consignees, the quality criteria that make the difference are essentially those related to the quality and duration of the operations, whether maritime or handling, criteria critical to quality for shipowners and receivers of goods and selection criteria. essential of the consignees and therefore of the port.

The advanced criteria are mainly part of the services offered by the handling department: flexibility in the handling of the goods, provision of adapted equipment and qualified personnel at the appropriate time, therefore responsiveness of the department to requests from consignees and quality in the handling of goods landed or shipped.

In addition to the services offered by the handling service, the acconage service is responsible for ensuring the availability of storage areas and the organization of storage areas

in order to optimize their management. The captaincy department ensures the smooth running of maritime operations.

Answer 6

Consignee 1: "The delay of course, even if the latter depends on several parameters outside the port, including meteorological, contractual, but we believe that the degree of mastery of delays whether at the roadstead or berth is an indicator key of quality. "

Consignee 2: "The time of stay of the ship, of course, is the most important aspect, the faster the operation will be, the less the costs and the more the number of operations executed. You know what is said "time is money".

Consignee 3: "The speed of execution of operations, because it is the requirement of our client."

Consignee 4: "Of course, it's the length of stay at the port level, the customer is looking for the best alternative to run his operations in a minimum amount of time, that's the real added value of the port, and that's what our customers expect from us, and we from the port. "

Consignee 5: "The turnaround time of course is the most important parameter in commercial ports. "

Consignee 6: "The turnaround time of operations. quality operations in the best time. "

Consignee 7: "The duration and quality of ship processing operations. "

Take away

Almost all the consignees agree that the deadline constraint is the most important in the port services, indeed, they require quality services without compromising the respect of the deadlines because, in maritime transport the time is synonymous money for all stakeholders.

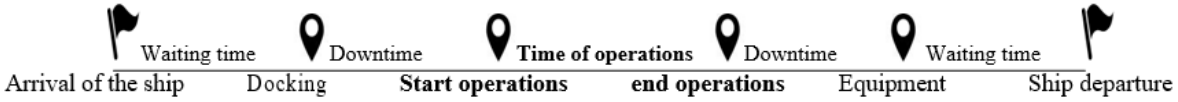
4.2.1.4. CTQ (Criticals To Quality)

Based on the interviews with the consignees, we have identified the quality of service requirements from the point of view of the latter, they can be summed up in 4 main criteria which are: the time, the good condition of the goods, the availability of space for storage, the availability of handling means.

The most important criterion from the point of view of the client being the delay (the most repeated, answer 6), we will focus on this criterion.

- The vessel registration stage Figure 3-1 at the port level is not carried out in the PCJ, so we will not include it in the total duration of service. Hence the distribution of delivery times at the port of Djendjen is as follows:

Figure 4-3 Distribution of delivery times at the port of DjenDjen

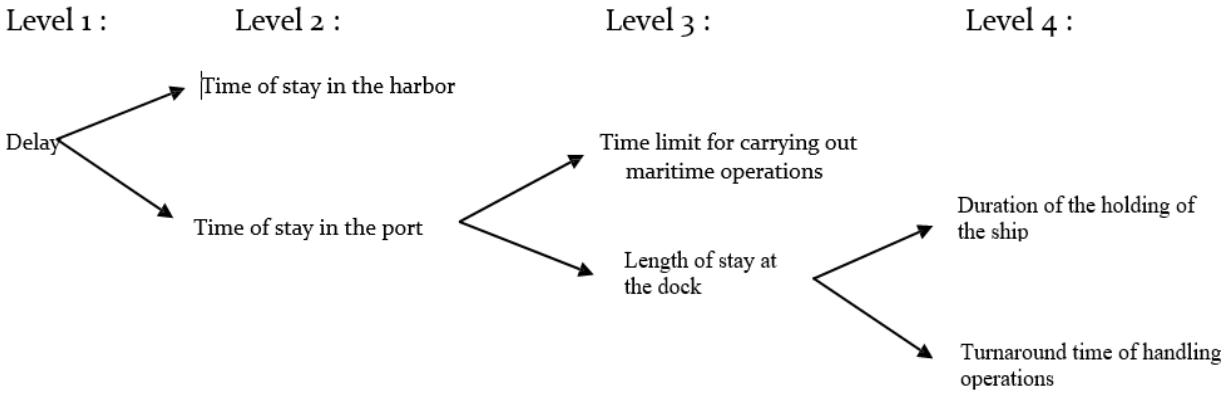


Source: made by the author according to the information obtained from the staff of the seaport.

4.2.1.5. CTQ Tree (Delay)

To make better use of the information provided by the consignees, we will use a CTQ tree, it will allow the identification of the most important aspect in the "Time Limit" from the consignee's point of view that we can work on.

Figure 4-4 CTQ tree



Source: made by the author according to the information obtained from the staff of the seaport.

4.2.1.6. The situation of the process

Since the period of stay in the harbor has been considered by the consignees to be quite competitive with the neighboring ports (lower traffic in the port of DjenDjen) in addition to the fact that it does not depend entirely on the performance of the port, which subjects to several external parameters, we will focus on the criterion: waiting times at the dock.

According to the operators in the handling department of the PCJ and our observations on the ground, the distribution of **the length of stay of the ship at the berth** is in chronological order as follows:

1. **A period of immobilization of the ship:** Between the berthing and the beginning of the operations of handling.

During this stage, specialized and obligatory visits take place in the presence of the consignee, these are:

- Visit of phytosanitary services.

- Visit of the customs services.
- Visit the services of the BPFM.
- Visit of the manager of QHSE.
- Visit officers of the port.
- A preliminary visit by the head of the wharf to define the landing gear.
- According to the operators in the field, this stage consumes from 01:00h to 02:00h of time depending on the availability of the necessary documents and without which visits cannot begin, for example: the bill of lading provided by the importer.

2. **A duration of handling operations:** From the beginning of the handling operations until their end.

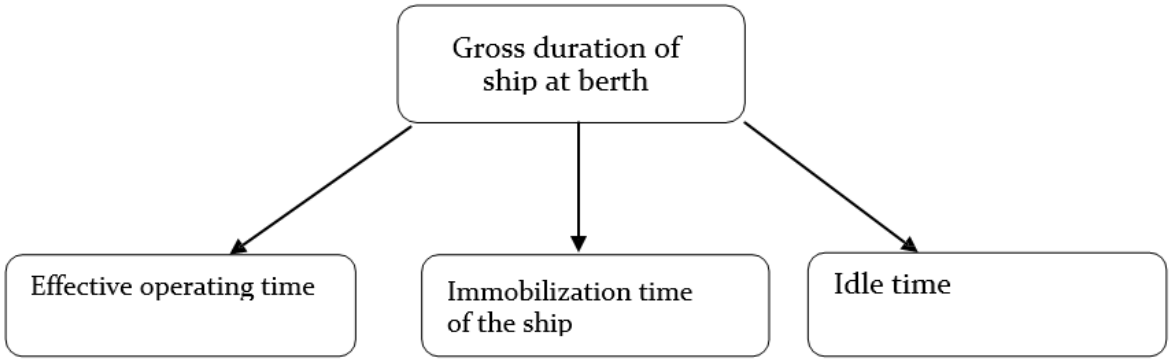
This step involves loading and unloading the goods.

3. **A duration of immobilization of the ship:** Between the end of the operations and the equipment of the ship.

During this stage, it is necessary to carry out the necessary formalities between the ship and the other actors of the process: The port authority, the consignee, the police the customs so that the ship can leave the quay.

Based on the internal documentation of the handling department (Handbook) and our observations in the field, it can be noticed that the duration of time consumed to carry out the operations of handling is not exploited efficiently, of this in fact, we propose the following decomposition of the stay-at-berth time:

Figure 4-5 Breakdown of the ship's berth time



Source: made by the author according to the information obtained from the staff of the seaport.

- The effective operating time: Represents the time used in handling operations.
- Idle time: Represents the length of time not used during the goods handling phase.
- The time of detention of the ship (immobilization) : Is the length of time between the berthing and the beginning of the operations of handling and between the end of these and the

apparatus of the ship, this duration is devoted to the establishment of the controls and paperwork.

To make this study a reality, we opted for one of the ships at berth treatment processes, the process of handling container vessels at the mixed wharf level. So, throughout our study it will be question of optimizing this process.

4.2.1.7. Project charter

Figure 4-6 The LSS project charter

<table>
<tr><td colspan="2">Name of project : LSS - treatment Process of Container Vessels at berth
Client of project : Consignment companies
Critical requirement for the client : The delay</td></tr>
<tr><td>The context</td><td>Scope of the project</td></tr>
<tr><td rowspan="4">Following the decline of the traffic recorded in 2018 by the port of DjenDjen, the PCJ is confronted with a significant turnover reduction compared to previous years, nevertheless, this decrease of the traffic resulted in an improvement of its level of stay in the harbor. quality criterion that attracts new customers, only in a market where time is synonymous with money, this advantage earned and not mastered is not enough. The delay of stay at the berth is revealed in the case of its optimization a criterion of A major differentiation that will allow PCJ to better manage its deadlines and thus strengthen its position in the market, particularly in the case of a further rise in traffic.</td><td>The processing by the PCJ of container ships at the wharf level from January to June.</td></tr>
<tr><td>Impact of the project on the company</td></tr>
<tr><td>Waste of time
Financial loss</td></tr>
<tr><td>Gain of the project</td></tr>
<tr><td></td><td>-Improve handling performance (loading / unloading) of containers.
-Improve the stay at the berth of container ships and thus improve the time of stay in the harbor and berth of other ships.
-Avoid the costs associated with waiting times and improve the productivity of the port.</td></tr>
<tr><td>Problem definition</td><td>Objective</td></tr>
<tr><td rowspan="2">The stay time of the vessels at the wharf is not exploited efficiently, causing a considerable loss of time especially during the handling operations, more</td><td>Optimize the service delivery process for consignees in the case of container ships</td></tr>
<tr><td>Sub-objectives</td></tr>
</table>

precisely: The handling efficiency of the containers is lower than the required yield (15 TC / h)	-Detect existing problems in the container handling process that is causing the program to be disrupted and thus the required performance. -Identify the zones at the origin of the recorded waiting times. -Identify the real causes of the recorded waiting times.
Key performance indicator	
Yield required for container handling Time occupation of the dock	15 TC /h (Universal standard) The least long and variable possible

Source: realized by the author.

4.2.2. Measure phase

The purpose of this phase is to measure the current performance of the selected process. "Container ship treatment process at the wharf level".

As discussed in Chapter 3, there are three sets of measures to assess the quality of port services for all stakeholders whose views may differ widely.

Since the customer of the process is the consignee, we will focus on the most representative measures of his expectations.

4.2.2.1. The selection of measurement indicators

The selection of measurement indicators was made according to two criteria:

• The process customer (consignee).

• The availability of the data necessary to exploit the indicators (the waiting times of vessels before docking and after departure and the quantities handled by each team do not show any follow-up by the PCJ, so we won't be able to calculate the handling operation efficiency per gang and per hours spent at the port in the third series of measurements).

Thus, the indicators listed are:

1. First series of measurements: **Time spent by the ship in the port**:

-Total time of immobilization at the port.

-Total time spent at the port according in the handling operations.

2. Second series of measures: **The indicators of occupation of the berth**:

-The period in which the position is occupied but without actual work.

-The period in which the position is occupied and in actual work.

-The period when the position is occupied but not in service.

3. Third series of measurement: **performance measures for cargo-handling on board and on shore.**

-The berth throughput.

- the quantity handled per hour and per ship.

-The quantity handled per hour spent at the berth.

4.2.2.2. The selected sample

In order to concretize the study, a sample of vessels will be taken and followed by a study of the indicators mentioned above (we opted for a sample of container ships because of the complexity of their treatment compared to other types of vessels. cargoes, vehicles, wheat ... etc) ,we choose the first half of 2018 according to the operating responsible recommendation.

Sample studied:

Table 4-13the sample information

Number of ships	37 ships
Duration of consideration	From January 2018 to June 2018
Number of containers handled	14566 containers
Berth	Mixed Berth

Source: made by the author.

4.2.2.3. Port performance indicators Calculation

Based on the information included in the Register of Data and Information of Various Material Handling Operations from January 2018 to June 2018, we have set up a database (Appendix C: database of container ship processing operations) here is the summary:

Table 4-14 Container Ship Processing Statistics (1st half of 2018)

Time to consider	14/01/2018 to 30/06/2018
Total number of ships	37 ships
Total stay in the harbor	401.56 hours
Total stay at the dock	1429.27 hours
Total ship's immobilization time	519.6 hours
Total gross handling operations durations	902.60 hours
Total Time Losses Recorded During handling Operations	123.70 hours
Total Time Durations actually worked	778.90 hours
Number of containers disembarked	7780 containers
Number of containers embarked	6786 containers
Total shifts	239 shifts

Source: Realized by the author on the basis of the handling register (January 2018-June 2018).

Comment

The table shows the length of stay in the harbor and berth of 37 vessels at the port of DjenDjen for a period of 6 months (from January 2018 to June 2018), as well as the number of containers handled during this same period and the number of corresponding shifts.

Note that the length of stay at the wharf is approximately 4 times the length of stay in the harbor (1429.27 hours / 401.56 hours = 3.65), which confirms the observations made during the interviews "The stay at the berth is a real disadvantage for the PCJ".

The disembarkation and embarkation operations are almost of the same level. 7780 full containers unloaded (equivalent to 7780 rotation) and 6786 empty containers loaded (equivalent to 6786 rotation).

During the first half of 2018, the port of DjenDjen processed 14566 containers with a gross duration of stay at the wharf equivalent to 1429.27 hours and a gross operating time of 902.60 hours.

From Table 4-13, we can derive the following port performance indicators:

1. 1st series of measurements **Time spent by the ship at the port:**

Table 4-15 Duration Indicators I 1st half of 2018 for 37 ships (Measure Phase)

Duration indicators	Value
Total immobilization time at the port	1429.27
Total time spent at port based on handling operations	902.60

Source: realized by the author.

2. 2nd set of measures: **The berth occupancy indicators:**

Table 4-16 Duration Indicators II 1st half of 2018 for 37 ships (Measure Phase)

Duration indicators	Value
The period when the position is occupied but without actual work (time losses)	123.70 hours
The period when the position is occupied and in actual work	778.90 hours
The period when the position is occupied but not in service (immobilization time)	519.6 hours

Source: realized by the author.

- The period in which the position is occupied but without actual work represents 8.65% of the total time of occupancy of the wharf
- The period of occupation in actual work represents 54.50% of the total time of occupancy at the wharf

- The period when the position is occupied but is not in service represents 36.35% of the total time of occupancy of the wharf.

It is noted that almost half of the time spent docked by ships is not operated effectively, so the system suffers from inefficiency in the productive use of the facilities.

3. 3rd set of measures **Container handling performance**

From Table 4-12, we can calculate the production and productivity indicators, we get:

- Ship's berth throughput = the total number of containers unloaded + the total number of loaded containers = 7780 + 6786 = 14566 containers.
- Amount handled per hour and per ship (Appendix D- *rendement du navire*).
- Amount handled per hour spent at berth:

it is a question of calculating the efficiency achieved by the PCJ in its operations of handling of containers, that is to say by taking into account the average number of containers handled at the average raw time spent at the platform composed of the time of effective operation + idle time + immobilization time.

$$performance\ indicator = \frac{Number\ of\ containers\ handled.}{Gross\ time\ spent\ at\ the\ berth.}$$

Knowing that there are two types of containers, 20-foot container and 40-foot container, we did not take into consideration the EVP used for pricing as a unit of measure, but rather the number of rotations that is i.e., the number of containers handled.

Also, landed containers are full containers used in import operations and those shipped are empty containers returned for other import operations.

This results in the following gross yield:

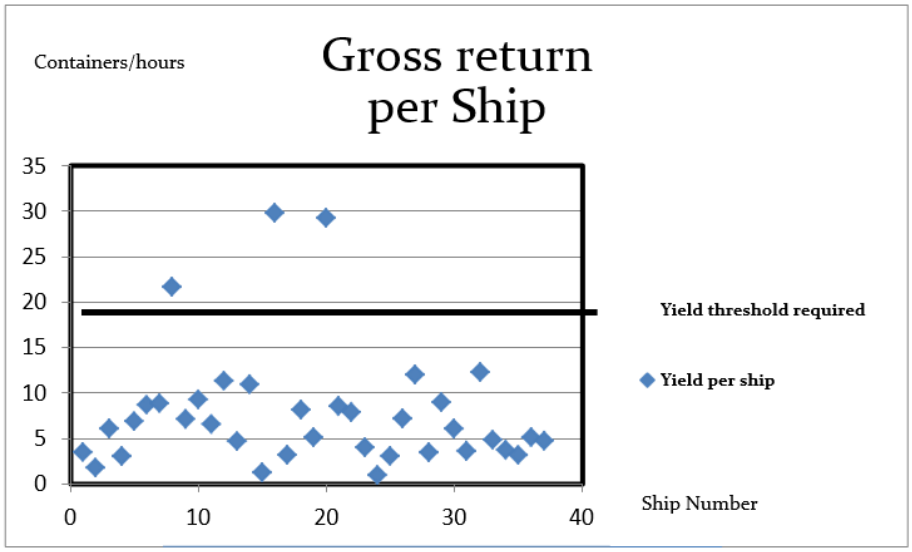
Table 4-17 Gross Yield Statistics

Time to consider	sample	Total number of containers handled	Gross processing time of the ship docked	Gross return	The standard deviation
1st semester 2018	37 ships	14566	1429.27	10.19	6.49

Source: realized by the author.

Comment: Gross operating return is 10.19 TC/h, so the current performance level of the process is below the target performance level of 15 TC/h.

The dispersal of Gross yields from container handling operations in the1st half of 2018
Figure 4-7 Dispersal of gross yields



Source: realized by the author according to Appendix C (database of container ship processing operations)

Comment: This points cloud represents the dispersion of gross returns for all container ship operations conducted during the first half of 2018 against the yield threshold required by the PCJ (15 TC/h).

It can be noted that in 8.1% of cases representing only 3 vessels, the performance of operations is significantly higher than the required standard (15 TC/h), while in 92.9% of cases representing 34 vessels, the performance of operations is below that same Standard.

It can also be noted that the level of returns in each operation performed is very dispersed. a standard deviation of 6.49 TC/h quite high for an average of 10.19 TC/h. The process is not mastered.

In the process studied, carrying out operations from one ship to another, differs from 6.49 TC/h, which means a variability of 6.49 TC/h between the 37 cases studied.

It can be concluded that the current level of performance of the process is far from optimal to meet the time requirements of its customers.

4.2.3. Analyze phase

The purpose of this phase is to establish the diagnosis of the selected process "treatment of container vessels at the wharf level" based on the data collected in the "measure" phase.

At the end of this phase, it will be a question of establishing a cause-and-effect diagram which will group in category the causes of failure identified and on which will be the improvement actions in the next phase (Improve).

Firstly, the total stay time at the berth was apportioned according to the value added to the consignee in order to highlight potential optimization areas.

4.2.3.1. Classification of process activities by value added

Table 4-18 Activities classification by value added

Nature of the activity	Phase	Volume of hours
Value-added activity for the customer (VA)	Net duration of handling operations	779.60 hours
Non-value-added activity for the customer (NVA)	Waiting time during handling operations	123.7 hours
Non-value-added activity for the customer but necessary (VAO)	The vessel's immobilization time	519.6 hours

Source: made by the author according to table 4-14.

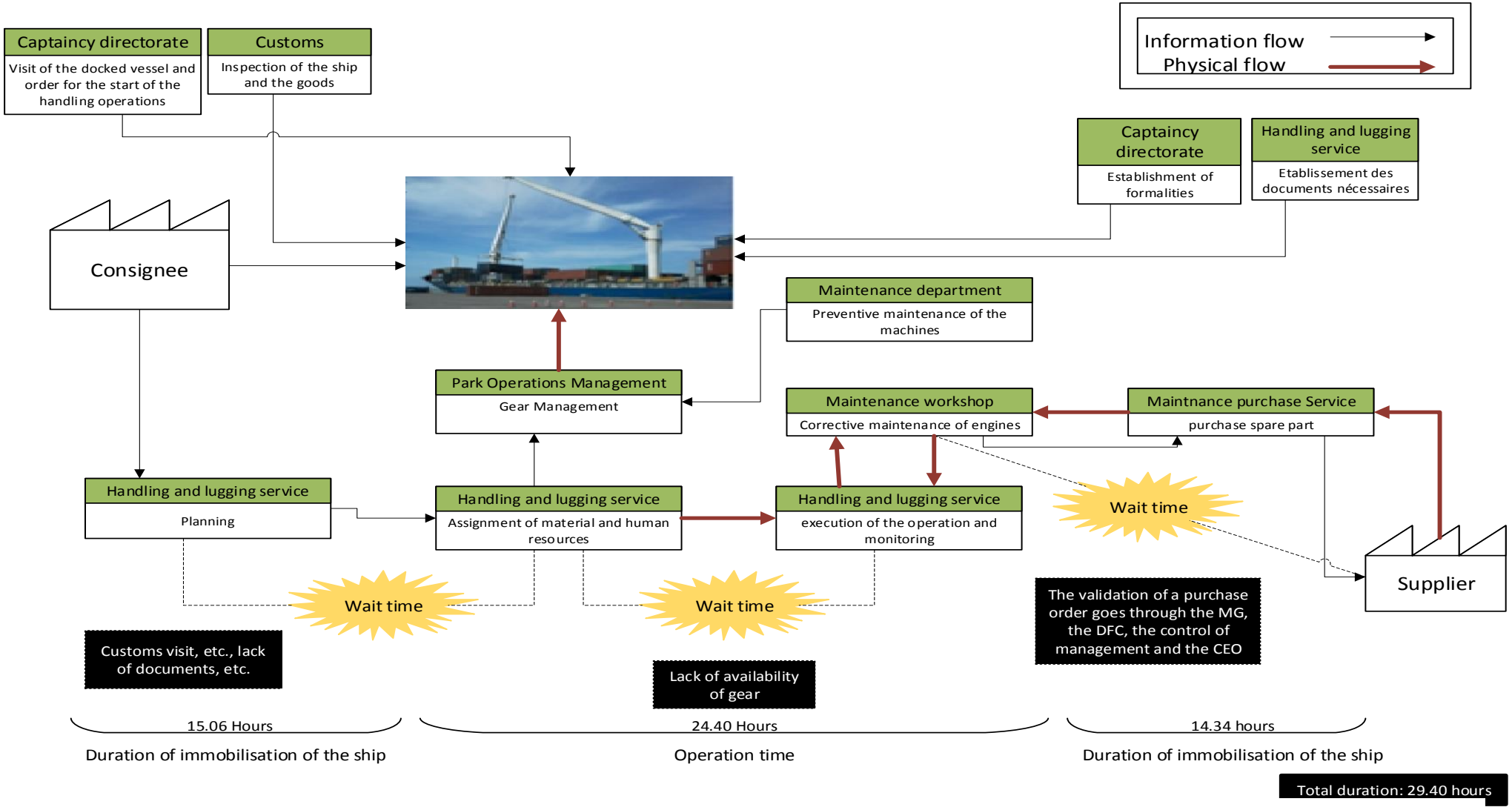
From this classification, we understand that optimization opportunities present themselves in the categories: NVA and VAO, so I will focus on these two categories to detect the causes of time wasting.

In order to have a better visibility on these optimization opportunities, I have mapped out a VSM that will allow us to highlight the value flows in our process.

4.2.3.2. The current VSM

The VSM established represents one of the 37 cases studied (Ship number 26: The Cielo of Agadir in Appendix C)

Figure 4-8 The VSM of handling process



Source: realized by the author based on information obtained from the consignees and the staff of the PCJ.

Comment

From the VSM it can be noted that:

- The loss of time in the process is mainly at the level of the handling department during planning, allocation and execution activities, which reveals a problem of lack of internal and external coordination.
- The bottlenecks are essentially at the level of the fleet of gear whose management is jointly the responsibility of the operations and maintenance departments..
- Also, the subcontracting process consumes a lot of time. the length of this subprocess is due to the complexity and length of the several levels of validation.

From this finding the following conclusions can be drawn:

- If the procedure is followed:

Cause	Failure	Risk	Opportunity
Long and complex procedure	Long delivery time periods	Financial loss	Control of incurred expenses

- If the procedure is not followed:

Cause	Failure	Risk	Opportunity
long and complex procedure	Uncontrolled incurred expenditures	Fraud	Improved RP Order Satisfaction Time

4.2.3.3. Waste sources analysis

On the basis of the handling register of the PCJ, a classification of the wastes was established: (Knowing that the wait times caused by the PCJ are not tariffed and that against those caused by the consignee, the team of the ship or even the receiver)

In this classification, we took into consideration at first, all immobilization time without distinction, then we proceeded by a sorting to highlight the immobilization time which represent a pure waste of those which represent a necessary waste but still reducible.

This classification is represented in the following table:

1. **Waste related to wait times and delay**

Table 4-19 Causalities of waste due to wasted time

Type of waste	Causality of shutdown	Process phase
Pure Waste (NVA)	Liebherr crane failure Stacker failure Liebherr crane defect Equipment Failure (Spreader, Stacker, Sling, Lifter) Waiting for parapet availability (evacuation rate)	Operating period
	Waiting to refuel cranes	
	Waiting for work teams	
	Waiting for lack of empty containers at the start of operations	
	Workplace accident	
Necessary Waste (VAO)	Waiting for TC control	Period of immobilization
	Waiting for equipment to disembark for the port Waiting for cargo to be boarded at other ports Waiting on the orders of the ship's crew	Operating period
	Waiting due to rain (at the request of the ship)	
	Waiting on the orders of the ship's crew Waiting for panels to be boarded inside the hold	
	Passing cars	
	Waiting for hold opening	Period of immobilization
	Waiting for hold closure	

Source: Realized by the author on the basis of the information in the handling register.

2. **Wastes related to travel and movement in the workplace:** The handling and stevedoring department has an office at the level of the building management away from the field, so that the head of the handling department is obliged to move several times in the day between the office and the field after the provision of a vehicle to supervise operations at the field level which consumes a lot of time.

3. **Waste due to obstinacy (Bad decision):** In the event of an error during the planning (Assignment of the equipment), the handling service is removed from the machines in service and mobilize others which causes an interruption of the equipment activity and therefore a waste of time.

4. **Overproduction:** If unloading or loading activities are more or less rapid than the rate at which containers are evacuated from the parapet, the entire process is interrupted, resulting in a waste of time

5. **Loss of know-how:** This is the non-valorization of staff skills and discontinuation of initiatives, such as the initiative of the maintenance workshop on the calculation of loss of profits, as well as the underutilization staff who have accumulated knowledge and who could provide training to other employees.

Based on this waste analysis, we selected the types of wastes on which optimization actions can be carried out (NVA, VAO) and calculated the volume of hours consumed by each type. As shown in the following table:

Table 4-20Time volume corresponding to each type of stop

Types of shutdown	crane failure	Crane issues	Equipment failure	Lack of equipment	Evacuation rate (unavailable parapet)	The full crane	Lack of work team	Moving cranes	Work Accident	container control	Total
Frequency	28	17	3	14	24	2	4	6	1	5	104
Time of stop in hours	32.98	13.27	2.75	10.75	14.58	1.33	2.92	2.68	0.75	2.92	84.93

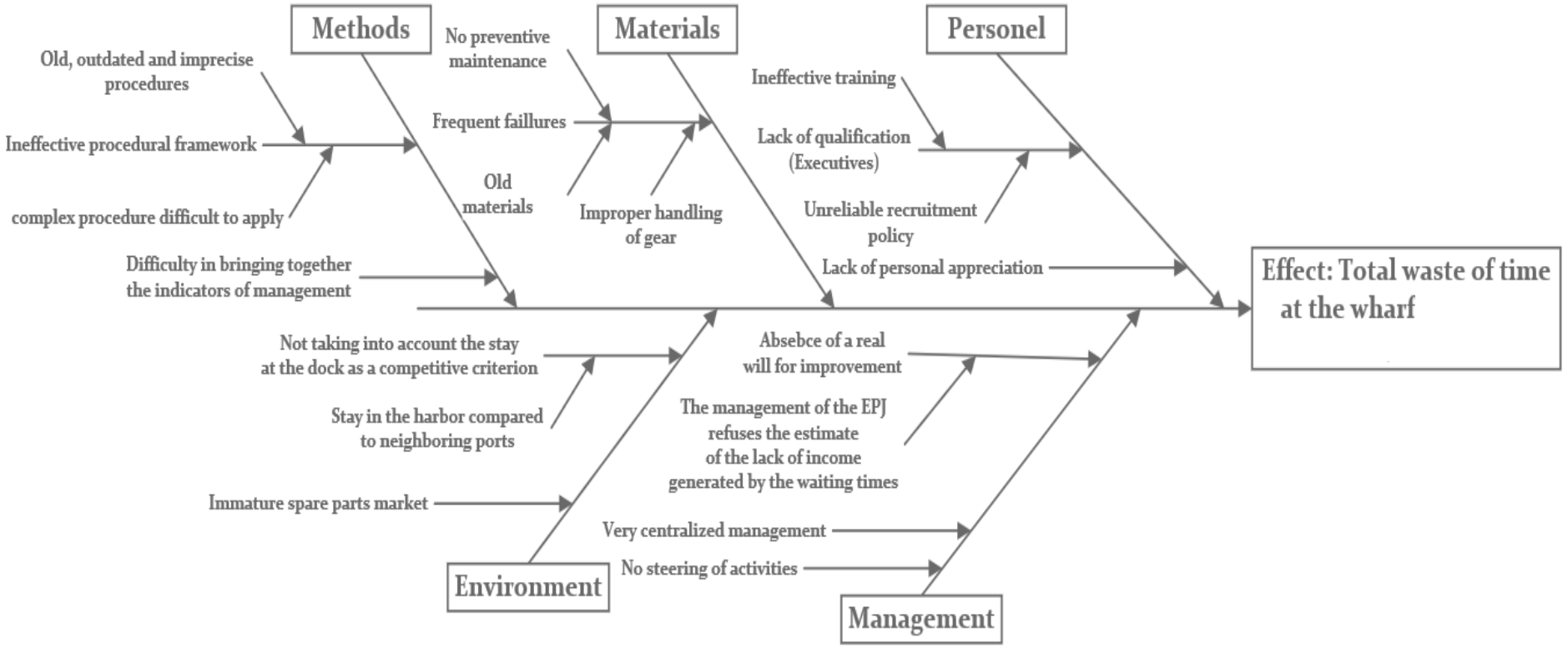
Source: Realized by the author on the basis of the information in the handling register.

Comment: Of the total time spent processing on ships 84.93 hours of non-productivity-related downtime can be avoided, representing 6% of the total processing time at the dock.

Based on discussions with the PCJ's corresponding staff and previous analyses, the cause-effect diagram can be constructed in efforts to summarize the causes of failure detected throughout the process per category to allow for better analysis.

4.2.3.4. Ishikawa Diagram (Cause and Effect)

Figure 4-9 Ishikawa diagram



Source: made by the author based on previous analysis and risks register

4.2.4. Improve phase

The purpose of this phase is to make the necessary improvements to the process treated based on the diagnosis made during the "Analyze" phase.

In this sense, it will be a question of rebuilding our process by acting on the root causes of the identified dysfunctions.

4.2.4.1. Proposed improvement actions

The proposed improvement actions are:

❖ **Optimize crane movements and avoid non-productive movements.**

✓ Always opt for the double cycling method (unloading and loading containers simultaneously).

✓ Monitor and educate operators about the maintenance of the machines (preventive maintenance by visual control, full of gear) in order to compensate for the aisles back to the maintenance shop and stops for full gear before start and after each operation of Handling.

✓ Ensure that training for crane operators is effective and establish a performance bonus system for operators.

✓ Strengthen the risk culture and professional awareness of operators by increasing their awareness of the risks associated with the activity and their impact on the port's performance.

✓ Strengthen team spirit by raising operators' awareness of the gains gen0erated.

❖ **Avoid crane breakdowns and handling accessories**.

✓ Introduce the Zero breakdown Principle (KAIZEN) through the application and reinforcement of preventative maintenance.

✓ Moving from repair maintenance, acting as a fire preventer nor a firefighter.

✓ Eliminate unplanned, improvised maintenance activities.

✓ Program maintenance and tracking of gear before and after ship handling operations.

✓ Develop the knowledge of maintenance personnel as well as operators to support a professional maintenance strategy.

✓ Ensure the cleanliness of the wharf and the workspace in general in order to compensate for certain types of breakdowns (punctures...).

❖ **Make up for time losses from shutdowns before operations start and before shifts end.**

✓ Set up a scoring system that allows for rigorous control of working time and handling teams.

✓ Supervise the progress in time from the beginning to the end of shifts.

❖ **Make up for time wasted from handling planning errors.**

✓ Improving the quality of operational planning by improving the quality of information exchange.

✓ Ensure coordination during the planning phase between the handling department and other stakeholders by formalizing this requirement.

❖ **Solve time wasted due to lack of documents presented during operations.**

✓ Require the completion of the various customs, police, plant health visits... etc. at the harbor level to reduce the vessel's immobilization time once docked.

✓ Require early and full clearance of containers prior to ship berthing in order to begin handling operations as quickly as possible.

✓ Require the presence of the necessary documents to carry out handling operations before entering the port (e.g. bill of lading).

❖ **Actions related to the management of the activities:**

✓ Standardize the management indicators of the same activity between the different departments concerned in order to enable an effective monitoring of the activity.

✓ To ensure that the internal audit is more responsive to the different structures of the organization and not just the CA by effectively considering the recommendations and concerns of the employees during the missions carried out.

✓ Supervise the activities of the port with rigorous work instructions regarding the optimization of crane movements, maintenance of equipment by employees... Etc.

✓ Ensure that internal audit missions explore and recommend potential risks for possible improvements.

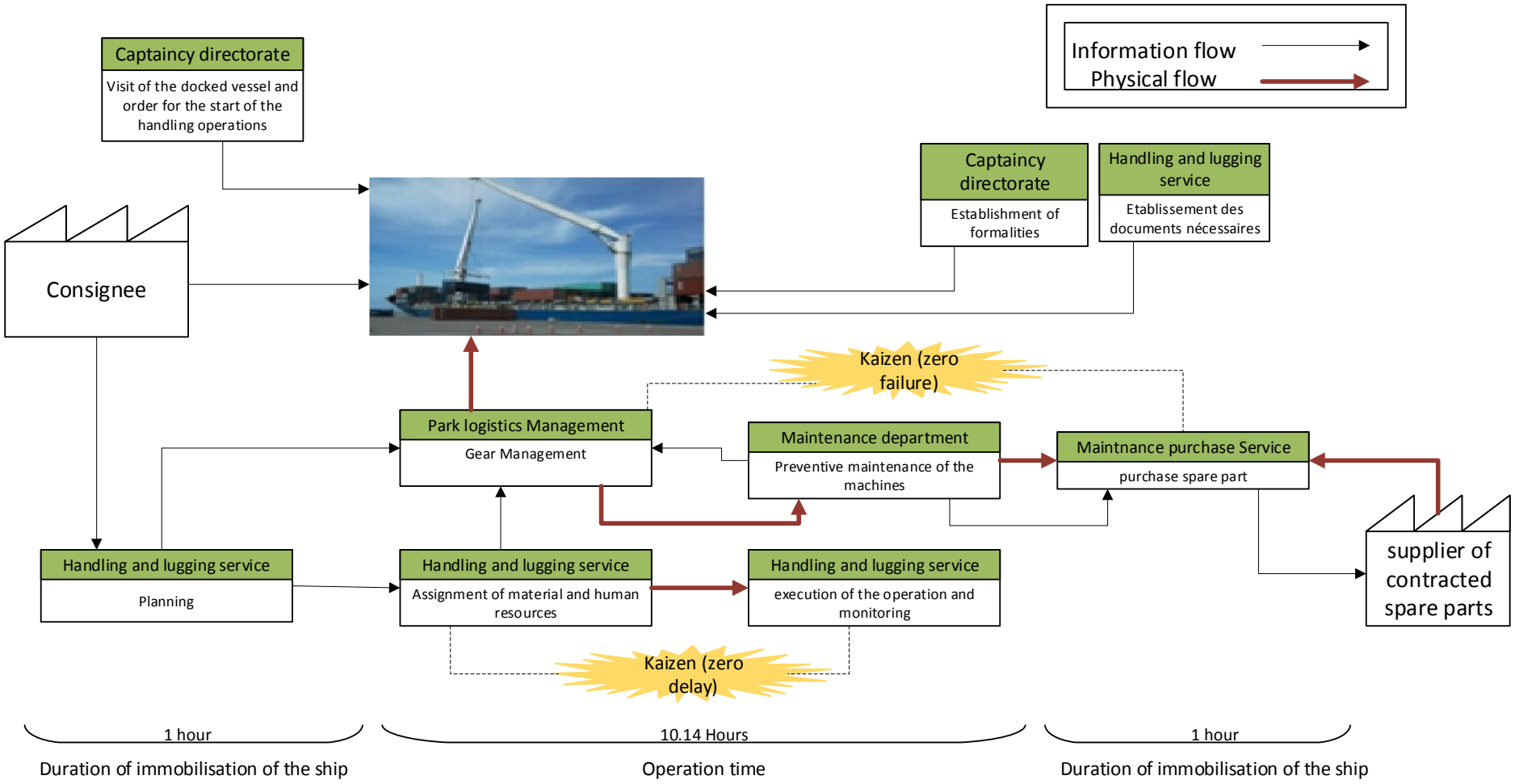
4.2.4.2. Results of the improvements

In order to highlight the result of the improvements made, we will trace the future VSM of the state of the process.

1. Improved VSM

Referring to the VSM established during the "Analyze" phase and the optimization tracks detected, the next VSM is set to address these optimization opportunities.

Figure 4-10 Improved approach over the current VSM process



Source: realized by author.

Comment:

Based on the proposed improvements, we can notice from the future VSM of ship No. 26 (the Cielo de Agadir) that:

- The vessel's total immobilization time at the wharf level decreased by 17.26 hours (29.4 - 12.14)
- The waste of time during handling operations has been greatly reduced by the implementation of a preventive approach to maintenance supported by the principle of kaizen zero failure.
- The management of the fleet of machines is now the responsibility of the logistics department, which oversees and handles handling and maintenance activities for better coordination.
- The time to meet maintenance orders has been significantly reduced by contracting with a few suppliers.

Also, by making sure to optimize the risk/opportunity torque in the sub-process of purchasing the RP by eliminating some levels of validation of the procedure, the time of this sub-process has been improved (**opportunity**), at the same time the necessary controls remain maintained (**better control of the risk of fraud and financial loss**).

2. Port performance indicators

Once the proposed recommendations will be implemented, the port performance indicators previously calculated during the "Measure" phase, would show positive results and will be as follows:

Table 4-21Duration Indicators 1st half of 2018 37 ships (Phase Improve)

First set of measurements: Time spent by ships at port

Duration indicators	Value
Total immobilization time at the port	1015.76 hours
Total time spent at port based on handling operations	863,83 hours

Second set of measures: The occupancy indicators 1st half of 2018 for 37 ships

Duration indicators	Value
The period when the position is occupied but without actual work	84.93 hours

The period when the position is occupied and in actual work	779,90 hours
The period when the position is occupied but not in service	151,93 hours

Source: realized by the author on the basis of the table 4-20

Comment:

Based on the previous waste classification, it was therefore possible to reduce the time lost during operations at the wharf level to **406,44 hours** = (123,70-84,93) + (519,6-151,93).

The following conclusions can be drawn:

- The period when the position is occupied but without actual work represents 8.36% of the total time of the wharf occupation.
- The period in which the position is occupied and in actual work represents 76.78% of the total time of the wharf occupation.
- The period in which the position is occupied but not in service represents 14.96% of the total time of the wharf occupancy.

I note that the duration actually worked represents almost 80% of the time of occupation of the wharf, which means an increase of 30% compared to the initial state before the application of the LSS methodology, as for the time spent at the wharf without effective work, it represents approximately 20% of the time of occupation of the wharf.

These performance indicators show an improvement in container ship processing operations at the wharf and are a sign of increased efficiency.

The third set of measurements: To calculate the new performance of the process, we used the net berth stay:

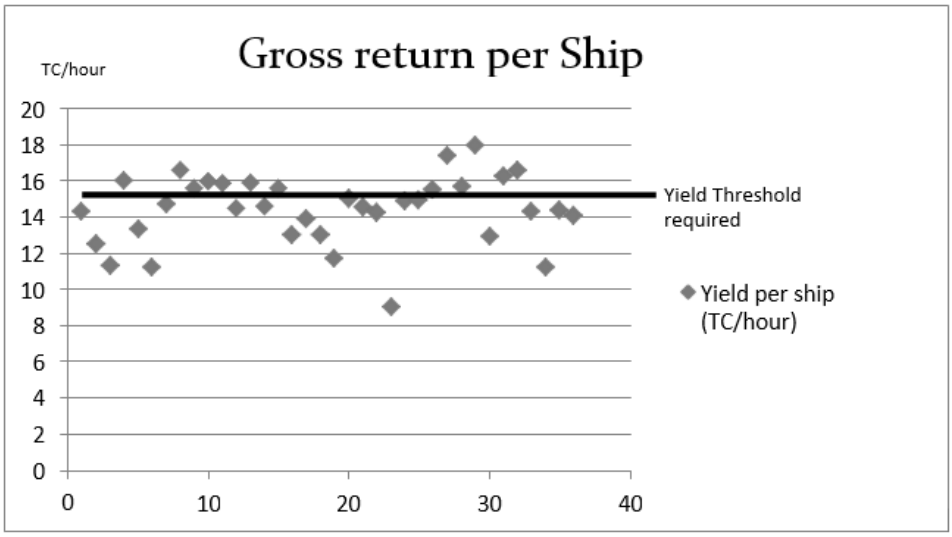
That is:

Table 4-22 Net Performance After Improvement Statistics

Time to consider	Sample	Total number of containers handled	Gross processing time of the ship docked	Net return	The standard deviation
1st semester 2018	**37 ships**	**14566**	**1015.76**	**14.34**	1.86

Comment: The net return on operations is 14.34 TC/h, so the future performance level of the process is close to the target level of performance of 15 TC/h.

The dispersal of Gross yields from container handling operations in the1st half of 2018:
Figure 4-11 Improved Dispersal of gross yields



Source: realized by the authors in the basis of Appendix C and table 4-20.

Comment

This point cloud represents the dispersion of net yields after optimizing the "container ship processing at the berth level" process.

We can notice that:

- In 38% of the cases representing 14 vessels, the efficiency of the operations is well above or equal to the required standard (15 TC / h).
- In 62% of the cases representing 21 vessels, the yield of operations is between 10 TC / 0h and 15 TC / h.
- In 3% of cases representing 1 vessel, the operating performance is less than 10 TC / h.

This means an improvement in the yield estimated at 4.15 TC / hour.

It can also be noted that the dispersion of net returns is low. the values of these yields are concentrated on the average value (14.34 TC / h), as a result of this dispersion a standard deviation of 1.86 TC / h quite low compared to an average of 14.34 so the process is more mastered.

These results mean that after the improvements performed the process performance differs in the 37 studied cases from 1.86 TC / h only and that the level of variability was reduced by 4.63 = (6.4 -1.86).

By displaying these results, it can be said that the current level of performance further satisfies the customers' requirements in terms of delivery time.

3. Estimated savings on saving dockside operating time

Based on the types of stop times previously identified in the (Analyze) phase, we proceeded to calculate the loss of earnings generated by these wasted times and this by referring to the PCJ's tariff book (Appendix E).

Table 4-23Savings on saving dockside operating time

Cost in the first half of 2018 (in DA)	Non-effective handling operating time (1st half 2018)	Cost per hour in (DA)	Time saving after optimization in handling operations	Economy for the first half of 2017 (DA)
18376159.2	83.93	218946,2552	38.77	8488546,315

Source: realized by the author according to table 4-20 and tariff book of PCJ 2017.

The PCJ could have therefore eliminated an estimate shortfall of **8488546,315** DA during the first half of 2018.

4.2.5. Control phase

Once the proposals have been recommended during the "Improve" phase implemented, in the control phase, the interest would be in the monitoring process of the implementation of these and their maintenance.

In this phase, control mechanisms will be proposed to preserve the progress made. Controls that fall under:

- Supervision of the company's activities: procedural and other frameworks (instruction, note, etc.), respect for these procedures and continuous improvement of the quality of this framework.
- Monitoring the performance indicators of the activity of the PCJ.

To be implemented mechanisms

The controls are as follows:

Table 4-24 Checks to be performed

Controlled parameter	Control method	Frequency of control
Performance of handling teams per hour	Followed productivity indicators of each team.	Daily
Prevention and maintenance of machines	Monitor the correct application of the precautionary approach using the maintenance indicators: MTTR :(Mean Time to repair), average repair time, it measures the responsiveness of the maintenance department (Efficiency). MTBF: (Mean time between failure), the mean time between failures measures the reliability of the equipment and the ability of the maintenance department to avoid breakdowns.	Daily
Equipment maintenance and use	Pointing system for the use of machines to locate responsibilities for their maintenance. work instructions for proposed	Daily

	crane motion optimization methods	
Punctuality of staff	Heuristic Presence Grid for Each Shift Person	Daily
Effectiveness of staff training	Continuous assessment of the quality of training provided through the consideration of staff feedback.	At each training

Source: Conducted by ourselves based on interviews with the staff of the PCJ.

Chapter conclusion

The LSS mission carried out on one of the key port processes of DjenDjen, has made it possible to identify deficiencies and thus optimization tracks throughout this process that can be exploited.

Thus, the conduct of the DMAIC approach has made it possible to detect and seize the opportunities for improvement of the PCJ's port processes: Reduced processing times, savings on operations, better risk assessment and opportunities that resulted in better quality served to port customers.

General conclusion

Lean Six Sigma is an operational excellence approach that has been proven in developed countries but regrettably it is barely non-existent in Algeria.

This research project aimed to study the contribution that the Lean Six Sigma methodology can have in improving the performance of an Algerian port company through its process optimization approach, the DMAIC.

Today, the major challenge for organizations is their ability to master their processes and efficiently leverage their resources to achieve their growth objectives.

As far as customer satisfaction is a primary requirement for improving the performance of a company, it becomes imperative to focus this latter's strategy on this aspect by opting for improvement initiatives oriented towards customer satisfaction. In this perspective, organizations are increasingly using optimization approaches to achieve their goals.

The Lean Six Sigma DMAIC used in this work is one of the most recognized approaches that has been proven in several multinationals.

The realization of this study within the PCJ allowed us to study the prospects for the application of LSS at the level of a port company and thus to have a better understanding of the possible lines of improvement and optimization opportunities that are present in the port.

Following the results of this research, we can now answer the problem raised at the beginning of this work.

At the end of the three theoretical chapters of our work we were able to understand that the Lean Six Sigma approach and the tertiary are in perfect adequacy, and the results of the practical case confirmed the complementarity between these two domains, which confirms the first hypothesis emitted at the beginning of our research and responds by the occasion to the first sub-question of our problematic.

After having measured and analyzed the various port performance indicators, we can conclude that this sector is at the heart of the concerns of the LSS methodology, especially taking into consideration the convergence between the port performance measures and the optimization tracks of this methodology, indeed, the LSS finds its place easily in this sector whose optimization of the capacities is a guarantor of quality and continuity, which confirms the first hypothesis.

In addition, the analysis of the causes of dysfunction in the process of handling container ships and the optimization possibilities that arise in it, has allowed us to realize that a large part of the opportunities for improvement of key processes of the PCJ can be achieved through the adoption of a management focused on process optimization and this can be done by using the

LSS methodology which will act on several aspects: the reduction of costs, the reduction of deadlines and the Improving the level of customer satisfaction through seizing opportunities for quality improvement and risk control in processes. The implementation of the LSS would thus facilitate opportunities for optimization and thus contribute to the improvement of its performance despite the economic disadvantage that it knows, hence the second hypothesis is confirmed.

With respect to the application of the LSS on the process of handling container vessels, it has identified several types of waste and sources of variability and has disassembled the considerable impact of the proposed improvements in the event that they actually occur. Therefore, the LSS has significant contributions to port delivery processes, which confirms the third hypothesis.

Generally speaking, in the event that the LSS is set up at the PCJ, it would contribute considerably to achieving savings and thus cope with the current situation, but not only, because the optimization spirit of the LSS should be introduced into the corporate culture and should not be seen as a relief solution that is used in difficult situations.

In addition, it should be noted that the conclusions of our thesis are the result of modest work that cannot be complete, so other more in-depth research could contribute more effectively to the treatment of this topic. Also, we consider that our research work could have brought more value to the host company in the event that limits on the confidentiality of certain data would not have been posed in addition to indifference and lack of collaboration of some employees that caused us a lot of wasted time. In addition to these constraints, we believe that the lack of quality management throughout our internship to be a handicap for our research that could be supported by its instructions and recommendations.

Finally, we hope to have contributed to the reflection on the contribution of a possible implementation of the LSS in the improvement of the performance of a port company and that the recommendations outlined in the (Improve) and (control) phase of the DMAIC process will be taken into account by the host company. Moreover, we wish to further investigate the contributions of this methodology in other sectors considered to be very sensitive, such as the health sector.

Further areas for research:

This study is based on case study research, and there might be limitations of transferability of the findings to other cases. However, I encourage further research for implementation of Lean tools and techniques in Port Company to increase the knowledge within this area. There is need for more studies related to Lean Six Sigma practices in service, which may lead to real implementation and improvement of services.

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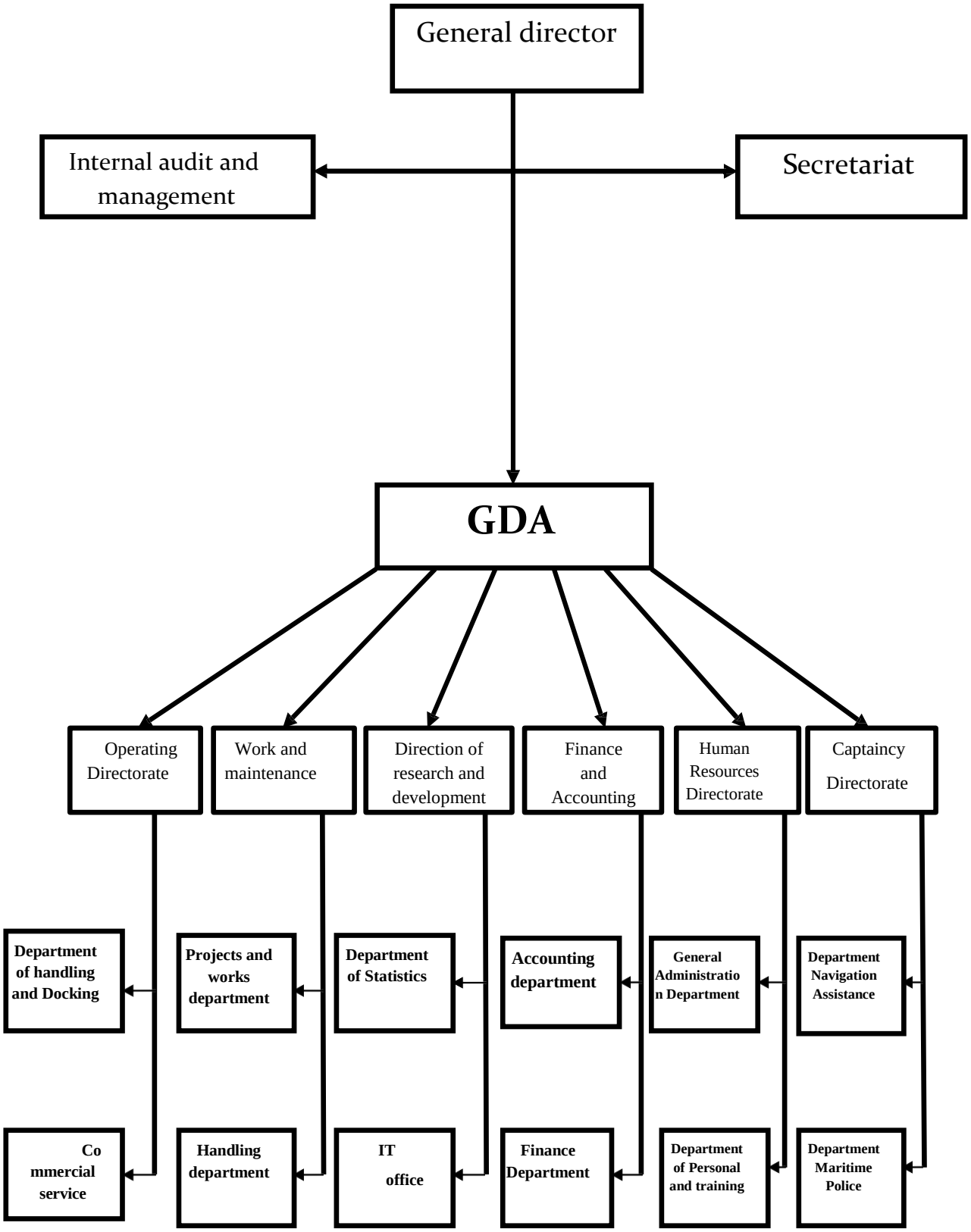
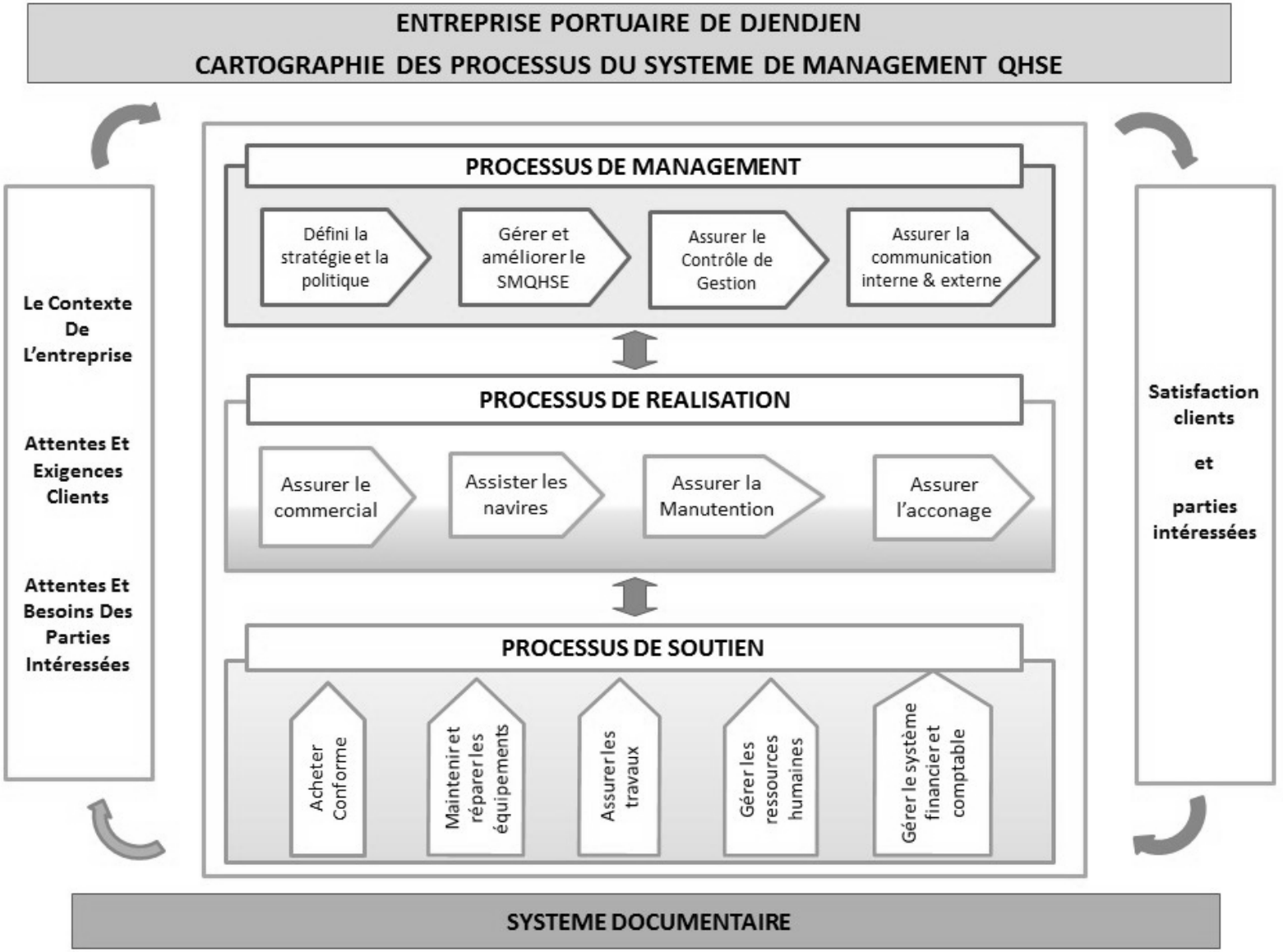
Appendices

Appendices table :

Appendix A : Organization Chart of the EPJ



Appendix B: Business management Processes map of DjenDjen



Appendix C: database of container ship processing operations (first half of 2018).

Date d'arriv	Nom du navire	Identification navire	Durée de séjour en rade	Durée de séjour à quai (en heure)	Durée d'immobilisatio	Durée d'opérations de	Temps perdu	Temps effectivement	Date de début des opérations de manutention	Heure de début des opérations de	Date de fin des opérations de manutention	heure de fin des opérations de manutention	Nombre de conteneurs	Nombre de conteneurs	Nombre total de conteneur	Nombre de shift	Nombre d'équipe	Rendement par navire
Janvier	OCEAN LORD	NAVIRE N°1	1,00	4,00	1,75	2,25	0,42	1,83	21/01/2018	15H 45	21/01/2018	16h 30	14	-	14	1	1équipes +	3,5
	CONESTE (CMA CGM)	NAVIRE N°2	1,22	23,00	3,75	19,25	0,00	19,25	14/01/2018	9h30	14/01/2018	18H45	-	51	51	2	4	1,75862069
	CORONA-J (CMA-CGM)	NAVIRE N°3	30,00	48,00	27,27	20,73	3,42	17,32	19/01/2018	14H20	21/01/2018	10H 40	201	88	289	6	12	6,020833333
	OCEANLORD (NASHCO)	NAVIRE N°4	39,00	6,00	3,75	2,25	0,83	1,42	21/01/2018	15H45	21/01/2018	18H30	18	-	18	1	2	3
	JANINA (CMA-CGM)	NAVIRE N°5	1,00	35,00	3,25	31,75	1,58	30,17	25/01/2018	13h15	26/01/2018	18 h 30	179	63	242	4	8	6,914285714
	NICOLA (CMA-CGM)	NAVIRE N°6	41,00	41,00		38,58	4,20	34,38	31/01/2018	9 H 00	01/02/2018	23h 35	251	108	359	6	12	8,756097561
Février	KARINA	NAVIRE N°7	90,00	64,00		66,70	5,25	61,45	10/02/2018	9h00	12/02/2018	21h20	266	305	571	9	21	8,921875
	TITTERI	NAVIRE N°8	11,33	39,00	2,37	36,63	1,08	35,55	19/02/2018	10h40	22/02/2018	22h30	809	37	846	6	6	21,69230769
	VEGA HERCULES	NAVIRE N°9	1,00	56,00		48,25	15,33	32,92	21/02/2018	9H00	23/02/2018	14H45	197	202	399	54	156équipes+59am	7,125
	PACAYA	NAVIRE N°10	1,00	41,00	31,25	9,75	5,58	4,17	25/02/2018	14H15	26/02/2018	1h00	292	88	380	5	156équipes+2 carrirtes	9,268292683
Mars	NICOLA	NAVIRE N°11	8,00	33,00	3,33	29,67	5,17	24,50	09/03/2018	9H40	10/03/2018	15H20	119	98	217	5	106équipes+17am	6,575757576
	HARMONY	NAVIRE N°12	33,00	122,00	98,40	23,60	6,75	16,85	11/03/2018	9h35	16/03/2018	7h35	1140	242	1382	22	53	11,32786885
	JAGUAR	NAVIRE N°13	1,00	54,00	14,83	39,17	8,67	30,50	09/03/2018	8H	10/03/2018	23H10	184	71	255	6	116équipes+25 am	4,722222222
	WEDELLSBORG	NAVIRE N°14	4,00	11,00	3,92	7,08	2,00	5,08	12/03/2018	8H 45	12/03/2018	17h50	120	-	120	2	26équipes+4	10,90909091
	TITTERI	NAVIRE N°15	7,00	29,00	18,92	10,08	1,50	8,58	15/03/2018	23h	16/04/2018	9h5	34	-	34	2	2	1,172413793
	TIMGAD	NAVIRE N°16	2,00	29,00	3,67	25,33	2,00	23,33	22/03/2018	10H	23/03/2018	11h20	862	-	862	3	6	29,72413793
	CMACGM HERODOTE	NAVIRE N°17	2,00	57,00	33,25	23,75	3,67	20,08	23/03/2018	11h30	24/04/2018	11H15	129	49	178	5	86équipes+2am +2amv	3,122807018
	CONTSHIP MAX	NAVIRE N°18	2,00	51,00	24,33	26,67	8,17	18,50	29/03/2018	9H	30/03/2018	10H40	191	226	417	7	12	8,176470588
Avril	TITTERI	NAVIRE N°19	8,08	35,75	4,42	31,33	1,25	30,08	01/04/2018	8H40	02/04/2018	16h	175	8	183	5	8	5,118881119
	CMACGM HERODOTE	NAVIRE N°20	2,00	33,00	3,67	29,33	3,67	25,67	11/04/2018	8H20	17/04/2018	14h55	606	358	964	6	9	29,21212121
	FRIJSENBORG	NAVIRE N°21	2,00	6,00	3,25	2,75	0,00	2,75	12/04/2018	18h	12/04/2018	20h45	51	-	51	2	26équipes+1 Chauffeur	8,5
	VEGA	NAVIRE N°22	2,00	27,00	3,00	24,00	0,83	23,17	20/04/2018	8h10	21/04/2018	8h40	97	115	212	4	7	7,851951952
	TITTERI	NAVIRE N°23	9,00	34,00	22,00	12,00	0,00	12,00	22/04/2018	9h55	22/04/2018	21h55	26	108	134	3	3	3,941176471
	SADAN BAYRAKTAR	NAVIRE N°24	0,92	10,92	2,50	8,42	4,00	4,42	24/04/2018	14h50	24/04/2018	20h15	5	5	10	2	2	0,916030534
	CONTSHIP MAX	NAVIRE N°25	1,00	42,00	25,67	16,33	4,42	11,92	25/04/2018	8h	25/04/2018	22H20	118	8	126	5	5	3
Mai	CIELO DI	NAVIRE N°26	12,00	53,00	29,00	24,40	13,17	11,23	06/05/2018	9H30	08/05/2018	9H30	169	208	377	7	146équipes+10M	7,113207547
	TINZIREN	NAVIRE N°27	11,00	52,20	26,45	25,75	6,75	19,00	07/05/2018	20h40	10/05/2018	20h25	627	2	629	9	16	12,04980843
	ARIFE	NAVIRE N°28	2,00	5,00	1,00	4,00	0,33	3,67	08/05/2018	14H40	08/05/2018	18H05	3	14	17	1	1	3,4
	TAS DAMMAN	NAVIRE N°29	1,00	50,00	27,43	22,57	2,33	20,23	17/05/2018	10h20	18am ai	17H40	214	227	451	5	126 qui + 2 am	9,02
	CONTSHIP MAX	NAVIRE N°30	8,00	30,00	2,58	27,42	2,42	25,00	25/04/2018	13H30	26/04/2018	14H55	28	151	179	4	5	5,966666667
	TITTERI	NAVIRE N°31	2,00	9,00	5,00	4,00	0,00	4,00	25/05/2018	13h20	25/05/2018	18h20	32	-	32	1	1	3,555555556
	SCLANITA	NAVIRE N°32	6,00	15,20	5,03	10,17	0,58	9,58	15/05/2018	10h35	15/05/2018	20h45	138	49	187	3	6	12,30263158
Juin	VEGA	NAVIRE N°33	2,00	68,00	33,92	34,08	2,67	31,42	02/06/2018	7h40	04/06/2018	16h45	195	133	328	8	13	4,823529412
	CONESTE	NAVIRE N°34	2,00	48,00	3,25	44,75	0,33	44,42	06/06/2018	12h	08/06/2018	9h45	47	131	178	6	8	3,708333333
	CONTSHIP MAX	NAVIRE N°35	2,00	82,00	3,42	78,58	3,08	75,50	21/06/2018	9h50	24/06/2018	16h20	61	197	258	10	15	3,146341463
	TITTERI	NAVIRE N°36	1,00	49,20	12,82	36,38	0,67	35,72	22/06/2018	9h20	24/06/2018	21h25	115	135	250	6	6	5,081300813
	EEMSDIJK	NAVIRE N°37	2,00	30,00	25,17	4,83	1,58	3,25	01/06/2018	11h25	01/06/2018	15h15	67	74	141	5	9	4,7
Total			401,56	1429,27	519,60	902,60	123,70	778,90					7780	3561	11341	239	342équipes+107	

Appendix D: Interview Guide with EPJ Clients (Consignees)

Interview guide:

As part of the preparation of our master thesis in Management, that is interested in bringing a process optimization methodology to the improvement of one of the key processes of the PCJ, we would like to solicit your contribution to provide some answers to our questions.

The objective of this interview is to have a precise idea on your requirements in terms of quality of port service, as well as your appreciation of the services rendered by the PCJ and in order to conduct our optimization study based on your requirements.

Our thanks for your valuable collaboration.

The questions :

Question 1: Can you please introduce yourself and since when are you a client of the PCJ?

Question 2: Under what circumstances do you use the PCJ services?

Question 3: What do you think the benefits of the port PCJ are?

Question 4: What do you think are the disadvantages that may be present in the port of the PCJ?

Question 5: What are, according to you, the essential creterions of quality of services of a port?

Question 6: Can you pick one criterion that you judge the most important?

Appendix E: Tariff Book of the PCJ

الجمهورية الجزائرية الديمقراطية الشعبية
REPUBLIQUE ALGERIENNE DEMOCRATIQUE ET POPULAIRE

MINISTERE DES TRANSPORTS
GROUPE SERVICES PORTUAIRES « SERPORT/SPA »
ENTREPRISE PORTUAIRE DE DJEN DJEN

مجمع الخدمات المينائية
المؤسسة المينائية لجن جن

Mise à jour du cahier des tarifs

1/ Outillages de manutention :

- Elingue 1 câble 1 boucle long 8 ml cap 06T : 16 250 DA
- Elingue 1 câble 1 boucle long 8 ml cap 11T : 31 070 DA
- Elingue 1 câble 2 boucle long 8 ml cap 12T : 32 370 DA
- Elingue 1 câble 2 boucle long 8 ml cap 16T : 38 610 DA
- Elingue 1 câble 2 boucle long 8 ml cap 30T : 161 330 DA
- Sangle plate 2 bandes long 8 ml cap 10T : 29 120 DA
- Sangle plate 2 bandes long 8 ml cap 05T : 10 764 DA
- Sangle plate 2 bandes long 10 ml cap 16T : 51 805 DA
- Rouleau de bâche : 7150 DA/l'unité.

2/ Gasoil et énergie électrique :

- Gasoil : 23.00 DA/L.
- Energie électrique :08 DA/KW/H.

3/Nouvel équipement :

- Balayeuse : 6000 DA/Heure, Ce tarif a été déterminé en prenant en considération son cout d'acquisition, son cout de maintenance, ses années d'amortissement et le nombre d'heures théoriquesd'exploitation.

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Abstract

Lean Six Sigma methodology was first introduced in the manufacturing industry to be later adopted by other sectors, namely the service industry.

The combination of the two methods Lean and Six Sigma aims at process optimization by acting on wastage and variability sources through DMAIC process.

In such an activity where time is valuable, Lean Six Sigma methodology significantly contributes to the optimization of the trilogy (Cost-quality-time), but also by considering the notion of risk/opportunity resulting in a better mastery of processes.

This paper combines Lean Six Sigma optimization concepts with port processes optimization opportunities.

Key words: Lean, Six Sigma, Lean Six Sigma, Process, DMAIC, Optimization, Port

ملخص :

تم ادخال منهجية "لين سيكس سيغما" لأول مرة في قطاع الصناعة ليتم اعتمادها لاحقا من قبل قطاعات أخرى كقطاع الخدمات.

الجمع بين طريقتي "اللين" و "سيكس سيغما" يهدف الى تحسين العمليات عن طريق استهداف مصادر الهدر والتغيرية و DMAIC ذلك من خلال عملية

في قطاع مثل الخدمات المرفئية حيث للوقت أهمية كبيرة, منهجية "اللين سيكس سيغما" تسهم بشكل كبير في الاستفادة المثلى من ثلاثية (التكلفة,النوعية,الوقت), ولكن أيضا من خلال أخذ مفهوم (المخاطر/الفرص) بعين الاعتبار ما ينتج عنه اتقان أفضل للعمليات.

هذا العمل يربط بين مفاهيم "لين سيكس سيغما" وفرص تحقيق الأمثلية في عمليات الخدمات المرفئية.

الكلمات المفتاحية: "اللين", "سيكس سيغما", DMAIC, "اللين سيكس سيغما",عملية,الأمثلية,ميناء