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RESEARCH ARTICLE

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THE APPLICATION OF LEAN SIX SIGMA TO PROCESS MANAGEMENT IMPROVEMENT OF A COMPANY IN THE ELECTRO-ELECTRONICS SECTOR: CASE STUDY

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ABSTRACT

The application of *Lean Six Sigma* philosophy or *Lean Manufacturing* has good results obtained in companies when using techniques and tools continuously with the objective of obtaining improvements by reducing waste and reducing variability. In this context, this work shows the case study carried out in a company in the electronics sector of how, through the application of *Lean* manufacturing, it obtained good results through the monthly measurements and analysis methodology of *Lean* maturity, creation of the *Lean* committee, and application of the tools, value stream mapping, improvement of 5S program, improvement of visual management and application of the ideas program. The study shows the gains obtained in the company reaching a *Lean* maturity improvement of 42,5% going from Bronze to Silver stage and manufacturing cost improvement of 30%, in addition we can highlight the change in culture mindset that has occurred in the company on continuous improvement.

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INTRODUCTION

Many companies still manage through the rearview mirror, which means that, there is a slowness in the decision-making process due to the available data due to the non-use of management tools that can provide speed to the system, and despite the use of some tools, they are not often used to add value to the company, focusing on the value chain and with the objective of eliminating waste. How can Lean Six Sigma, through its tools, contribute to improving a company's

performance and be a permanent applied methodology? Many organizations have defined Lean Six Sigma as one of their guidelines and have been implementing tools with the objective of speed up the system and, at the same time, focusing on reduce waste and improve the value chain. According to [Basu, 2011] "The Lean Six Sigma emerged from the union of two management approaches known as Lean Production, developed based on TPS, and Six Sigma developed by Motorola" [Chiarini, 2012]. According to [Antunes, 2008]. The construction method of the Toyota Production System is not completely formalized in the books". But let us use information from [Womack, 2003] which describes the purpose of this system: "It is a

system that aims to eliminate total losses [...] it is 80% elimination of losses, 15% a production system and only 5% the kanban". "Eiji Toyoda and Taiichi Ohno, from Japanese Toyota, were the pioneers in the concept of lean production" [Womack, 2003]. The use of the term Lean Six Sigma has currently been used by organizations because Lean is used to solve less complex problems and operators can use tools such as: 5S, Visual Management, the 8 Waste, Standardized Work, Jidoka, SMED, TPM, VSM, A3 and Kaizen events. Six Sigma is used to solve more complex problems through the use of the DMAIC methodology. D- Define; M-Measure; The analysis; I – Improve and C – Check). There is no cake recipe for implementing Lean Six Sigma, but for many authors this approach should start with the stabilization of the company by implementing 5S, followed by visual management and from there apply learning to see the 8 wastes and after performing the process mapping using VSM (Value Stream Mapping) in order to identify waste and define the Kaizens to be applied [Stewart, 2011]. The word Kaizen has Japanese origin and means "change for better". In practice in companies, it means that no one day should go by without improvements being made [Maleyeff, 2006]. According to John Miller (who grew up in Japan) the basic meaning of kaizen is to change for the better, eliminating what is problematic and inefficient in this context [Miller, 2014]. "Kaizen can also be defined as continuous improvement, and its objective is to promote successive and constant improvements, that is, more and smaller steps of incremental improvement" [Slack, 2002].

For [Imai, 2014] more specifically, "Kaizen means small improvements, as a result of continuous efforts" and not drastic improvements resulting from large investments, which characterize innovation. Kaizen is an umbrella for: Productivity Improvement, Total Quality Improvement, Zero Defects, Just-in-time, Suggestion System etc. Kaizen strategy focuses on Kaizen Management: Management maintains and improves standard operations (procedures, etc.). As I could interact with companies to contribute to improving their processes, this motivated me to carry out a case study in a company in the Industrial District of Manaus on how it is inserted in Lean Manufacturing and how to interact in the process continuous improvement of the company.

Literature Revision

This section explores the theoretical foundations of Lean Six Sigma through a historical context of how evolution has happened and how we can measure Lean in companies and how its evolution takes place.

Lean Fundamentals: According to [Kubiak, 2009] the expression Not Adding Value is defined as a term that describes a step of the production process or a function not necessary for the direct performance of process activities, this step must be identified for future elimination of the process. This represented a shift to production engineering that was fundamentally focused on improving functions and activities, for example: how to make the process run faster. Lean thinking does not ignore value-added activities, but seeks to focus on eliminating waste [Al-Araidah, 2010]. The history of lean thinking can be attributed to Eli Whitney, (who is given credit for spreading the concept of interchangeable parts). Eli set up a gun factory in New Haven, Connecticut in 1820, of the 700 gun production only 2% were good (14 pieces). Henry Ford (who went to great lengths to reduce cycle times) for the Toyota Production System. The TPS (Toyota Production System) which encompasses most of the tools and concepts known today as Lean Manufacturing. Lean manufacturing, also called Toyota Production System (TPS), was defined to develop the mentality of doing with less - less time, less space, less human effort, less equipment, less material - and at the same time deliver to the customer what he needs, want [Dennis, 2008]. The Toyota System is composed through the application of several tools where we have the roof with the Customer as the focal point, as shown in Figure 1.

Six Sigma Fundamentals: The quality movement can trace its roots back to medieval Europe, where in the late 13th century, artisans began to organize themselves into unions called guilds. Six Sigma as

a measurement standard has its ascendancy in 1800 with the introduction of the Carl Frederick Gauss normal curve concept.

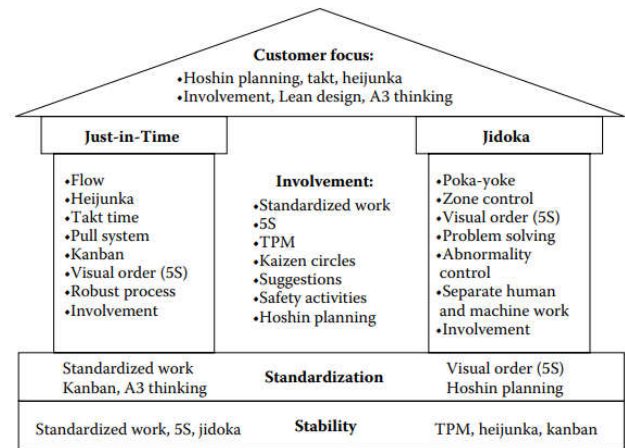


Figure 1. Model TPS of Production [12]

The foreshadowing of Six Sigma as a standard for measuring product variation came around 1920, when Walter Shewhart demonstrated that three sigma off-average is the point at which a process requires correction. According to [10] The American Society of Quality (ASQ) says that Six Sigma has its chronology linked to the following years:

- 1940 – The US Army relies on quality and consistency of products to support the war effort, becomes the foremost advocate of quality. Inspection and sampling techniques are implemented and improved; processes have been redesigned to increase production efficiency. Statistical Quality Control is an emerging quality approach:
- 1950 - After World War II, the quality revolution in Japan stimulates the birth of total quality in the United States. The Japanese welcome the input of Americans Joseph M. Juran and W. Edwards Deming, and instead of focusing on inspection, they focus on improving all organizational processes down to the operational level. Juran facilitates the move from statistical quality control (SQC) to total quality control (TQC) in Japan.
- 1970 - High quality products from Japan constantly erode the market share of American industries. The US response, emphasizing not just statistics but organization-wide approaches, becomes known as total quality management (TQM).
- 1980 - Six Sigma begins in 1986 as a statistical-based method for reducing defects in production processes at Motorola Inc. In the late 1980s it extends to critical business processes.
- 1990 - In 1991, Motorola certifies its first Six Sigma specialists "Black Belt", signifying formal training in Six Sigma methods. Allied Signal Industries becomes the second company to adopt Six Sigma followed by GE.
- 2000 - New quality systems evolve from the foundations of Deming, Juran, and early Japanese quality practitioners. Quality movements go beyond the manufacturing process and into service, healthcare, education, and government sectors.

Origin of Continuous Improvement: According to ASQ, although the term "Six Sigma" also has a specific statistical meaning, the improvement system called Six Sigma contains a wide range of concepts and tools used to discover organizational defects and their solutions. Each of these tools was started by one person, who developed a particular facet of the quality improvement effort, tested it, and proved useful to the world community. As in many companies we focus on two segments, eliminating waste and reducing process variability, we can classify Lean and Six Sigma as complementary in the company and thus the program has been defined as Lean Six Sigma as fundamentals for improvement to be continued. The demarcation between Six Sigma and Lean presents a blurred area, often we are hearing terms like "Lean Six Sigma" because the

improvement process requires aspects of both approaches to achieve positive results. Six Sigma focuses on reducing process variation and improving process control, while Lean focuses on eliminating waste (non-value-added activities) and promotes standardized work and flow. Lean Six Sigma professionals must be well trained in both. Lean and Six Sigma have the same general objective, providing the customer with the best possible quality, cost, delivery, and a more recent attribute: agility [10].

When to use Lean and Six Sigma?: The most successful users of implementations have started with the Lean approach, making the workplace as efficient and effective as possible, reducing the eight wastes, and using value stream maps to improve understanding and the rate of value-added. When process problems remain, the Six Sigma technique is applied through statistical tools. One thing they have in common: they both need strong support from the company's management team to support the new way of doing business. Some organizations have responded to this dichotomy of approach by forming a Team Lean Six Sigma with experts from different areas. A task force is defined for this team and remodeled depending on the area of expertise [10].

Característica do Lean e Six Sigma: According to table 1, we can define the followings characteristics between Lean and Six Sigma.

Table 1. Characteristics of Lean Six Sigma

TOPIC	LEAN	SIX SIGMA
Improvements	Reduction of waste	Reduction of variation
Justification	Speed	Six Sigma (3.4 DPMO)
Time of learning	Short	Longer
Project Selection	Value Stream Mapping	Many approaches
Project Lead-time	1 week to 3 months	2-6 months
Driver	Demand	Data
Complexity	Moderate	High

Lean Maturity Measurement: Understanding the lean stage of maturity of companies is a starting point for applying appropriate actions for continuous improvement. According to [Santos, 2011] R.V. SANTOS (2011) the understanding of maturity is realized when the tools are well defined, documented, clear, and immaturity is manifested through improvisations, subjectivities, and lack of understanding of the processes. During the development of Lean manufacturing processes, the need for improvements and their measurement arose [Womack, 1991]. Thus, evaluation models were developed for this, with a special focus on measuring the processes [Lai-Mit, 2001]. It is necessary to clarify that the use of tools from the Toyota Production system by itself does not reveal the company's level of maturity [Soriano-Meier, 2002]. Choosing which items should make up the maturity measurement must be appropriate to the type of company and the way in which it seeks improvement. According to [Gama, 2009], the chosen tools must have a direct connection not only with the organization to be analyzed, but also with the chosen diagnostic model. Indicators that support the strategy chosen by the company's management must be used.

Creation of the Lean Council – Lean Committee: The Lean Council is of fundamental importance in the company for the management of the Lean program and with the objective of making the program continuous and lasting. According to [18], the formation of a committee with representatives from the departments is important for the realization of planned events. Many companies corporately define the Lean structure that should drive the strategies in the organization, through deployment for all group companies, this facilitates deployment and especially continuous improvement, as the company's main managers are engaged in the process. Each company defines its strategy and the way it will act with its employees for the cultural transformation of the company.

Benchmarking: Benchmarking is a process that seeks to identify how advanced companies are within the processes to be researched, this allows a company not to have to start an activity from discovery,

but through on-site verification in other companies, implementing processes and tools in a way agile based on the experiences of the visited companies. For [Tomelero, 2012], lean benchmarking is a diagnostic method of companies aiming to generate information for the strategic planning of companies, which can be used at all levels of the organization. According to [RAMOS, 2013], benchmarking began in the late 1970s with the objective of seeking the best practices that lead the company to improve its performance. The beginning of the process was given by the company XEROX Corporation and since then it has undergone many transformations over the generations [KYRÖ, 2003]. The benchmarking concept for [GARVIN, 1993] is a process that begins with a thorough search to identify best practices in organizations and continues with the study of the company's own practices and performance and evolves through systematic visits, interviews and concluded through the analysis of results and development of implementations.

Learning to See: One of the main problems of companies not focused on lean manufacturing is the fact that they do not know how to see what waste is, and because of this, they have difficulty in carrying out work to reduce costs and add value to the business. MUDA means waste in Japanese, and this waste is everything that the customer is not willing to pay [Dennis, 2008]. In the example of a metal archive factory we can exemplify waste as waiting time, correction or excess activities and would only pay for metal plates that are cut, bent, welded and painted. As shown in Figure 2, in most activities in a production process, it can be observed that 95% of activities are considered waste – non added value - and only 5% are really value-added [Dennis, 2008]. According to [Dennis, 2008] we can classify the waste into 8, which are:

- **Motion:** It is the wasted movement having as a human or mechanical component. Human movement is often related to ergonomic problems at work. Time wasted in the movement of a person transporting materials from one location to another, or in an assembly process moving their arms to pick up material, tools, etc. Wasted mechanical movement is related when a spot welding machine applies the weld spots too far apart.
- **Waiting:** Waiting waste occurs when a worker has to wait for a material to be delivered or a production line stop to be resumed, that is, any stop that causes a waiting time to perform a certain activity.
- **Conveyance:** Transport waste is that caused by inefficient workplace layout, excessively large equipment, or traditional batch production, where they have to be transported from one process to another.
- **Correction:** The change of correction is related to the production of products with defects and then having to carry out the correction. It consists of all the material, time, human effort and energy involved in solving the problem.
- **Over processing:** This waste is related to producing more than the customer requires. This type of change is often related to companies managed by their engineering departments. For example, companies looking for a certain technology and forget what the customer wants.
- **Overproduction:** This waste is related to producing what will not be sold or necessary for the production process.
- **Inventory:** Waste of inventory is related to excess stock of raw material, parts and WIP unnecessary for production. This condition is linked to the repressed production flow and not related to market demand.
- **Knowledge disconnection:** Waste linked to lack of communication within the company that can be horizontal, vertical, or temporary. The lack of communication between company and customer. This waste inhibits the flow of knowledge, ideas and creativity creating problems between employees and managers.

Value Stream Mapping – (VSM): When looking for opportunities for improvement in a company, one of the best tools to use is Value Stream Mapping, it allows us to see the entire production chain and helps us to identify points of improvement (current flow map) that

will allow us to work in the definition of a new improvement rearrangement (future map).

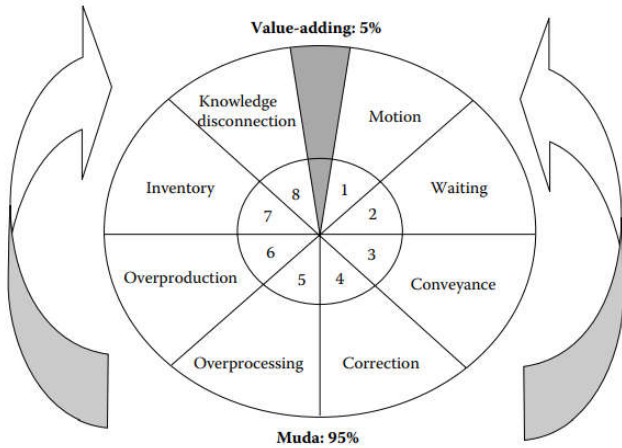


Figure 2. MUDA [12]

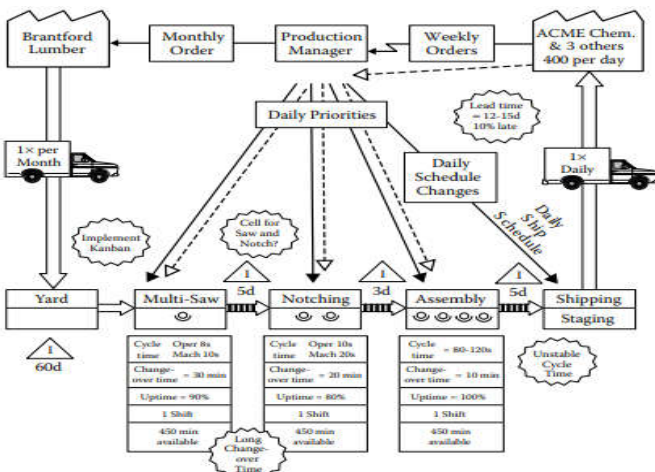


Figure 3. Value Stream Mapping- Current [12]

According to [Dennis, 2008], the mapping of the value stream is a valuable tool that helps us understand our current situation and identify opportunities for improvement in processes. In Figure 3, [Dennis, 2008] tries to show a flow map carried out in a company called St. Clair Pallet pallet manufacturer where the process flow was verified, such as sawing, notching and assembling the various types of wood from the demand received by the customer. There are frequent programming changes. Production time varies by products and there are several production delays. Through mapping the opportunities for improvement were indicated through the “pointed clouds” and will be the basis for mapping the future state. For the success of value stream mapping, the ideal is to use cross-functional teams trained in the tools to learn to see and mapping, this way it is much easier to identify opportunities. According to [Ferro, Jose Roberto, 2005], during the development of the current map, it is important to focus on the value stream that points that require substantial improvement and responsibility should not be delegated, as the process owners must monitor the activities. Once the current map is defined, the future map must be defined by applying the improvements defined in the current map, as shown in Figure 4. According to [Dennis, 2008], the value stream thinking consists of verifying the best combination of processes to take the product to the customer as quickly as possible. According to [Boonsthonsatit, 2015], the VSM is able to maximize the added value through the reduction or elimination of waste, this result reduces production times and consequently increases flexibility. The VSM involves the identification of value addition and waste identification activity based on the seven OHNO wastes [HINES, 1999]. Manufacturing industries today face increasing challenges regarding cost effectiveness, delivery time and quality in the production system.

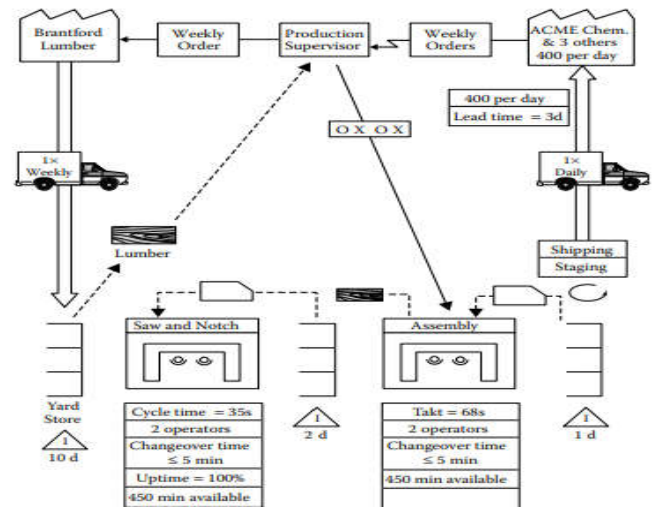


Figure 4. Value Stream Mapping – Future [12]

Dealing with these contradictory objectives, an important task is the selection of suitable solutions for the integration of suitable solutions for the integration of inspection processes within the process chain, which are necessary to guarantee the quality of lean production. For this, it supports applicable planning techniques necessary to analyze and design the configuration of a respective process chain. Value stream mapping is a state-of-the-art tool for this by lean manufacturing professionals [Haefner, 2014]. According to [CHEN, 2010], the value stream encompasses all materials and information, as well as its flow through the production system. Furthermore, the value stream includes all the activities that add and do not add value necessary to transform a raw material into a product [Hines, 1997], [Erlach, 2013] covering the three management tasks of a company: development of product; information management; and physical transformation [Antunes, 2008]. [Tapping, 2003] consider the value stream in three different meanings: as a process from product concept to production; as a non-series production process; and as an administrative order entry process for payment.

5S System: The 5S program is a starting point for creating stability in the company and only in this way can we continue to implement the lean philosophy. According to [Imai, Masaaki, 2014] the 5S is composed of the following senses:

- **Seiri** (Use) – this is step of classifying the items that serve from those that don't, and remove those that don't from the value-added area.
- **Seiton** (Organization) – once unnecessary items are removed, they are classified according to their use and stored. A place for everything, everything in the place.
- **Seiso** (Cleaning) – cleaning the work environment, machines, benches and tools, floors, walls, and other areas of the company.
- **Seiketsu** (Standardize) – it is tested of standardize that guarantees continuity once the previous processes have been executed and must be maintained.
- **Shitsuke** (Self-discipline) – ensuring that people make standardizations over time.

Many companies consider 5S to be quite simple and do not consider it a continuous improvement program. The establishment of a group with representatives from each department is necessary and a general coordinator to define the guidelines with the participants according to the definitions of the top management is necessary. It is also necessary to have a recognition and competitiveness program among the company's departments for its continuous improvement. Periodic audits are required to ensure proper measurement of the system's maturity level. For [Coutinho, 2015], they concluded in their case study in a long steel producer, that despite the 5S being considered a simple tool, it has the ability to solidify a system of individual and group habits, creating a pleasant environment by creating good habits in the organization's routines and customer needs. Define the

evaluation criteria that will be applied, establish those responsible for the audited areas, define the frequency of audits and schedule dates, adequately train the auditors, and avoid that the focus of discussions with the auditees is the scores, but the opportunities for improvement, are some of the tips for an excellent audit to be carried out [Ribeiro, 2015].

The Visual Management: The visual management process is presented through the fastest possible visualization of various indicators that can contribute to a quick response to the production process so as not to impact the customer. The company has adopted several electronic tools to streamline the visual management system and thus be able to meet new business demands. According to [Ferro, 2010], Visual Management is one of the most important tools to support Lean Production leaders, it allows everyone to know how things are going, without having to ask anyone or turn on a single computer, that is, everyone can see and understanding the same thing, making the situation transparent, helping to focus on processes rather than people, and prioritize what is really needed. According to [Brynjolfsson], whenever it is possible to define one or more rules (algorithms) to specify a certain action, the computer will always be necessary. The information system has brought great evolution to companies in the current context, making use of new and constant technologies. In this way, information becomes crucial for the good performance of companies [Neves, 2011].

Lean Program of Ideas: According to [Dennis, 2008], the effective suggestions program channels employees' ideas directly to management and rewards members' initiatives. Successful suggestion programs have the following characteristics according to [Dennis, 2008]:

- A simple and hassle-free process for participants.
- Decision making and quick feedbacks to the employee/team member.
- Impartiality – no group should have partial access to the rewards.
- Promotion, and.
- Rewards for both extrinsic and intrinsic motivation.

There are several ways to generate rewards for Lean suggestion programs, ranging from points program to withdrawing gifts, such as the more sophisticated ones with awards for dinners in restaurants, weekends in hotels, trips etc. Each company must define, according to its program, what best fits the company to create a motivational customer. The ideal is always to have good publicity and a board with the rewards and people who were rewarded. Some companies also create competitions between teams where presentations range from the local company to the head office in the corporate, these are called corporate programs. While the ideas program generates benefits for the company, the worker feels more motivated, more important and becomes more committed to the organization. He starts to feel more and more part of the company and with that, he is concerned and dedicated to solving problems and achieving goals [Yonamine, 2002; Ohno, 1997]. For, teamwork is essential for the performance of a production line and draws a parallel with collective sports teams such as volleyball, which currently has six players, but in the past nine players have joined teams to a game certainly the team of six will perform better if they are well prepared, as it is not just quantity that will guarantee the result, but performance. Another factor is the ability to pass the bat through a process with different people, there will be operators with low performance at any given time and teamwork must be paramount so that another operator can support the operator with low performance until its restoration, assure the result of the group, train and practice continuously until knowing and doing instinctively.

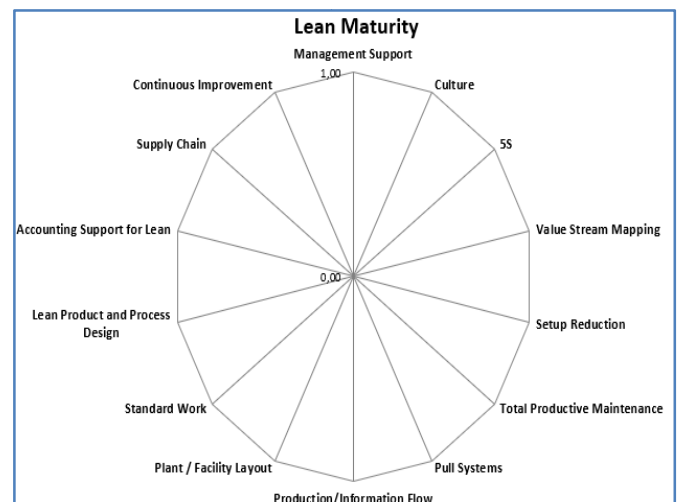
MATERIAL AND METHOD

The methodology used to define the company's needs was guided using a tool called Lean Maturity, which defined through the application of the tool where the company was positioned at that time

through the analysis of categories and how it could seek continuous improvement.

Contextualization: The case study has been carried out in a company in the field of Electronics, which produces cable TV and internet products (set-box), which is the market leader in this segment. This product has a board with assembled components, a plastic top and bottom cover with an external power supply, and an HDMI cable for transmitting/receiving digital signals. The company does not have the process of assembling boards with electronic components, as this activity is performed by local and international suppliers, the company only performs the final assembly of the products, having around 8 production lines and approximately 500 employees operating in one shift 8.4 hours a day in 5 days. In 2019, the company went through an organizational restructuring process with the objective of reducing costs and optimizing production processes and in this way, despite the company having some lean tools, it was defined as a corporate strategy that the company implement Lean Six Sigma as a program structured with the objective of presenting cost reduction projects and seeking continuous improvement. The company had already worked with the Six Sigma methodology in the past and several employees received Yellow Belt, Green Belt and Black Belt training, but due to various factors the program was losing strength due to the company's own restructuring and strategic employees for the program changed roles or left the company. In line with the current situation, the company decided to carry out a Lean diagnostic to verify which stage it was at and how it could seek continuous improvement.

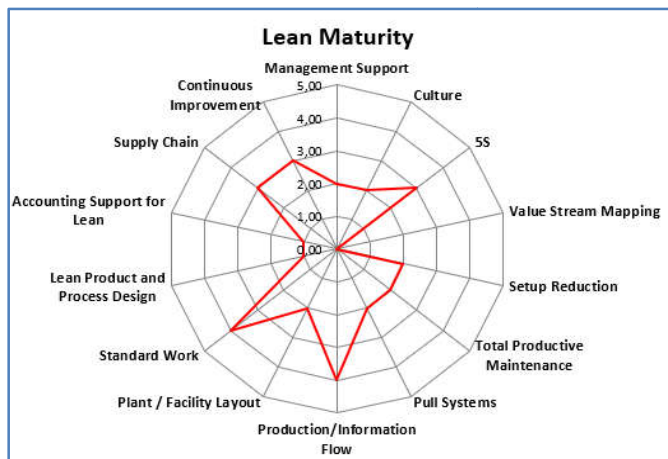
Experimental methodology: The company under study has some tools, but it did not apply any structured tool that could define which stage of Lean maturity it was in, the thing was very intuitive, even though the company had control tools, there was no methodology to define how to measure the maturity of the Lean. According to benchmarking carried out in which ways the plant maturity could be measured, the company decided to use a more adequate checklist called Lean Maturity, this checklist had 14 categories for assessment that directly contribute to Lean, those categories are: Management Support, Culture, 5S, Value Stream Mapping, Setup Reduction, Total Productive Maintenance, Pull Systems, Production/Information Flow, Plant / Facility Layout, Standard Work, Lean Product and Process Design, Accounting Support for Lean, Supply Chain, and Continuous Improvement.



Source: Adapted from company (2019).

Figure 5. Radar of lean maturity

The first diagnosis verified for each category was carried out in December 2019, defining the score for each one. The results can be verified as shown in Figure 6.



Source: Adapted from company (2019).

Figure 6. Initial evaluation of lean maturity

Stages of the evaluated categories

Step 1. Management Support – Score: 2: According to the defined score, it was verified that the company made the decision to implement the Lean program, however a formal plan for the Lean Six Sigma program was not identified in the company, none a Lean committee responsible for program decisions in the company was identified. No lectures about the program were identified in the company, we can show that the company's new management is committed to the program and seeking to define a formal structure for it.

Step 1.2: Lean Culture – Score: 2: Relating to Lean Culture in the company, it obtained a score of 2 because there is no evidence of defined plans for Lean, despite the company having an unstructured continuous improvement monitoring. There is no clear evidence of employee involvement, especially those on the shop floor, and engineering is the one who seeks to work on improvement projects, but not in a structured way. There is no evidence of time available for employees to focus on Lean as a continuous improvement tool.

Step 1.3. 5S – Score: 3: The company has a 5S audit system with defined audits on the production lines and are carried out by the quality team, there is no clear evidence of 5S being treated as a tool that encourages continuous improvement of the production lines. production. No evidence was found of the existence of a 5S audit in the company's administrative departments, only in the Warehouse and Industrial Maintenance sectors. In general, 5S is not defined as a structured program in the company that encourages continuous improvement, there is no evidence of disclosure of the senses.

Step 1.4. VSM - Value Stream Mapping – Score: 0: No VSM (Value Stream Mapping) of the production processes was evidenced in the company, leading the company to a score of 0 in this item. It was also verified that the employees of the engineering, quality and manufacturing departments had no knowledge of the tool. Despite the evidence that the company works with standardized work through the use of software that facilitates the calculation of the Takt-Time, it was also verified that the Industrial engineers are not trained in production line capacity calculation techniques and all the knowledge was acquired with the time of experience in the production process.

Step 1.5. Setup Time Reduction - Score: 2: Although most production lines are dedicated by product, in the few where more than one product runs, no evidence of a product change control where a work process could be observed was found to reduce setup time.

Step 1.6. Total Productive Maintenance – Score: 2: Evidence of a preventive maintenance plan for the production lines was found, but in some cases the checklist for carrying them out according to the scheduled date was not found. No evidence was found of a full productive maintenance plan with clear operator involvement where

they can solve minor problems, no documents evidencing operator commitments were found.

Step 1.7. Pulled System – Score: 2: The company works with a production line feeding system through the feeders to check how the materials are running out in each line, there is no clear defined methodology that alerts the warehouse for feedback to the production lines, the warehouse uses a manual system through pallets, where according to the removal of the material, it is fed back, but kanban-type tools are not used and not even for the material that is received from the supplier where 3 days of stock is established, it was verified that several items are way above the forecast stock, this makes the company have a lot of waste in local material stock. Material is often paid for to manufacture in batches as is standard from the supplier causing in some cases excess material in the process due to the non-existence of a proper feed control system. The production lines have a pull system through conveyors, but there is no clear identification of control to avoid excess production between the workstations, showing the jamming of operators and products that are placed on each other due to the conveyor's own speed. far above the takt-time provided for each product, this causes quality defects to be generated due to scratched products etc. There is no clear way to demarcate the conveyors so that they can define the moment when the operator must release the product on the conveyor and thus avoid jams, quality problems, etc. Several types of waste from overproduction, tailings, waiting and stocks were identified, thus the score obtained was 2.

Step 1.8. Production/Information Flow – Score: 4: The company has been working with standardized work through the use of software that allows the automatic calculation of the needs of each line and defining a production flow according to customer demand, thus the takt time is defined as well as the resources required for the process. The lines are structured by product according to your demand. The company has a production control system where managers such as leaders and supervisors have a vision of hourly production, however it was found that this information does not reach the operators in order to contribute to the line being able to reach the hourly and final production the shift to meet customer demand. There is no escalation system implemented on production lines in order to have a quick response to problems, there is evidence of software in the test maintenance area where technicians can identify which test table is failing for easy identification and repair. Data for continuous improvement are used late as the company's culture is not for hourly production. WIP is defined according to operator feed, but there is no material management system on the production lines.

Step 1.9. Plant/Facility Layout – Score: 2: The company works with a production line system on conveyors and the operating and test tables are allocated on the lines according to the layout definition elaborated by the production engineering. Excessive WIP identified on some lines due to lack of evidence of a material control system on production lines

Step 1.10. Standardized Work – Score: 4 The company works with standardized work for all production lines and auxiliary departments, there is no evidence of formal continuous improvement and easy access to all, such as kaizens etc.

Step 1.11. Lean Design – Score: 1: Little evidence found of the company working with Lean design in its products and processes, despite some feedback being generated on the development of products that takes place in other countries.

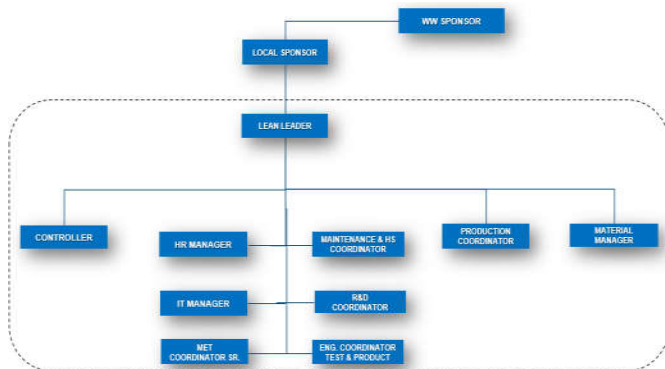
Step 1.12. Accounting Support for Lean – Score: 1: As the company does not have a Lean program, there is no evidence of the finance sector's participation in the calculation process of those that directly affect the company's financial result (hard saving) and those that do not directly affect the financial result of the company (soft saving) as well as the provision of financial information in order to support the program.

Step 1.13. Supply Chain – Score: 3: The company has a chain of local suppliers where there is a definition of material supply to meet a demand of 3 days of production through a pull system, however there is opportunity for improvement in a function of 3 days be a very high stock since the suppliers are in the same city and can optimize the supply chain by reducing production days and implementing control over the values of the material supplied.

Step 1.14. Continuous Improvement – Score: 4: Despite the processes being standardized, there is no evidence of the use of Lean tools disclosed in the continuous improvement process. There are no working groups focused on the company's continuous improvement process and focus on waste reduction.

RESULTS AND DISCUSSIONS

Creation of the Lean Committee (Steering Team): Through the result obtained in the first initial assessment of 44.20% of the company's Lean maturity, the initial strategy was to create a Lean Committee with clear definitions of action objectives within the program. The Committee was formed as follows as shown in Figure 7.



Source: Authors, (2021).

Figure 7. Lean Committee

Representatives from all areas of the company were defined, that is, a cross-functional team in order to have a perspective of each area, and having as Sponsors the Vice President of Operations and the Company's Local Director. A Lean Leader aiming to coordinate all Lean activities.

The Lean Committee will have the following function:

- Gather improvement ideas from across the company.
- Assess and prioritize improvement opportunities (closely linked to the company's annual business goals).
- Enable alignment between leadership teams.
- Communicate improvements and future results.
- Assistance in the necessary culture change.
- Define improvement strategy.
- Ensure continuous process measurement and continuous improvement.
- Determine ongoing workforce development needs
- Stay informed about competing priorities and change the focus of improvement in line with new strategies.
- Assess progress and adjust, as necessary.
- Encourage leaders to go to Gemba and implement kaizen
- Allocate resources.
- Define improvement team leaders.

The Committee meetings were defined to be monthly and in these meetings the evolution of the company's Lean Maturity would be verified in accordance with the defined actions. After the creation of the Lean committee, an action plan was defined with the objective of attacking the most relevant points raised in Lean Maturity and as a way to improve the knowledge of the group, some strategies were defined to improve:

- Lean Six Sigma Training
- Benchmarking
- VSM
- Kaizen
- DMAIC
- 5S
- Visual Management

Training for the team in VSM – Value Stream Mapping: Through the diagnosis, it was immediately verified the need for training of management personnel with a focus on knowing Lean and its tools and mainly preparing the personnel to carry out the Value Stream Mapping (VSM), this training was the kick-off for the certification of the company's team, thus opening the doors to the program. In the first week of January 2020, the company's team began training, as shown in Figure 8.



Source: Authors, (2021).

Figure 8. Training for Staff and Operators

The training consisted of a definition of what Lean and its tools are and how to use them in the company, practical exercises were carried out with visits to the company's Gemba to collect data and activities being carried out in the training room. The goal was for each team created to present the VSM of the current stage of the company and opportunities for Kaizen improvements to be carried out. This training was already part of the company to improve Lean Maturity, seeking to make some employees aware of VSM. Training was also carried out with the manufacturing team for them to get to know the Lean Six Sigma model and how the company intended to work with them for them to contribute to continuous improvement. This training was also carried out by me to standardize the concept in the company, as shown in Figure 8. In these trainings, operators had theoretical classes in the classroom and then went to Gemba to carry out practical work and present the results in a group.

The training scope included: Introduction to Lean; Learning to See the 8 Wastes; Visual management; 5S and Practical Work in Production – (5S + Kaizen). After all the training carried out, the employees were certified. As the program progressed over the months, there was a need to conduct training in Lean Six Sigma in more detail and with much greater content, and in this way a menu and workload of approximately 60 hours was defined to carry out the training with a larger group of company managers including everyone, the Managers and the Director of the company. This training was essential for the evolution of the program in the company. The training was given by the Creathus Institute through its specialized and experienced instructors in the subject with experience in industry. At the end of the event, there was a Certification process with the commitment of the Director of the Company to maintain the focus on the program with the objective of obtaining continuous improvement.

Benchmarking with companies: In order to verify how some companies that apply Lean are evolving with it, a benchmarking was carried out with two companies in the Industrial District of Manaus, in this benchmarking the following issues were addressed, as shown in table 2. The committee carried out the visit to the companies where several opportunities were verified.



Source: Authors, (2021).

Figure 9. Lean Certification

Table 2. Points covered in benchmarking

Item	Questions	Area
1	Responsibilities of the areas in the Lean program (Quality, Eng., Manufacturing, HR etc).	All
2	Factory Lean routines for each area (Quality, Eng., Manufacturing, HR etc).	All
3	Lean training and qualification program	RH/Lean
4	Lean Indicators (Maturity, Kaizen, DMAIC, 5S etc).	Lean
5	Lean approach to meetings (which meetings and frequency).	All
6	Dissemination of projects (Mural/Gallery/Internet).	Lean
7	Lean events/campaigns at the factory throughout the year	RH/Lean/Dir.
8	5S Program	Lean/Dir.
9	Ideas and Recognition Programs	Lean/Dir.
10	Barriers and challengers	All

Source: Authors, (2021).

Benchmarking in the company 1: At company 1, the coordinator of the Lean Six Sigma program gave a presentation with the various points explaining how the company identifies opportunities and classifies them in the Lean Six Sigma program and what the benefits of the program are for the organization. He presented the types of projects that are carried out such as Kaizen Blitz; Project A3; DMAIC/DMADV and Kaizen events. The Certification process they use as:

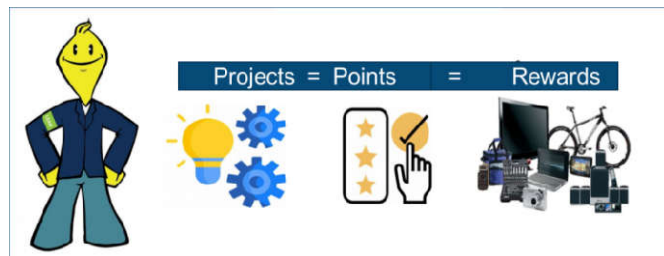
- Lean Six Sigma Shop Floor Certificate
- Lean Six Sigma Bronze Certificate
- Lean Six Sigma Silver Certificate
- Lean Six Sigma Gold Certificate
- Lean Six Sigma Blackbelt Certificate

All projects were explained in detail which criteria were adopted for each one. Lean Six Sigma indicators that a practical company in search of excellence were presented:

- Engagement: The factory's engagement in relation to projects
- Shop Floor: The percentage of certified DLs in Shop Floor
- Lean Bronze: The percentage of ILs certified in Lean Bronze
- Lean Silver: The percentage of Lean Silver certifications
- Saving: The savings achieved with projects over time.
- Kaizen event: Number of KE executed
- 5S: 5S level per area (audit)
- Lean Council Meeting: Number of Lean Council meetings held per month
- Lean Maturity Progression: Site maturity level according to assessment
- Scrap, DII, OLE.

The company's Lean Maturity Index is used to measure the progress of the program. It was also presented how the reward program is carried out in the company, which is through a point system, where, according to the number of points, employees can use them to acquire

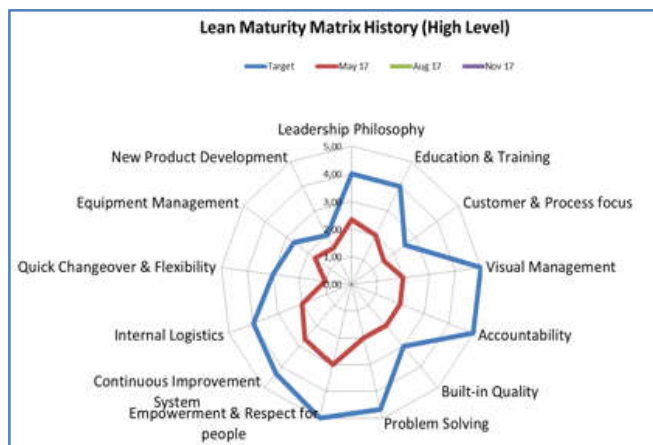
various awards, as shown in Figure 10, we have the rewards through points. For each type of Lean Six Sigma project presented, it corresponds to several points and as it accumulates, it can acquire bigger prizes. Finally, the form of dissemination of the program, its metrics and awards were presented, which is through the company's Blue Wall. The program encompasses local and global competitions with awards from the most varied to the winners. The committee was pleased with the visit, where several doubts were resolved and many opportunities to apply in the company.



Source: Company 1 (2021).

Figure 10. Awards from projects

Benchmarking in company 2: In company 2 there was also a presentation of the company by the Lean Manager explaining how they are working with Lean Six Sigma. The company manages the program through an existing Lean committee. There is a Lean tools training program for employees. The company also uses a Lean Maturity to measure program maturity across the company according to Figure 11.



Source: Company 2 (2021).

Figure 11. Lean maturity

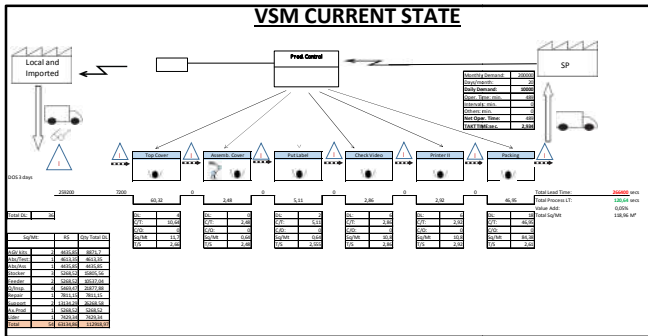
Program management is carried out through Lean Six Sigma indicators defined as Safety; Quality; Productivity; Cost; Moral; Lean Maturity. Specific events are held at the company to publish and promote the program, such as: Crazy race; CIC; Quality Event and Kamishibai. In the company there is an Ideas and Recognition program called CIC – Continuous Improvement Champions where it is local and global. Recognition is carried out in monetary form for the ideas and winning groups in competitions. During the benchmarking in one of the companies there was a dynamic and photo with the company's managers as shown in Figure 12. Based on the results obtained in the benchmarking, the company developed the strategies to improve the Lean Six Sigma program internally.

Value Stream Mapping – VSM: As identified in Lean Maturity, the company did not have the mapping of the value stream of the production lines identified, as well as opportunities for improvement. To understand the process flow of the production lines and identify the waste in the production process, the company, after the training carried out, began to raise the VSM of the lines and identify the improvements to be implemented. Cross-functional teams were formed with the objective of making the VSMs, as shown in Figure 13.



Source: Company 2 (2021).

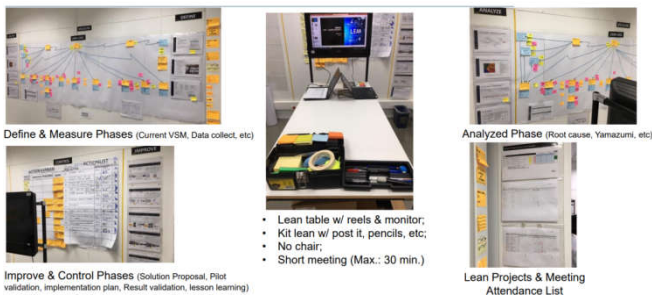
Figure 12. Company 2 visit



Source: Authors, (2021).

Figure 13. Value Stream Mapping (VSM)

As an initial survey 7 Kaizen projects were surveyed with a potential cost savings around US\$108K on one production line. For each line, a schedule was defined with planning to carry out the initial VSM and identified the opportunities where a list of projects was developed, and priorities defined. Through the continuous evaluation of the lines, the process evolved, thus a new evolution of the VSM evaluation was established and a room called the War Room was created, which would facilitate the evolution of the VSM through the use of the DMAIC tool, it would be simpler to work with the projects and the monitoring of the teams. Kaizens were defined and this dynamic gave a better increment to the process and weekly meetings with the involved team took place to verify the implemented actions and the evolution of the process. Within the WAR ROOM we had the following flows in the Figure 14.



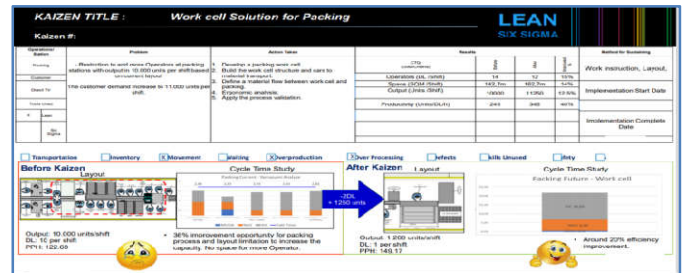
Source: Authors, (2021).

Figure 14. War Room

The VSM is fully aligned with the business policy and is carried out with the purpose of seeking opportunities for improvement, making up a process of continuous improvement in the company and an implemented culture. With this evolution in the company, several improvement projects were implemented and the evolution of Lean Maturity in relation to VSM was significant over the months until the end of this work, leaving a score from 0 to 4. The VSM became a tool for use continuous as there are variations in demands in the company and as a search for continuous improvement. As a result, the improvement in the plant was notably verified through its products (A,B,C,D,E and F) manufacturing cost reduction indicator which reached an average 30% improvement since the beginning of the

program in Q1-19 and closure projections for Q2-21, as presented in table graphic1. In addition, the company went from an operation with 5 production lines to 3 flexible lines.

5S: The 5S in the company despite obtaining an assessment of 3, it was identified that it was performed only on the production lines and occasionally by the quality person and it was not throughout the company, there was a great opportunity to implement a much more structured 5S program and actions were defined for improvement to be comprehensive across the company. One of the first points was the definition of a new schedule for reactivating the program with the definition of facilitators by department and the definition of D-day for launching the new program.



Source: Authors, (2021).

Figure 15. Kaizen

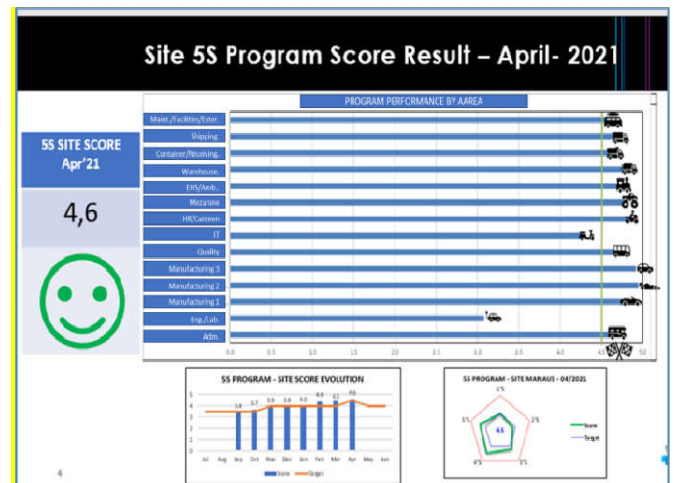
A kick-off meeting was held with the representative from all departments to explain the role for each one, as shown in Figure 16.



Source: Authors, (2021).

Figure 16. Meeting with 5S departments teams

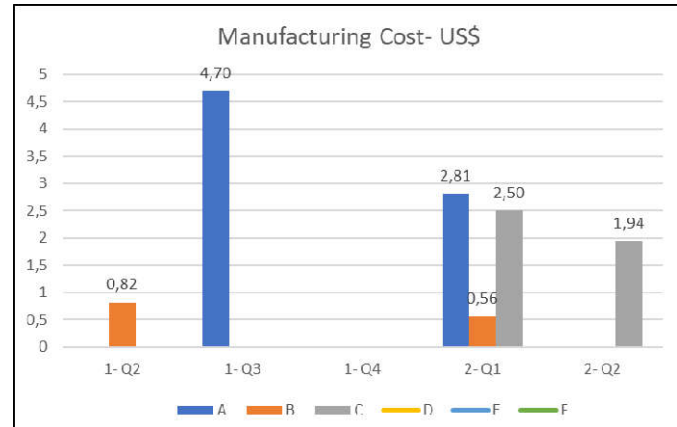
With the definition of D-day for the launch of the new program, an audit schedule was defined. After several monthly audits and follow-up meetings with the area team, the continuous monthly evolution was noticed and until the last survey of the study carried out in April 2021, the 5S result at the plant was 4.6%, that is, an improvement of around 35% compared to the initial result. See Figure 17.



Source: Authors, (2021)

Figure 17. 5S audit

Visual Management: As part of the evolution process of the Lean Six Sigma program in the company, an evolution of the factory's visual management system became necessary, especially in the production lines where there was no proper verification process from time to time for production lines well such as the occurrence of the hour, which could sometimes impact the company's productivity, despite the company having a data collection software (Shop Floor Control/MES), the data was not properly treated in real time where operators could understand what was happening on your production line on an hourly basis. As a strategy, the company defined the development of a new system called Smart Manager, adapting to the needs of the company's new moment of transformation and that could provide real-time information to employees and managers for quick decision-making. During the initial development process several new functions would be added to the system such as:



Source: Authors, (2021).

Graphic 1. Manufacturing cost improvement

Hourly Production Control; Line Stop Home Escalation System; 4 quadrants for defect analysis by improvement teams; Stop Control System with MTBF and MTTR calculation and Meeting Control System to evaluate the company's KPI's. The system should allow all managers to have access to it in real time, and the escalation system should be in real time via email or phone. As with all the needs raised, the use case was developed to understand all the features of the system that would be developed in order to meet the company's needs. As with all the needs raised, the use case was developed to understand all the features of the system that would be developed to meet the company's needs. The system starts with the part of hourly data collection to be monitored and shown on a 57" TV in front of the production, the previous system showed the data in spreadsheet form and was not visual to provide a better understanding for operators.



Source: Authors, (2021).

Figure 18. Production and Quality Indicators

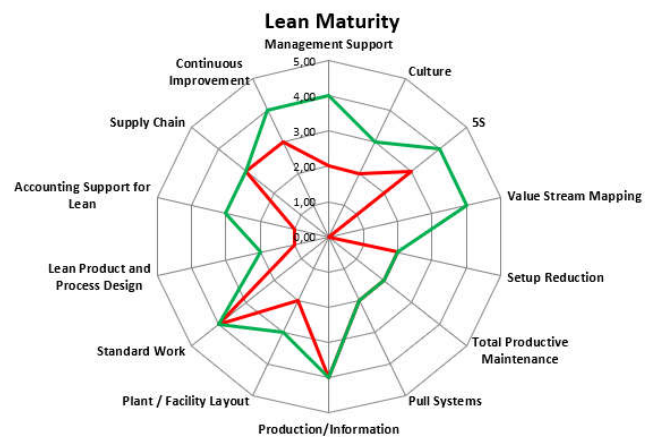
The idea of the indicator is to have the production hourly and with color variation when the production varies, if it is in the hourly target

it is green, if it is below 5% yellow and above it red. In the accumulated there is a productivity indicator where the pointer indicates where the accumulated is, which indicates that if you continue this way you will not close the shift within the defined target, a face in the corner of the indicator shows the current situation, this all does with Visual management is very fast and in seconds we have the situation of the production line. On the quality side, it presents the First Pass Yield Composite to measure the quality of the stations being measured in real time, the OBA is also shown, if any failure occurs during the sampling process, it is shown in the indicator. As shown in the production and quality indicator in Figure 18. As a way for operators to have an hourly view of the line performance, monitors were implemented on the lines to facilitate the visualization, giving greater speed to the feedback process online productivity, as shown in Figure 18. With the recording of quality data, the system of 4 quadrants was implemented in the system to have the main quality indicator, the accumulated breakdown of the problems and after the actions, how each item in the quadrant is evolving. Another report developed automatically in the system was the downtime of lines –

Downtime, all defects were collected via test equipment and those that were not automatically pointed out were manually imputed. In the report a Pareto chart could be removed by period, an action plan could be imputed and the result through the histogram could be removed from the system. With this, the maintenance control gained another speed, as it moved from an analysis only at the end of each week to a daily analysis in real time. Another function created in the system to provide agility and control was the implementation of the production, engineering, quality, and materials meeting management system. The management system was created, and all indicators could be monitored in the system through the meetings, including the control of attendance of participants.

Lean Ideas Program: As part of the benchmarking in the companies, a comparison observed in table 4 about the companies was related to the companies' Lean ideas program and how it compares in relation to the company:

After several rounds of meetings with the Management Committee, the Ideas program was launched in April 2021. After all the evolution carried out in the company where the Lean Maturity assessment was carried out monthly, the company's evolution was notorious. According to the latest Lean Maturity assessment, the company had a substantial improvement gain in some categories, achieving a gain around 42.5% compared to the initial stage of the assessment as shown in Figure 19.



Source: Authors, (2021).

Figure 19. Comparison of Lean Evolution in the Company Dec_2019 and April 2021

When we start the case study in the company, we can identify when the application of Lean Six Sigma is important for the development of an organization and, primarily, for the development of the Cost Reduction Culture.

Table 4. Benchmarking with companies regarding Lean Ideas program

Item	Description	Company 1	Company 2	Our Company
1	Identification of Improvement Ideas	Leaders collect ideas through a form and forward them to the Lean committee to assess feasibility. In direct seekers directly for the Lean team.	All operators directly search for the Lean Team or put it in the suggestion box.	As we do not have dedicated Lean people, I would suggest the Benchmark of Company 1 (Proposal 1).
2	Idea Evaluation – Who Evaluates?	A committee evaluates the idea (feasibility / cost / complexity / need / impacts / gains / etc.)	A committee assesses the viability of the ideas (feasibility / cost / complexity / need / impacts / gains / etc.)	– We can define a committee composed of representatives from each area and define evaluation and approval criteria (Proposal 1)
3	Evaluation time	Return within one week at most	Return within one week at most	Return within a maximum of one week (Proposal 1)
4	Idea Implementation – Who is How to Implement?	Once approved, the committee directs the necessary support to implement the idea with the operator's participation or the operator itself can propose the prototype.	Once approved, the committee directs the necessary support to implement the idea with the operator's participation or the operator itself can propose the prototype.	Once approved, the committee directs the necessary support to implement the idea with the operator's participation or the operator itself can propose the prototype (Proposal 1)
5	Presentation Tool	<i>Kaizen Blitz</i> , 8D, A3, <i>DMAIC</i>	<i>Kaizen Blitz</i> , A3	Suggested the Company 1 model, as it gives more tool options (Proposal 1)
6	Results Validation and Recognition - Validation Points	3 Consecutive periods of positive results in the impacted goals/waste (3 Shifts, 3 Days, 3 Weeks, 3 months, depending on the complexity)	3 Consecutive periods of positive results in the impacted goals/waste (3 Shifts, 3 Days, 3 Weeks, 1 month, depending on the complexity)	Suggested Company model 1. Some data and waste are validated only in the monthly period (Proposal 1)
7	Method of Presentation and Disclosure of Results	Wall Presentation, Highlights Presentation and Certificate Delivery at Quarterly Events, Project Presentation at Weekly Meetings, Participate in WW evaluation for Global competitions	Wall Presentation, Highlights Presentation and Certificate Delivery at Quarterly Events, Project Presentation at Weekly Meetings, Participate in WW evaluation for Global competitions	Presentation on the Wall, Presentation of Highlights and Delivery of Certificate at Monthly Factory Events (Disclosure of Results/Staff), Presentation of Projects at Weekly Meetings
8	Program name	PIT – Our Company's Ideas Program	PIP - Internal Participation Program (Same as above)	Run an Internal Competition to choose the name of the Ideas Program
9	Rewards Method	Accumulation of Points to exchange gifts (Pen, Notebook, School Kit, Playing Cards, Dominoes, One, R\$50.00, Phone, Flat Iron, Vacuum Cleaner, Bicycle, TV, Mobile, Note Book, etc.)	For every 5 completed Projects (Kaizen/A3), you earn R\$50.00 (I'm waiting for more details on this process)	To be defined

Source: Authors, (2021).

It is important to note that the definition of a tool to identify how much the company is involved with Lean is important in order to identify the gaps that the company has to work with and the key in this case study was to verify how much support and the complicity of the company's managers is important to obtain the results, because without monitoring, there is no way to achieve the results. The continuity of the program is mainly due to the follow-up system of the Board of the company which must buy the program, otherwise it is doomed to failure as has happened with several companies. Continuous process mapping (VSM) is always important to constantly define the opportunities for continuous improvement, and for each change that occurs in demand, it should be used as a standard tool for analyzing the processes. There was a significant evolution in the company in this process simply because it did not exist before. Throughout the company, 5S should be seen as a program and should be structured and commanded by departments members group and practiced throughout the company. Through the new program applied in the company under analysis, the results were significant. Visual management was also a major factor for improvement as it can provide operators and managers with real-time information for quick decision-making in events that may happen during the production day. Another key point to highlight was how much Lean can bring people together and make knowledge standardized within the organization, where people can talk to at the same level between concepts, being operators or bosses always in search of cost reduction and continuous improvement in the company, the ideas program launched at the company increasingly allowed the involvement of operators in the day-to-day tasks of continuous improvement. As a result, we can highlight how much the company has been recognized worldwide by managers and serving as a reference for the application of the various tools in other companies that supply the group.

So, in this case study, Lean is a successful program for company and people improvement.

REFERENCES

- Basu, Ron. *Fit Sigma: A lean approach to building sustainable quality beyond Six Sigma*. John Wiley & Sons, 2011.
- Chiarini, Andrea. *From total quality control to lean six sigma: evolution of the most important management systems for the excellence*. 2012.
- Antunes, J. et al. *Sistema de Produção: conceitos e práticas para projeto gestão da produção enxuta*. Porto Alegre: Bookman, 2008
- Womack, J.P. and Jones, D.T. *Lean Thinking*. Banish Waste and Create Wealth in Your Corporation, 2nd ed., Free Press, New York, NY. 2003.
- Stewart, John. *The Toyota Kaizen continuum: A practical guide to implementing Lean*. Crc Press, 2011.
- Maleyeff, John. *Exploration of internal service systems using Lean principles*. management decision, 2006.
- Miller, J., Wroblewski, M., & Villafuerte, J. (2014). *Creating a kaizen culture: Align the organization, achieve breakthrough results, and sustain the gains*. USA: McGraw-Hill Education
- Slack, N., Chambers, S., Johnston, R., *Administração da Produção*, 3. ed. São Paulo, Atlas. 2002
- Imai, Masaaki. *Gemba Kaizen: uma abordagem de bom senso à estratégia de melhoria contínua*. 2ª ed. - Porto Alegre: Bookman, 2014.
- Kubiak, T. M.; BENBOW, Donald W. *The Certified Six Sigma Black Belt Handbook*, - 2009.
- Al-Araidah, Omar et al. *Lead time reduction utilizing Lean tools applied to healthcare: The inpatient pharmacy at a local*

- hospital. Journal for Healthcare Quality, v. 32, n. 1, p. 59-66, 2010.
- Dennis, Pascal. Produção *Lean* Simplificada. Bookman, 2008.
- Santos, R. V. "Desenvolvimento de um mecanismo para medir impacto da aplicação do seis sigma na maturidade do processo de fabricação". Dissert. de mestrado Universidade Tecnológica Federal do Paraná-UFTPR, Paraná, 2011
- Womack, J. P. D. T. Jones e D. Roos, "The Machine That Changed the World", s.l.:Harper Perennial, 1991.
- LAI-MIT, "Lean Enterprise Self-Assessment Tool - Facilitator's Guide". S.L.:Massachusetts Institute of Technology, 2001
- Soriano-Meier, H. E P. Forrester, "A model for evaluating the degree of *Leanness* of manufacturing firms". Integrated Manufacturing System, v. 13, n. 2, p. 104-110, 2002
- Gama K. T. E V. Cavenagui, "Measuring performance and *Lean* Production: a review of literature and a proposal for a performance measurement system." Anais... Production and Operation Management Society (POMS) 20th Annual Conference, mai 2009.
- Uhlmann R, Iracyanne, Aplicação de ferramentas do *Lean* manufacturing em um processo de SMT: Estudo de caso. Dezembro, 2015.
- Tomelero, Roberto Luiz. Benchmarking Enxuto Ambiental: método para diagnóstico de práticas e performances aplicado ao gerenciamento de ferramentas. Dissertação (Mestrado em Engenharia Mecânica) - Programa de Pós-Graduação em Engenharia Mecânica, UFSC, Florianópolis. 2012.
- Ramos, Aline Ribeiro et al. Benchmarking da produção mais limpa para a análise de empresas de manufatura. 2013
- Kyrö, Paula. Revising the concept and forms of benchmarking. Benchmarking: An International Journal, 2003.
- Garvin, D. A. Building a learning organization. Harvard Business Review, v. 71, n. 4, p. 78-91, 1993.
- Ferro, Jose Roberto. A essência da ferramenta Mapeamento do Fluxo de Valor – *Lean* Institute Brasil, 2005. Disponível em: <http://www.Lean.org.br/artigos/61/a_essencia-da-ferramenta-mapeamento-do-fluxo-de-valor.aspx>. Acesso em: 26/06/2021.
- Boonthonsatit, Kanda & Jungthawan, Siripong, *Lean* Supply Chain Management-Based Value Stream Mapping in a Case of Thailand Automotive Industry, 2015.
- HINES, Peter; Rich, Nick; ESAIN, Ann. Value stream mapping: a distribution industry application. Benchmarking: An International Journal, 1999.
- Haefner, Benjamin et al. Quality value stream mapping. Procedia Cirp, v. 17, p. 254-259, 2014.
- Chen, J.C., Li, Y. and Shady, B.D. (2010), "From value stream mapping toward a *Lean*/Sigma continuous improvement process: an industrial case study", International Journal of Production Research, Vol. 48 No. 4, pp. 1069-1086.
- Hines, P. and Rich, N. (1997), "The seven value stream mapping tools", International Journal of Operations and Production Management, Vol. 17 No. 1, pp. 46-64
- HAEFNER, Benjamin et al. Quality value stream mapping. Procedia Cirp, v. 17, p. 254-259, 2014.
- Erlach, K, Value Stream Design. The Way towards a *Lean* Factory, Springer, Berlin, 2013
- Tapping, D. and Shuker, T., Value Stream Management for the *Lean* Office: Eight Steps to Planning, Mapping and Sustaining *Lean* Improvements in Administrative Areas, Productivity Press, New York, NY. 2003
- Coutinho & Aquino. Os 5s Como Diferencial Competitivo Para o Sistema de Gestão da Qualidade: Estudo de Caso de Uma Empresa de Aços Longos. 2015
- Ribeiro, Haroldo. 5S – Os 5 passos para uma implantação de sucesso/Haroldo Ribeiro. São Caetano do Sul: PDCA Editora, 2015.
- Ferro, J.R. Gestão visual para apoiar o trabalho padrão das lideranças. Blog *LeanSigma*, 2010. Disponível em: <http://blogLeansigma.blogspot.com/2010/12/gestao-visual-para-apoiar-trabalho.html>. Acessado em: 26/06/2021
- Brynjolfsson, Erik & McAfee, A segunda era das máquinas: trabalho, progresso e prosperidade em uma época de tecnologias brilhantes. – Rio de Janeiro, RJ: Alta Books, 20
- Neves, José Manoel de Souza – Contribuições da implantação das tecnologias da informação MÊS – Manufacturing Execution System – para a melhoria das dimensões competitivas da manufatura – estudo de caso Novellis Brasil Ltda. Guaratingueta, 2011
- Yonamine, J.S.G & Souza A. Os Impactos de um Programa de Sugestão de Melhorias para a Lucratividade do Negócio e Motivação dos Funcionários: Um Estudo de Caso, 2002.
- Ohno, Taiichi. O Sistema Toyota de Produção: além da produção em larga escala. Porto Alegre: Bookman, 1997
