Universidade do Minho
Escola de Engenharia

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Implementation of Lean Leadership System at indirect areas in a component manufacturing company for automotive industry

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Master Dissertation
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Professora Doutora Anabela Carvalho Alves

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"Tell me and I forget,

teach me and I may remember,

involve me and I learn"

Xun Kuang

STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

Implementation of Lean Leadership System at indirect areas in a component manufacturing company for automotive industry

ABSTRACT

Over the years companies have sought to implement business excellence models to improve their competitiveness and performance. Therefore, Lean Production has been a widely adopted model by multiple organizations from different business areas. However, to successfully implement Lean in an enterprise, it needs to be performed from the shop floor to the indirect areas. Leadership is then a fundamental ingredient to deploy and sustain an approach like this. Hence, it is needed to establish Lean Leadership to promote a continuous improvement environment through the involvement of employees. This dissertation was developed as part of the Master's in Industrial Engineering of the University of Minho, with the objective of implementing a Lean Leadership System in a process development department in Bosch Car Multimedia Portugal, S.A.

The research methodology used was Action Research. Initially, a diagnostic analysis of the current state of the group was performed through a set of tools such as surveys, observations, interviews, and workshops to collect and identify problems. From the wastes identified, it was possible to develop improvement proposals regarding processes, information, and communication with the support of Lean Leadership elements as part of the strategy to reduce waste.

With the implementation of proposals, it was expected to lead to productivity gains through the reduction of at least 5,4% of waiting time, defects, and inventory from the Total Available Time. In terms of the maturity level of Lean Leadership System, the progress is in the right track to be able to reach the maximum until the end of the Lean Project. Furthermore, the implementation of the tools from Lean Leadership elements were acknowledged by team members and seen as beneficial. This is also relevant to the positive feedback regarding this project in which people recognized that helped to change the mindset of the team.

KEYWORDS

Continuous Improvement; Indirect areas; Lean Leadership System; Lean Mindset; Waste reduction

Implementação de um Sistema de Liderança *Lean* em áreas indiretas numa empresa de componentes para a indústria automóvel

RESUMO

Ao longo dos anos as empresas procuraram implementar modelos de excelência organizacionais de modo a melhorar o seu desempenho e competitividade. Nesse sentido, o *Lean Production* tem sido um modelo amplamente adotado por muitas organizações de variadas áreas de negócio. No entanto, de forma a implementar o *Lean* com sucesso numa empresa, tem de ser feito desde a área produtiva até às áreas indiretas. A liderança é, então, um ingrediente fundamental para disseminar e sustentar uma abordagem como esta. Por isso, é necessário estabelecer a Liderança *Lean* de modo a promover um ambiente de melhoria contínua através do envolvimento dos colaboradores. Esta dissertação foi desenvolvida como parte do Mestrado em Engenharia Industrial da Universidade do Minho, com o objetivo de implementar um sistema de Liderança *Lean* num departamento de desenvolvimento de processos na Bosch Car Multimédia Portugal, S.A.

A metodologia de investigação utilizada foi a *Action Research*. Inicialmente, foi realizada uma análise diagnóstico do estado atual do grupo através de uma série de ferramentas como inquéritos, observações, entrevistas e workshops para coletar e identificar os problemas. Dos desperdícios identificados, foi possível desenvolver propostas de melhoria relativamente a processos, informação e comunicação com o suporte dos elementos de Liderança *Lean* como parte da estratégia para reduzir o desperdício.

Com a implementação das propostas, espera-se que leve a ganhos de produtividade através da redução de pelo menos 5,4% dos tempos de espera, defeitos e inventário do Tempo Total Disponível. Em termos do nível de maturidade do Sistema de Liderança *Lean*, o progresso está no bom caminho de modo a atingir o valor máximo até ao final do Projeto *Lean*. Para além disso, a implementação das ferramentas dos elementos de Liderança *Lean* foi reconhecida e vista como benéfica para os membros da equipa. Isto também é relevante para a resposta positive relativamente a este projeto em que as pessoas reconheceram que ajudou na mudança da mentalidade da equipa.

PALAVRAS-CHAVE

Áreas indiretas; Melhoria continua; Mentalidade *Lean*; Redução de desperdício; Sistema de Liderança *Lean*

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Acronyms List

AE – Automotive Electronics

BPS – Bosch Production System

CM – Car Multimedia

EAI – Engineering and Interconnect Technologies

HC – Headcount

LC – Lean Champion

LLS – Lean Leadership System

LPR – Lean Progress Review

MFT – Manufacturing Technology

PCB – Printed Circuit Board

PCBA – Printed Circuit Board Assembly

PDCA – Plan Do Check Act

PL – Project Leader

SMT – Surface-mount technology

SW - Software

TAT – Total Available Time

TIP – Tactical Implementation Plan

TL – Team Leader

TPS – Toyota Production System

VSDiA – Value Stream Design in Indirect Areas

VUCA – Volatility, Uncertainty, Complexity, Ambiguity

1. INTRODUCTION

The present dissertation, entitled "Implementation of Lean Leadership System at indirect areas in a component manufacturing company for automotive industry", was developed in the Centre of Competence for Printed Circuit Board (PCB) of Bosch Car Multimedia Portugal in Braga. This dissertation was developed under the scope of the Master's in Industrial Engineering at University of Minho. The first chapter of this master's dissertation is the introduction which includes the topics related with the motivation and context, objectives, research methodology and, finally, a brief description of the structure.

1.1 Context and motivation

The rapid changes in the market during the last decades have led to an increase of the competition and a more volatile and unstable demand for companies. Therefore, businesses started to implement models of excellence to decrease costs and improve their performance and competitiveness. Undeniably, management systems such as Lean Production are fundamental for the sustainable future of enterprises (Chiarini, 2013; Hallam et al., 2018).

Lean Production is one organizational model already successfully adopted in several industries and services that contribute for the economic development of many countries and sustainability (Amaro et al., 2019; Sanidas & Shin, 2017). Although its development began with Toyota Production System, aiming to eliminate waste in production processes, there is a natural interest expanding Lean application in other areas than the shop floor (Alves et al., 2012; Liker, 2004).

In fact, manufacturing processes may not be the primary cause of waste in production, giving other business processes a paramount importance. As the production processes and the indirect areas are dependent on each other, there must be a synergy to apply Lean tools and techniques. Consequently, Lean should be deployed throughout the company, including indirect areas (Ehrlich, 2002; Locher, 2011). The challenge is then to implement and create a continuous improvement culture based on Lean practices and Lean Thinking principles (Womack & Jones, 1996) that will prevail over time. Despite being of strong interest from many organizations worldwide, the majority fails to implement Lean in their companies. Many causes for failure are related to organizational culture (Amaro et al., 2021). Organizational culture could be the trigger or an inhibitor of such implementation (Amaro et al. 2020).

For that matter, the Lean systematic will only be able to succeed if the most important assets, people, are engaged and encouraged to participate (Liker, 2004), hence, the implementation of a Lean

Leadership System. This means that for a Lean implementation a knowledge of Organizational culture is important (Amaro et al., 2020), as the many authors reviewed in Amaro et al. (2021) referred. This could be even more difficult to implement in indirect areas of companies, as it involves irregular and non-repetitive activities that people is not accustomed to measure (Monteiro et al., 2017; Monteiro et al., 2015; Vicente et al., 2015; Witeck et al., 2021).

Lean Leadership could be then the connection that is needed between waste reduction and a continuous improvement organization. It is a concept that is valid for every leadership relation within a company. Therefore, Lean Leadership is a method that promotes a sustainable implementation of Lean Production (Dombrowski & Mielke, 2013).

The company where this dissertation was developed has a long tradition in implementing Lean practices in production processes, but it seems that the success does not extend to indirect areas. This motivates this dissertation that analysed the current situation to understand why this happens and propose measures to overcome the difficulties with this implementation.

1.2 Objectives

The aim of this master dissertation was to develop and implement a Lean Leadership System in an indirect area in an automotive company that produces electronic components. The focus was to propose a strategy to:

- Improve work productivity by 15% through effectiveness and efficiency gains and sustainable elimination of waste;

- Implement Lean Mindset by establishing good collaboration, feedback and coaching culture through a series of workshops and activities defined.

With these strategies, it was expected to:

- Increase customer satisfaction by focusing on customer needs and demands;

- Increase associates' satisfaction by involvement of team members/team spirit;

- Promote Leadership mindset based on company principles;

- Increase productivity by eliminating waste;

- Improve global collaboration within the organization.

1.3 Research methodology

To achieve the aforementioned objectives, this master's dissertation was guided by the following research questions: How to improve the work productivity through a Lean Leadership System? How to implement a successful Lean Leadership System?

To answer these questions, the method used was Action Research.

Action-Research is characterized as "learning by doing" which involves generation of theory with changes in the social system, by implementation of actions and reflection (Susman & Evered, 1978). Therefore, action research can be divided into five phases (O'Brien, 1998):

1) Diagnosing: problem identification and data collection. In this phase, several tools were used (e.g. workshops and surveys) to identify and assess the problems of the group.

2) Action planning: formulate possible solutions. The Design Phase, where the proposals for improvements were formulated based on the issues found from the previous phase.

3) Taking action: implement actions. During the Implementation Phase, the first measures, usually the easier ones, started to be implemented.

4) Evaluating: collect and analyse results. After the start of implementation of measures, the results were continuously verified and analysed.

5) Specifying learning: interpret the findings. The results were then compiled either on the productivity gains or on the LLS maturity assessment.

These phases were followed attending to the defined plan for the Lean project. The whole Lean project has a duration of one year, divided into two main parts: 1) Lean Wave and 2) Sustainability Phase. The Lean Wave took about three months and had the support of a local Lean team to implement several tools and conduct workshops to the team members. This part represents the first three phases of the cycle of Action Research methodology, where the first reflections, planning and implementation of measures were made. Later, during the Sustainability Phase, the team continued to take on the implementation of the new measures and step further in the Lean practices.

1.4 Dissertation structure

This dissertation is divided into seven chapters with the aim of organizing and structure the work done during the project.

The first chapter describes the background and motivation for the present work, the objectives to be accomplished and how this work is organized.

The second chapter encompasses the literature review focused on presenting the concepts about Lean Production and topics related to the work such as Lean Leadership and Coaching.

The third chapter describes the Bosch Group, specifically Bosch Car Multimedia plant in Portugal (Braga). It is also explained the Lean Program within the Automotive Electronics (AE) division.

The fourth chapter reflects on the status of the section where the work was done.

The fifth chapter presents the improvement proposals and actions planned.

The sixth chapter presents the discussion of the work and the results.

Lastly, Chapter 7 addresses the main conclusions of this dissertation, contributions, and limitations, as well as suggestions for future work.

2. LITERATURE REVIEW

In order to understand the Lean philosophy and its concepts, that are the basis for Lean Leadership System, it was presented the basis and origin of Lean. It is of paramount importance to outline the relevance of Toyota Production System, Lean Thinking and Coaching as organizational culture/model in the sustainable implementation of a Lean System. It is necessary to study the connection between Lean practices and Leadership as an approach for implementation of Lean in indirect areas. This chapter presents an historical overview and discussion on the topics, highlighting advantages and disadvantages.

2.1 Lean Production

This section briefly introduces some production paradigms and personalities relevant for the Lean Production development.

2.1.1 Origins

As one of the major drive forces of the major economies, manufacturing plays a significant role. Only in Europe, approximately 70 million people work directly or indirectly for the industrial sector. It is therefore a crucial economic area which creates value added through the transformation of material into products (Westkämper, 2014).

Manufacturing is no longer than two centuries old but already evolved through several paradigms. The most predominant ones are: Craftmanship, Mass Production, Lean Production, Mass Customisation and Global Manufacturing (Mourtizis & Doukas, 2014). This evolution was normally triggered by crises in which companies fail to adapt to new environmental factors or even innovate. For this reason, organizations that do not overcome these crises through their transformation, are susceptible to failure (Doll & Vonderembse, 1991).

Manufacturing started with craft production which relies on skilled craftsmanship. Its focus is to deliver high quality products to fulfil customer demands. Usually, this method of production is performed by skilled workers, manually, using hand tools. The skills were passed through generations of craftsmen to apprentices, so the products were built in small machine shops. Each product is created separately, therefore workers not only had to do bodywork but also assemble the products. Consequently, products have low reliability and production volume is low while the costs are high (Mourtizis & Doukas, 2014).

It was not until the creation of interchangeable parts that the transformation of craft production began. Parts started to be created in batches in a way that it was possible to assemble any part into an assembled product. The era of mechanization and division of labour had just started.

2.1.1.1 Motion-time studies

In the beginning of the 20th century, Frederick Winslow Taylor started to develop some studies and practical work in the improvement of operations. Later, he continued the study on a broader level up to the management. He is therefore considered as one of the pioneers in the Management field and responsible for its entitlement as a science (Turan, 2015).

His studies were compiled in a book, published in 1911, *Principles of Scientific Management*, where he claims that there is one best way to perform tasks and the production efficiency can be attained through the rationalization of work (Vinet & Zhedanov, 2005).

The motivation for his work were the major issues of industry he found during his research: systematic disruption from workers who reduced by a third the production rate; the lack of knowledge, from managers, of the work tasks and lack of working methods (Taylor, 1911).

At that time, the payment system was performed by parts or tasks. While managers sought to increase their profit by establishing the price per hour, the workers tried to reduce as much as possible the production flow of the machines in order to balance the price per part. Due to this, with the support of his assistants, Taylor studied all the production issues in detail, analysing all the movements of the workers, by measuring and dividing them, and then allocating a defined time for each task (Vinet & Zhedanov, 2005).

He then argues that the main purpose of management is to provide the maximum prosperity not only for the employer but also for the employee. In order to do this in the long term, the profit is not the single factor for a company prosperity but also depends on the development of all the units of the business to their maximum of excellence (Turan, 2015).

Contrarily to common belief, these interests are not opposite and are, in fact, the same: scientific management explains that a lifelong well fare of a company is not possible without the well fare of the employees and vice versa. Hence, it is possible to provide the employee what he really expects, higher wages, and the same for the employer which is lower production costs (Blake & Moseley, 2010).

Taylor presents the roles and responsibilities of managers as being the four principles of scientific management:

1. Development of a science for each element of a job (though examination and test) instead of the rule-of-thumb method.
2. Scientific selection of workers, giving training and preparation to improve their work.
3. Cooperation with employees to guarantee the fulfilment of the work according to the principles of the science previously advanced.
4. Equal distribution of work and responsibilities between management and employees (Taylor, 1911).

Taking these principles into account, is noticeable that Taylor prioritizes the employees as they are of paramount importance for the productivity of organizations.

However, he still warns managers about the implementation of rapid changes to introduce these new methods and habits to people. The changing process requires discovering and adapting the way to transform the attitude of managers and workers otherwise it would hinder the successful execution of the new system (Blake & Moseley, 2010).

Taylorism philosophy rapidly inspired numerous peers in industrial management with worldwide repercussions and it is still recognized up to this day.

2.1.1.2 Fatigue study

As Taylor begins studying and developing scientific management, another engineer, Frank Gilbreth, starts following his work. Together with his wife, Lilian Gilbreth, who is considered the "Mother of Industrial Engineering", engaged in the pursuit to find the "best way" to perform work tasks (Tietjen, 2020). Gilbreth soon discovered that workers to whom they have set a time standard for a task, were not performing them by using the best methods. So, he studied workers' movements and tools, complementing Taylor's work.

He was the pioneer of time and motion studies as a method for the rationalization of work providing comprehensive documentation on motion processes. He believed that unnecessary, inefficient, and uncoordinated motions were the wastes that hindered productivity.

Other major contribution from his studies, is the connection of productivity with the human element: the individual impact on productivity due to physical environment and the development of workers to their full potential (Gibson et al., 2016).

2.1.1.3 Mass Production System

One of the most renowned personality of mass production and modern management is Henry Ford. He started as a mechanic and later in 1903, founded the Ford Motor Company (Nicholas, 2018). Ford's work was always linked to automobile industry and his first objective was to find a way to overcome the limitations of parts supplied due to their lack of reliability in terms of tolerances. Through the usage of interchangeable parts, he was able to produce almost identical cars. Moreover, he distrusted his material suppliers, demanding to produce all components in-house. As a consequence, the product quality increased while production costs were plummeting (Doll & Vonderembse, 1991).

It was only when the Model T was introduced that the assembly process was changed so that each worker performed only one task by moving from one car to another. Following Taylor's Scientific Management principles, Ford intensively divided and subdivided each operation of the work in his factories. However, due to the different pace between people, the production rate was dictated by the slowest worker (Watt, 2020).

To tackle this issue, Ford was inspired by slaughterhouses, where the meat is moved from each workstation instead of demanding the workers to move around, to create the *moving assembly line*. This change forced slower workers to keep the production rhythm defined by the line, as we can nowadays define as *takt time*. The combination of both technologies (interchangeable parts and moving production line) gave him productivity advantage and was known as Ford's *mass production system* (Nicholas, 2018).

The implementation of this new system resulted in lower production costs and allowed unskilled workers to perform repetitive, specific tasks in an efficient way. This pursue for minimum waste and human efforts by the systematic mechanization and simplification of operations, has led however, to a new cultural paradigm, designated some years later as *Fordism* (Tomac et al., 2019).

Despite the astonishing results in productivity and work performance, the company environment hindered information sharing such as suggestions or problems. Workers were easily replaced and felt estranged by the monotonous repetitive tasks.

Consequently, and in order to solve this issue, Ford increased the minimum wage and established the eight-hour shift in order to retain his employees. The outcome of these measures had also increased productivity which later on were implemented around the world so that the five-day working week is still the current practice (Valli, 2018).

2.1.1.4 Toyota Production System

To understand the source of Toyota Production System, first it is needed to go back to the origin of Toyota company. The Toyoda family had initially started in the textile industry during the nineteenth century. After inventing the automatic loom, Sakichi Toyoda founded the Toyoda Automatic Loom Works in 1926, which is still the parent firm of the group. The looms became so sophisticated that had a mechanism to automatically stop the machine when a thread broke, the first step for one of the pillars of TPS, *jidoka* (humanized automation) (Liker, 2004).

With the patents from this company, being aware of the upcoming technologies, he was able to convince and fund his son, Kiichiro Toyoda, to invest in the automotive business. A new division inside the company was created and Toyoda started to develop vehicle prototypes. The first vehicles to be produced were simple trucks but the quality was poor, and the technology used was archaic. Later in 1937, the Toyota Motor Corporation was established, based on Sakichi's philosophy and management principles (Holweg, 2007).

Meanwhile, World War II struck and as Japan lost, it was occupied by Americans. However concerned Kiichiro was that the occupation would cease Toyota's production, there was still the need to build trucks and the orders continued to be placed. Despite the apparent positive perspective for the company, Japan post war situation presented many obstacles for economic upturn:

1) The cost of raw material was high due to the strong dependence on importation of goods since Japan lacks natural resources.
2) Salaries were too rigid due to the imposition by Americans causing uncontrollable inflation.
3) Internal demand was lower than in other western countries due to the economic crisis provoked by the war (Chiarini, 2013).

Toyota struggled in debt so, in order to avoid bankruptcy, they started to implement cost saving strategies such as salary reduction. In the midst of the financial turmoil, Kiichiro took the responsibility and decided to resign. His cousin, Eiji Toyoda, assumed the presidency of Toyota Motor Manufacturing, leading the company during the most critical years.

Hence, Eiji decided to study U.S. plants with the aim to improve Toyota's manufacturing processes. In 1950, he and his managers spent 3 months studying diverse plants, including Ford's River Rouge complex. Despite their high expectations, it came as a surprise to realize that the production system had many flaws and was not possible to implement in Japan. Mass production required a lot of equipment and technology that Toyota was not able to afford due to capital shortage. On the other hand, in the

United States only one model of car could be produced in each location, a strategy that Toyota wanted to change: to produce a wider range of cars in the same plant (Nicholas, 2018).

After returning, Eiji reached his plant manager, Taiichi Ohno, to assign him the task of improving Toyota's manufacturing system. Ohno studied and even did further visits to U.S. plants, reaching to the conclusion that they needed a flexible and more efficient system than traditional mass production in order to fulfil customer demands. Along with others, through a series of iterations of learning by doing, he developed the prototype of Lean Manufacturing: the Toyota Production System (TPS) (Liker, 2004).

The TPS is often represented as a diagram of "TPS house" (Figure 1) because it is a structural system and if any of the links is weaker; it will destabilize the whole system.

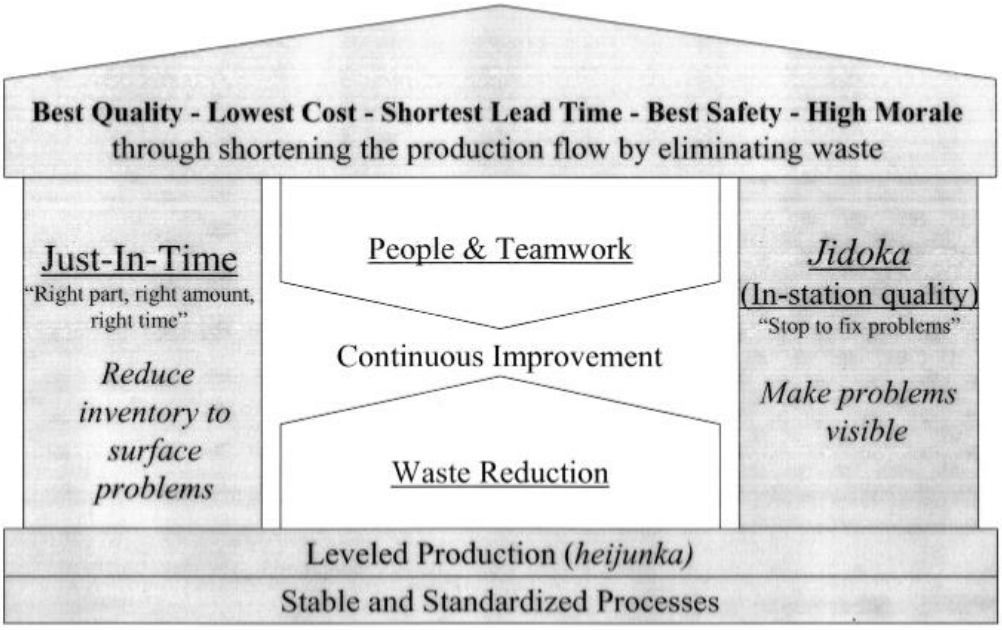


Figure 1 - TPS House
(Liker & Morgan, 2006)

The TPS house has diverse representations but the main aspects are represented above. The two pillars that are the most characteristic of TPS are: *just-in-time* and *jidoka*. Just-in-time is claimed to be a concept created by Kiichiro who considered manufacturing to be more productive if all the components needed for production are near so they can be used just in time by their user. It means that the material should flow at the right pace, by removing the inventory that causes buffer in operations. The ideal scenario is to produce one piece at a time (one-piece flow) according to the customer demand (*takt time*). Therefore, the use of smaller lot sizes was a requirement and the changeover time to be reduced, which is even considered as an essential method for the achievement of JIT. Shiego Shingo developed the Single-Minute

Exchange of Dies (SMED) that consists in techniques to perform the changeover in a significantly lower amount of time (Shingo, 1985).

Whenever a system requires an interruption, for example in the case of batches, the supermarket concept is used so that the next process can have the right quantity of parts at the time it is needed. After removing the parts, the earlier process has to replenish the same quantities that were taken. The method that binds these operations is through instructions generally contained in a piece of paper, named *Kanban*. This paper carries the information about pickup, transfer or produce parts. At certain point of the time, the methodology was also extended to the suppliers (Ohno, 1988).

The other pillar, *jidoka*, consists of automatically stop the machine when a possible defect or deviation from standard is detected. From there, an *andon* is activated in a form of lights or sound to call for help until a team leader comes.

There are many variations for the foundation elements which include stable and standardized processes and levelled production (*heijunka*). The goal is to provide stability to the processes by levelling the orders and the workload. By doing this, we can promote standardization and ensure there is the adequate inventory to compensate the inherent instability of the system (Liker & Morgan, 2006).

On the opposite side, the roof, the goals of TPS can be seen: best quality, lowest cost, shortest lead-time, best safety and high morale.

Finally, at the center of the house is people and teamwork as they are the main contribution for continuous improvement (*kaizen*). Ohno argued that the assembly workers could have better performance in some tasks than the so-called specialists because they were more familiarized with the workstations. Hence, he organized employees into teams with certain responsibilities and promoting them to gather for the discussion of problems and find improvements. People should have the tools to solve problems, and so Toyota introduced the questioning of why five times. All of this culminates into a less acknowledged lean principle: respect for people. This refers to respecting people's abilities in a way that training, coaching and personal development is promoted (Nicholas, 2018).

Other concept that is visible in the centre of the TPS House is the waste reduction. Toyota Production System has the aim to systematically search for waste that becomes unnoticed due to daily work.

Operations can be classified as those with value added (VA) and those with no value. Operations that add value are the ones in which the raw materials are transformed into parts or products, meaning that they are processed through activities that increase their value. The non- value adding operations can be

described as activities that do not add value but are necessary for the existing processes. Besides operations, there are activities that do not have any contribution for them and only add costs and time that are classified as waste. Furthermore, the percentage of value added work in process operations is often lower than expected therefore to improve the processes it is needed to eliminate the waste (Shingo, 1989).

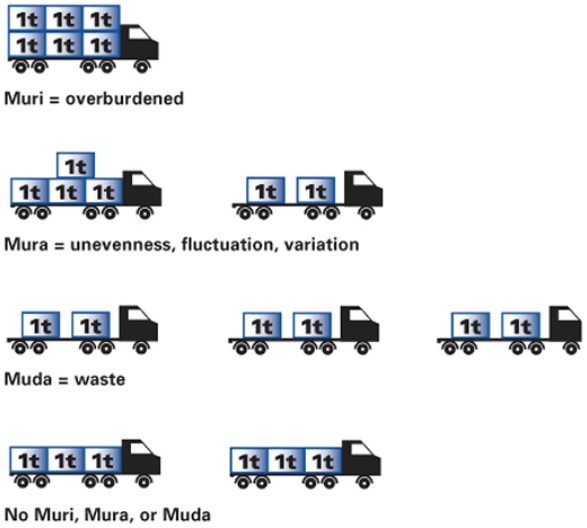


Figure 2 - The three types of waste: Muri, Mura and Muda (Southworth, 2010)

In order to cover the essence of waste, Ohno defined three types (known as 3M): Mura (unevenness), Muri (overburden) and Muda (waste) (Ohno, 1988).

Mura means unevenness and irregularity, referring to production volume. It can be related to variations on scheduling or uneven workload and pace of work. It is mainly caused by batch production, especially big batches, which generates buffer stock. Although this type of waste is commonly seen in companies, management teams tend to ignore it. The rapid increase and decrease in production volume, constant changes in the schedules require more capacity from the resources, not only reducing the efficiency of work but also generating longer periods of idle time (Pienkowski, 2014).

Muri implies overburden, beyond people or machine capacity, or unreasonableness. It can also mean the opposite, i.e., underutilization of resources. Muri can be a result of lack of standardized work, poor organization of the workplace or even by Mura (Southworth, 2010).

The last concept is Muda, which means waste, futility, or uselessness, being the contrary of value-added. This refers to activities that are unnecessary in the customer's point of view. The main objective of TPS is, therefore, to reduce the waste (Muda) that was categorized by Ohno into seven categories:

- Overproduction: produce more than what is necessary or not requested by the costumer resulting in excess inventory.
- Waiting: in another way, means having nothing to do. Operators that need to stand idle during an automated process in a machine or just waiting to work due to lack of parts supply, delays or equipment failure.
- Transportation: unnecessary movement of material or products such as transferring work in process (WIP) on a long distance or moving parts to storage.
- Overprocessing: perform unnecessary steps during processing due to weak product design or inefficient tooling or even when trying to achieve a greater quality than customer demands.
- Inventory: create stock of WIP or finished goods which results in other types of waste and higher costs. Having more inventory also disguises other problems such as production unevenness (Mura) and late delivery schedules.
- Movement: any motion that does not add value to the product like searching for material or documents.
- Defects: producing defective products or need to correct defective parts. Every task that is related to scrap, repair, or replacement (Liker, 2004; Ohno, 1988; Pienkowski, 2014).

In summary, TPS endorses the improvement of operating efficiency by producing only what is needed, so that the extra manpower can be released. Despite the suspicion that TPS means laying off employees, the main idea is to identify and eliminate wasteful and meaningless jobs which in turn will reinforce the value of work for the employees (Ohno, 1988).

2.1.2 Timeline of concepts

Until the beginning of the 70s, the economic growth was steady in the industrialized countries followed by the increasing earnings of the population. However, the mass production saturation and the first oil crisis in 1973, that caused the increase of the prices for fossil fuels, broke the concept of unlimited development. Consequently, the Japanese industry was able to remain competitive because they had already implemented the methods for waste elimination. It was only after this crisis, that industries worldwide started to have interest in new industrial philosophies such as Lean Production (Chiarini, 2013).

Simultaneously, TPS was only officially documented during that decade and the first paper available in English was published in 1977, in which contains the first comparison of productivity between Japanese and western countries plants (Sugimori et al., 1977). Although these initial papers already presented

Toyota advantage in terms of productivity, the subject had no further developments from academics until some years later.

The term "Lean" was firstly used by a MIT (Massachusetts Institute of Technology) researcher, John Krafcik, to describe the Toyota Production System, however, it was only made popular after the publication of "The Machine that Changed the World" (Samuel et al., 2015).

In Figure 3 is the representation of the publications and main events that contributed to the Lean Manufacturing concept.

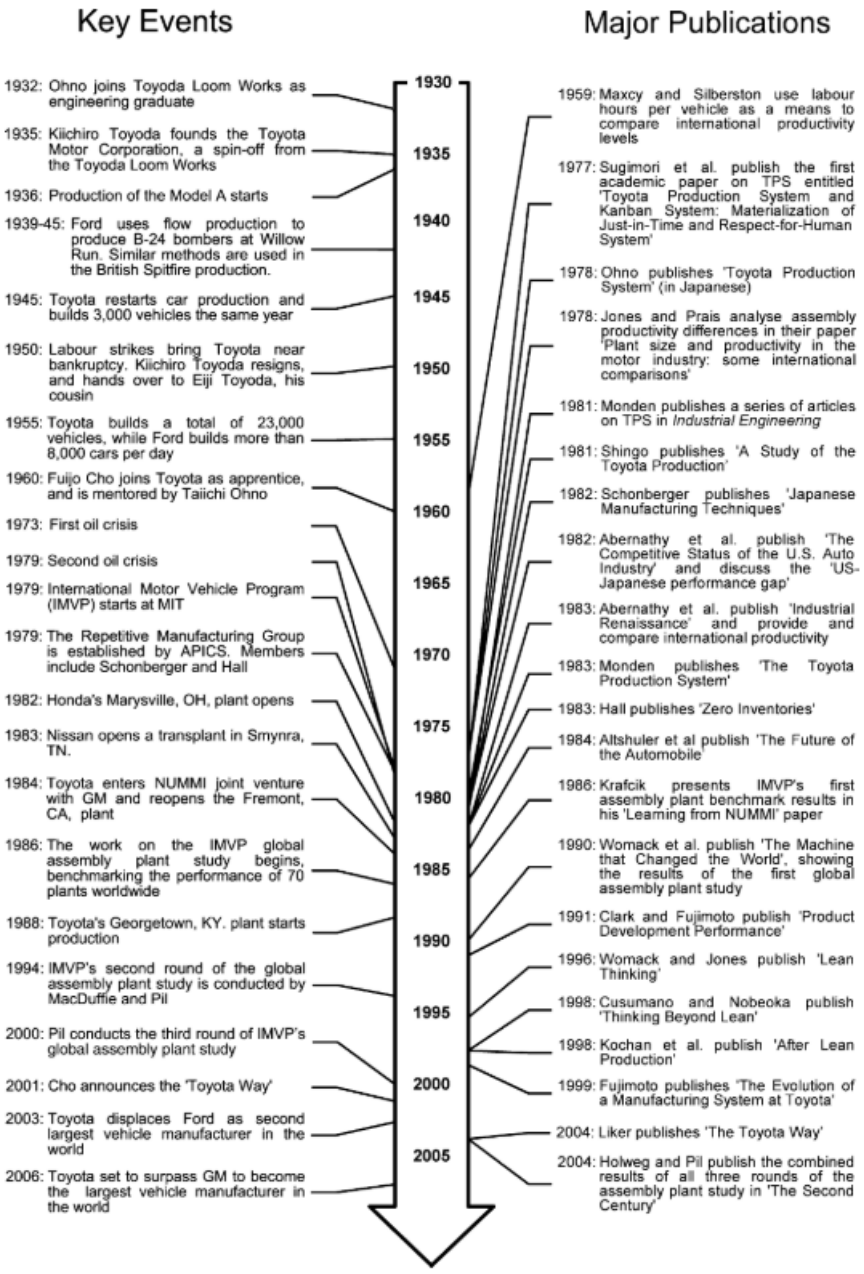


Figure 3 - Timeline of the concepts that contributed to Lean Manufacturing (Holweg, 2007)

The publication of the book from *Womack et. al.* (1990) triggered the research for Lean practices implementation and expanded it to other manufacturing sectors than automotive. In fact, even after so many publications, some authors argue that there is no clear definition of Lean since there is no consensus about it. Despite this, the different interpretations of Lean continue to emerge over the time.

Hence, Lean can be defined as a production paradigm, philosophy, or system, depending on the feature that we look at. From a production and management philosophy point of view, Lean stands for simplicity, organization, and agility. On the other hand, it also comprises a set of methods for production as well as a system for control and planning (Esmaeilian et al., 2016; Nicholas, 2018).

The implementation of Lean in organizations pursues a similar progression between each other, i.e., it initially starts by shop-floor improvements and progressively extends to the whole organization by applying the principles of Lean. For that reason, nowadays Lean is also seen as a management philosophy and sometimes is indeed renamed as business or operational excellence model. The priority is no longer the Lean methods and tools but to establish leadership and cultural changes in such a way that employees are empowered to be involved in the transformation and everyone is responsible for the implementation of improvements (Nicholas, 2018).

Even though Lean has evolved, it will certainly continue to experience continuous improvements to adjust to new needs and different perspectives.

2.1.3 Lean Thinking

After the success of "The machine that changed the world", Womack and Jones published the sequel "Lean Thinking" as a guide for organizations to implement Lean. The book aims to present and explain the principles of Lean Thinking and how managers can bind them together so that are maintained in a steady form. It also describes some case studies and plans of action to become leanness (Samuel et al., 2015).

Lean is considered as is a complex philosophy, which involves the complete enterprise including the value chain from supplier to customer, and for that reason it can become difficult to implement its practices. Only a set of methods and practices integrated with the philosophy into a coherent system that intents to eliminate waste and maximize the flow can help to implement it (Mathaisel & Comm, 2000; Smith A, 2015).

The authors presented then the five principles of Lean Thinking:

- Specify value: value is the most critical topic of Lean Thinking, as it is defined by the customer. It can be referred as the product or service that meets the customer demands. The main message is to rethink value from the customer perspective with specific capabilities that the customer is willing to pay at a specific time (Koskela, 2004).
- Identify the value stream: The value stream is the series of specific tasks that are required in a production system to make a product. It includes *problem-solving task* through searching and working in solutions for problems found since the product concept until production launch, *information management task* that works with the organization of information since the order taking until the delivery to the customer and physical transformation task that engages with raw material acquisition and the transformation process of those into finished products until delivered to the customer. This principle is rarely used in organizations but it allows to identify all the activities required to create a product and determine which of them add value and, in consequence, exposes the waste which will then help to eliminate it (Womack & Jones, 1996).
- Flow: After identifying value and have the value stream mapped with wasteful activities eliminated, it is needed to make the remaining steps flow. It consists of the method of one-piece flow where components go from a station to another at a constant pace without interruptions (Smith A, 2015).
- Pull: The pull principle is based on the idea of letting the customer pull the product from the manufacturer instead of pushing products, sometimes even unwanted, to the customers. It requires to move the production parts from one workstation to another only when they are requested upstream (Haque & James-Moore, 2004).
- Perfection: The initial principles dawns to the enterprise that the process of reducing effort, time, space, cost, and mistakes never ends. Therefore, companies constantly seek new opportunities for improvement, striving for perfection. Hence, the culture of continuous improvement is induced in the organization (Garnett et al., 1998).

The Lean Thinking principles guide the focus on customers and core competencies which result in creation of value. These principles help management to transform organization and create the sense of continuous waste elimination.

2.1.4 Lean Office

Lean Office is normally included inside Lean Services and refers to the application of Lean Thinking principles in administrative processes. The objective is the same as Lean Production: optimize the flow

of the services and information and minimize waste (Locher, 2011). Although this objective is similar, the task is not as easy as it may seem since the processes are not as visible as in Lean Production (Monteiro et al., 2017).

Taking into account that the costs associated to administrative functions represent 60% to 80% from the total to satisfy a customer demand, it should have a higher focus to implement optimizations (Tapping & Shuker, 2003). On the other hand, administrative areas are characterized by having more variations in their processes in comparison with production either by multitasking, unpredictable demands and sometimes creativity needed (Bicheno, 2008; Locher, 2011).

The high amount of information that is generated and processed consists in another challenge for Lean Office, especially for the current information age. In the modern office the work relies on heavy computer use with a set of applications generating and consuming information. Therefore, simply applying tools such as 5S does not relate to a tidy workplace (Gonzalez-Rivas & Larsson, 2011).

Moreover, in the era of Industry 4.0, which combines technology solutions such as Internet of Things and Cloud Computing that generate data to improve decisions and profit, data is becoming more important for manufacturing. These data are set to be further analysed through the identification of patterns and relationships to increase value (Alieva & von Haartman, 2020).

All these characteristics have generated a new concept of digital waste that refers to unnecessary data transfer and storage. Romero et al., 2018 define that digital waste is any non-value-added digital activity, from losing digital opportunities to over-use of digital capabilities.

As a consequence, from the seven wastes seen in Section 2.1.1.4, more wastes can be added to adapt to Lean Services (Bicheno, 2008):

- Incorrect inventory: unable to provide the correct information/service required.
- Delay: time the customer is waiting for a service that was previously promised.
- Unclear communication: wastes that result from confusion over an information, seeking clarification and searching for the right information.
- Opportunity lost: failure to retain or win new customers and strengthen relationships
- Duplication: repeat and copy the same information across the same organization
- Unnecessary movement: excessive movements from employees
- Errors: errors during information exchange and service defects.

However, other wastes were identified specifically for Lean Office. Some of them are the root cause of others and they are not simply eliminated by establishing rules but rather by going to the "Gemba", it represents going to "the place", i.e., operational process walks. The 14 wastes are the following:

- Sorting and Searching: search for information or documents that are not in the right place
- Inappropriate measurement: as measures influence the behaviour, the misuse can lead to deceiving the system
- Underload
- Overload
- Inappropriate prioritising: prioritization of tasks should follow a categorization, for example, according to the Eisenhower Matrix. It categorizes topics into urgent or urgent as there is the tendency to perform firs the activities that are urgent but not important.
- Interference: disturbances caused by phone calls or e-mails that may affect the priorities
- Inappropriate frequency: activities that are performed with more frequency than necessary such as meetings, reports, or measures
- Start up and End off: situation in which the work is not at an appropriate productivity level, especially at the start or the end
- Mistakes, errors or lack of appropriate knowledge
- Misunderstanding or communication errors
- Sub-optimization: improvements made to individual parts may turn the whole system worse than before
- Waiting: waiting for decisions or information
- Inappropriate presence: attending activities (e.g., meetings) without any productive purpose or that is taking more time than expected. An effective meeting can be described as a meeting where only relevant information and issues are discussed according to the feedback and actions (Gonzalez-Rivas & Larsson, 2011).
- Inappropriate trade-off

Some of these are adaptations from the seven wastes identified by Ohno in TPS that are considered as universal in all organizations. It is usually added one more waste from the original seven, which results in eight wastes that are currently considered (Nicholas, 2018). In the following table (Table 1) it is presented the comparison of the eight wastes in Lean Production and Lean Office (Chiarini, 2013; Locher, 2011; Nicholas, 2018).

Table 1 - Comparison of the Wastes between Lean Production and Lean Office

Waste	*Lean Production*	*Lean office*
Defects	Quality issues on the product or materials	Inaccurate or missing information
Overproduction	Producing when it is not needed	Processing more information than needed
Waiting	Waiting for parts, materials or equipment repair	Waiting for information that is not being worked
Transportation	Moving items to other location in order to be processed	Excessive or unnecessary movement of information/documents
Inventory	Product or material that is being stored	Excessive quantity of information archived and even duplicated
Motion	Movements of workers that do not add value	Unnecessary movement of people (e.g. searching for information)
Over-processing	Process activities that could be unnecessary to the product	Time consuming processes that can be unnecessary
Non-utilized human talent	-	Not fully use people's skills and abilities

These wastes are even more problematic at the office because they bring additional toxic effects to people such as physical and emotional fatigue, increased frustration and stress, decreased self-worth and indecisiveness (Tapping & Shuker, 2003).

The first step into the elimination of these wastes is to people acknowledge them. A further step could be made through the estimation or quantification in order to have more details and work on possible solutions (Bicheno, 2008).

2.1.5 Benefits and barriers of Lean implementation

Innumerable studies address many advantages of Lean implementation: from case studies, literature, and surveys. Lean can be implemented in any business sector at any location in the world (Amaro et al., 2019). Melton (2005) has compiled the benefits of Lean:

- Decreased Lead-time
- Reduced inventory
- Reduced process waste
- Improved knowledge management as there is more understanding of all processes within the Value Stream
- More robust processes (less rework)
- Financial savings due to the increased speed of response and decreased operating costs

Simultaneously, other studies reviews from several articles refer other advantages such as (Amaro et al., 2019):

- Efficiency improvement

- Increased customer satisfaction
- Better communication
- Higher productivity
- Higher team morale

As a result, Lean implementation has a positive impact on a financial, cultural and organizational point of view and, if applied correctly, in the ability of any organization to learn (Emiliani, 1998; Melton, 2005).

Despite the benefits presented above, some studies report that those benefits increase as programs are implemented comprehensibly. This can be supported by the theory of organizational inertia which states that an organization has the tendency to continue the same trajectory and the resistance to change is higher at the beginning of a transformation (Netland & Ferdows, 2016).

Netland and Ferdows (2016) found that the Lean implementation programs follow an S-curve shape that is supported by the pattern of spread of other events as spread of innovations within society, infectious diseases and others. Lean implementation usually starts at pilot areas which are more likely to present quick improvements and are less resistance to change. Then it evolves rapidly to other areas that are willing to adopt the systematic until it reaches a point where there are fewer beginners so it starts to slow down. To understand this theory, a graphical representation was created as it is presented in Figure 4.

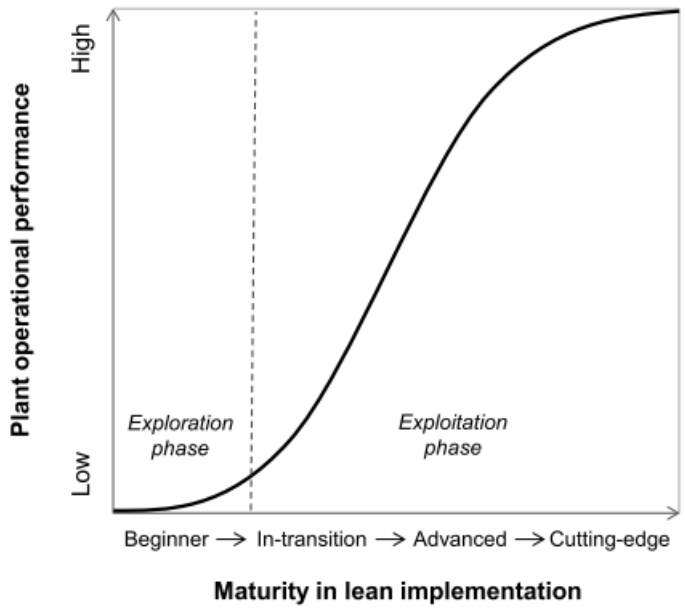


Figure 4 - The S-curve theory of Lean implementation (Netland & Ferdows, 2016)

The axes represent the level of maturity that the organization has in relation with its operational performance. This is also related to the phase of transformation (exploration to exploitation). This theory then, suggests that at the beginning (in the exploration phase), the operation performance does not evolve

as quickly as during exploitation phase. After the performance improvement in the middle, it starts presenting a slower rate.

This theory helps to understand why applying the same strategy to different plants in different locations may result in different outcomes of the program. Therefore, programs should be established carefully as, for example, setting ambitious targets to locations with a low maturity level may discourage and demotivate the participants. On the other hand, to maintain the higher maturity level requires top management support which, if it is not the case, can send the wrong message and result in coming back to a decreased performance (Netland & Ferdows, 2016).

As there is no ideal approach that can be generally applied to every company, there are different factors that can either be enablers or barriers to the implementation journey (Amaro et al., 2019). There are some barriers that are commonly referred by different authors (Amaro et al., 2021; Bakås et al., 2011; Emiliani, 1998; Lodgaard et al., 2016; Melton, 2005):

- Lack of organizational culture
- Lack of leadership and top management commitment
- Resistance to change
- Misunderstanding of the concept
- Lack of resources required for the implementation
- Lack of training and skills
- Use models that are not adapted to the characteristics of the enterprise
- Lack of Lean behaviours, i.e., behaviours that add or create value

The resistance to change is considered by some authors as the main inhibitor to Lean implementation as it presents a great challenge of the way people work. Therefore, the management support should be strong in order to promote continuous improvement and employees must believe that the change is needed. Coch and French (1948) studied the phenomenon of resistance to change through experiments in a textile industry. They concluded that resistance to change is a motivational issue that can be tackled by using group meetings where management communicates the need to change and encourages employees to participate. Furthermore, the success of the change is directly proportional to the amount of the participation (Coch & French, 1948).

Hence, to implement a Lean program in different locations worldwide the model must be adapted to the context of the organization and the tracking of the maturity of the implementation is essential to avoid any inhibitors (Netland & Ferdows, 2016).

2.2 Leadership

As competitiveness continues to grow in the current market, companies need to constantly adapt and make organizational changes. Since more focus has been given to this topic, it has been recognized that leadership is a main driver for successful organizational change (Lirong & Minxin, 2008).

Leadership is not easily defined because researchers adjust the definition according to their own perspectives and interest on the different aspects. Some even argue that the number of definitions of leadership is proportional to the number of authors that tried to define it. One of the most famous definition is from House et al. (1999): "leadership is the ability of an individual to influence, motivate, and enable others to contribute toward the effectiveness and success of the organization".

Most of those leadership definitions consider that it is a social process where influence is applied to other people to promote relationships and activities in an organization. The differences remain in the influencer, its purpose, the way this influence is exerted and the outcome. For that reason, there are also several leadership variables that have impact on the outcome (Fischer et al., 2017; Gary Yukl, 2013).

Leadership roles and behaviours are also important for innovation and R&D through the generation of new ideas, project leading and coaching. It was found that behaviours such as supportiveness, task orientation and technological skill contribute to scientific knowledge, especially when scientists are not so experienced (Elkins & Keller, 2003).

Every leadership behaviour reflects into a leadership style that leads to a certain result. During a process of change inside an organization, leaders should guide their vision to ensure its progress (Lirong & Minxin, 2008).

2.2.1 Situational Leadership

The most worldwide used theory in the business sector is the Situational Leadership Theory. Developed by Hershey and Blanchard (1982), it defines that the most effective leadership style is specific for the situation. So, if the conditions change, the leadership style may differ from the previous one (Hambleton & Gumpert, 1982).

The two styles can be defined as:

- Task/directive behaviour – the extent to which a leader defines the roles of their team members by explaining what tasks has to do, where, how and when it has to be concluded.

- Relationship/supportive behaviour – the extent to which a leader maintains a personal relationship with their team members by open dialogue and delegation of responsibilities (Blanchard & Hersey, 1981).

These behaviours (task and relationship) are taken from observed behaviour so, Situational Leadership represents how people behave. The model is represented in Figure 5.

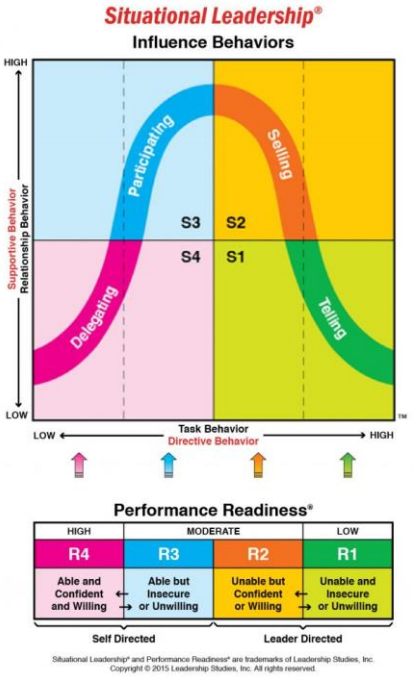


Figure 5 - Situational Leadership Model (Centre of Leadership, 2021)

From those dimensions, four quadrants of the leadership styles are represented. The quadrant to which most of the responses correspond, is the dominant leadership style of a person, whereas the supporting style is the one used occasionally. The four leaderships styles correspond to:

- S1 or Directing/telling – is characterized by high task and low relationship behaviour. The leader has close supervision to identify progress of the tasks and the communication is usually from the leader to the team member. This style is recommended to followers with lower experience or skills for the task and, at the same time, are insecure or demotivated.
- S2 or Coaching/selling – is an approach with high task and high relationship behaviour. The leader still decides the tasks that the team must do but it also has a component of explaining the reason for its importance. This style aligns with members with less experience but with confidence and motivation to proceed.

- S3 or Participating/collaborating – is considerably different from the previous ones as it is high on relationship but low on task behaviour. In this case, the follower is capable of performing the task by himself but does not have the confidence or motivation to do it.
- S4 or Delegating/Laissez-faire – this style is characterized by being low in both task and relationship behaviour. It aligns with embers that have more experience and a high level of motivation so, the communication is usually from the follower to the leader.

Therefore, according to the occasion, it is recommended for leaders to adjust their leadership style. The leader is then a social and emotional support for their team as necessary (Centre of Leadership, 2021; Hersey & Blanchard, 1982).

2.2.2 Transformational Leadership

Transformational leadership is one of the most relevant systems that has impact on organizational changes. It is considered as an appropriate leadership style for encouraging employees to engage in the change process. Through the articulation of the vision of leaders, its acceptance by people and harmonization of people's self-interests with the vision it has positive effect on organizational changes (Lirong & Minxin, 2008).

Transformational leadership encourages people to view problems from different perspectives, it consists of four dimensions:

- Idealized influence: the leaders act as a role model and followers have respect for them;
- Inspirational motivation: leaders communicate and represent an inspirational vision;
- Intellectual stimulation: leaders challenge their team members to solve problems in a different way and listen to their ideas;
- Individualized consideration: leaders provide support and encouragement for e.g., through coaching, to followers according to their individual needs (Akkaya, 2020).

According to research, this leadership style is set to increase leadership effectiveness due to its transformational behaviours. For creativity and innovation, a transformational leader is beneficial because they contribute to the inspiration and motivation of people and boost to think differently and take risks. Therefore, these behaviours are needed during the early stage of a project to create a vision and promote intellectual stimulation (Elkins & Keller, 2003; Lee et al., 2020).

2.2.3 Visionary Leadership

Visionary leadership is a form of transformational leadership that provides opportunities to improve the capacity of an organization to fulfil its requirements (Taylor et al., 2014).

Leaders are expected to support people to be involved in their work in such a way that employees feel motivated, committed to future, and understand the future vision. Visionary leadership can be descried as a dynamic model where an idea is repeated into a vision and then through emotion and action it is concretized (Westley & Mintzberg, 1989).

Visionary leaders use vision as a basis for their work, by providing purpose and meaning to work. They focus on employee engagement because motivation and commitment of people is the way to get effective results. For that reason, communication plays a major role because people need a direction in order to act. Therefore, visionary leaders have the capacity to express the vision and mission to their team and inspire and empower them to participate in organizational changes. Hence, visionary leadership creates cohesion, trust, motivation and commitment in organizations (Cheema et al., 2015; Taylor et al., 2014).

2.3 Lean Leadership

Lean has been used in different manufacturing companies, in numerous industry sectors, trying to imitate Toyota but only a few of them had success (Spear & Bowen, 1999). For example, in UK only 10% had implemented a successful Lean system (Alnajem & Dhakal, 2012). In fact, there are several different perspectives of Lean from researchers which demonstrates that the systematic can't simply be copied.

There are other variables that play an important role in a Lean journey. Lean implementation requires effective leadership to prepare and sustain the change (Aij & Teunissen, 2017). The Lean leader needs to encourage personal development, to inspire and support the employees so they can improve and overcome obstacles (Trenkner, 2016).

Lean leadership appears to be the missing link to become a continuous improvement enterprise. It is considered that the creation of an environment that encourages success by senior management is responsible for 80% of Lean implementation (Aij & Rapsaniotis, 2017). Lean leadership can be defined as a systematic to sustainably implement Lean with the cooperation of leaders and employees to strive for perfection (Dombrowski & Mielke, 2013). For that reason, Lean Leadership is recognised as a type of transformational leadership (Aij & Rapsaniotis, 2017). There are several approaches from different authors to describe the Lean Leadership System, however, only a few of them are presented in this dissertation.

2.3.1 The Toyota Way Model

As Toyota has become a worldwide success of operational excellence through Lean Manufacturing, several other companies tried to apply the tools and train their employees. However, this journey is more complex, it is a learning process and cultural transformation. This requires then to make deeper reflection and continually learn (Liker & Morgan, 2006).

Compiling 20 years of studies of Toyota and their followers, Liker (2004) describes in his book the principles that are behind the "Toyota Way". These principles are the "DNA" of the company and were the base of TPS. He then created the concept of Toyota Way model (4P) by dividing the principles into four categories, as a pyramid model, as presented in Figure 6 (Gao & Low, 2014).

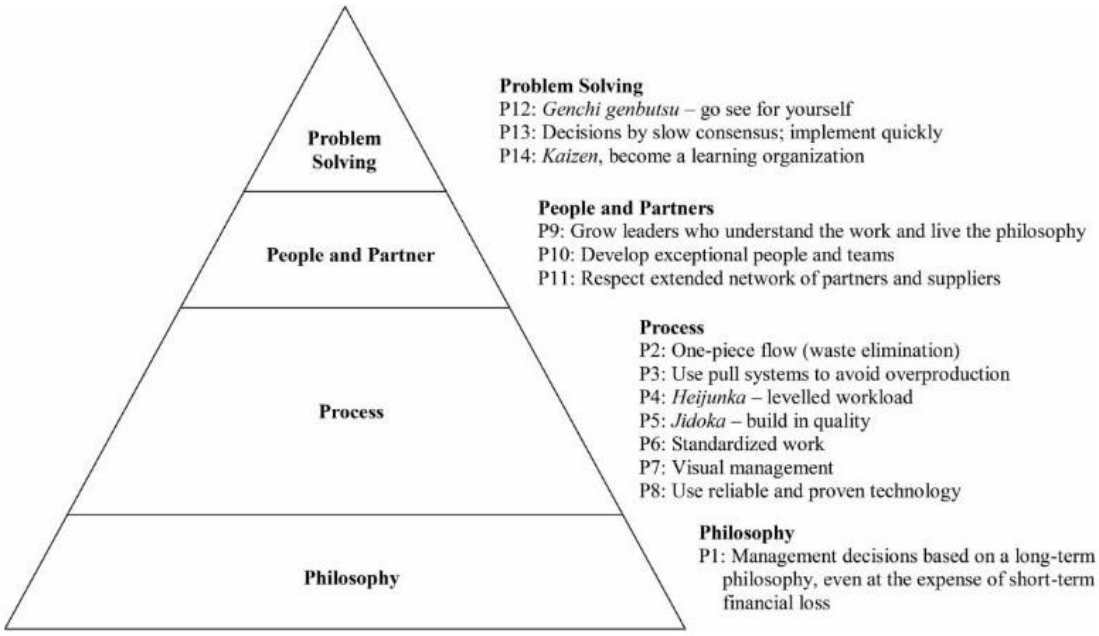


Figure 6 - The Toyota Way Model

(Liker, 2004)

The Toyota Way Model consists in four levels that are required for the implementation of a sustainable Lean System: philosophy (long-term thinking), process (eliminate waste), people and partner (respect, challenge, and growth) and problem solving (continuous improvement and learning). Most companies are typically interested at the Process level although without the other levels the improvements made will not have the cultural background to sustain them within the organization (Liker, 2004).

The base for the Lean System to become permanent it's the people by encouraging and support the involvement of employees. It is people dependent as employees identify problems, eliminate wastes and promote teamwork. The principles that define the Toyota Way are the following:

1. Base your management decisions on a long-term philosophy: the philosophical purpose is the base for the other principles and should bring the organization to the next level. It must be worked and aligned through the whole company as common target.
2. Create continuous process flow: processes must be redesigned and re-organized in order to achieve continuous flow.
3. Use "Pull" systems to avoid overproduction: customer establishes the production pace because the production process will deliver the right product at the right time in the correct quantities.
4. Level out the workload (*heijunka*): do not just eliminate waste but also eliminate the overburden to people and machines, work in levelling out the workload in all processes.
5. Build a culture of stopping to fix problems: set quality as one of the values of the organization and use available quality methods.
6. Standardized tasks are the foundation: use proven and stable methods to maintain the output of process and promote the standardization of good practices from individuals.
7. Use visual control so no problems are hidden: use and design simple visual indicators and systems to help people know the status according to the standards.
8. Use only reliable, thoroughly tested technology: use technology that is already proven and conduct trials before implementing new technologies into processes.
9. Grow leaders that thoroughly understand: grow leaders within the company that can be role models of the organization mission and vision.
10. Develop exceptional people and teams: create a strong culture that promotes training of employees, cross-functional teams and teamwork.
11. Respect your extended network of partners: respect partners and suppliers as an extension of the business and challenge them to grow.
12. Go and see for yourself: go and see things for yourself and solve problems at the source.
13. Make decisions slowly by consensus: take time to make decisions, considering all alternatives but once it is picked, act quickly.
14. Become a learning organization: use continuous improvement process (*kaizen*) to identify root causes and apply countermeasures. Use reflection (*hansei*) at milestones and at the end of the projects to identify weaknesses and define improvements.

An organization that applies these principles is set to be on the right path for a sustainable competitive advantage (Liker, 2004).

2.3.2 The Toyota Way to Lean Leadership

At Toyota, leaders need first to develop themselves before taking over the responsibility of developing a team in the Toyota Way. The approach is to create a challenging environment that allow leaders to evolve to inspire continuous improvement at every level.

Toyota envisages leadership as personal task, but it also occurs inside a system. Top management is expected to prioritize quality but also that all working groups find the root causes and deal with any quality issue. So, all leaders should share the same values and philosophy at the different levels of hierarchy (Trenkner, 2016).

Liker & Convis (2012) created a leadership model, presented in Figure 7, to illustrate the approach that Toyota has with leadership.

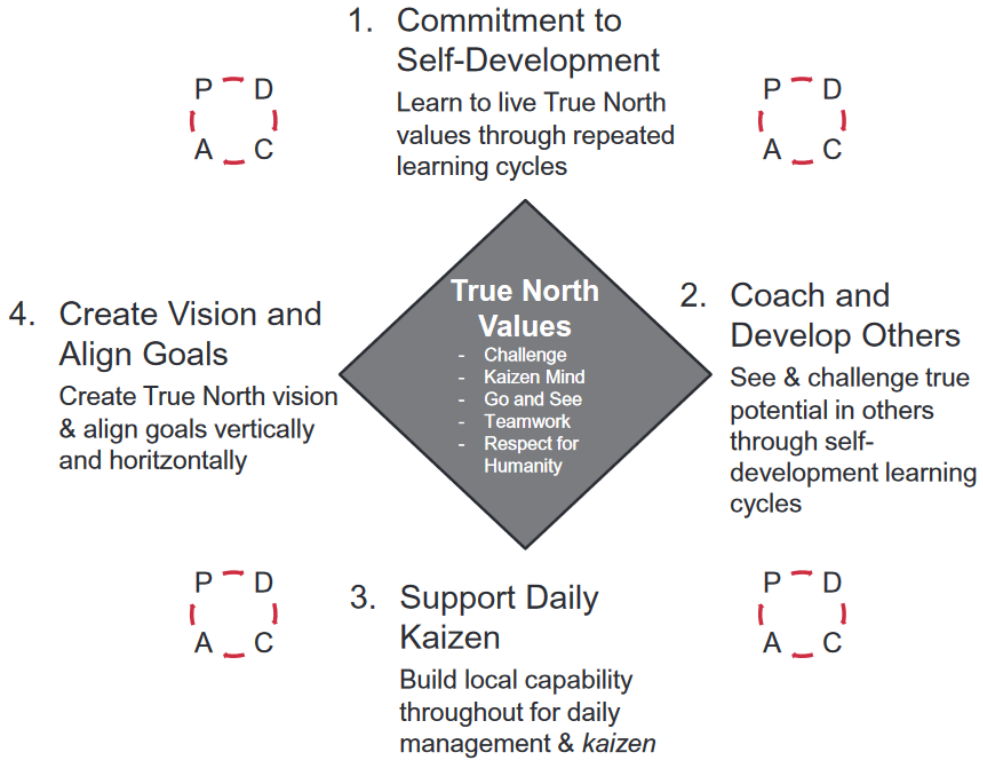


Figure 7 - Diamond Model of Lean Leadership Development (Liker & Convis, 2012)

At the centre of the model are represented the core values that define the Toyota Way (True North): spirit of challenge, *kaizen* mind, *genchi genbutsu* (go and see), teamwork and respect. The model is represented as cyclical which means that throughout the career of each person, the sequence is repeated many times. The four stages consist in:

1. Self-development: Potential leaders are distinguished by their eager to improve themselves and others. However, leaders do not do this by their own so they must be given the opportunity to find challenges and coaching at the right time.
2. Coach and develop others: Leaders are expected to coach and develop everyone in their team as they should be able to recognize strengths and weaknesses of their employees.
3. Support daily *Kaizen*: This stage starts to focus on institutional leadership so that teams keep focused on the True North. Leaders promote their team to maintain the standards and objectives not by forcing *Kaizen*, but empowering, inspiring, and coaching it bottom up.
4. Create vision and align goals: The last stage concerns the alignment of objectives and strategy from leaders of all hierarchy levels (*Hoshin Kanri*). This dynamism is difficult to understand as the processes are always being adjusted to attain the True North. Therefore, if not performed in the right way, could lead to opposite directions (Liker & Convis, 2012).

From this model, managers are accountable for the development of employees and the way of performing work with added value (Trenkner, 2016).

2.3.3 Principles of Lean Leadership

As there is no structure or consistent definition for Lean Leadership, Dombrowski (2013) compiled its principles from other studies. The five principles of Lean Leadership are represented in Figure 8.

Figure 8 - Principles of Lean Leadership (Dombrowski & Mielke, 2013)

The improvement culture is a fundamental principle that is often misunderstood as shop floor workers are not able to fix failures by themselves, management support is needed to sustain improvement activities throughout the company. As Lean Leadership requires new leadership skills, self-development

becomes important since some of those need to be learned. Using learning cycles as the PDCA (Plan-Do-Check-Act) and having a mentor are some of the approaches to reach self-development.

The development of others though qualification enables people to engage in continuous improvement. Since this qualification is performed day by day, companies use coaching approaches.

The fourth principle, Gemba, refers to go-to-gemba in which leaders should go to the shop floor and observe the processes and make decisions based on facts. The last principle (*Hoshin Kanri*) is sometimes also referred as target management. As already stated before, ensures that the improvement activities contribute to the strategic goal of the enterprise (Dombrowski & Mielke, 2013).

Based on these principles and the required cooperation of workers and leaders, the author also identified 15 rules to help leaders sustainably implement Lean (Dombrowski & Mielke, 2014).

2.3.3.1 Lean Coaching

Coaching is a form of advisory in which the customer (coachee) has full responsibility. It is a supportive relationship between a coach and a coachee that helps him to get started doing something in a different way (Ross, 2019).

Coaching comprises a way of analysis, reflection, and operationalization. Coaching can be defined to "unlocking a person's potential to maximize their own performance. It is helping them to learn rather than teaching them" (Whitmore, 2002). In literature, the Greek philosopher Socrates is considered the "father" of coaching since his method consists in a dialogue that allows the coach, through questioning, to lead his student to reflect and discover his own values.

A coach gives the challenge and confidence to start doing something new to the coachee. The purpose is to help the coachee to overcome their fear by encouraging new behaviours that lead to new habits.

Coaching is a way to facilitate the release of people's potential, bringing the best out of them, so that they can reach their goals. It is a process to take a person from the current state to the desired one. It is more than technique, is a way of thinking, managing, and treating people.

According to the International Coaching Federation, the coaching practices present advantages such as increased productivity and increased self-belief of employees (Marques & Couto, 2013).

Since coaching acts as a tool that supports to successfully transform, it can accelerate the implementation of Lean in organizations as it can motivate people and promote the coaching culture which allows continuous development (Ellam-Dyson & Palmer, 2011). Therefore, Lean coaches help to guide their

employees to apply the learning practises while providing an environment of trust and safety (Solaimani et al., 2019). Consequently, coaching requires the coach to be empathic, supportive, and detached.

Lean thinking and coaching have similarities since both start from a diagnostic state until a defined future state. Issues are also dealt as challenges and the improvements should be concrete and visible. Therefore, Lean and coaching share the same goal of continuous improvement. Due to this correspondence of characteristics, Lean coaching has arose as a new area for people development (Tscharf, 2020).

Most of the times, managers have difficulties in coaching implementation because there is a tendency to dictate employees what to do. This behaviour presents another issue as studies suggest that people rarely recall something they were told in comparison with having the experience by themselves.

Despite being usually seen as taking place between a manager and employee, one to one coaching can occur between peers or even between a subordinate and his boss.

To assist the focus of coaching, a structure for coaching conversation was defined by Whitmore (2002) through the GROW model. It is one of the most used methods for structuring coaching as it provides a sequence by using the acronym to represent each stage of the conversation (Brown & Grant, 2010; Whitmore, 2002). Figure 9 represents the four stages of the GROW model and some example questions that can be used.

Acronym	Description	Example Questions
Goal	Coachee is asked to clarify what they want to achieve from each session. Determines the focus of coaching.	What do you want to achieve this session? How would you like to feel afterwards? What would be the best use of this time?
Reality	Raise awareness of present realities. Examine how current situation is impacting coachee's goals.	How have things gone in the past week? How have you handled any problems? What worked? What didn't work?
Options	Identify and assess available options. Encourage solution focused thinking and brainstorming.	What possible options do you have? What has worked for you in the past? What haven't you tried yet that might work?
Way forward	Assist the coachee to determine next steps. Develop an action plan and build motivation.	What is the most important thing to do next? What might get in the way? Who will be able to support you? How will you feel when this is done?

Figure 9 - The GROW model
(Brown & Grant, 2010)

This sequence should not be linear, because the dialog can move back and forth, and it must have the context of awareness and responsibility of the coachee in order to work effectively. Each coaching session ends with a set of defined actions to be implemented until the next session (Brown & Grant, 2010).

2.3.4 Lean Tools

Leadership and philosophy without the application of Lean tools will not help to reduce waste and maximise the value added. The correct use and selection of Lean tools, using a project-based approach, ensures a proper Lean implementation (Purushothaman et al., 2020).

For that reason, people involved in the Lean transformation must have a deep understanding of the tools and apply them accordingly (Leksic et al., 2020). In the next sections it is described some of the Lean tools that are relevant for this dissertation.

2.3.2.1 Skill Matrix

Any employee should be aware of their responsibilities, competencies and trainings that are required for their job. The Skill Matrix is a tool that helps visualize the characteristics of each employee compared with the competencies required for the job. It supports identifying possible proxies, training needed or even to provide coaching (Locher, 2011; Nicholas, 2018). Not only it is referred in the TPS house, but it was also shown through research that the skills needed to perform tasks combined with knowledge about lean is a key factor for the successful implementation of lean (Lodgaard et al., 2016).

2.3.2.2 Workshops

This tool enabled to understand the employees attitudes and demands, identify specific needs and potentially increase the motivation of the team members by demonstrating interest in their desires (Harris Ehrlich, 2002). This does, however, imply that the consolidation of qualitative responses is more difficult.

2.3.2.3 Process Observation

The Process Observation tool is a variant from “Go to Gemba” method. Similarly, to “Go to Gemba”, it represents going to “the place”, i.e., operational process walks. The idea is to go to the place where there is a problem, look at the process and talk with people involved (Mann, 2005).

Leaders in organizations already transformed by Lean, seek for opportunities to “go to Gemba” as it is an easy practice. Issues that are discussed in a meeting room can immediately be seen and even solved (Locher, 2011). The focus of the observation may vary but for Process Observation the objective is to identify waste.

This tool consists in registering and recording the steps and timing of each task during an observation of the process. The person who is observing should have some experience in the process to raise questions to who is being observed. Hence, the observer can understand the way the process is being conducted and classify the task into waste, support or value add activity.

The results are represented in a graphic with the percentages for each category of activity.

2.3.2.4 Visual management

Communication is a competency that is required to Lean Leadership. Leaders should be able to communicate with employees the expectations from the organization and what they can expect. Transparency is especially needed during transformation periods to reduce uncertainty and resistance to change. One form of communication is through visualization. Visual management consists in using simple tools to transmit organization's goals and all necessary information to work (Aij & Teunissen, 2017).

Some of the tools are whiteboards where information is displayed with charts and colour codes. It also involves the practice of 5S, which comes from the Japanese terms: *Seiri, Seiton Seiso, Siketsu* and *Shitsuke*. They mean sorting, simplifying, standardizing and self-discipline (Gao & Low, 2014).

3. COMPANY PRESENTATION

In this chapter it is presented the company where the internship to develop this dissertation was performed. This presentation focuses on describing the Bosch Group, its business areas and main products while comprising the unit from Braga, Bosch Car Multimedia Portugal S.A. It is also introduced the Lean Project implemented within the company and the respective organization.

3.1 Identification and location

Bosch Car Multimedia Portugal S.A. is a company located in Braga since 1990 which develops and manufactures components for automotive industry, such as multimedia solutions and chassis sensors. Initially started with the Blaupunkt factory in 1990 which was European leader of car radio production. As the market evolved, Blaupunkt was sold and restructured into a new unit which was then renamed as Bosch Car Multimedia Portugal S.A. in 2009.

Figure 10 - Facilities of Bosch Car Multimedia Portugal S.A. (Robert Bosch GmbH 2018)

Previously belonging to Car Multimedia division, comprising 4 plants worldwide, its product portfolio included infotainment, navigation and instrumentation systems. Meanwhile, during 2020, Bosch unit in Braga was integrated in a wider division named Automotive Electronics (AE). This new division encompasses 40 locations (21 manufacturing sites) around the world and is divided into two business areas: Electronic Control Units and Semiconductor Components. Although being merged in a broader organization, Braga plant is still the main producer of car multimedia solutions, having increased its range of products which currently consist in:

- Navigation systems: smart integrated solutions for entertainment, navigation, telematics, and driver assistance.
- Next infotainment Gen: integrated system for connectivity, tuner radio and PC Hardware approach.
- Instrumentation Systems and Cluster: programmable instrument cluster and Head-up Display.

- Sensors: systems and functions for vehicle safety, dynamics, and driver assistance.
- House-hold electronics: complex electronic controllers for a wide variety of different applications.
- Instrumentation clusters for two-wheelers: integrated connectivity clusters.

Bosch Car Multimedia Portugal also holds the divisions of Chassis Systems, Automotive Aftermarket, and more recently, Cross-Domain Computing Solutions, a new division focused on the development of intelligent, autonomous and connected mobility solutions (Robert Bosch S.A., 2021).

Furthermore, the company has received awards and recognitions from diverse entities, from which it could be highlighted the: Bosch Quality Award from the Bosch Group (2007, 2011 and 2013), CES Innovation Award from the Consumer Technology Association (2017 and 2019) and EFQM Excellence Award from European Foundation for Quality Management (2015 and 2017).

3.2 Bosch Group

The Bosch Group started in 1886 when Robert Bosch founded the Workshop for precision mechanics and electrical engineering founded in Stuttgart. The company expanded globally and throughout its history it is characterized by a strong innovative and social commitment (Robert Bosch GmbH, 2018). The next figure (Figure 11) presents some of the historical highlights of Bosch.

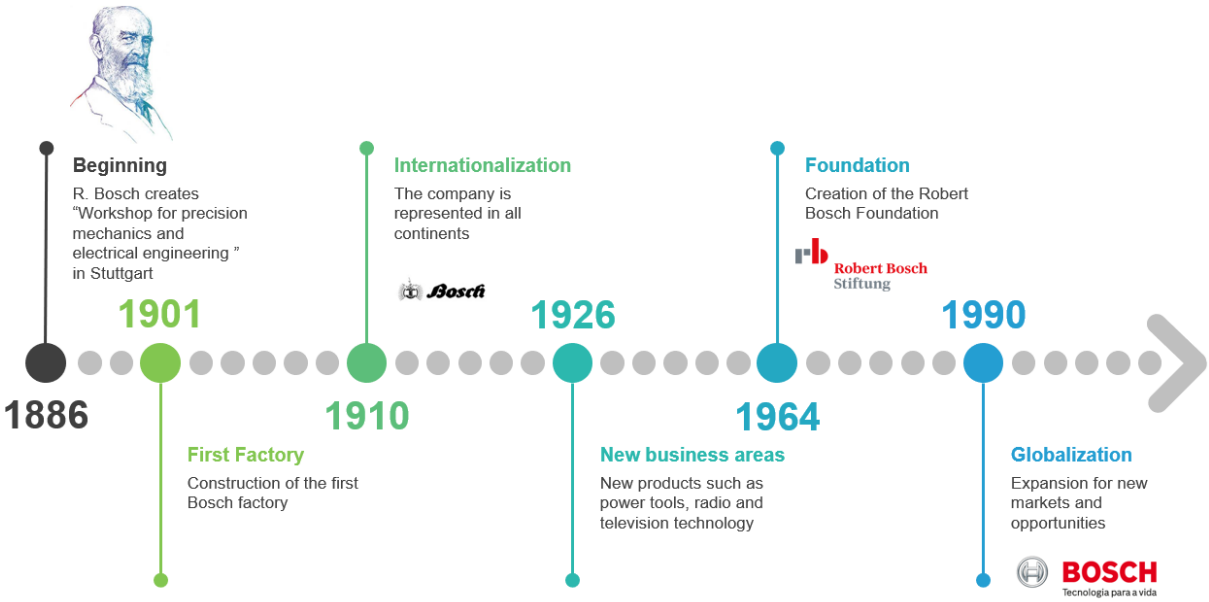


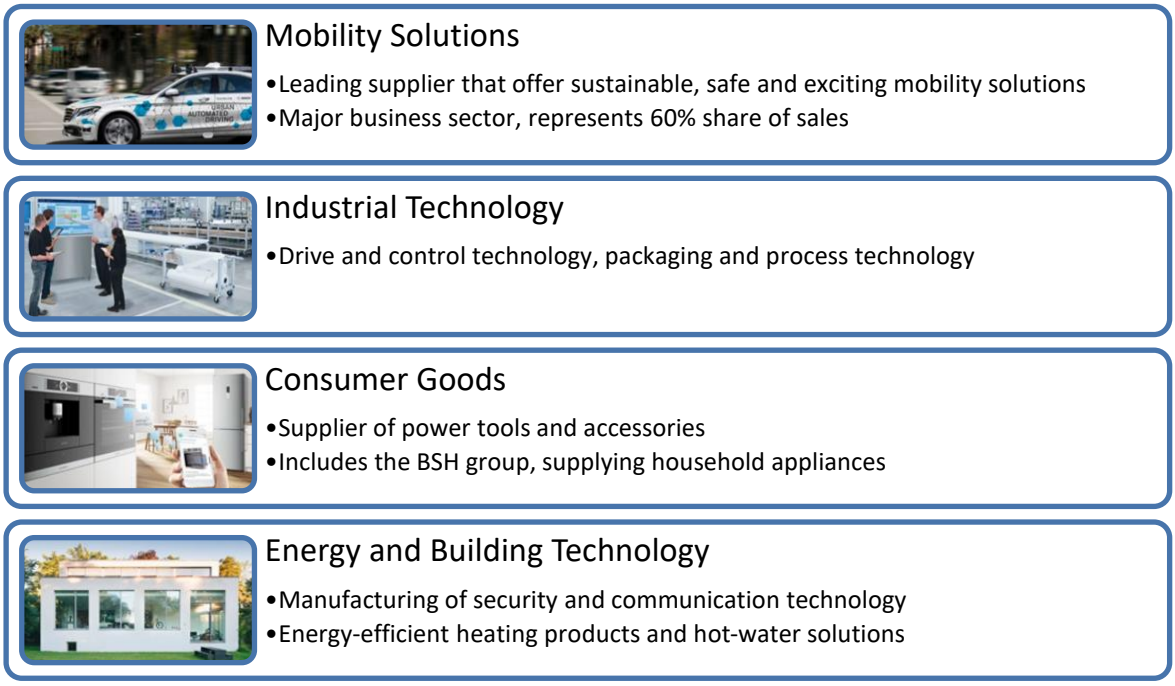
Figure 11 - Bosch Group History.
(Adapted from: (Robert Bosch GmbH, 2018)

Since 1964, when Robert Bosch Stiftung GmbH was founded, it has been responsible for implementing Robert Bosch welfare projects. This foundation is financed by the dividends from Robert Bosch GmbH. In fact, the ownership of the company guarantees it stability and long-term investments. The majority of the

share capital (94%) is held by Robert Bosch Stiftung GmbH while the remaining shares are from Robert Bosch GmbH and Bosch family .(Bosch Global, 2019).

Bosch is currently one of the world's leading international suppliers of technology and services, having generated 71,5 billion euros in sales during 2020. It employs approximately 395 000 associates around 60 countries in 245 manufacturing facilities. The company is divided into four business sectors as described in the table below.

Table 2 - Bosch Business Sectors
(Adapted from: (Robert Bosch GmbH, 2018)



The strategy of the company concentrates on securing the future of the organization through the development of innovative and useful products and services that upgrade the quality of life of its customers while maintaining its financial independence. For that matter, the slogan of the organization is "invented for life". The pursue for continuous innovation is noticeable by the investments in this field, just in the past years, several billion euros were invested in research and development, which, in turn, are represent by 129 engineering locations worldwide (Robert Bosch GmbH, 2018).

3.2.1 Bosch Mission and Vision

To answer all the questions related to Bosch values, the company launched, in 2015, a new mission statement called "We are Bosch". This new statement replaces the older "House of Orientations" because of the changes in the world, which has become more complex, dynamic, and unpredictable.

The aim is to express the organization as it is and serve as reference for the strategy and provide motivation for further company development.

Figure 12 - Mission statement of Bosch Group

(Bosch GmbH, 2019)

"We are Bosch" Mission Statement:

- Objective (what we want to achieve): In the spirit of Robert Bosch, the aim is to secure the company's future by ensuring its development while preserving its financial independence.
- Motivation (what drives us): Invented for life, the products should spark enthusiasm, improve quality of life and help conserve natural resources.
- Strategic focal points (what will help us succeed):
    - Focusing on costumers: understand customer requirements, tailor the products to them and create innovative business models.
    - Shaping change: build change and seize its opportunities, namely in connectivity, electrification, energy efficiency, automation and the emerging markets.
    - Striving for excellence: evaluate against the strongest competitors by working fast, agile and accurate. Work on efficient processes, lean structures, and high productivity to secure and increase the value of the company.
- Strengths (what we do well):
    - Bosch culture: distinctive corporate culture that seeks to follow the company's values and strive for continuous improvement.
    - Innovation: creativity is the foundation for new technological solutions that translated into successful products.
    - Outstanding quality: products delivered offer the best quality and reliability to meet the customers' expectations.

    - Global presence: as an international company, it constantly extends its global presence while strengthening local responsibility.
- Values (what we are built on):
    - Future and result focus: the actions are result-focused which allows to protect the future of the company and create basis for social initiatives.
    - Responsibility and sustainability: act responsibly in the interest of the company, taking social and ecological impact of the actions into consideration.
    - Initiative and determination: act on the company's initiative, take entrepreneurial responsibility and pursue the goals with determination.
    - Openness and trust: communicate important company matters in a timely and open way.
    - Fairness: deal fairly with colleagues and business partners since fairness is a cornerstone of corporate success.
    - Reliability, credibility, legality: promise only what can be delivered, accept agreements as binding and respect and observer the law in every business transaction.
    - Diversity: acknowledge and encourage diversity for the enrichment it brings.

3.2.2 Bosch in Portugal

Bosch is represented in Portugal since 1911 by Robert Bosch S.A., an affiliate from Robert Bosch GmbH, as a supplier of technology and services. Currently it has around 6250 employees, being one of the major industrial employers in the country. During 2019, the revenue in sales was 1,6 billion euros, with 95% of it to be exported.

As represented in Figure 13, Bosch in Portugal is present in different locations: Braga, Aveiro, Ovar and Lisbon. The headquarters in Lisbon, were the first to be established in Portugal, in 1960. They are responsible for the central accounting services, purchasing, communication, marketing, and training.

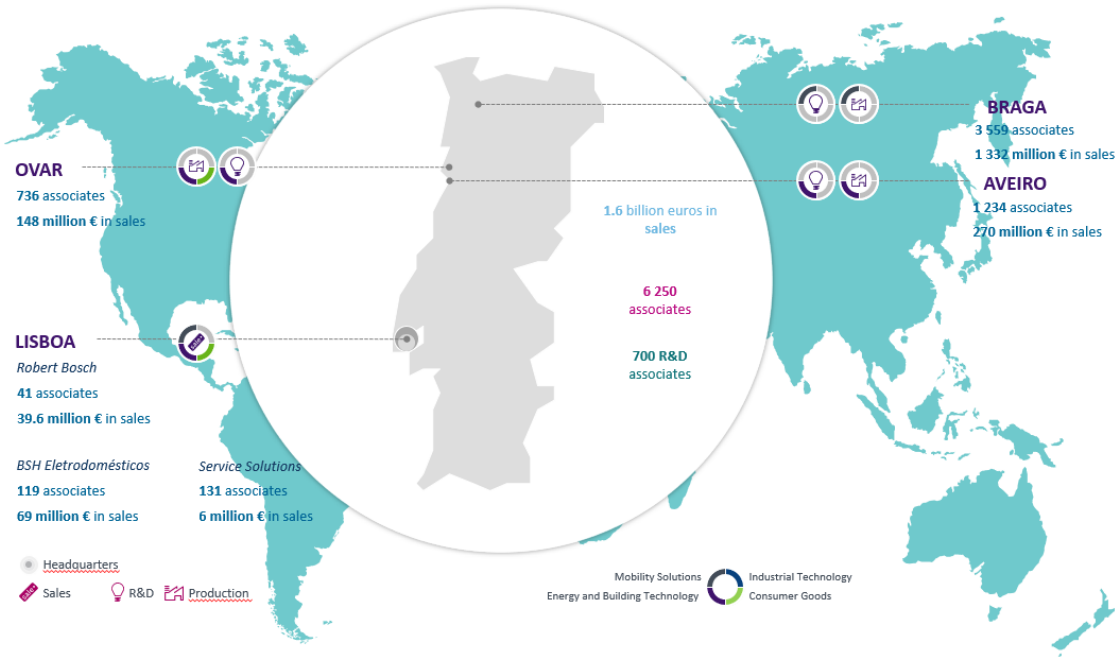


Figure 13 - Bosch in Portugal

(Robert Bosch S.A., 2021a)

The unit of Aveiro (Bosch Termotecnologia,S.A.) belongs to the Thermo-technology business unit. Previously a Portuguese company, Vulcano Termodomésticos, it was acquired by Bosch in 1988. Since then, it supplies water heating solutions such as boilers, heat pumps and gas heaters. It is also the worldwide centre of competences for thermo-technology.

Ovar is part of Bosch Security Systems since 2002, employing approximately 700 associates. Its production focuses on innovative solutions for communication and security systems, fire alarms and electronic displays. Although being strongly concentrated in manufacturing, the plant has invested in assets for research and development (Robert Bosch S.A., 2021).

3.3 Lean in indirect areas at Bosch

Bosch has been implementing, since 2001, a production systematic that is similar to TPS, designated as Bosch Production System (BPS). BPS is a philosophy of continuous improvement, focused on production and material flow. It is a system of Lean Production developed by Bosch with the aim to promote value add through the waste reduction and performance optimization. This is also linked to Bosch strategy "We are Bosch", referred in section 3.2.1, since it highlights the motivation for excellence (Peitzger, 2017).

BPS is divided into eight principles that when combined allow to optimize all processes as it is described on Figure 14.

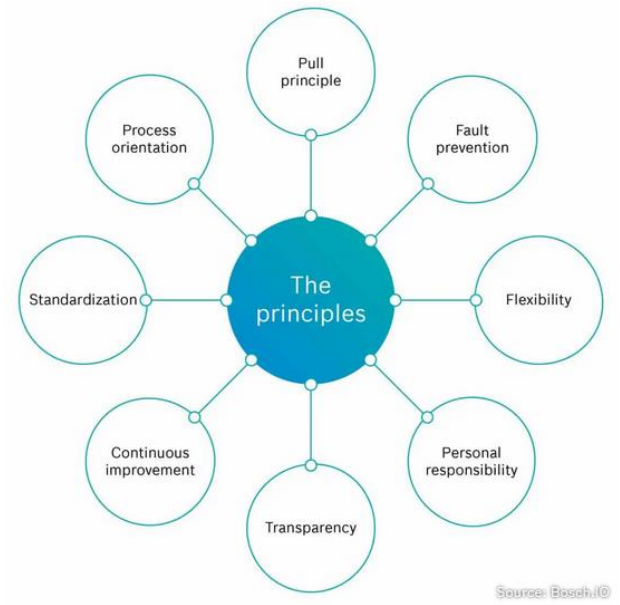


Figure 14 - BPS Principles

(Peitzger, 2017)

Although Bosch is a worldwide manufacturer, it continuously battles to increase competitiveness by adapting to the VUCA (Volatility, uncertainty, complexity, and ambiguity) world. For that reason, Bosch has decided to start to implement a Lean Program in indirect areas. The purpose is to apply the Lean Management principles by reducing waste and optimizing internal processes (become more efficient and effective). Its objective is the same as Lean Production, however, the tools and systematic must be adapted to a different situation. This implies not only changing the way people work, but also the mindset of every associate that is involved in this program. Therefore, leadership and communication are of paramount importance for the success of the project.

To go forward with the program, Bosch hired an external company to help develop and adapt a Lean management system centred on the client. On the other hand, managers also have their functions altered: the aim is to do less operative work and increase their leadership and management time.

The program started in 2013 at Thermo-technology division and soon spread to other Bosch divisions. In AE, it only started in 2017 and from there on, a new department, responsible for Lean Management was created. Since then, Lean Management Department is responsible for creating and updating the tools and methodology to be used in Lean projects. Furthermore, they provide support to the groups that participate in the Lean project by training, facilitating, and guiding them through the tools and systematic.

Each project lasts for one year long and since the beginning of this program inside AE division there were already successfully performed 57 projects (Bosch, 2021). The aim is to continue to implement Lean in all departments and groups from AE division, corresponding to around 12750 associates worldwide.

3.3.1 Lean in indirect areas methodology

The implementation of Lean in indirect areas' purpose is focused in two main areas: productivity and leadership. From the productivity point of view, the project intents to increase effectiveness and efficiency by teaching associates to see waste and sustainably removing it. The goal is to set a continuous improvement systematic. For the Leadership, the target is to implement the Lean Mindset according to AE principles through good collaboration within associates and establish a feedback and coaching culture. This topic is then evaluated through a Maturity Level where the goal is to reach Level 4.

The Lean Project has defined targets, and, in order to achieve them, five dimensions of Lean were defined to have a broader approach and support reaching the goals. In Figure 15 it is presented the dimensions and their targets.

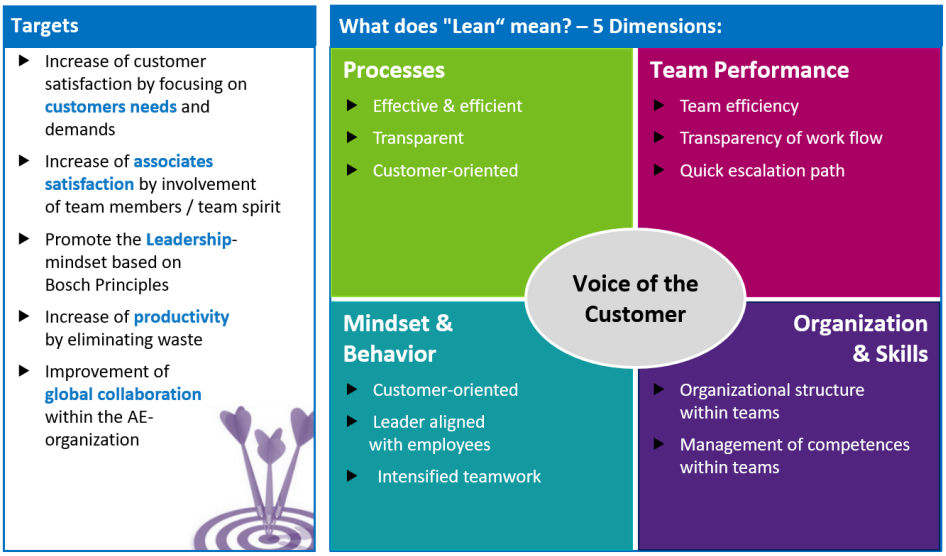


Figure 15 - Lean Targets and Dimensions (Bosch, 2021)

As it is noticeable, the dimension for Voice of Customer is represented in the centre since it is the most important entity for the Lean purpose as every product is intended to satisfy customer needs. Each dimension has a set of tools that can be used during the Lean Project and are adaptable according to the situation of the group. Therefore, different groups may use different tools to undergo their project.

The steps of each Lean Project are divided into four phases, similarly as Action Research Methodology. It starts with the setup and preparation by Lean Management Department as they must coordinate the

projects both globally in AE and locally in each plant. The overview of the Lean Project phases is described in Figure 16.

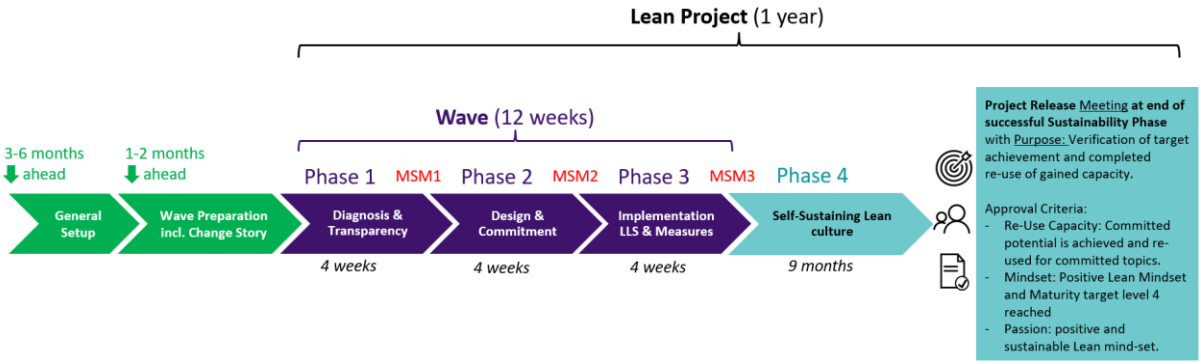


Figure 16 - Lean Project overview (Bosch, 2021)

There are two clear stages within the Lean Project: the Lean Wave and Phase 4, the Sustainability Phase. The first one, the Lean Wave takes about 3 months and it is when the Lean Management Team is fully dedicated to conduct and support the activities. After that, they step out and there are only periodical follow-ups by the Sustainability Consultant.

The Project Phases consist in:

1. Phase 1 – Diagnosis Phase: it is the first phase of the Lean Wave that has the objective to identify the current situation of the group. The approach is to use tools that address the 5 dimensions of Lean according to the situation. The aim is to evaluate how satisfied are the customers, how efficient the processes are, how is the current performance and the balance of the workload. All of these activities to reach concrete insights into potential for improvement.
2. Phase 2 – Design Phase: the target of this phase is to define improvement measures to be implemented during the Lean Project in the Tactical Implementation Plan (TIP) in order to reduce at least 15% of the capacity of the group. This includes the evaluation of potential for improvement and start the implementation of Lean Leadership System (LLS) elements. The result is a Ramp-up curve with the overall gain in productivity and increasing Maturity Level in LLS elements.
3. Phase 3 – Implementation Phase: during this phase, some measures, especially quick-wins, start to be implemented and the implementation progress is tracked. It is also when most of the workshops and activities occur to introduce and develop the LLS elements. The outcome is having the first results visible (first PDCA cycles completed) and LLS elements with Maturity at Level 3.
4. Phase 4 – Sustainability Phase: this is the last phase of the project and lasts for 9 months. Measures need to be implemented according to the TIP and new ones may surge. The capacity of the group starts to be freed-up and it can start to be re-used. The LLS elements must be

continuously and consistently applied in everyday life to anchor Lean Mindset within the team. The goal is to reach the end of the project with the productivity gain and LLS maturity level 4.

During the Lean Wave, each group has to set up a team that has most of its time dedicated to the project which consists in people assigned to be Lean Experts, the Lean Champions (LC) and the group Team Leaders or Group Leaders (also Head of Section). They are supported by a Lean Navigator, an external colleague, assigned by the Project Leader (PL) from Lean Management Department who will guide and support the group activities. Together, they implement the tools, conduct workshops, and develop other activities accordingly to the group needs. After each week, there is a Lean Progress Review (LPR) with the Management, normally Head of Department and Managing Director of the Plant, Project Leader, Sustainability Consultant and all teams currently undergoing the Lean Wave in the plant in order to exchange results and good practices. Whenever a Phase is terminated, the LPR becomes a Milestone Meeting (MSM) where the overall results of that phase and presented and a commitment with the Management is done.

After the Lean Wave, the Lean Team retires, and the group is up to themself to continue the Lean Project. The Sustainability Consultor becomes the main character as support for the team and is the one that does the follow-up and evaluates the LPRs. LPRs change their frequency to monthly meetings since the capacity allocated to the Lean Project is reduced and the main tasks are implementing TIP measures and LLS elements, which require more time.

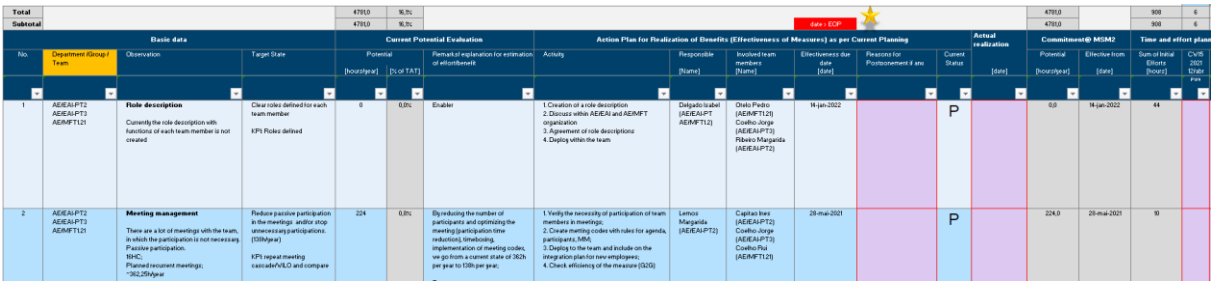
It is also important to refer that each Lean Project is influenced by the team (e.g., tools selected, measures defined, etc.), situation and even from one Lean Wave to another since there some adaptations implemented by the Lean Management Department. In conclusion, although the progress of the same Lean Project in different teams may differ, the result is the same.

3.3.2 Lean Project Outcome

As aforementioned in 3.3.1 chapter, the Lean Project is focused on productivity and leadership that correspond to the Tactical Implementation Plan (TIP) and Lean Leadership System (LLS). These are the main outcomes of the project since the TIP establishes the measures defined, their potential for capacity reduction and LLS ensures that the Lean Mindset is established within the team.

The TIP tool is where the improvement measures are defined after collecting all the results from the Diagnosis Phase. The issues are identified and based on these, target states and activities are defined. For each measure the potential for improvement is evaluated by calculating the benefit in hours versus

the effort needed to implement. This also enables to prioritize the measures since some can be considered as quick wins (low effort and high benefit). The TIP is usually represented in an Excel file with the following aspect:



Total				4791,0	16,3%										4791,0		908	6
Subtotal				4791,0	16,3%										4791,0		908	6
Basic data				Current Potential Evaluation			Action Plan for Realization of Benefits (Effectiveness of Measures) as per Current Planning						Actual realization	Commitment@ MSM2		Time and effort plan		
No.	Department /Group / Team	Observation	Target State	Potential [hours/year]	[% of TAT]	Remark/explanation for estimation of effort/benefit	Activity	Responsible [Name]	Involved team members [Name]	Effectiveness due date [date]	Reasons for Postponement if any	Current Status	[date]	Potential [hours/year]	Effective from [date]	Sum of Initial Efforts [hours]	CW/Y 2021 Under PWK	
1	AE/EAI-PT2 AE/EAI-PT3 AE/MFT121	**Role description** Currently the role description with functions of each team member is not created	Clear roles defined for each team member KPI Roles defined	0	0,0%	Enabler	1.Creation of a role description 2.Discuss within AE/EAI and AE/MFT organization 3.Agreement of role descriptions 4.Deploy within the team	Delgado Isabel (AE/EAI-PT AE/MFT12)	Otelo Pedro (AE/MFT12l) Coelho Jorge (AE/EAI-PT3) Ribeiro Margarida (AE/EAI-PT2)	14-jan-2022		P		0,0	14-jan-2022	44		
2	AE/EAI-PT2 AE/EAI-PT3 AE/MFT121	**Meeting management** There are a lot of meetings with the team, in which the participation is not necessary. Passive participation. NHC: Planned recurrent meetings: ~362,25h/year	Reduce passive participation in the meetings and/or stop unnecessary participations. (159h/year)	224	0,8%	By reducing the number of participants and optimizing the meeting (participation time reduction), timeboxing, implementation of meeting codes, we go from a current state of 362h per year to 159h per year.	1.Verify the necessity of participation of team members in meetings; 2. Create meeting codes with rules for agenda, participants, MM; 3. Deploy to the team and include on the integration plan for new employees; 4. Check efficiency of the measure (Q2G)	Lemos Margarida (AE/EAI-PT2)	Capitao Ines (AE/EAI-PT2) Coelho Jorge (AE/EAI-PT3) Coelho Rui (AE/MFT12l)	28-mai-2021		P		224,0	28-mai-2021	10		

Figure 17 - TIP file
(Bosch, 2021)

The first columns have a description of the problem and the target of implementation. From there, it is estimated the productivity potential (in hours per year) that can be gained, which then in turn, are converted to a percentage. To help understand the potential calculation, there is also space for remarks and explanations.

From there, it is described the activity itself that has to be implemented either during the Lean Wave or Sustainability Phase. The responsibilities, team members and due dates are also assigned. The status of the measure is then visualized using the PDCA cycle, so, initially all measures are set with the status of "Plan". Finally, the timing and effort are planned by assigning the predicted number of hours and the weeks during the year that require effort to complete the activity.

The sum of all the estimated potentials will result in a productivity potential that consists in a percentage of the Total Available Time (TAT) from the group that can be re-used. The objective of the Lean Project is to achieve more than 15% of productivity. To help understand the TIP evolution, it is usually represented by a Ramp-up Curve where the target and potential achieved are visible and it is represented the freed-up capacity (Figure 18).

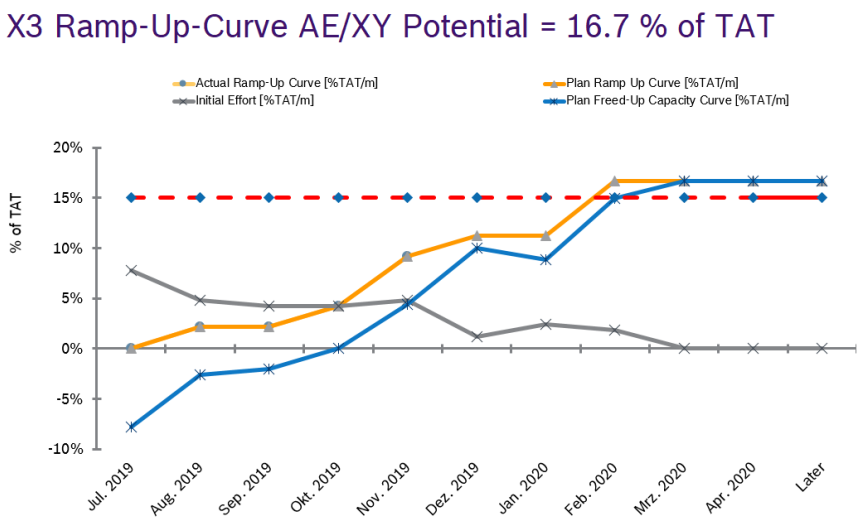


Figure 18 - Ramp-up curve (Bosch, 2021)

To support the establishment of a Lean Mind-set of continuous improvement for and with people in the daily work routine, a Lean Leadership System was created. It is constituted by 12 elements divided into three categories (Focus on Customer Needs, Operational Excellence and Future Oriented Working Culture). These elements, represented in Figure 19, help to focus on customer benefits, increase productivity, efficiency and effectiveness, strengthen personal responsibility, reflecting on attitudes and dealings, identify opportunities for development and growth and promote future-oriented working methods. The implementation of LLS elements, is therefore, of paramount importance for the success of the project as it is based on the Leadership Culture and will enable it to change and grow inside the organization.

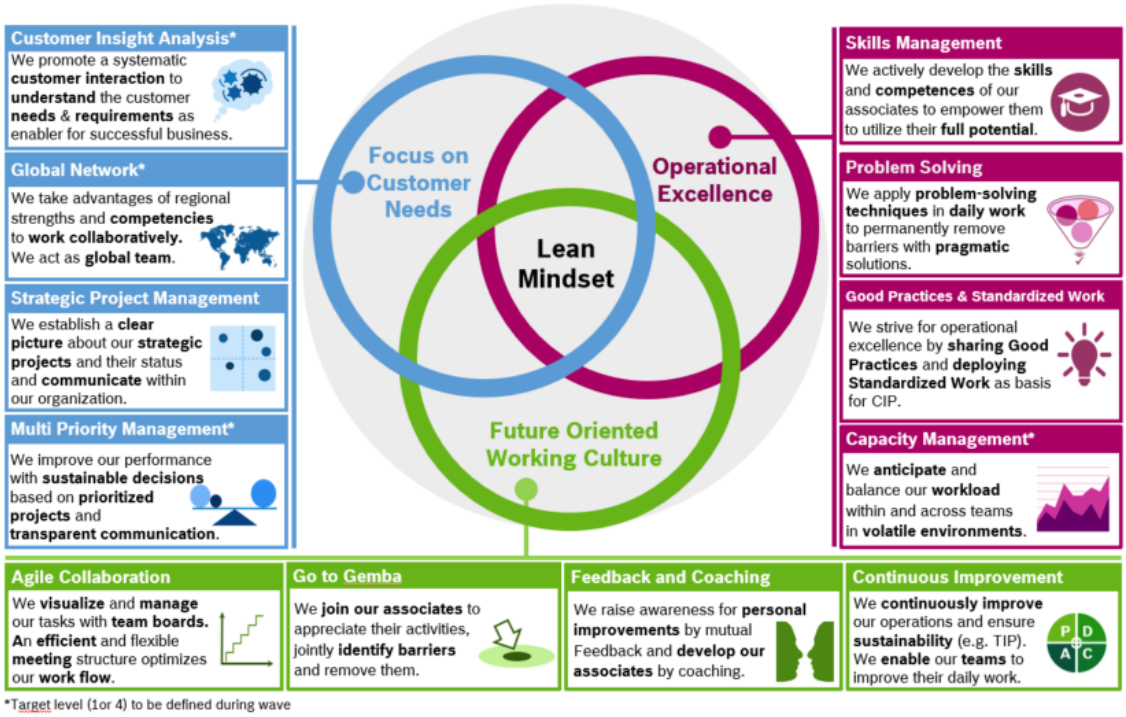


Figure 19 - Lean Leadership System
(Bosch, 2021)

In terms of implementation, after conducting the first Phase of the Lean Wave (Diagnosis Phase), the LLS elements are introduced to the group which will the select the elements that should be dealt in a more advanced level, named focus elements (normally 3 elements are chosen). From there on, LLS elements are introduced to the employees of the group through trainings and workshops where feedback is also pulled. There are other interactive trainings performed according to the focus elements and to define the systematic for LLS elements implementation. Consequently, workshops and trainings will differ depending on the group since those variables must be considered.

As a form of evaluation of the degree of knowledge about LLS elements, it was created a tool, Maturity Assessment, to classify how much it is understood by the group (Figure 20).

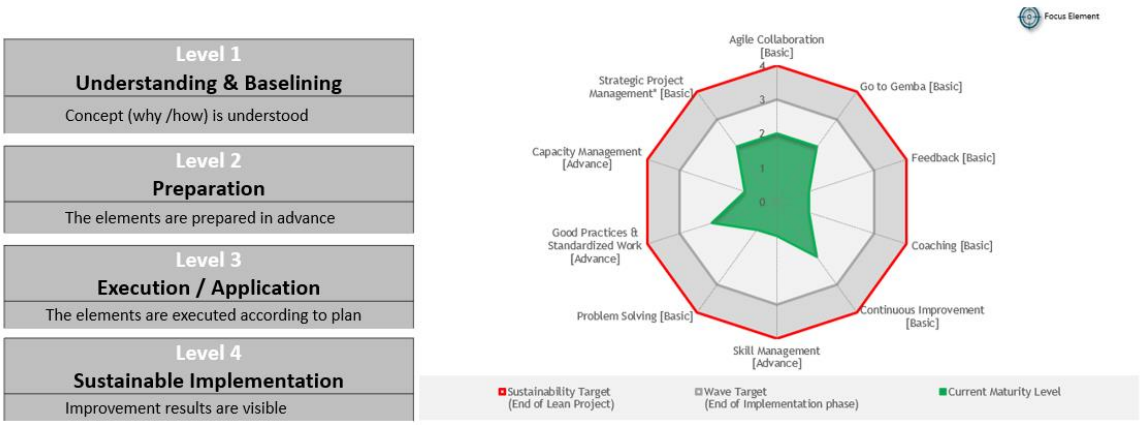


Figure 20 - Maturity Assessment
(Bosch, 2021)

The Maturity Assessment is divided into four Levels where all teams, at the beginning of the Lean Project being at zero (meaning no knowledge). Each of the level has an assessment criterion that must be fulfilled in order to reach the next level. Since there are focus elements that are chosen by the team, the assessment criteria for those are generated accordingly. The target of the Lean Wave is to reach Level 3 in all LLS elements so, all of them should be executed according to plan. During Sustainability Phase the elements continue to be develop until the end of the project where the Maturity must reach Level 4 (Bosch, 2021).

3.3.3 Value Stream Design for indirect Areas (VSDiA) Tool

Value Stream Design for indirect Areas (VSDiA) is a tool adapted by Bosch to map the flow of information within indirect areas. Indirect areas refer to nonproduction areas such as administrative and office areas. The tool also analysed the existing documentation and the quantity of waste (Chaves et al., 2017; Keyte & Locher, 2004).

VSDiA is then a combination of Business Process Model and Notation (BPMN), a model notation that represents business processes graphically, and Value Stream Mapping (VSM), a process mapping tool that represents the product value-creation chain with activities that are considered as wastes. In Figure 21 the various VSDiA elements are represented.

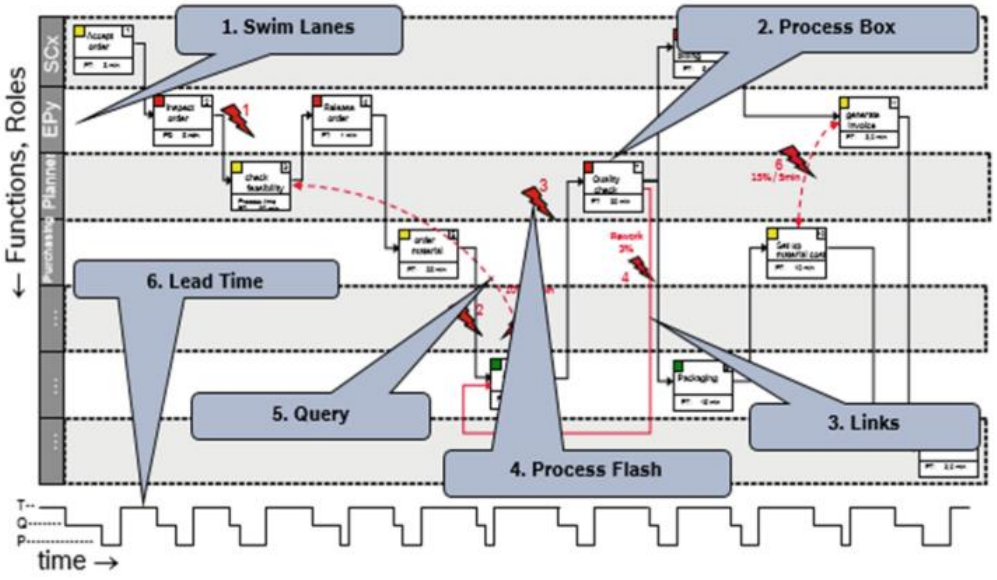


Figure 21 - VDSia elements
(Adapted from (Etzel & Kutz, 2009)*)*

The VSDiA is organized in a workshop with relevant stakeholders for the process to be analysed. For each process, the performance indicators are defined:

- Transition period: time between the end of the process and the next one.

- Process time: time required to perform a process.
- Lead time: total of Transition period (TP) and Process time (PT).

The representation of process flow is made through swim lanes that each one represents a role/function. Then, the process steps are described in process boxes with the identification of the number and colours according to the category of activity (value add, support or waste) similarly to the process observation tool (Abreu et al., 2017).

4. DIAGNOSIS AND CRITICAL ANALYSIS OF CURRENT SITUATION

According to the objectives defined for this dissertation, this chapter presents an overview of the current situation in the group analysed, in this case AE/EAI-PT AE/MFT1.2 department, by presenting the results from the tools used during the Diagnosis Phase. Therefore, it is explained the scope, main processes, and difficulties that the group endures.

4.1 Scope of the project

The scope of this dissertation was based on a group from AE/EAI-PT AE/MFT1.2 department. This department was transferred from the previous Car Multimedia into AE organization. Previously named CM/MFT3, after the merge with AE it became part of two centralized different areas: EAI and MFT. MFT (Manufacturing Technology) was the department responsible for AE worldwide manufacturing processes (industrialization) and they leaded a global competence network. All new production processes from the concept to its transfer into production plants were under MFT responsibility.

Engineering and Interconnect Technologies department (EAI) was a development department that focuses on PCB and soldering technologies and was responsible for finding stable and reliable soldering process solutions for new components and design elements and to release new technology, material and processes considering interactions within the product. Together with the MFT, they identified technology needs and defined standards for the plants.

As a result, AE/EAI-PT AE/MFT1.2 department was a combination of different functions so, it also had distinct functional management reporting. Furthermore, both of those central departments (EAI and MFT) were in Germany, so there was only a disciplinary relationship with Braga Plant.

For the scope of Lean Project, the department was divided into two groups according to their function (Figure 22). The first group was purely constituted by MFT teams which are focused on industrialization functions. Whereas the second group, mainly performed process development activities (even AE/MFT1.21 is mainly performing tasks related to this and in strong cooperation with EAI). Hence, group 2 consisted of AE/EAI-PT2, AE/EAI-PT3 and AE/MFT1.21, which was the focus of this dissertation and from which the results and conclusions were analysed further. The teams from group 2 had the corresponding functions:

- AE/EAI-PT2: PCB technology and material releases

- AE/EAI-PT3: project management of projects from AE/EAI-PT AE/MFT1.2
- AE/MFT1.21: component process release and layout rules

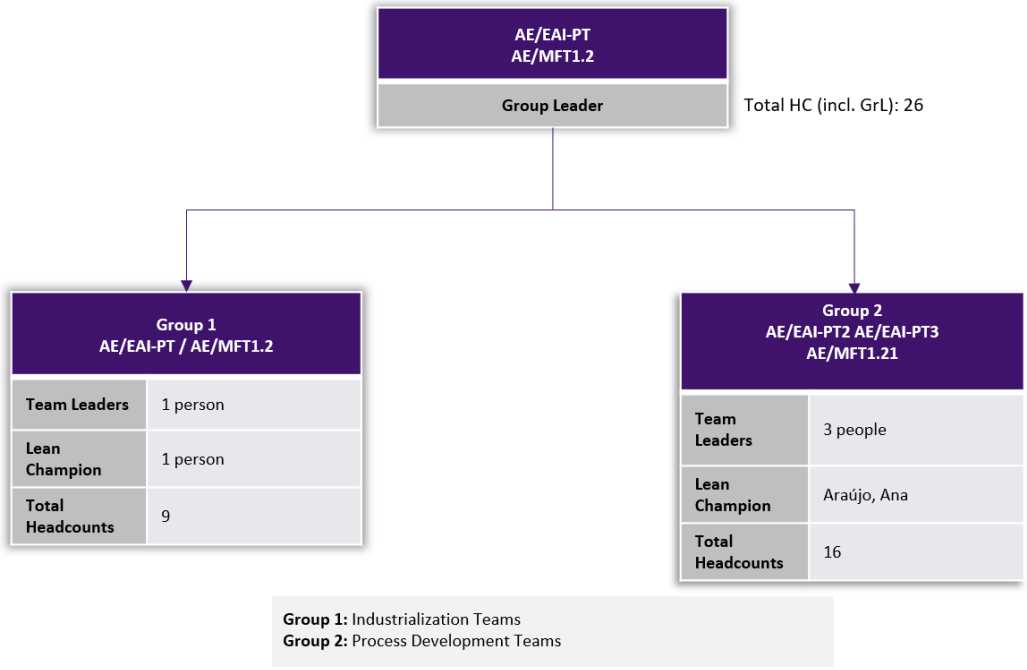


Figure 22 - Organigram of AE/EAI-PT AE/MFT1.2 during Lean Project (Bosch, 2021)

Consequently, this group was formed by teams working for the same goal but with distinct tasks and responsibilities. For the context of the Lean Project this did not constitute an issue by itself but for some tools it was more complex to work with.

4.2 Tools before Lean Project

Before the Lean Project starts, there were a set of preparations that needed to be developed to have the right start. The reason for this was based on the 8-step process for leading change for transforming organizations introduced by John Kotter. This approach seeks to conduct changes into the way businesses work so that they were prepared for new challenges. It started from the top levels of the organization and then was promoted through the organization down to the operating levels. The process required a considerable length of time, through a series of phases, that cannot be skipped if a successful result was expected.

The eight steps for transformation were:

1. Create urgency: Examine the company's competitive situation and market position and identify crises, potential threats and major opportunities that motivate the need for change.

2. Create a coalition: Establish a group of change leaders that will guide the effort and encourage teamwork. The change leaders are not only senior managers but also influential people outside the usual hierarchy.
3. Develop a vision and strategy: Identify the values that are essential to help direct the change and create a vision statement. A strategy for achieving that vision must be developed.
4. Communicate the vision: Communicate the vision and strategy consistently during the change process and validate the sense of urgency and change benefits. Apply the new behaviours throughout the organization by providing the example from the change leaders.
5. Empower action: Remove obstacles to change, such as obsolete systems or processes. All obstacles need to be addressed and new out of the box ideas and activities should be encouraged.
6. Get quick wins: Plan and implement visible and quick performance improvements that support the change and recognise and reward employees that were involved.
7. Leverage wins to drive change: After having the first wins completed which boosts credibility, the organization needs to promote changes in structures and policies that are no longer suitable for the vision. This can be achieved through employee development, start new projects, and change agents.
8. Integrate change in culture: Continue to communicate the new behaviours as a mean to achieve successful results and ensure that the change becomes part of the company culture (Kotter, 1996).

Therefore, most of these actions were taken by top management before the start of the Lean Program as explained in Chapter 3.3 and then spread across to the entire AE organization aiming to reach all departments and groups. However, for each case the same actions needed to be implemented at department level.

So, it was needed to establish the team that works closely in the project (change leaders), define the vision and strategy of the Lean Project for the group and continue to implement the sequence of phases.

For that reason, one of the first tools developed by the group was the Change Story. It described the project target and alignment of the area of responsibility to the future so that employees get the direction they need. The Change Story contained the starting point, the goal after finishing the project, productivity target and the first ideas for the capacity re-use.

The document was prepared and presented for the whole department as it was a guideline for all the employees. As it is presented on Figure 23, the document starts by presenting the current situation of

the department in terms of customer & business, associates, processes and leadership. The main highlights are the current challenges from customer requirements and technology with tight timelines while there is a lack of time from management to focus on coaching their associates and strategic work.

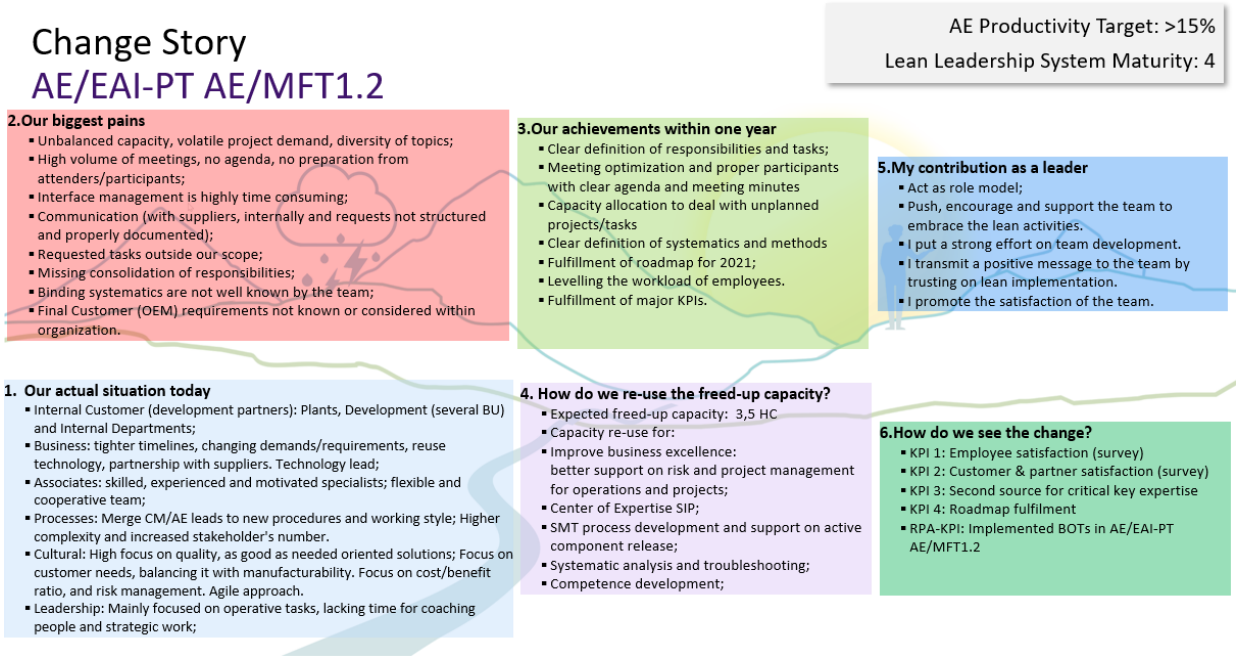


Figure 23 - Change Story for AE/EAI-PT AE/MFT1.2

From there, it was described the most painful topics for the team and their interfaces. This was the starting point, with the main issues that need to be further scrutinised.

On topic 3 it was defined the targets at the end of the Lean Project while on point 4 was the strategy for the use of capacity that was going to be released.

Finally, it was included a statement from the Group Leader for her commitment with the team and the KPIs defined to the project.

Meanwhile, the group itself (group 2) works to give directions for the analysis during the Diagnosis Phase of the project by collecting assumptions about the conditions, situation or process in the group that are leading to productivity loss. This data was compiled in a tool named Hypothesis (Figure 24) and it covers the five Lean dimensions in order to have a basis for further verification. These assumptions were then refined and were either confirmed or rejected according to the observations and diagnostic tools.

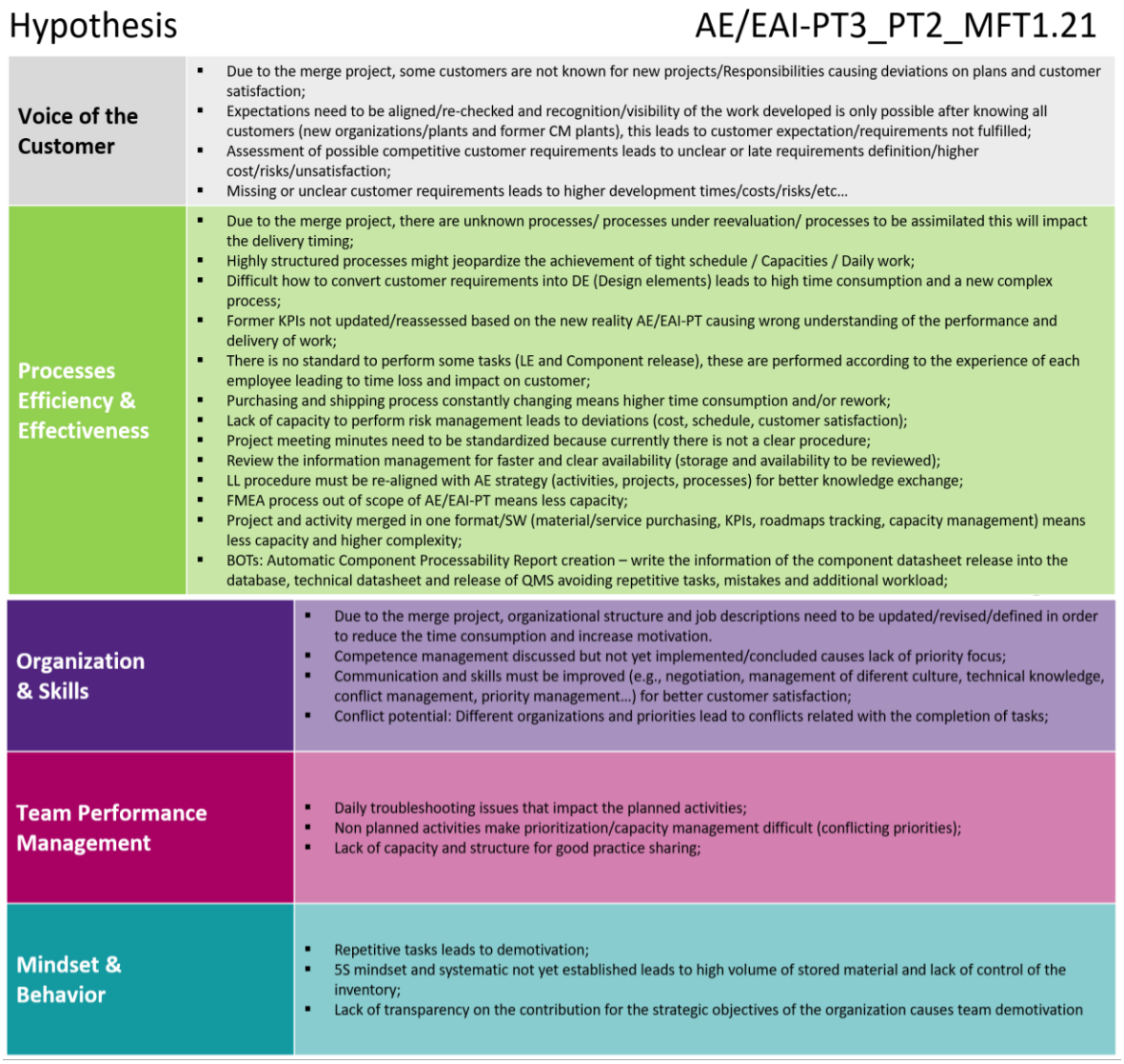


Figure 24 - Group 2 Hypothesis

4.3 Diagnosis Phase

The Diagnosis Phase was the first step of the Lean Project and after collecting the Change Story and Hypothesis, it was focused on tools according to the situation and the group. It was an extensive analysis performed during four weeks with the aim to collect the major problems from the group without going into much detail. It was intended to analyse the situation without spending too much effort in order to remain the focus on searching for the wastes of the group. The tools selected for this project are presented in Figure 25. Although there are more tools available, for this project only 14 were selected. Each of the tools is related to one of the five Lean dimensions and some of them may also be used during the following phases (e.g. Process Observation and Retrospective).

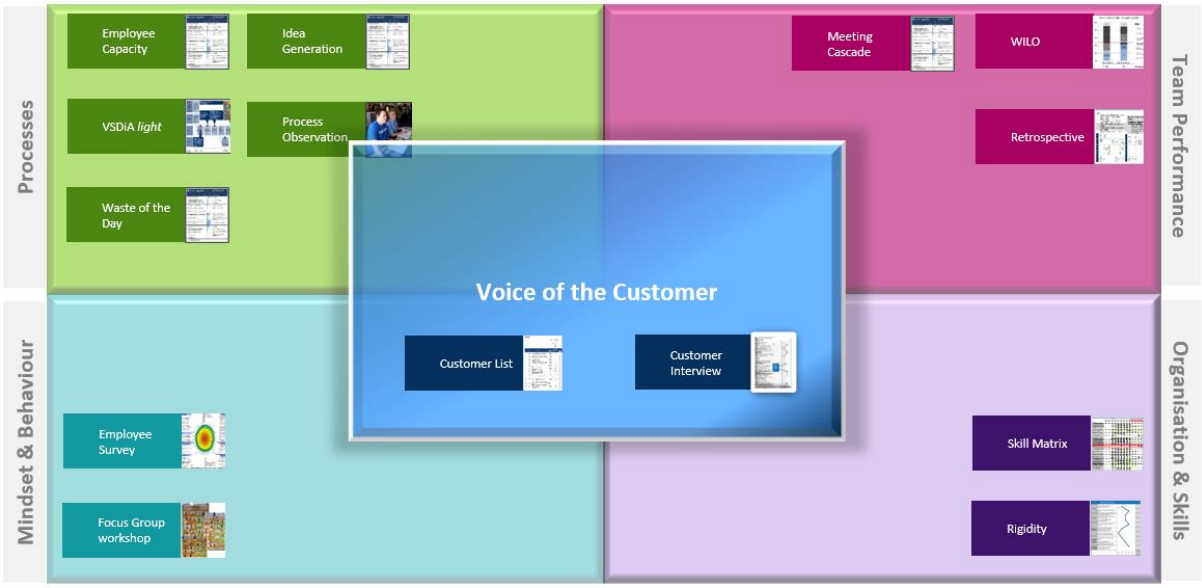


Figure 25 - Lean Tools Overview

In the next sections the purpose and explanation of the tools is provided.

4.3.1 Idea Generation Workshop

The Idea Generation Workshop was the first workshop performed with the involvement of employees that aimed to collect their improvement ideas and is a basis for improvement measures. The ideas were collected into a board (in this case virtually due to the pandemic situation) according to the five dimensions of Lean.

After everyone writes their ideas, they were discussed within the group and classified according to an Effort/Benefit Matrix: Quick wins, Slow win, Motivation Boost and Low Priority. This matrix allows to establish a priority for the ideas in order to have an alignment between team members. Quick wins were measures that have a high benefit but the effort for implementation was low. On the other hand, Slow Win was classified when the benefit was high but the effort for implementation was also high. The remaining classifications had lower benefits of implementation, so they were distinguished by the effort, i.e., higher the effort, lower the priority.

In Figure 26, it is visible the ideas collected by the team, a total of 51 ideas and their corresponding classification into priorities: 10 ideas were motivation boosters, 20 quick wins and 21 slow wins. None of these ideas were classified as low priority.

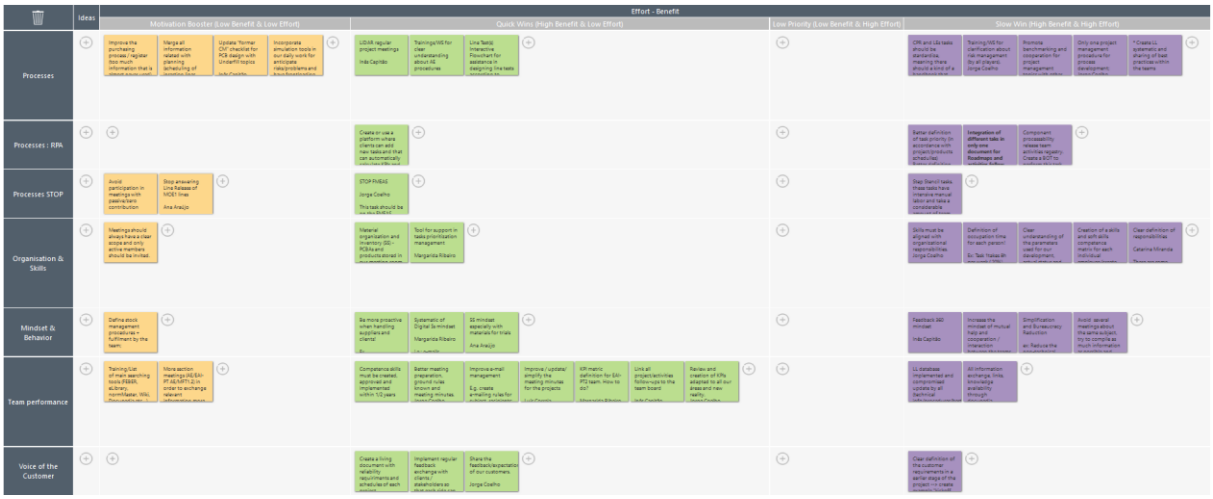


Figure 26 - Idea Generation Workshop from Group 2

For the dimension of Processes, there were three rows: Processes, RPA (Robotic Process Automation) and Processes to Stop. For that reason, there were a total of 20 topics related to processes, being this dimension the one with the majority of ideas.

Apart from the improvements proposed for the processes, in the other dimensions the main issues are related to inefficiency of meetings (duration, participants, preparation), the definition and alignment of competences of the employees and not knowing the feedback and expectations of the customers.

4.3.2 Week in a Life Of (WILO)

Week in a Life Of (WILO) is a tool specifically for managers to assess in which tasks they spend their time. The evaluation was performed during, at least, five days and they needed to register the time spent in each and every task. The tasks were divided into 10 categories that were represented in the graphics below in the form of percentages. As it can be verified, the results from AE/EAI-PT2 and AE/EAI-PT3 are similar in terms of percentage of time spent in each category (Figure 27).

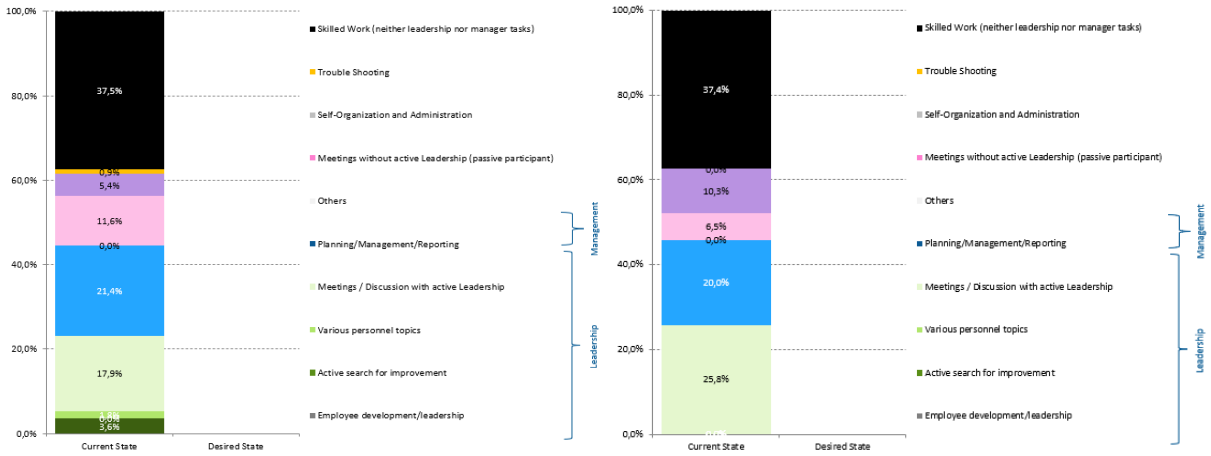


Figure 27 - WILO results from AE/EAI-PT2 and AE/EAI-PT3, respectively

Both team leaders spent almost 45% of their time in Leadership and Management tasks however 37% was still dedicated for skilled work, mainly operative tasks. This overview represented a state that was not desirable for the team leaders as the skilled work was taking more time than expected. Therefore, they aimed to reduce the time spent on meeting with passive participations and had more capacity for employee development.

On the other hand, for AE/MFT1.2 the time spent in Leadership and Management represented more than 60% of the time whereas skilled work stands for 16%. Although the result was satisfactory for the manager, there was still the need to delegate some meetings since most of time was spent on meeting participation (Figure 28).

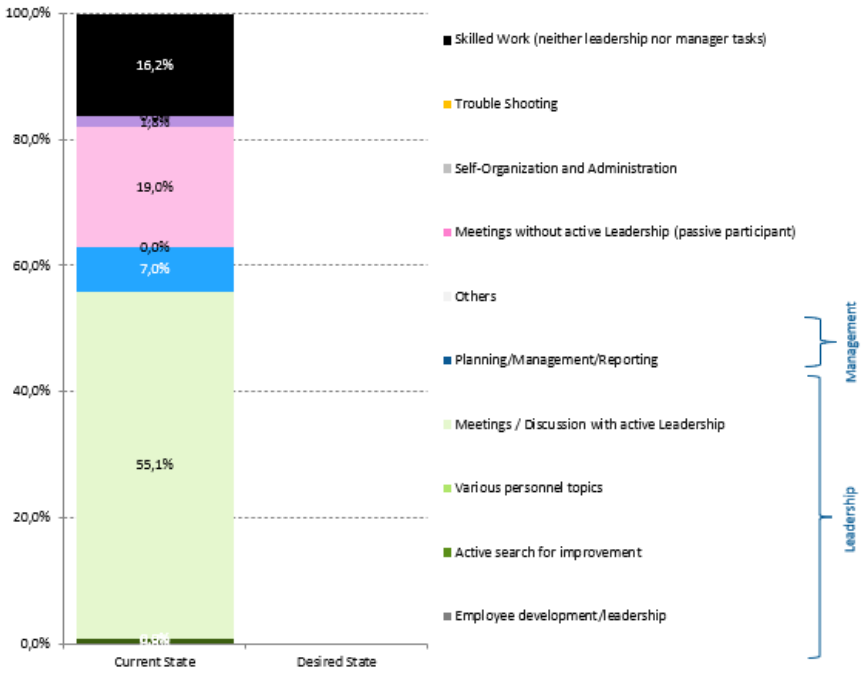


Figure 28 - WILO results from AE/MFT1.21

4.3.3 Rigidity Estimation

Rigidity was defined by the disturbances generated during the working time that differentiate the effective working time from the ideal. Essentially it was the Mura type of waste. It was generally caused by interruptions, unbalanced workload, multi-tasking, and unclear priorities. The evaluation was performed by a questionnaire considering the five dimensions to have an estimation of the rigidity of the group. Each question is scored from 0 to 4% according to the answer, meaning 0 as no effect and 4% as high effect. So, the total score can go until the maximum of 40%.

In this case, as displayed in Figure 29, the total result was 24% with most of the rigidity deriving from processes and customer. This result was caused by the high request fluctuation from customer side and

the number of parallel activities performed by employees. Consequently, the quantity of interruptions triggered by external parties were also high.

There was still, however, room for improvement in the organization and skills dimension, since some tasks from employees were controlled externally (by projects) and not within the group area which had impact on the workload.

To reduce rigidity in the group, it was proposed to define proxies and implement a skill matrix with the competencies of all employees involved and also free-up some capacity to handle unpredicted requests.

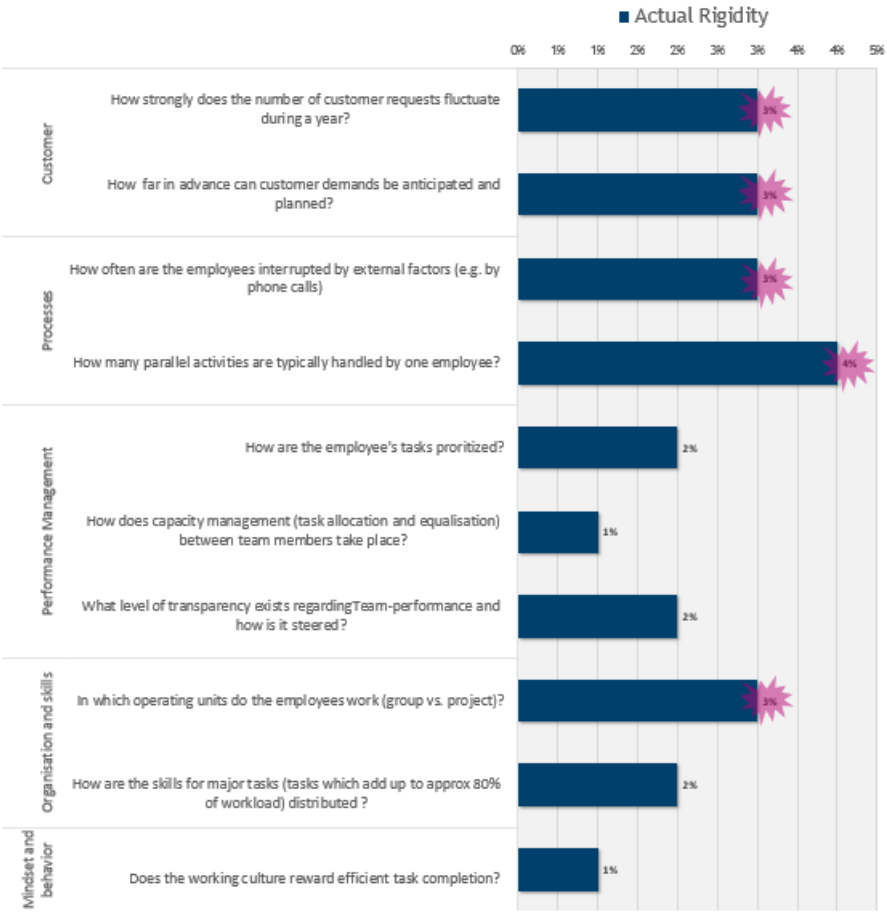


Figure 29 - Rigidity Estimation of the group

4.3.4 Meeting Cascade

The Meeting Cascade had the purpose of providing a transparent chronological and hierarchical overview of regular meetings. This allowed to reflect on the outcome and identify potential improvements on meeting structure and escalation possibilities.

At first, it was needed to calculate the Total Available Time (TAT) of the group so the hours could be converted to a percentage. The calculation considered all the working hours from one year. Considering a work week of 40 hours and 22 leave days (holidays), it resulted in 252 days per year. However, people

could not be considered as machines so, there was a risk of illness which was assumed to be 2% of the time. Hence, the TAT for each employee was 1799,7 hours/year. Since the group was composed by 16 employees and one Group Leader (manager of AE/EAI-PT AE/MFT1.2), the time was only considered by 50%, which resulted in a TAT of the group of 29738,7 hours.

The TAT value was inserted in the Meeting Cascade tool where all the regular meetings were listed, including some information such as number of participants, frequency, duration, and potential for improvements. This tool did not include meetings that were not scheduled in advance and, for that matter, were not foreseen in the following work weeks.

In this case, 68 meetings were analysed in the tool but for the purpose of presentation only the top 10 are displayed in Figure 30.

Top 10	Meeting name	% of TAT	Associates	Number of Meetings per Year	Meeting-hours cumulated for number of particpants per year (h/year)	Improvement Potential exists?	Where?		
							Preparation	Execution	Follow-up
Top 1	Daily follow up meeting AE/EAI-PT2	1,9%	5	226	565	No	-	-	-
Top 2	Follow-up ETE1-PT tasks	1,9%	5	226	565	No	-	-	-
Top 3	SE-Team RPS	1,5%	5	46	460	Maybe	X	-	X
Top 4	AE/MFT1.21 regular meeting	1,4%	9	91	410	No	-	-	-
Top 5	AE/EAI Department info	1,3%	17	46	391	No	-	-	-
Top 6	In-House SIP Module Project Meeting	1,2%	16	23	368	Yes	X	X	X
Top 7	Overall project meeting	1,2%	16	23	368	Yes	X	X	X
Top 8	FMEA Meeting	1,2%	2	91	364	Yes	X	X	-
Top 9	DAI CIVIC Gen 20x - SIP Module production	1,2%	3	46	345	Yes	-	-	-
Top 10	AE/EAI-PT3 Daily meeting	1,1%	3	226	339	Yes	-	X	-
	Other Meetings	17,3%		46					

Capacity used for Top 10 meetings	14%
Capacity used for all Meetings	31,3%

Figure 30 - Top 10 meetings from Group 2 in terms of TAT

The results show that 31,3% of TAT was spent on scheduled meetings, from which 14% was taken by the Top 10 meetings described above. The majority of the meetings required the participation of several associates and manager. However, half of the listed meetings were marked as potential for improvement either in terms of agenda/objectives or participants, timing, and protocol minutes. For these reasons, meetings were considered a pain point without any procedure or rules.

4.3.5 Employee Capacity

A deeper analysis to the capacity of the team and how it was spent in core-tasks was the foundation to discuss topics like skills, balanced capacity, and substitution rules. Data was collected from the tasks of all associates and then it was estimated the time each associate spends in each task.

A total of 32 tasks from the group were analysed, but this time the manager (Group Leader) was not considered in the calculations. Some employees obtained an estimation of more than 100%, meaning that they were overallocated. The remaining ones were just around that maximum which indicates they did not have any margin to perform any other unpredicted tasks.

Similarly, with the previous tool, the Top 10 is presented in the picture below.

		FTE Total	16,0		
Top 10 Final Product or Deliverable		Tasks, activities, projects, processes of department (incl. subject-related tasks of manager but without leadership tasks)	Working time per year (in FTE)		Main Pain Points / Waste Drivers
			in FTE	in %	
Top 1	Report for New component/material or technology development approval for usage at Bosch	Feasibility, processability and/or reliability	3,3	20,8%	-
Top 2	Expertise Support	COLORs activities, Support for MoB decision, technical information exchange, industrialization, Project Management and risk management, etc.	2,4	15,1%	-
Top 3	Report for New component/material or technology development approval for usage at Bosch	Planning, Tracking, Control and Closure of Projects	1,6	9,8%	-
Top 4	Autocad drawing files insert in SAP with Step stencil areas to be applied in Stencil design	Steps - Creation of Step Stencil files for stencil ordering	1,2	7,7%	-
Top 5	PDF + autocad drawing files sent by email with land design + stencil design to be used in PCB for components soldering	LEs - Footprint design	1,1	6,7%	-
Top 6	Deliverables	Deliberables to innovation project	0,8	4,7%	-
Top 7	Lab report	Perform analysis on AE/EAI-PT-LAB	0,5	3,0%	-
Top 8	Expertise Support (Lab analysis/soldering processes)	Strategy and methods definition for analysis; Interpretation and support on decision making and conclusions;	0,5	3,1%	-
Top 9	Merged processes and documentation	COLORS Project: KFV, DMD, LVL, PRE, PRP	0,5	2,9%	-
Top 10	Standard PFMEA	Create and moderate PFMEA for Standard processes	0,5	2,9%	-
		Others	3,7	23,3%	

Figure 31 - Top 10 tasks from Employee Capacity

The sum of the Top 10 tasks represented 76,9% of the group TAT whereas 30,6% was spent on reporting (including planning, executing and all preparation activities). The Standard PFMEAs task represented 2,9% although it was out of the scope of the functions of our department, which means less capacity for the group.

4.3.6 Waste of the Day

The involvement of associates in the tools was crucial to highlight the wastes from the group. They were requested to document the following file with tasks that they consider as waste or meaningless. For a period of a week, employees would write, at least, one waste they had identified during the day, its duration and estimate how many times it happened in a year. In Figure 32 it was represented some of the inputs collected from the team. A total of 77 wastes were identified being overprocessing, waiting, overproduction and missing skills the most represented.

Date	Waiting	Motion	Transportation	Inventory	Rework	Over Processing	Over Production	Missing Skills	Description	No. of affected employees	Waste [min]	No. of occassions / year	Total Waste / year [hrs]
15-fev-2021	X	X							Move to the Printer	1	3	50	2,5
16-fev-2021	X	X	X	X					Collect material	1	30	20	10,0
17-fev-2021	X	X	X	X					Inventory Organization	1	60	4	4,0
18-fev-2021	X	X	X	X					Recycling/disposing material	1	120	2	4,0
19-fev-2021	X					X			Passive participation on a meeting (reasons: Someone overused his time, poorly organized meeting or invited and at the end my participation was not even required)	1	30	125	62,5
22-fev-2021	X					X			Reading emails that do not require my help	1	45	30	22,5
22-fev-2021	X	X				X			Unnecessary face to face meetings	1	10	20	3,3
22-fev-2021						X			Unexpected visit from a colleague from other department with "pseudo-urgent" topics	1	60	20	20,0
17-fev-2021					x				E-mail management (deleting e-mails without relevance)	1	5	231	19,3
17-fev-2021							x		Filling more fields than necessary in internal file of purchasing	1	2	220	7,3
18-fev-2021					x				Parallel meetings at the same time	1	30	94	47,0
19-fev-2021	x						x		Wait for feedback to unlock NLAG and have to repeat the same information filled in SAP	1	40	6	4,0
22-fev-2021			x	x	x				Scrap process (more than 2 times per year)	1	240	2	8,0
23-fev-2021	x				x				Wait for participants in meeting	1	10	47	7,8
23-fev-2021	x				x				Wait for feedback to approve an investment which had to be requested again	1	20	3	1,0
23-fev-2021						x			Report e tracking de tarefas	1	60	230	230,0
23-fev-2021				x					Arrumação de containers utilizados para testes	1	30	4	2,0
23-fev-2021			x						Envio de Containers para o Laboratório	1	60	5	5,0
24-fev-2021							x		Repetição do envio/recepção de email de lembrete sobre tarefa que ainda está em execução	1	5	100	8,3
24-fev-2021								x	Multitasking	1	30	30	15,0
17-fev-2021	x								Waiting for e-mail response	1	60	50	50,0
24-fev-2021	x								Meetings - passive partcipation	1	30	53	26,5
24-fev-2021		x							Not knowing exatly how many samples available to test - waste tame inventorying	1	20	6	2,0
24-fev-2021		x							Lack of paper in the printing	1	5	5	0,4
24-fev-2021	x								Meeting room occupied during the time that I have scheduled	1	5	10	0,8
17-fev-2021		X		X					High amount of inventory dificults the search for the required material for trial and/or use	1	30	47	23,5
17-fev-2021							X		Duplication of the information form a meeting minute (duplication of tasks on SuperOPL and Docupedia)	1	20	10	3,3
17-fev-2021								X	Search for information	1	60	47	47,0
18-fev-2021	X								Waiting for approval of purchasing material	1	60	47	47,0
18-fev-2021								X	Repeat purchasing process, because there are changes	1	45	10	7,5
18-fev-2021	x								Meeting at the same time, means that either one meeting was not important	1	60	100	100,0
19-fev-2021							X		Present at na MRL Meeting where I was not the PM	1	90	30	45,0
19-fev-2021					X				NLAG SAP layout changes from EN to DE randomly, and the NLAG process has to be repeated	1	30	40	20,0
22-fev-2021			X	X	X				Scrap proces	1	240	2	8,0

Figure 32 - Extract from Waste of the Day tool

Due to the Covid situation, the group was working from home so, the wastes related with motion, transport, and inventory were not representative. However, from this analysis one of the most reported

wastes identified was before and during meetings due to poor preparation, meetings scheduled in parallel and passive participation. Another highlight was the search for information either on the intranet, file share folders or SharePoint since people take too much time (between 30 minutes to one hour each time) finding the right information in the right place. Furthermore, the reporting and tracking of tasks that was demanded during home office was regarded as over processing.

4.3.7 Skill Matrix

Initially, a list of necessary skills for our area was defined (either operational or soft skills) and for each of them the number of required employees in the level basic, advanced, specialist or champion is defined. Each level represents a value from 1 to 5:

1. No knowledge about this skill area or skill not necessary.
2. Basic knowledge of skill: frequently needs support from other experienced employees.
3. Advanced level: knows the skills and can identify potential improvements.
4. Specialist level: besides the knowledge of the skill are and highlight improvements, can act as a coach for other colleagues.
5. Champion level: knowledge of skill and its interdependencies with other areas.

For the Skill areas setup, the first level it was not necessary since we were registering the desired “dream team”. Then, for each employee, the current state of his/her skills and the target to be achieved in one year according to the levels.

For this tool, the group decided to split the Skill Matrix into 2, one for AE/EAI-PT2 and AE/EAI-PT3 and other for AE/MFT1.21, due to the high number of different skills between the teams. In this dissertation, it was only included the Skill Matrix for AE/EAI-PT2 and AE/EAI-PT3 for scope purposes as the author’s functions were within this team.

In Figure 33 it is presented the skills required for the desired team in AE/EAI-PT2 and AE/EAI-PT3.

Listing of Skills (Please define the skills necessary for your area)	Type Operational/Strategic - optional -	required Skill Coefficient	required Number of "basic" (Please insert required number of employees in "Basic" level)	required Number of "advanced" (Please insert required number of employees in "Advanced" level)	required Number of "Specialist" (Please insert required number of employees in "Specialist" level)	required Number of "Champion" (Please insert required number of employees in"Champion" level)	Numbers of employees needed with this skill
Cooperation (Conflict management & Negociation skills)	Strategic	18,18		5	6	0	11
Communication skills & Presentation skills (confident personality)	Operational	25,00			11	0	11
English	Operational	10,00		11		0	11
Operations Management (Project Management + risk management)	Operational	21,18	8			3	11
Overview and ability to influence	Strategic	18,18		5	6	0	11
Efficiency with quality of work carried out	Strategic	25,00			11	0	11
Coping with ability to solve problems	Strategic	18,18		5	6	0	11
Leadership	Strategic	16,82		6	5	0	11
Resilience/ability to work under pressure	Strategic	25,00			11	0	11
Knowledge in MTE process;	Operational	12,09	8		2	1	11
KPIs	Operational	2,00	2	2	0	0	4
ECR tool	Operational	1,82		2	0	0	2
Project/activity (direct financing + EVL) + 3S-List and project list updates;	Operational	6,82			3	0	3
Knowledge of the MCR tool	Operational	2,73		3	0	0	3
Analysis AIT	Operational	7,73	10			1	11
Statistics	Operational	8,64		7	1	0	8
CAD/CAE tools	Operational	3,09	4	3		0	7
PCB Technology	Operational	2,09	3	2		0	5
PCB Cause-effect-relationship	Operational	2,09	3	2		0	5
Component Technology (how is it built? Validation tests, etc...)	Operational	2,00	2	2	0	0	4
Component design for PCB AIT	Operational	4,64	1		2	0	3
SMT Process	Operational	5,64	7	3	1	0	11
SMT Cause-effect-relationship	Operational	3,18	5	3		0	8
Simulation	Operational	2,27			1	0	1
Chemical AVT - Thermal interface materials	Operational	1,09	2	1		0	3
Chemical AVT - Surface protection	Operational	3,27	1	1	1	0	3
Chemical AVT - Component Fixation	Operational	10,00		1	1	1	3
Surface & Backend Technology	Operational	3,27	1	1	1	0	3
Interaction AIT PCB	Operational	8,91	3	7	1		11
Product know-how	Operational	1,00	11				11
SIP Modules process	Operational	15,00	5	1		2	8
SIP Modules cause-effect-relationship	Operational	5,91	5	1	2		8
Problem solving	Operational	8,64		7	1	0	8

Figure 33 - Skill areas for matrix of AE/EAI-PT2 and AE/EAI-PT3

The required skill coefficient expresses the need of a certain skill and the different levels within the group. It then helps to compare the current and the target state with this requirement. It means that the higher the coefficient, the higher the effort required to achieve the required level. The calculation was automatically performed through the formula:

$$\frac{(nº\ employees\ level\ 2) \times 1 + (nº\ employees\ level\ 3) \times 10 + (nº\ employees\ level\ 4) \times 25 + (nº\ employees\ level\ 5) \times 75}{team\ size}$$

From there, the skill matrix was filled with the corresponding levels to each employee (Figure 34) that in this case, for confidentiality reasons, were identified with numbers in the columns from A to K. This scoring was performed by team leaders, without the intervention of any other team members.

The evaluation of the Skill Matrix was generated automatically with colours and values from the coefficient and compared the current level with the target level. If the current level was higher than target level, then the team competencies were higher than required, which means that the value was marked with green. If there was a gap that was set to be improved, the colour was set to yellow. Finally, if the team skills were lower than required and it had impact on the team performance, the values were defined as red.

The Skill Matrix was a living document so it should be updated regularly but in this initial phase the intention was to analyse the existing gaps in terms of skills.

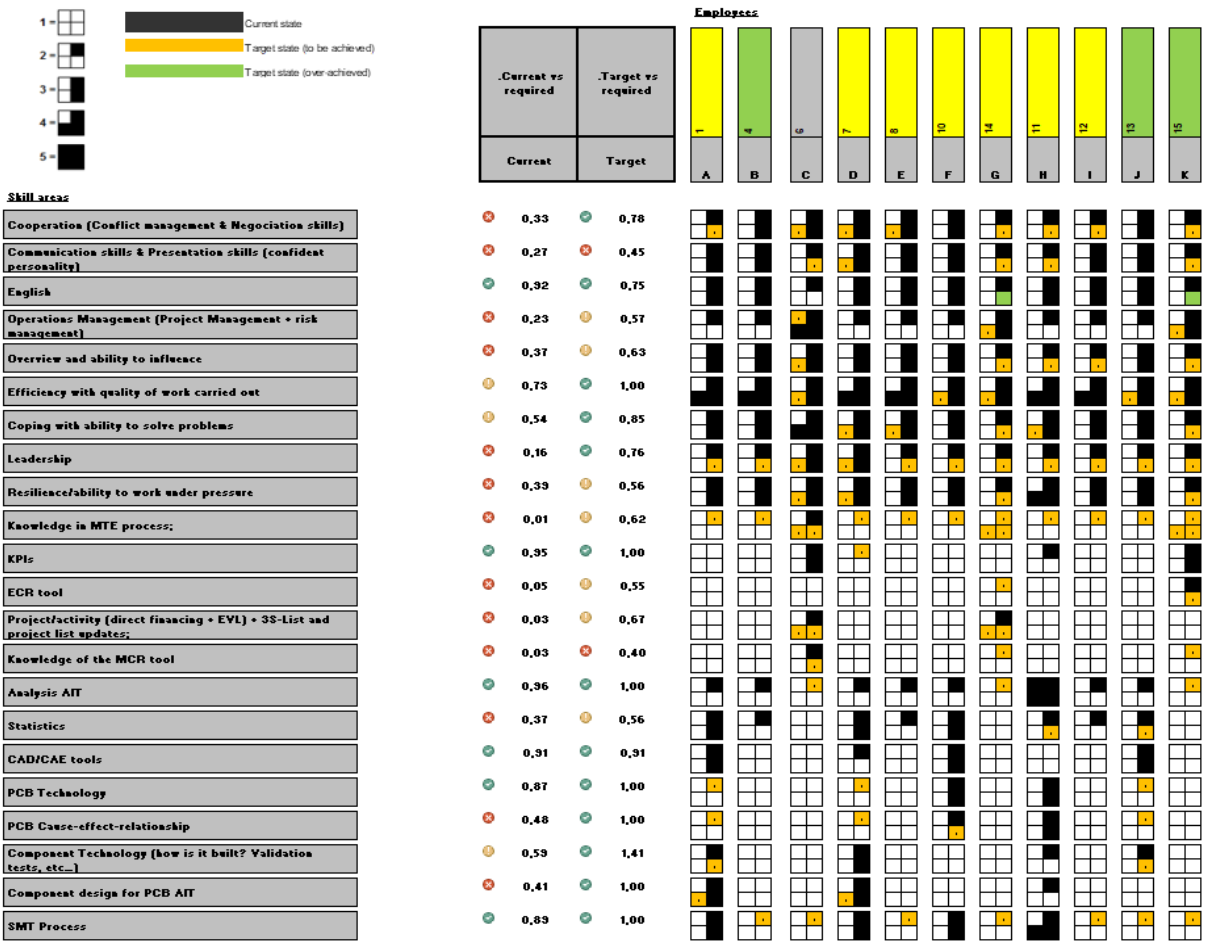


Figure 34 - Skill Matrix for AE/EAI-PT2 AE/EAI-PT3

It was verified that the ratio between the current state and target state of skills in the team was 81%. There were various skills that were according to target but there was still room from improvement in soft skills such as conflict management, negotiation and leadership and other technical skills related to process development activities.

4.3.8 Focus Group Workshop

The Focus Group Workshop consists in a meeting with a small group, in this case 13 people (team leaders are not included), with a moderator. In the workshop several pictures were presented to creatively reveal employees' perceptions and feelings about the subject. It encouraged the exchange of ideas that normally did not happen in the presence of team leaders.

The scope of this workshop was to understand people's opinion about the collaboration within the team, with the team and manager (both Group Leader and Team Leader) and the working environment. Each team member was asked to answer those three questions by choosing one or two pictures with a short description with reference to the current state and the future state they desire. In Figure 35 is represented one example per question from the results.

Figure 35 - Focus Group Workshop results

The results demonstrated that the team generally feels that there was good cooperation. However, some of them reported that they did not know what the tasks of the other team members were. The excessive workload and lack of clear definition of responsibilities were also highlighted as issues.

As for the perception from collaboration with team leaders, employees saw them as advantageous since the function was created about one year ago. Team leaders were seen as a way to have more support from management side with whom they easily communicate and saw good cooperation.

In terms of working environment, many people complained about the physical area due to lack of storage space and organization. The team worked in a container that was set as temporary solution, so it did not have the same working conditions as other facilities in the plant. As the group functions were related to

process development, there was a need to perform SMT insertion trials which then requires space to store all the raw and assembled material.

On the other hand, related to the social features, the team felt that the bound within the group was good although they did not feel as connected as with the rest of the department. Therefore, they suggested more activities to help bring the department together such as team building.

4.3.9 Customer Interview

Similarly, as Focus Group, the interviews to customers are a method to understand the customer expectations and, consequently, identify how to increase the value add for the customers. The interviews consist in 1 on 1 questionnaire with qualitative and quantitative questions. It aims to analyse if the customer expectations are met, what are the high-level expectations and understand the level of timeliness, quality and problem solving.

The interviews were conducted to 10 different customers from our core processes and deliverables: XC Development, Production Department from Plants, Plant Project Manager, Quality Department and Component Processability Release responsible.

For quantitative questions the rating goes from 0 (not applicable), 1 (Exceptional) to 6 (Poor), so the lower the average, better is the rating.

The compilation of the results from the interviews is represented on Figure 36. The global average rating was 2 which represented a good overall satisfaction.

All questions had the average result and the range of rating from all the answers. Related to cooperation, customers identified difficulties in having on-time deliveries and ad-hoc queries due to the different time zones. Since our group works with different plants worldwide this was a common struggle within the organization. Apart from this, the cooperation was seen as good and to maintain in the future.

Figure 36 - Results from Customer Interviews

The support and services provided by the group had quality and good degree of completion which enables customers to proceed without having to involve other groups. Nevertheless, the tasks performed by the teams were so complex that sometimes recursions were needed.

The rating for the customer satisfaction presented more variance because some customers did not have their expectations met. Despite this, the openness to accept new challenges was favourable for our group.

As global feedback, customers stated that there is still room for improvement in terms of timing and level of detail of the feedback provided to the customers. Also, they perceive that the organization was not aware of the responsibilities of our group neither the structure which was previously identified during the workshops with the team members. However, our laboratory services were considered as excellent and made suggestions to invest more time in the investigation of innovation topics.

4.3.10 Employee Survey

One tool that was used to understand the mindset and behaviour of the team was the Employee Survey. It helped to identify strengths and potential for improvement within different dimensions like leadership, management, goals of the department and working environment.

The survey was conducted to team members anonymously with a ranking of 1 to 5. The 30 questions and the results are compiled in the Appendix 1 – Results from Employee Survey. As the survey was voluntary, not everyone from the team answered the questionnaire, so from 13 employees (team leaders were not included), only 11 people responded. Even though some answers were lower than three points, the average rating from the survey was 3,5 which represents a good score.

It is also noticeable that there were some topics with higher scores (between 4 and 5) especially in the category of improvement of work processes which demonstrates the willingness of the team to improve and provide active and visible contribution to the department and organization.

On the contrary, the lower rated questions were related to the exposure to stressful situations and the need to take a longer working day to finish the tasks.

The team felt that they provided a good performance in the AE division, but the future was still unclear, and it was difficult to know customer demands. There were some topics that needed improvement such as communication of changes by the supervisor, personal development measures and workplace conditions.

The Employee Survey confirmed some of the observations from the previous tools by the identification of the same issues.

4.3.11 Process Observation

Based on the previous diagnosis tools, some activities were selected to perform a deeper analysis through the Process Observation. It was select the creation of a new footprint design for PCB and cross sections preparation in the laboratory (cut a PCBA).

The results are represented in Figure 37 and Figure 38. Both observations lasted for, at least, one hour and the start time and end time of each task was registered.

The first Process Observation had 28% of waste such as waiting for the programs to open/respond, rework of some tasks due to errors and registering the tasks just to perform tracking. The support activities (56%) included using different tools to help to verify dimensions of land pattern design and using the

component datasheet to check information. The value-add activities for this case were performing the drawings in AutoCAD and sending the final design by email to the customers.

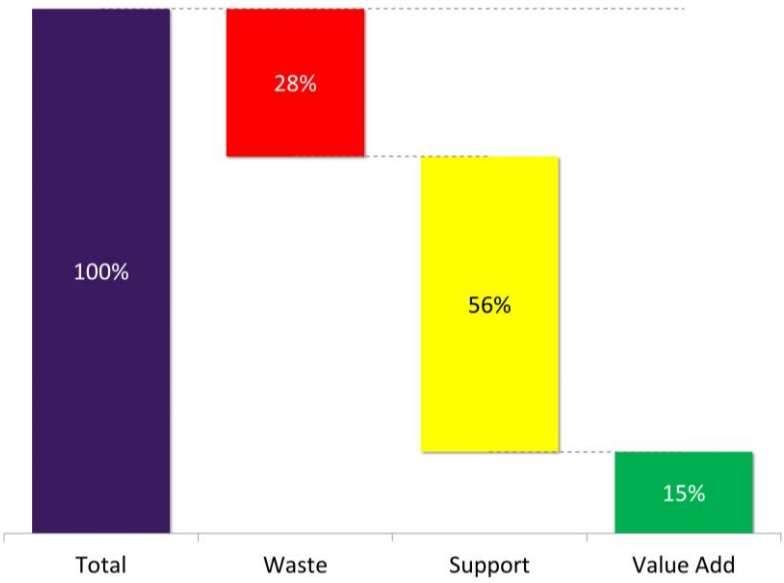


Figure 37 - Process Observation results from creation of a new footprint design

The high percentage of support activities in a process must not be mistaken with value add because although they can have a valuable purpose, they are not part of the output for the customer. So, these activities may be considered as non-value-added but are necessary for the organization. If an organization can be distinguished into two organizations, production organization and support organization, it can be verified that there was a large number of activities within the support organization, which in turn, were considered as support activities (non-value-added) (Nicholas, 2018). Therefore, in the context of our group, the portion of activities classified as support was according to expected.

From the analysis, it was identified some improvements that could be implemented:

- Task management could be improved by using a tool to follow and manage activities directly with the customer instead of using different tools.
- Create a standard procedure to describe the task since the team members are performing it in different ways.
- Reduce the number of platforms used to store and send files to reduce digital waste (tools used are Excel, Email, WorkOn).

Opening all the programs that were needed to perform this process instead of waiting for each one to open was also identified as good practice.

The second Process Observation was performed on the laboratory, during the preparation of samples for cross sections. This process requires to follow a test plan which determines the areas where the PCBA must be cut in order to perform the cross section. Then it had a series of steps before and during the machine operation.

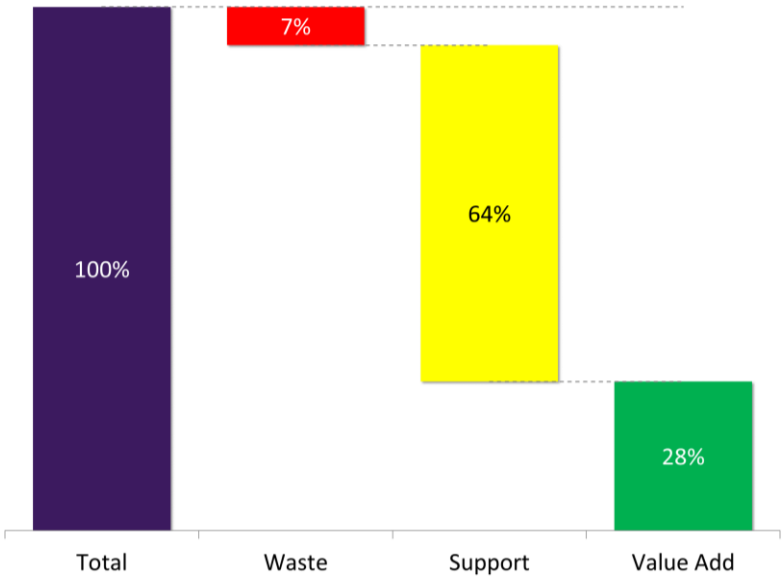


Figure 38 - Process observation results for cross sections preparation

From the analysis of the observation, it was verified a higher percentage of value in comparison with the previous process. This is justified by the manual work it involves since the value add is performing the cuts in the PCBA which takes longer. The wastes identified were related with getting the wrong test plan (rework) and not having the tools to start the process (clean area to work and chemical solution for the machine).

As support activities there were adjustments made to help cut the PCBAs, perform the dilution of the chemical solution for the machine and identify the boards that are cut. Overall, the process seems to be optimized without any further ideas for improvement.

4.3.12 VSDiA results

The scope of the VSDiA performed within the group was the SMT insertion trials. This process was highlighted as confusing, without any standard procedure and with potential for improvements by employees. Our group frequently needed to perform trials in the SMT insertion lines in the plant (Braga) so the request and planning was made with the production department. Hence, the need to perform a deeper analysis which is represented in Appendix 2 – VSDiA analysis from SMT insertion trials.

The process flow involved the planning and preparation of the trial up to the end of the SMT insertion. The group was split in the swim lanes by each respective team leader (AE/EAI-PT2, PT3 and AE/MFT1.21) because each team had different tasks during the process.

The lead time of the process was approximately 80 working hours in which 6% (4,8 hours) were value added activities. In this case it was mainly the SMT process to produce a complete PCBA. Support activities represented 14,5% of the total time and included planning, preparation activities and setup.

The process flashes (Figure 39) were also identified that help to describe the issues on the SMT insertion trials.

	Problem description
A	There is no standard checklist with the needs for production, stencil, solder paste type, labels.... This can lead to lack of material on the insertion day.
B	Request information not complete.
C	Unclear Process. Who is the responsible?
D	Plant specialist limited capacity. Strong dependance on their availability;
E	Line is some times unavailable, even though it is booked.
F	Program not optimized.
G	Specialist availability.
H	Waiting time between adjustments

Figure 39 - Process flashes with problem description

In terms of activities, the remaining time was related to waste (62 hours) that refer to:

- Transition period: the waiting time between activities especially at the planning phase, such as getting feedback and waiting for the availability of the programs for the machines.
- Transport of the materials to the SMT line.
- Line setups (temperature adjustments) after starting the trial.
- Change the parameters of the machines back to the previous status.
- Send a report of the parameter changes and confirmation of reestablishment of the SMT line to previous state to the production department.

As a consequence, this process was identified as one with potential for improvement.

4.4 Synthesis of problems

After identifying the problems through Diagnosis tools, in the next table (Table 3) it is presented a synthesis of those and the respective wastes and consequences.

Table 3 - Synthesis of problems identified during Diagnosis Phase

Problem	*Type of Waste*	*Consequence*
Unnecessary and inefficient meetings	Waiting	Too much time spent on meetings Wasted time due to unnecessary meetings or passive/unnecessary participation Delay in taking decisions or deadlines of projects Lack of participation of employees in meetings
Too much waste in SMT Insertion Trials	Waiting, Defects and Transportation	Need to repeat the trial due to lack of time available Conflicts during the planning phase
Lack of prioritization of tasks/projects/activities	Rigidity (disturbances) and unbalanced work	Conflicting deadlines of projects, tasks and activities Not meeting stakeholders' expectations
No current overview of different tasks and projects	Unbalanced work	Multitasking which leads to stress Difficulties in prioritization of activities
Too much time spent on searching for the correct information	Motion and Waiting	Too much time spent to conclude a task Rework when the right information is found
Lack of organization and dedicated space for material storage	Inventory and Waiting	No deadline for storage time of material which results in not knowing the material that is stored No register of inventory so the current storage space is not enough
Missing skills for all the current responsibilities or activities assigned	Non-utilized human talent	Need to request to other colleagues for help in some activities
Lack of Digital 5S mindset	Inventory	Duplicated or unnecessary information stored
Communication issues	Defects, Overproduction and Waiting	Not knowing the expectations of the customers Lack of engagement within the team and management No feedback culture

5. PLANNING AND PRESENTATION OF PROPOSALS FOR IMPROVEMENTS

This chapter presents the improvement ideas developed during this dissertation taking into account the issues highlighted in Chapter 4. So, now the research questions referred on Chapter 1 need to be answered. The second step from Action Research methodology takes place, as possible solutions are formulated, and an action plan is defined.

5.1 Tactical Implementation Plan

As stated in Section 3.3.2, the most relevant issues were compiled, and measures defined in the tactical implementation plan (TIP) file. It was also estimated the time spent and the potential improvement in hours and percentage of Total Available Time (TAT). This allows to calculate the potential productivity gain of the group.

The measures were defined and discussed within the group during the Design Phase of the project. In the Table 4 are presented some of the measures planned to use the 5W2H methodology. Although the timing of each measure was defined for the Lean Project, it was decided not to include the "When" factor in this table as it was not relevant to obtain the results of this work. Also, since the Lean Project was longer than this dissertation, the results of some measures were not possible to evaluate so, it was decided not to include all topics that were considered. The measures that refer to general topics which were not specific for Group 2 were also discussed and presented to the whole AE/EAI-PT AE/MFT1.2 section.

Table 4 - TIP measures defined for the group

What	*Why*	*Where*	*How*	*Who*
Improve meeting management	Too many meetings within the team with many inefficiencies: Unnecessary meetings (could have been an email) Passive or unnecessary participation Too much waiting time at the beginning Meeting overtime	Planned recurrent meetings within the group or with externals. Ad-hoc meetings.	Define a Meeting Codex with rules for meetings: standard agenda, time keeping, meeting minutes and good practices.	AE/EAI-PT AE/MFT1.2

SMT insertions for trials	SMT insertions for development trials which have 80% of waste. Several team members, depending on trials (acc. to VSDiA)	AE/EAI-PT AE/MFT1.2 Production department	Create Standard Procedure to perform SMT insertion trials (request, flowchart, data needed, operator request). Get agreement and approval by plant specialists. Use Lean Leadership System to identify and solve key problems	AE/EAI-PT AE/MFT1.2
Prioritization	Lack of prioritization of tasks/projects/activities. Unbalanced workload which causes struggles with capacity management of human resources.	AE/EAI-PT AE/MFT1.2	Training to the team about "Work Efficiency" (self-organization). Deploy and train the team about the "Overall Overview of Projects A/B/C/D). Deploy and train the team about Capacity Management tool. Deploy and use Teamboard for short-term capacity management (Lean Leadership System)	AE/EAI-PT AE/MFT1.2
Projects and activities management overview	No current overview of different tasks and projects with key topics: - milestones; - responsible; - standardization of names - requirements; - Requester/etc	AE/EAI-PT AE/MFT1.2 Stakeholders	Create and use a structured, easy to use overview of all projects and activities from the team available for all organization	AE/EAI-PT AE/MFT1.2
Improve information management	Too much time spent on searching for the correct information in different locations.	AE/EAI-PT AE/MFT1.2: Drive O and Docupedia	Improve information management (Drive O and Docupedia): - Clear information; - Organization of folders; - Do not duplicate content (e.g. same content in different folders/platforms); - Integrate with Docupedias from AE/NE-CT (EAI) and MFT; Update Data Concept.	AE/EAI-PT AE/MFT1.2
Improve inventory management	Lack of organization and dedicated space for material storage which hinders the preparation for trials, increases the time to find the correct material and inventory control - No inventory control and follow-up; - No material identification; - Overcome expiry date;	AE/EAI-PT AE/MFT1.2 area	Integration of BPS 5S systematic. Create procedure for inventory and update inventory file.	AE/EAI-PT AE/MFT1.2
Assign trainings for the skills that are missing	Missing skills for all the current responsibilities or activities assigned (e.g. using new required software, new responsibilities/tasks).	AE/EAI-PT AE/MFT1.2	Define the necessary trainings for each employee and align with the role (Implement Skill Management from Lean Leadership System)	AE/EAI-PT AE/MFT1.2

Create awareness regarding Digital 5S	Lack of Digital 5S mind-set within the team which generates Digital Waste (e.g. e-mails, presentations, organization, etc.)	AE/EAI-PT AE/MFT1.2	Create a workshop for the team to understand current mind-set and aware them about the waste generated digitally.	AE/EAI-PT AE/MFT1.2
Communication issues	Not knowing customer requirements Lack of interaction between team members and management No culture of Feedback 360 within the team	AE/EAI-PT AE/MFT1.2	Establish Teamboard to promote information exchange and promote feedback. Implement Agile Collaboration practices.	AE/EAI-PT AE/MFT1.2

From these measures defined during the Design Phase, some started to be implemented during the Implementation Phase and continue during Sustainability Phase. In the next sections it is presented the proposals for improvement.

5.1.1 Improve meeting management

One of the major pains identified during Diagnosis Phase by the tools and also by employees was the inefficiency of meetings in which the group participates whether they are internally lead or external.

During this project, most of the work and, as a result, the meetings, were performed in a virtual environment. For that reason, one of the wastes mostly attributed to meetings is related to motion since people may need to travel from one place to another. Using virtual meetings, the participants do not need to move away from the workstations while they can use collaborative methods based on software to interact (Gonzalez-Rivas & Larsson, 2011). Of course, some may argue that a virtual meeting can also distract some people and even promote multitasking. This in turn, highlights the need for face-to-face meetings and to focus on its purpose.

The potential productivity gains are calculated when the measures are included in the TIP file. For this case of meetings, three types of wastes were identified:

- Waiting time and overtime of meetings: based on Waste of the Day data, each employee spends 20 minutes per day either waiting for the meeting to start or by extending the meeting more than the scheduled time. The overtime from one meeting has a snowball effect on the next ones since they may start delayed. This results in a waste of 1220 hours per year in the group. The target is to eliminate the waiting time and stop meetings on time, with no delays.
- Too many participants: There are a lot of meetings with the team in which the participation is not necessary. Appointments are made for the first meetings where some people are required but along the time, their participation is not active. By the Meeting Cascade tool, it was possible to

visualize that there are 362 hours per year scheduled for regular meetings. The purpose is to reduce the number of participants and optimize the meetings through reduction of time.

- Unnecessary meetings: There are some unnecessary meetings (often ad-hoc meetings) in which the subject is not clear, with too many participants invited and sometimes with not enough time for preparation which then requires a subsequent meeting. This waste was identified as rigidity since it is considered a disturbance from planned work. Rigidity is established by Lean Team as a waste of 0,5% of time, which in this group, represents 150 hours/year.

The proposal to tackle issues with meetings was to create a Meeting Codex with rules and standards for the meetings. As there were already some rules defined in other departments in the plant, the first step was to check what was existing to be analysed.

One of the first improvements was to define a template for the agenda of the meetings (Figure 40). The template was adapted from other departments to adjust to our needs.

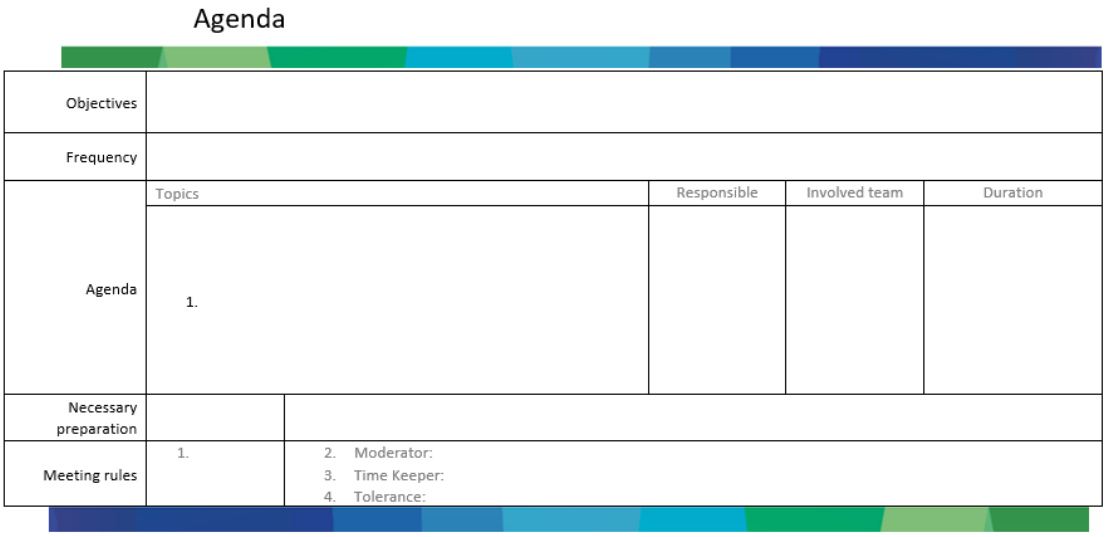


Figure 40 - Template created for the Agenda of meetings

One of the main advantages is that this template is in a table format that can be saved inside Outlook program, so it can be easily accessed when scheduling a meeting. It presents a structured way to present the objectives and topics to be discussed and the timing for each topic.

The Meeting Codex needed to comprise the activities before, during and after the meeting. So, it was created a manual and information to be displayed inside the meeting room. In the next figuresFigure 41,Figure 42 and Figure 43 it is presented the meeting codex created that was presented to the team. The Figure 41 presents the meeting codex before the meeting.

Figure 41 - Meeting Codex for rules before the meeting

The Figure 42 presents the meeting codex during the meeting.

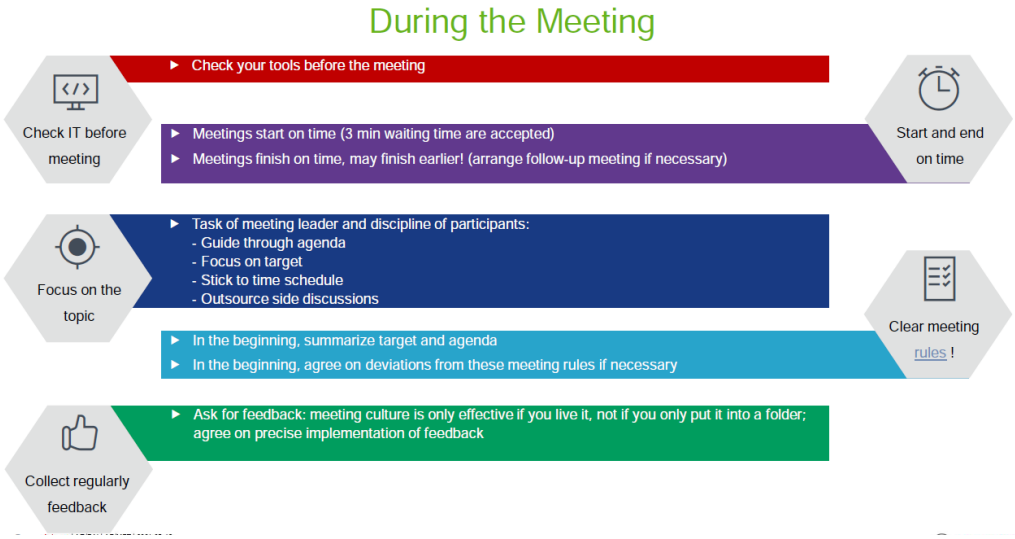


Figure 42 - Meeting Codex for rules during the meeting

The Figure 43 presents the meeting codex after the meeting.

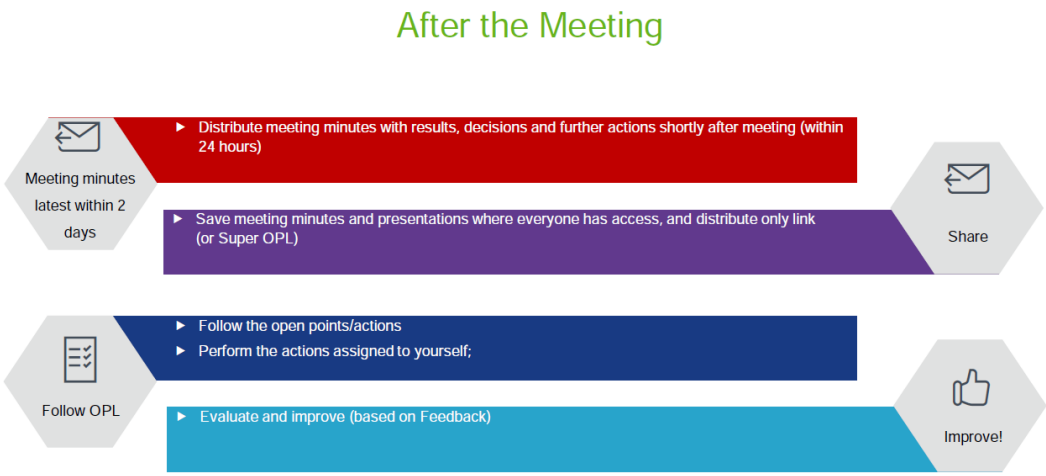


Figure 43 - Meeting Codex for rules after the meeting

5.1.2 SMT insertions for trials

After the VSDiA analysis that highlighted that SMT insertions had 62 hours of waste (approximately 80% of the total process), considering that the group performs around 32 SMT insertions trials per year, it represented a total of 1984 hours/year of waste.

Therefore, from the waste identified it was possible to propose the following improvements:

- Create a standard procedure for this process
- Reduce waiting time for programs and reflow profile
- Reduce waiting time during planning phase

The remaining wastes identified such as transportation, making line setups and changing the parameters back to the state before the test (including sending the report) cannot be eliminated due to the nature of this process. As our department is not located inside the production area and the material needs to be sent for further analysis, there is no possibility to reduce transportation. Since these trials were related to process development activities, there was always the need to adjust the line due to the new technologies or processes being tested which implies trial and error so, the line setups and changing the parameters are always needed.

However, some suggestions regarding these topics were also considered such as preparing all the material beforehand to reduce the number of transportations and prepare as much as possible the line setup.

In terms of productivity gain with this measure it was expected to:

- Reduce the waiting time of reflow: if the PCB is prepared beforehand for taking the reflow profile it can reduce 2 hours per insertion, which represents 32 hours per year.
- Reduce remaining wastes by the implementation of the proposed measures in 7,5% which translates in 148 hours per year.

To reduce the waiting time during the planning phase, it was decided to perform a Problem Solving to the SMT insertion planning to understand the root cause. In the next Figure 44 and Figure 45 it is represented the fundamental problem description and the logic tree analysis.

Questions	Is The problem exist	Is not The problem not exist, but could be	Differences	Why? Root cause
Who?	MOE1	EAI-PT	Responsible for planning in MOE1	
What?	Lack of awareness and flexibility within the teams	Lack of defined requirements		
Where?	MOE1 lines			
When?	During EAI-PT trials	Planning Phase		

Figure 44 - Fundamental problem description for SMT insertion planning

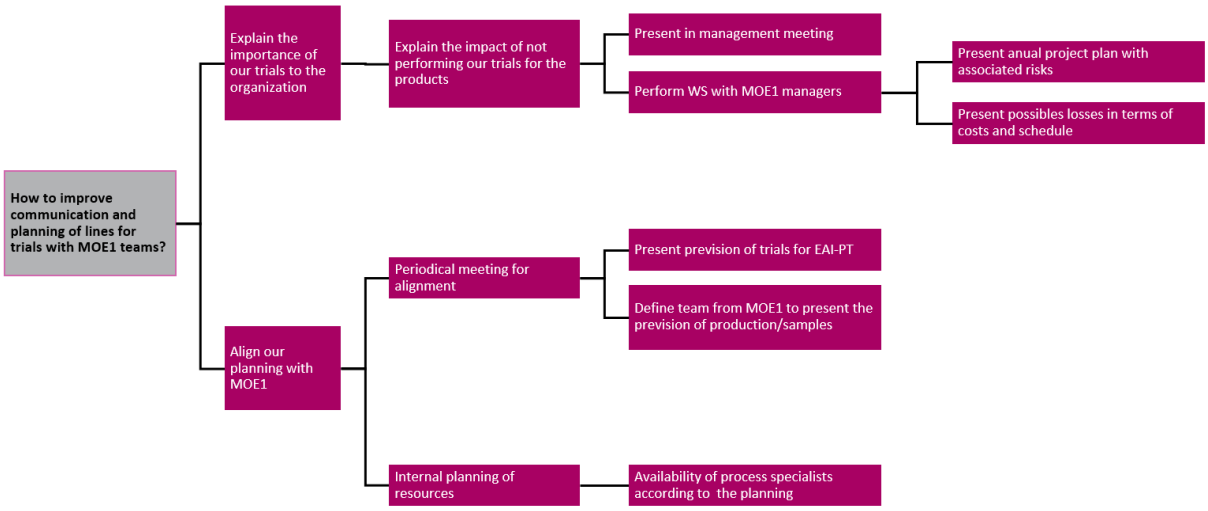


Figure 45 - Logic tree analysis for SMT insertion planning

From this Problem Solving it was decided to perform meetings with MOE1 department to explain our issues and concerns about the SMT insertions and to define a method to improve the planning:

- SMT insertion trials from AE/EAI-PT AE/MFT1.2 were considered with lower priority because they are neither standard production nor product samples. After these meetings, managers understood our concerns and decided to give our trials the same priority as for product samples
- Due to the previous topic, our planning for trials was only sent to production department behind schedule since they did not provide any booking beforehand. It was possible to make an agreement about the planning and since we have any prediction of our trials and make a booking for that week.
- It was also established our planning contact and how to communicate and escalate topics if needed.

5.1.3 Prioritization

The number of parallel activities per employee had the highest score on Rigidity Estimation (Chapter 4.3.3) with 4%. Similarly, in Focus Group Workshop (Chapter 4.3.8) and in Employee Survey (Chapter 4.3.10) it was stated by the team that there was an excessive workload, not clearly defined responsibilities and consequently they felt stressed and had to spend more hours at work in order to finish the tasks.

The main issue for these problems was identified as lack of prioritization of the activities that had impact on various topics. This measure is also linked with one of the LLS elements: Capacity Management.

The Capacity Management implies to also make prioritization of activities and have an overview of all projects and activities allocated to a person.

The aim with this measure was to reduce the rigidity by 0,5% of TAT, which represents 150 hours per year. Therefore, it was established to perform:

- Training to the team about "Work Efficiency"
- Explain to the team the measure about "Overview of Projects and activities"
- Use Teamboard for short-term capacity management and prioritization
- Use and deploy a Capacity Management tool

The workshop about "Work Efficiency" aimed at training the team about self-organization where it was presented some prioritization techniques such as the Eisenhower matrix, 80-20 rules and making a list with the tasks for the day. It also explained the Deep Work technique to help focus on activities that require more attention.

The Teamboard was a tool that was implemented in the scope of the Agile Collaboration in the LLS and is explained later in this dissertation. In this tool, it is possible to create different buckets, and, in this case, it was defined to create a bucket for Mood and Capacity (Figure 46).

This systematic of using tickets to define the capacity of employees allows them to give feedback about the status of their workload to the team and manager during team meetings. Not only allowed for the team leader to adjust their activities but also for the rest of the team to check and even have the opportunity to offer their support.

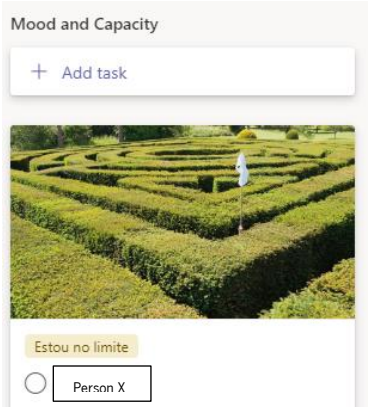


Figure 46 - Mood and Capacity representation on Teamboard

This proposal only works for short-term capacity management, so it was necessary to design a concept for a tool for long-term analysis. The tool should consider all the inputs for the group such as projects, activities, and requests. Then, the tool should consider the responsibilities, proxies, and corresponding workloads (Figure 47).

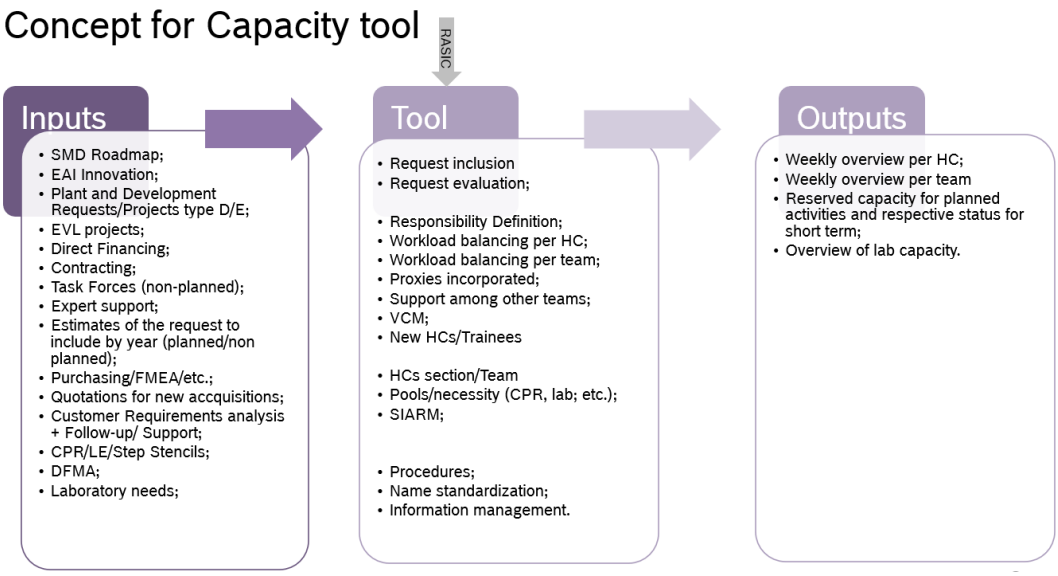


Figure 47 - Tool concept for Capacity Management

Finally, all the inputs and the processing of the tool should result in the expected output of weekly overview of the capacity of the team and headcount. Furthermore, this would also allow to reserve capacity for unplanned activities that may appear.

While there was no final concept for the Capacity Management developed, it was developed an Excel file to allocate to all projects and operations the category, priority and then a place to put the estimated time needed for each team and employee. The objective was to know where the capacity would be allocated, and which projects required more effort. In Figure 48 is represented the file that was created for this intent.

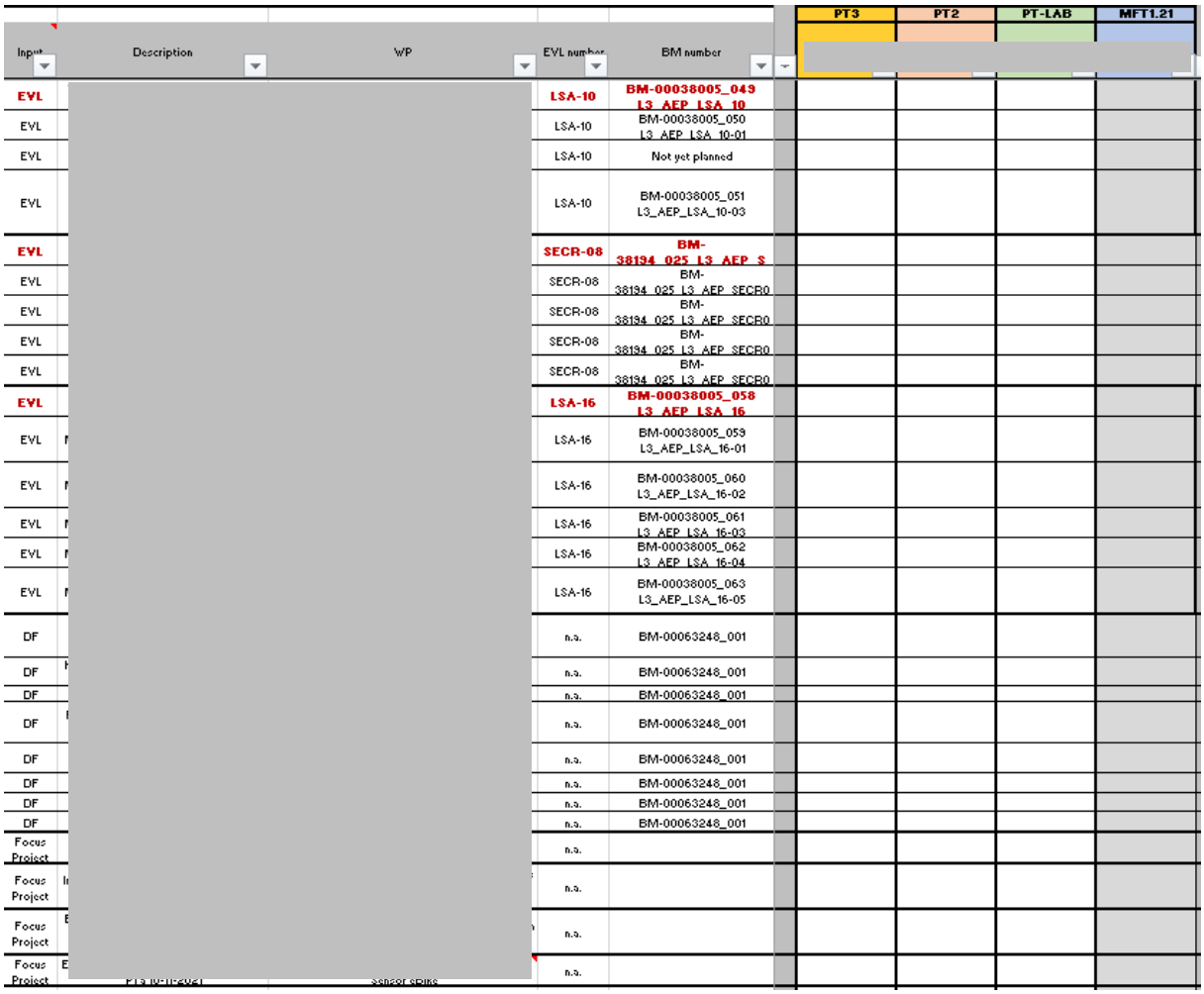


Figure 48 - Excel file to allocate capacity and prioritize projects and operations

5.1.4 Projects and activities management Overview

Taking into account the previous measure and one of the ideas from Idea Generation Workshop, it was decided to establish an overview for all the projects and activities of the department. The team does not have any overview of current milestones, requirements, responsible person, etc. so it was suggested to have a structured, easy to use overview of all activities that was also available for the whole organization.

This measure can also be regarded as searching for information since people spend time searching for the requirements and details of the projects. For the calculation of potential improvement, it was then considered a waste of 30 minutes per week, representing 370 hours per year. The objective was to reduce to 20 minutes per week which would provide a gain of 126 hours (0,4% of TAT).

To achieve the productivity target, it was defined to:

- Compile the needs of the team members to know the requirements for the tool
- Search for tools available to create this overview

- Implement the tool so it fulfils the requirements of the team
- Present and provide training for the users

Firstly, to evaluate the needs of the team members, it was decided to perform a retrospective analysis through the Keep-Improve-Start-Stop technique. The scope was to reflect the current practice for trigger and follow-up operations. In EAI systematic, projects could have distinct classifications according to their complexity so, whenever there was an endeavour that had lower score, it was classified as operation. The result is presented in the picture below (Figure 49).

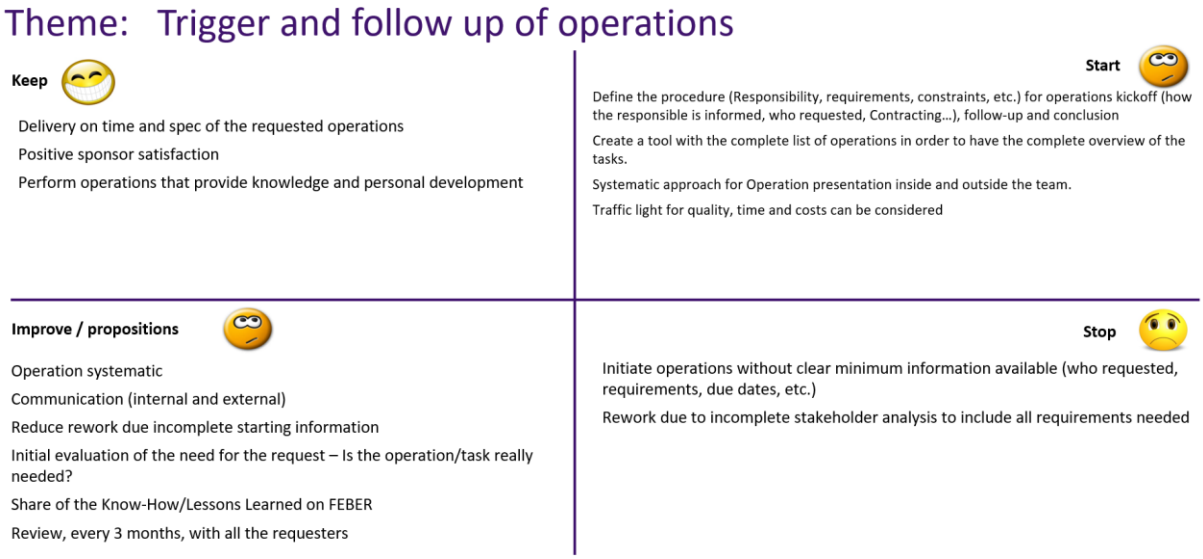


Figure 49 - Retrospective analysis of the follow-up of activities

It could be concluded that people yearn to continue to deliver activities on time and according to customer expectations although they see room for improvement. Topics such as internal and external communication, operation systematic and incomplete information at the start were stated as proposed for improvement. On the other hand, they suggested to start to have a procedure defined, to have a complete list of operations with traffic lights for quality, time, and costs. It was also requested to have a systematic for the internal and external presentations of the operations.

These reflections could all be considered in the projects and activities overview tool. With these requirements, the objective was to search for a tool that would suit them.

One tool that was already existent in the plant is the Project Overview Web Report, where all product projects were listed and had their respective milestones like Quality Gates and product samples (Figure 50).

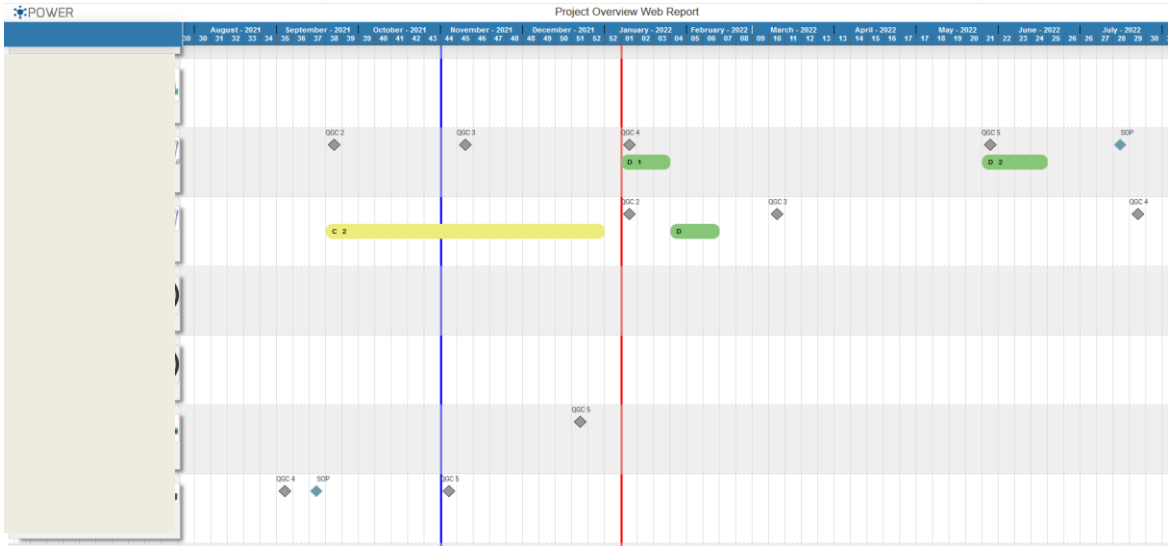


Figure 50 - Project Overview Web Report Tool

However, this tool did not provide any further information than what is represented in the picture, so it would not bring advantage considering the high effort to create and maintain this kind of information.

After checking with other colleagues from Project Management Department, it was verified that there was already an ongoing project to improve this tool. The new tool, named iPower, would then consider the complete time schedule of the project, risks, OPL and could include the team members in order for them to have access and receive notifications. Besides these functions, when the time schedule was set and team members assigned to the tasks, it could help to manage their capacity.

The tool could help manage all the projects in the same place and have centralized information that could also be shared with stakeholders. In the Figure 51 is represented the new tool with some functionalities.

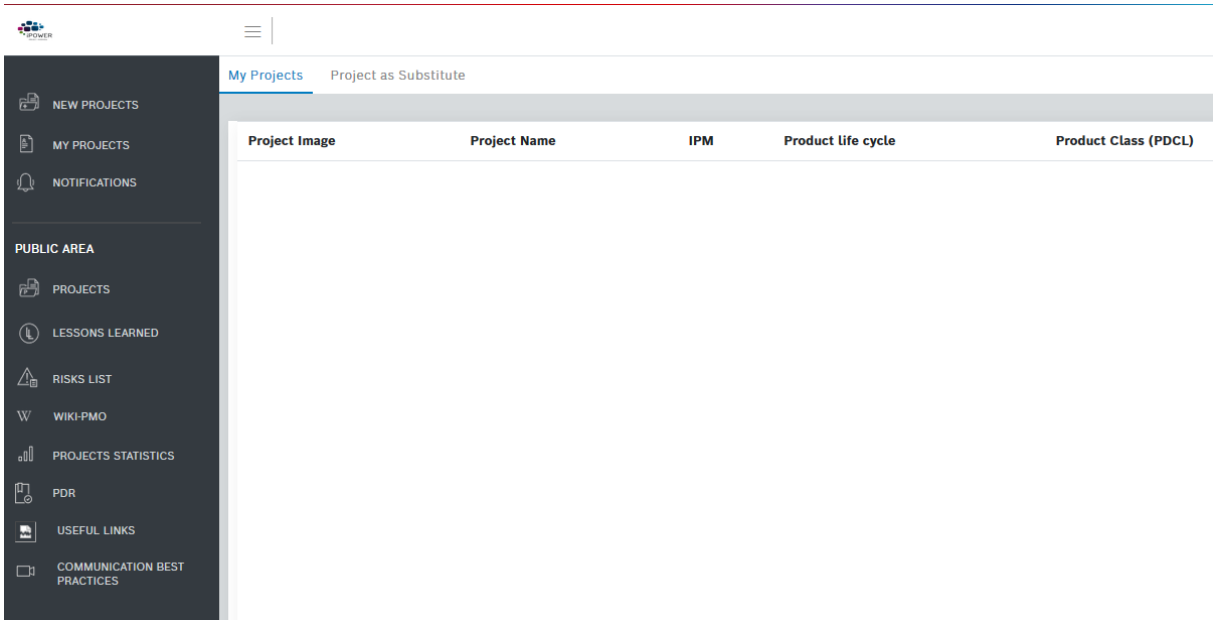


Figure 51 - New Project Overview Web Report Tool

Since the project was still ongoing, the tool was in the testing phase and had some bugs when trying to have any project. Nevertheless, it was considered our requirements and the possibility to add projects and activities from our department, which may not be associated to a specific product.

5.1.5 Improve information management

Information had been one of the most highlighted topics in Idea Generation Workshop and Waste of the Day. In fact, it did not come as a surprise due to the pandemic situation as the team was even more dependent of digital documents and cloud storage. People claim that they spent approximately 30 minutes per week searching for the right information. There were diverse sources of information in the department: File Share folders, Intranet page named Docupedia and Sharepoint Sites. Documents were stored in those diverse locations, sometimes even duplicated or with obsolete files.

The target was to reduce the time people spend to 20 minutes per week, which represents a gain of 126 hours per year through:

- Improve information management (File Share, Sharepoints and Docupedia) with clearer information, organization of folders, remove duplicate content (e.g. same content in different folders or platforms) and integrate with Docupedias from EAI and MFT
- Update Data Concept
- Create procedures
- Present to the users

To work on this measure, it was split according to the storage media. So, initially it started with the resource that was used more often: File Share. In the File Share it was stored all the working files and information because, for security reasons, files were not allowed to be stored on the hard drives of employee's computers. File Share was a system of folders, similar to a hard drive that was located in a central server. Each plant had a server that was organized by folders, each for every department. The overview of the current folder for AE/EAI-PT AE/MFT1.2 is represented below in Figure 52.

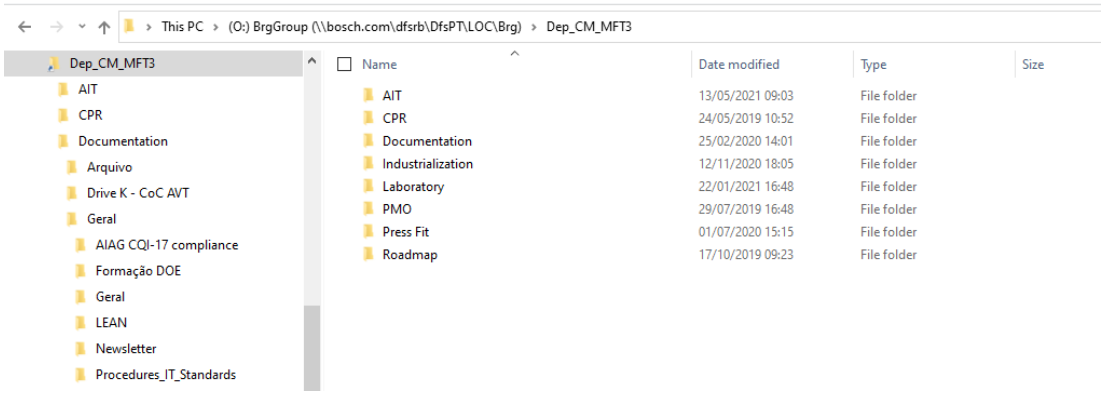


Figure 52 - File Share folder structure for AE/EAI-PT AE/MFT1.2

In addition to have the older department name for the folder (CM/MFT3) that was not valid for more than a year, the corresponding sub-folders did not clearly identify their content. It was neither organized by the existing groups nor current functions. Moreover, the folder "Press Fit" did not contain any information, it was just waste.

To tackle this issue, a series of meetings were performed with the Team Leaders to align the strategy for these folders and discuss its organization. A new proposal for the organization of folders was created (Figure 53) taking into consideration the structure and usability by team members.

The structure was then organized with folders that were valid to the whole department (General Info, Projects and Operations and Innovation and Thesis) and folders that were specific to each group (AE/EAI-PT2, etc.). To avoid any mismatch in the order of the folders, the name started by the number from which it should appear.

Some common sub-folders inside each group were also added with the name "Communication" where it should be stored documentation regarding competences, team organization or other documents that other groups may consult.

Another issue that was previously also jeopardizing the search for information was the access rights. People had different accesses according to their function and team, so, sometimes there were restrictions to access folders they would need. Based on the strategy that EAI and MFT had related to the access rights to their folders, it was decided that everyone would have read and write access to all folders in this new structure.

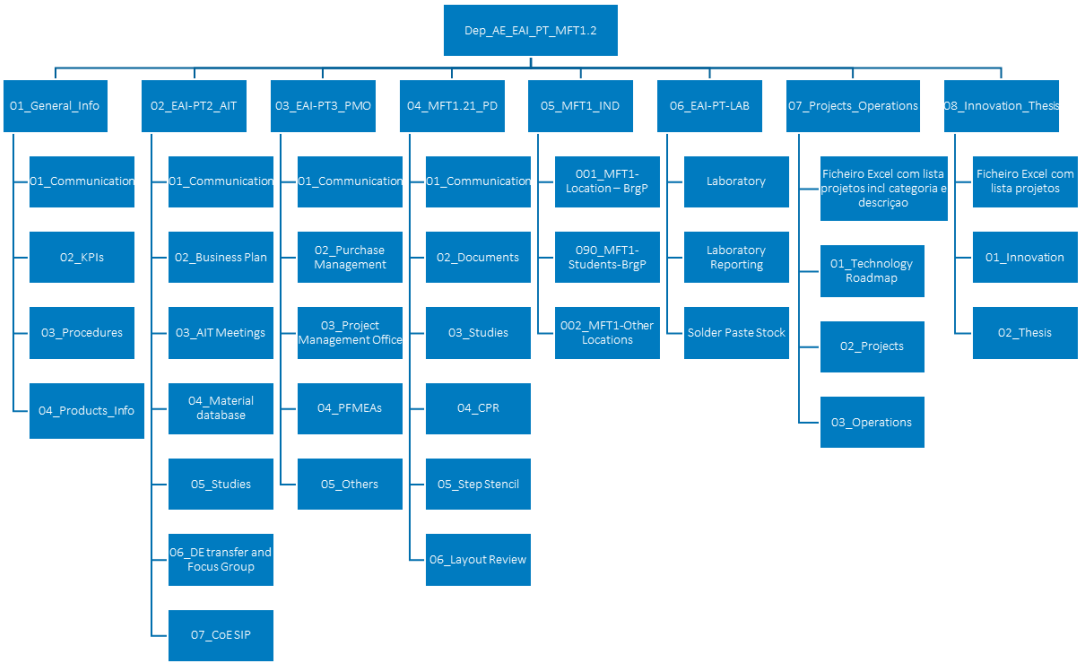


Figure 53 - Proposal for new folder organization in File Share

This decision would give people more flexibility and at the same time accountability by their actions with the files and documents stored.

5.1.6 Improve inventory management

Due to the current functions of the group, it was inherent the storage of material that was needed for the trials as well as tooling. Most of it were either raw material (components and PCBs) or assembled PCBs (PCBAs). Hence, material could be divided into chemicals, raw material or tooling and final samples (PCBAs).

At that moment, there was no procedure or criteria for material storage in the department so, the team usually stored all the material because they could eventually need it. This has caused disorganization in the cabinets and even across the department area and consequently, lack of space for the storage. An example of a cabinet can be seen in the Figure 54 which represents some of the issues:

- No material identification
- Material with expired date
- Material stored that is scrap
- No inventory control and follow-up

Figure 54 - Example of a cabinet with raw material

The result was more time required to find the material needed which could be estimated with the number of times it was used:

- Number of shipments performed to external entities: sometimes material needed to be sent to suppliers or other plants, which was performed 59 times during the previous year. Considering 30 minutes to find the right material, this represented 1770 minutes (29,5 hours).
- Number of requests to the laboratory: after assembling the PCBs, they needed to have further testing in the laboratory so, since the number of requests was 258, it resulted in 7740 minutes (129 hours).
- Number of SMT insertion trials: the material for the trial needed to be prepared in advance. In this case, it was considered 2 hours to find the right material. Since 32 SMT insertions were performed, this resulted in 64 hours.

In total, during a year it was needed 349 times to search for material, representing 222,5 hours. The target was to reduce the searching time for one hour for SMT insertions and 10 minutes for the remaining material. This could result in a gain of 138 hours per year.

The target was then to:

- Search for current guidelines regarding the storage criteria of samples
- Perform a brainstorming workshop with the team to get ideas for the storage systematic
- Create a Standard procedure
- Plan and follow-up 5S activities

The first topic that was verified was the storage criteria guidelines and, for our development samples which are not directly related with products, it was found that there were no obligations to store anything, and each department should have their risk analysis and establish their criteria. With this information, the workshop with colleagues was performed where the first ideas for the criteria were compiled.

Not only it was referred the storage time, but it was also considered other topics related to the conditions such as stacking PCBs or components and temperature and humidity conditions. These topics were never considered before although they had guidelines for them in the production area and are relevant for the assurance of the good condition of the material.

Taking these results into account, it was started to make a proposal for the storage criteria. So, samples could be defined according to their category and where they are used. In Table 5 it is presented the different material, where they are used and where there is any output in which a decision was needed.

Table 5 - Categories of material stored

	Pre-insertion	*Insertion*	*Testing*	*Release*
Raw Material	Enter Material (Expiry date follow-up)	Left Over Raw Material **(A)**	X	Remaining raw material from the act/project **(A)**
Tooling	Enter tooling (no expiry date)	Tooling available for other trials **(B)**	X	Tooling form project/act **(B)**
Final Samples	X	Final samples for analysis	Final Samples analysed w/ destructive tests **(D)** and w/out destructive tests	Remaining samples **(E)**
Others	X	Defect/setup samples **(C)**	X	X

For example, for the final samples, they were only produced after the insertion trial and then, after testing there could be samples that can be scrapped (marked as D) since they had already undergone destructive tests. Whereas, after the release of the project or activity, the remaining samples (E) are no longer needed. This was the base to start to define the storage criteria.

However, for the case of Raw material, since there were different categories (PCB, components, etc.) it would be necessary to specify each one and the quantity that could be stored. This proposal would allow to only store raw material that remained from trials if there was enough amount that may justify keeping them, always taking into account the expiry date. A questionnaire to the team was submitted to evaluate timings, quantity of samples, components and PCBs to store before and after the trials.

The results of the questionnaire would generate a proposal of the standard to be validated and tested with the team and throughout the time of this project.

5.1.7 Assign trainings for the skills that are missing

The initial Skill Matrix was able to present a rough overview of the status of the team in relation to the competences at that time. However, the group had to functionally respond to departments located in Germany: EAI and MFT. Therefore, the skills and competences should be aligned with those departments' strategy and job description. The activities proposed for this measure were:

- Discuss the Skill Matrix with Group Leader
- Align role description of the department with the Skill Matrix
- Verify mandatory and optional trainings for the roles in EAI and MFT
- Create training plan for the team members
- Present and discuss the training plan with team members

The activities defined were also aligned with the Lean Leadership System as Skill Management is one of the elements to work and are part of the activities to reach the Maturity Level 4, as explained later in this dissertation (Chapter 5.2). It was also included as productivity improvement because, as described in Chapter 2.1.4, one the wastes from Lean Office are Non-utilized human talent. Hence, enhancing people's skills and align the individual competences to the tasks would reduce errors and lack of knowledge.

Although this measure could have potential for productivity improvement, it was not quantifiable due to its subjective characteristics.

So, from the Skill areas defined in the first version of Skill Matrix (Chapter 4.3.7), the trainings required for each of the levels of each skill were defined as presented in Figure 55.

Required Competence and training for "Basic" level	Required Competence and training for "Advanced" level	Required Competence and training for "Specialist" level
(Please insert required competence and / or training for "Basic" level)	*(Please insert required competence and / or training for "Advanced" level)*	*(Please insert required competence and / or training for "Specialist" level)*
A: Ability to work focused on the customer; T: '[COM-VK011] Telephoning successfully - a customer oriented approach-A (German) [AE-COM-CCQF] Customer communication with quality focus-B Incluir formação de QFD pois está focado no cliente [BES-PE-002]	A: Able to work by objectives in order to achieve customer requirements; ->T: '[RBIB-MS-211] Customer Relationship Management-B	A: - Able to lead the team in order to fulfill the overral customer requirements; T: Formação de KPIs/obejectivos gerais
[COM-VK012] Communicating in a successful way-B [COM-VK003] Presentation and speech training: presenting in a confident and convincing way-B [COM-VK004] Advance d presentation and speech training: enhance your style of speaking convincingly-A [CN-MD-SfJ] Storytelling for JMP-B	[COM-VK005] Trigger your audiences' imagination through storytelling-A [COP-010] Conflict or Opportunity-A [RBIB-COM-193] Communication and Cooperation-B -> texto	T: [COM-VK015] Debating and negotiating – Engaging in dialogue-A [BEG-COP-KMT01] Conflict management while moderations and team coaching-A
Equivalent to A2 level (CEFR level)	Equivalent to B2 level (CEFR level)	Above B2 level (CEFR level)
A: T: - VA001: [LO-VA001] Time Management (Part1) Workplaces and Working Environment-B - VA002: [LO-VA002] Time Management: Delegation - Basic-B - [COM-VK003] Personal impact and presentation skills-B - [MOD-010] Basic moderation skills-B **Curricula RBV_OT_PM_Project Team Member:** Mandatory: [PM-PMF-B0-WBT] Project Management Fundamentals - WBT Basics 0-B [PM-PMF-B] Project Management Fundamentals: Basics-B [PM-AGI-BAS-WBT] Agile Basics @ Bosch-B [PM-AGI-RM-WBT] Risk Management in Projects - Basics-B Optional:	A: - Intercultural teamwork T:	A: T: [PM-PMF-B0-WBT] Project Management Fundamentals - WBT Basics 0-B [PM-PMF-B] Project Management Fundamentals: Basics-B [PM-PMF-T] Project Management Fundamentals: Project team development and communication-A [PM-PMF-L] Project Management Fundamentals: Leadership in projects-A - [AE-PE-PMECU] EHB-ECU Project Management Platform/Customer-B (Req.: to be PM or member of a project team or Process Coach or to obtain a detailed overview of the latest PM-Process **Curricula RBV_OT_PM_Project Manager A:** Mandatory: [PM-RK-PMQ] RK Project Manager Qualification-S [LS-RK847] Agile Leadership & Agile Organization-A [PM-AGI-BAS-WBT] Agile Basics @ Bosch-B

Figure 55 - Required Trainings for Basic, Advanced and Specialist level

The set of these trainings was the starting point to establish the requirements and then align with the function of the respective team member. Then, for each skill the level required for each function was defined in Figure 56.

Listing of Skills	responsável por descrever	Type	Project manager	Materials expert eng.				Technical Cleanliness expert eng.	Simulation expert eng.	SMT process deve.		Lab Analysis eng.	Team lead	Component release eng.
(Please define the skills necessary for your area)		*Operational/Strategic - optional -*		Surface Protection	Comp. Fixation	Thermal Inter. Materials	Soldering Materials			SIP (EAI)	General (MFT)			
Costumer orientation		Strategic	S - Specialist	A - Advanced	A - Advanced	A - Advanced	A - Advanced	A - Advanced	A - Advanced	A - Advanced	A - Advanced	A - Advanced		A - Advanced
Business Communication		Strategic	S - Specialist	S - Specialist	S - Specialist	S - Specialist	S - Specialist	S - Specialist	S - Specialist	S - Specialist	S - Specialist	S - Specialist		S - Specialist
English		Operational	A - Advanced	A - Advanced	A - Advanced	A - Advanced	A - Advanced	A - Advanced	A - Advanced	A - Advanced	A - Advanced	A - Advanced		A - Advanced

Figure 56 - Required level of each skill for the functions

It is visible that for example for Customer Orientation, the role of Project Manager was set as Specialist level required whereas for Materials Expert Engineer it was defined as Advanced.

From there, these requirements should be established for each one of the team members as their individual training plan and discussed.

5.1.8 Create awareness regarding Digital 5S

Improvements proposed for the information management would be useless without small daily actions from the team. Therefore, creating awareness regarding digital 5S was crucial to help sustaining the measures.

The impact of digital waste was mainly on rigidity since it hinders the organization of files and documents. This represented 0,5% of TAT, meaning 150 hours per year.

The aim of this measure was to create a workshop to the team with tools that would allow them to be aware of the current storage space in use and make a survey to understand the results.

In the next pictures it is illustrated the costs from the department related to IT services (licenses, devices and storage). After the re-structure from CM to AE, a new cost centre was assigned to the department, so there were 2 costs centres, which also explains the differences in the amount. Figure 57 represents the costs for AE/MFT1.2 whereas Figure 58 represents the costs for AE/EAI-PT.

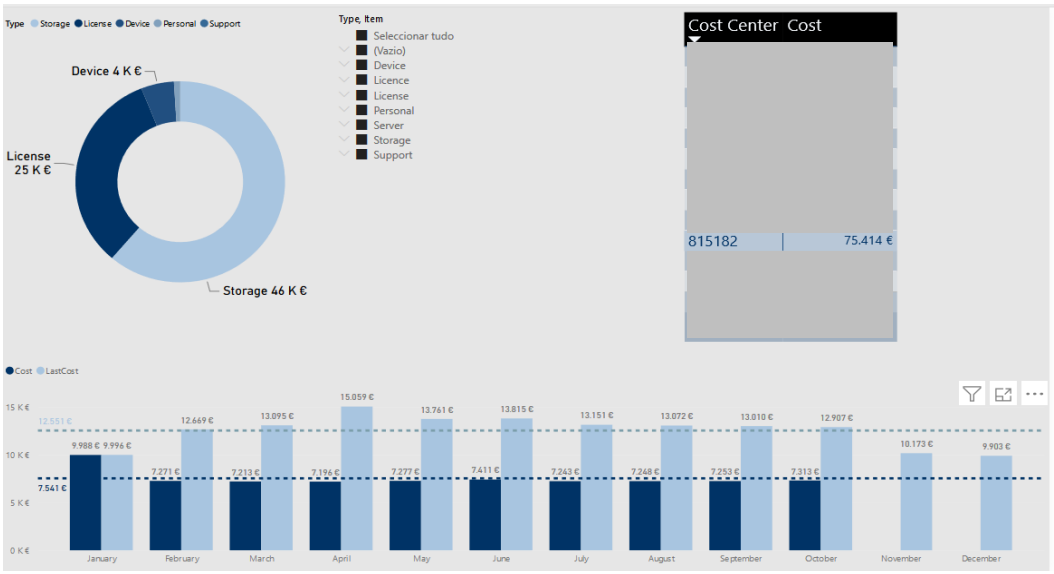


Figure 57 - Department IT costs for AE/MFT1.2

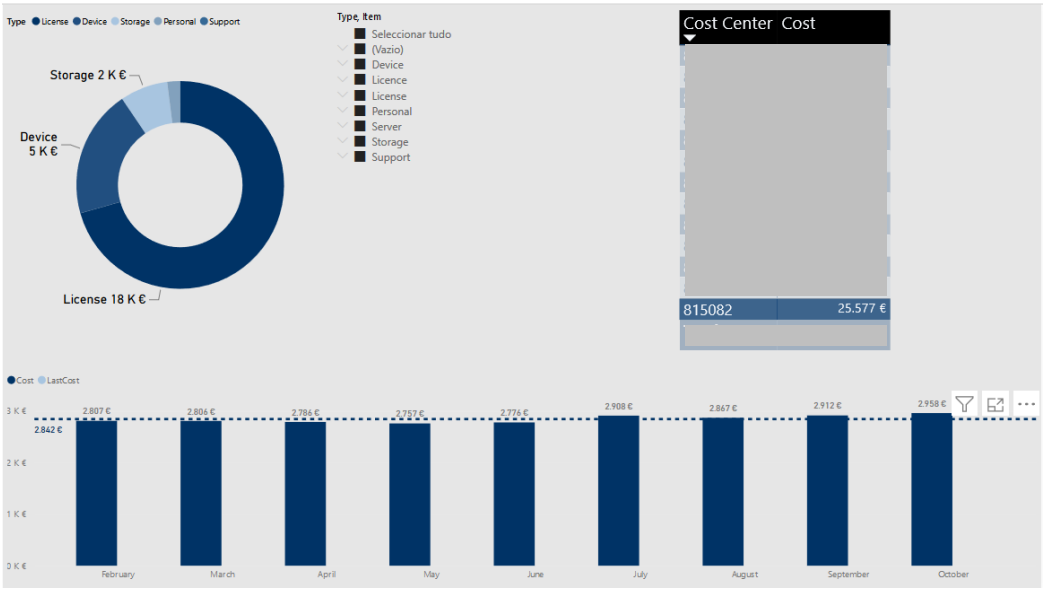


Figure 58 - Department IT costs for AE/EAI-PT

In total, the costs with storage ascended to 48k€, which included e-mail, File Shares, SharePoints, etc. Hence, by presenting this overview during the workshop and the tools people could use to verify their own individual costs (like the tools above) was expected to have a positive impact on them and to create the digital 5S mind-set.

5.1.9 Communication issues

To overcome the communication issues within team, management and even customers, the measures defined include Lean Leadership System implementation.

Previously, there were no team meetings defined inside each group nor within the department. This was performed from time to time whenever the management team decided. After reflection and to fulfil team members feedback and incorporate the Agile Collaboration element from LLS, it was decided to establish a Virtual Teamboard for each group and for the department.

From the tools available at Bosch to create a Teamboard, Microsoft Teams was the chosen one due to the ease of use, ability to assign a responsible and receive e-mail alerts about tasks. In MS Teams was possible to define buckets according to the needs, so different topics could be shared within the team.

In the picture below (Figure 59) is represented the Teamboard for AE/EAI-PT3 where it is visible the buckets for capacity, urgent topics, good practices, and idea sharing.

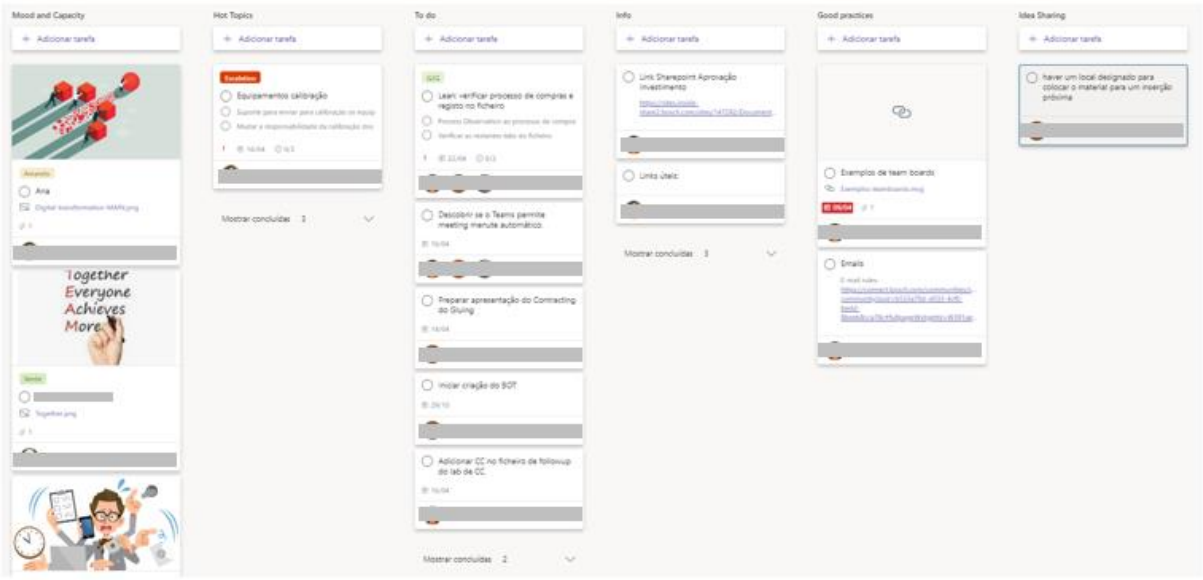


Figure 59 - Teamboard of AE/EAI-PT3

The team of AE/MFT1.21 even went a step further and invited their customers to participate in their Teamboard so they could easily check the status of their requests. Since they had a lot of requests that have a unique number and normally take just a few weeks to be concluded, they decided to include the customers to improve their interaction and avoid back and forth e-mails.

Regarding the Teamboard of the department, it also had specific buckets and it was defined a biweekly periodicity of the meeting with rotating moderation, so each person had a date assigned when they should take over the moderation role. The objective was to give the opportunity to different people to be in a different role and take the responsibility of being a moderator.

5.2 Lean Leadership System

Simultaneously to productivity improvement, the objective of the Lean Project is to establish a Lean Mindset. In order to do that there are 12 Lean Leadership System elements that have progressive maturity levels up to Level 4, as referred in Chapter 3.3.2.

Level 3 is required until the end of the Lean Wave while Level 4 is set to only be reached at the end of the project. Initially, all the elements were evaluated according to the team needs and 3 of those elements are chosen as Advanced. This will result in different criteria to reach from Level 2 to beyond as some criteria were defined by the team. As a result, each team will have different objectives in terms of LLS elements.

For this case, the elements Skill Management, Good Practices & Standardized Work and Capacity Management were defined as advanced. The element Strategic Project Management was not considered

in the scope of this dissertation since it was handled at the department level and there was no involvement of team members. The Table 6 presents all LLS elements and the respective measures to achieve each of the Maturity Levels.

Table 6 - Lean Leadership System Maturity Assessment

	Level 1	*Level 2*	*Level 3*	*Level 4*
Agile Collaboration	The group understands the objective of Agile Collaboration (basic training)	The manager and team select the appropriate agile practices from Agile Toolbox (e.g. Timeboxing, retrospective) Design and setup an exchange platform such as Teamboard with Agenda, Capacity Mgmt, Good Practices, etc.	Apply the first agile practices and define future use cases. Take the first sessions of Teamboard and implement quick fixes.	Apply agile practices as planned and verify results. Team meets repeatedly to reflect collaboration and improvement needs.
Go to Gemba	The group understands the objective of Go to Gemba (basic training)	The manager establishes a method to integrate G2G in daily work and defines use cases.	Planned G2G activities are performed by the involved team members.	G2G activities lead to concrete measures.
Feedback	The group understands the objective of Feedback (basic training)	The manager creates awareness regarding feedback. Give refresher training about benefits and method.	The manager gives regular feedback according to a model of 3 + 4 steps and asks for feedback to employees as regular basis.	The manager and team give feedback to each other on a regular basis.
Coaching	The group understands the objective of Coaching (basic training)	The manager establishes a systematic to integrate coaching methods in his leadership tasks.	Manager starts applying coaching methods in daily work.	The application of coaching methods leads to improvements within the team.
Continuous Improvement	The group understands the objective of Continuous Improvement (basic training)	Establish TIP as improvement plan for the group. Distribute tasks by team members and assign responsibilities for each task. Define appropriate frequency of timeslots for updating improvement measures.	Regularly update TIP and discuss with employees. Use PDCA cycle to process the measures.	Use TIP as standardized plan for continuous improvement actions. Generate new improvement measures and include into TIP.
Skill Management	The group understands the objective of Skill Management (basic training)	Create and update a list of skills using the Skill Matrix tool containing the evaluation of current and target skill-level for each member. Pull feedback from internal customers. Define a set of skills and expectations for each role.	Include in the list of skills the long-term business needs (>3 years).	Discuss with employees and include in a roadmap how to develop skills based on long-term business needs. Link Skills Management with other Lean elements (Good Practice, Coaching, etc.)

Problem Solving	The group understands the objective of Problem Solving (basic training)	Develop a systematic to integrate problem solving for non-technical problems in a daily basis.	Non-technical problems are identified and sustainably solved using appropriate problem-solving methods.	Implement improvements based on the measures defined by problem solving. Document solutions and communicate to the team.
Good Practices & Standardized Work	The group understands the objective of Good Practices & Standardized Work (basic training)	The manager encourages the exchange of Good Practices within the team and establishes a suitable exchange platform. The manager schedules the description and implementation of the non-up-to-date description of core processes.	Document the first good practices in a standardized way. Make the first sessions to improve or update core processes.	Platform for Good Practices is regularly updated, and good practices are used by employees. Regularly check the Knowledge platform for additional improvements. Set proven Good Practices as mandatory standard. Based on the schedule, non-up-to-date description of core processes are updated, and employees trained. The manager can evaluate the performance of core processes by using objective process KPIs.
Capacity Management	The group understands the objective of Capacity Management (basic training)	Identify concrete bottleneck resources and define measures. Link Capacity Management with multi-project management on department level.	Unblock critical situations as short-term solution. Create the tool concept.	Define KPI for monitoring the reduction of over-allocated employees. Create and update tool for mid and long-term overview.

5.2.1 Agile Collaboration

It was characterized by practising team board meetings regularly by visualizing and prioritizing team tasks with exchange between team members. It was a suitable framework to allow the team to be self-organized and react quickly.

Besides the Teamboard, it also includes a set of agile tools to reinforce team collaboration with tools such as:

- Timeboxing: set a defined time for a subject during a meeting and keep up with it, moving on to the next topic
- Return on Time Invested (ROTI): it consisted on giving feedback at the end of a meeting to evaluate the effectiveness and try to improve the next time
- Retrospective: Keep-Improve-Start-Stop technique to reflect on previous steps

The aim was to implement these tools within the team to help have more productive tasks and meetings and improve communication.

5.2.2 Go to Gemba

As aforementioned in previous chapters, Go to Gemba consists in observation and discussion at the Gemba. So, in order to include it in daily work, not only during the definition of measures some of the evaluations were performed with the G2G, but it was also implemented in the department Teamboard, as can be seen in picture Figure 60.

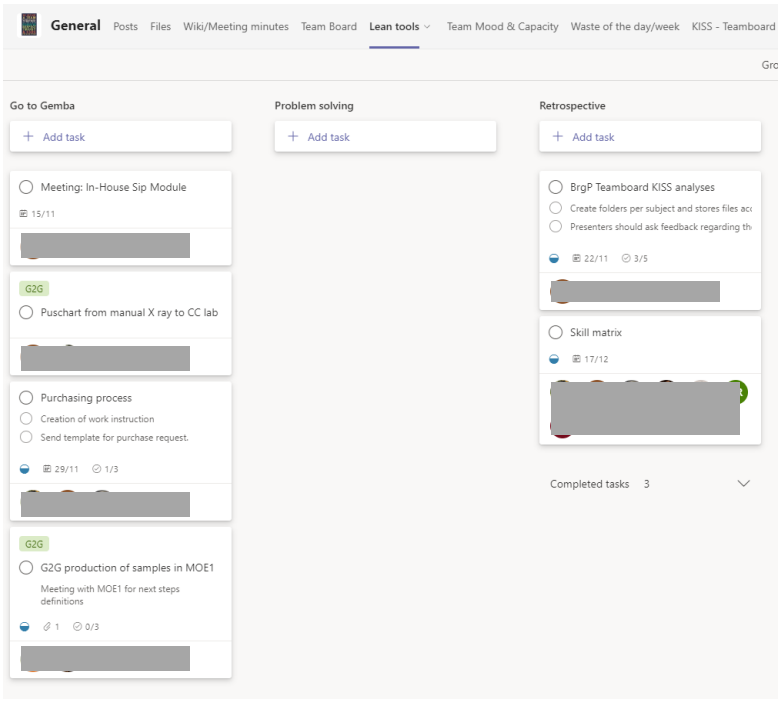


Figure 60 - Some Lean Tools included in Teamboard

5.2.3 Feedback

Feedback was an important topic for communication as it consisted in the response from feedback provider on their own perception and subjective evaluation of a specific behaviour of the feedback receiver. The message should be constructive and could be given between manager and employees (in both directions) and just between employees. To help the team with this practice, feedback cards were distributed to everyone so they could learn and apply it (Figure 61).

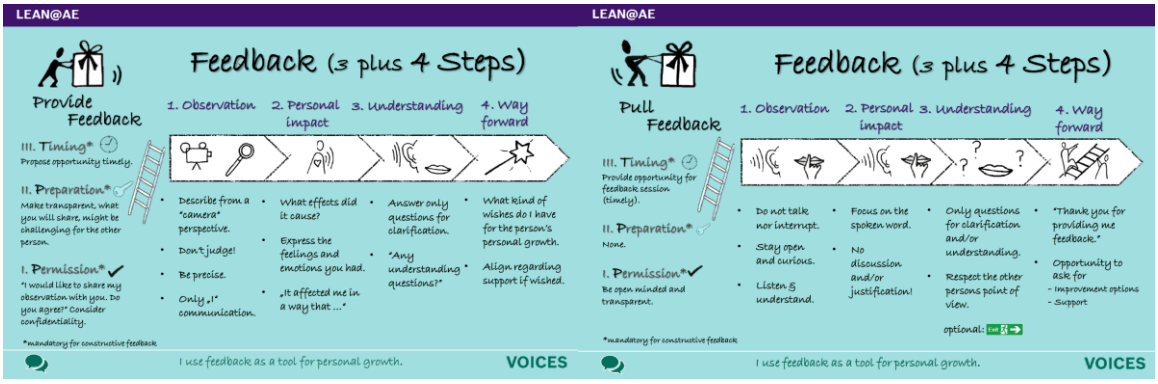


Figure 61 - Feedback Cards

Besides this, some team leaders also booked one on one sessions with their team members to ask and give the opportunity to receive feedback. The frequency could be either weekly or monthly and team leaders also fomented to pro-actively give and receive feedback.

5.2.4 Coaching

Coaching was a conversation in which the coach supports the development of solutions by the coachee through questions. It facilitated self-help and supported the coachee in structuring his thoughts.

To facilitate the application of the systematic, the structure should follow the GROW model – Goal, Reality, Options, Way forward as presented in the Coaching Cards below (Figure 62).

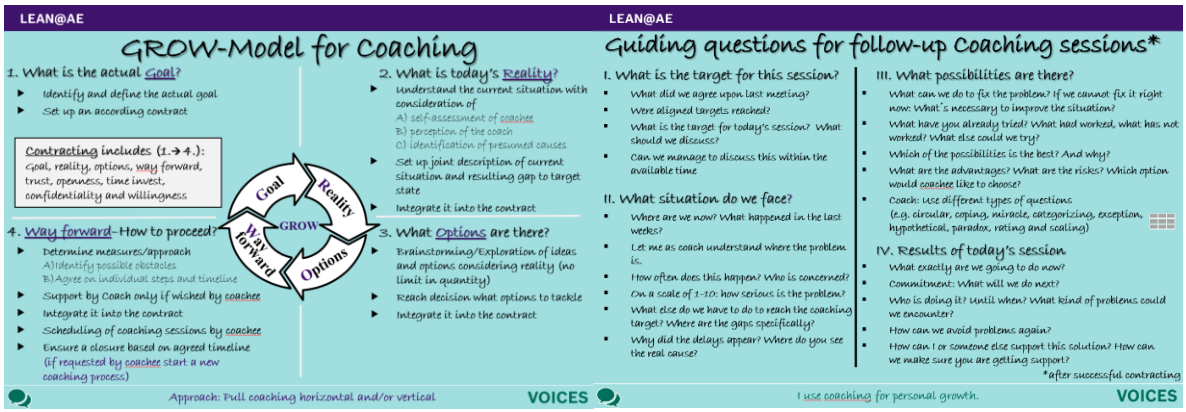


Figure 62 - Coaching Cards

To instigate the Coaching practice within the team, the manager booked one hour per week that people could schedule to ask for coaching. The aim was to allow people to pro-actively seek for support.

5.2.5 Continuous Improvement

Continuous Improvement was the ongoing incremental improvement in all areas. The manager served as role model and drove, with the participation of employees, the continuous improvement process.

Throughout the Lean Project, several improvement measures could be identified using the tools Change Story, Hypothesis, and the findings from Diagnosis Phase. Those improvement potentials were described in the TIP file and were continuously followed through PDCA cycle.

5.2.6 Skills Management

Skills Management consisted in the active development of skills and competencies of the associates to empower them to reach their full potential. It provided a good overview of core competencies in the team and identification of development needs. It also provided additional input for coaching meetings mainly for soft skills development.

5.2.7 Problem Solving

Problem Solving was a method to achieve a thorough understanding by the complete problem description so it assured that the appropriate measures were defined and implemented. This was a tool that was suitable for business coaching, developing the whole team with this competency and consequently create a learning organization.

To establish a Problem Solving systematic it was proposed to include a bucket on Teamboard (Figure 60) and store the results from the team on One Note as presented in Figure 63.

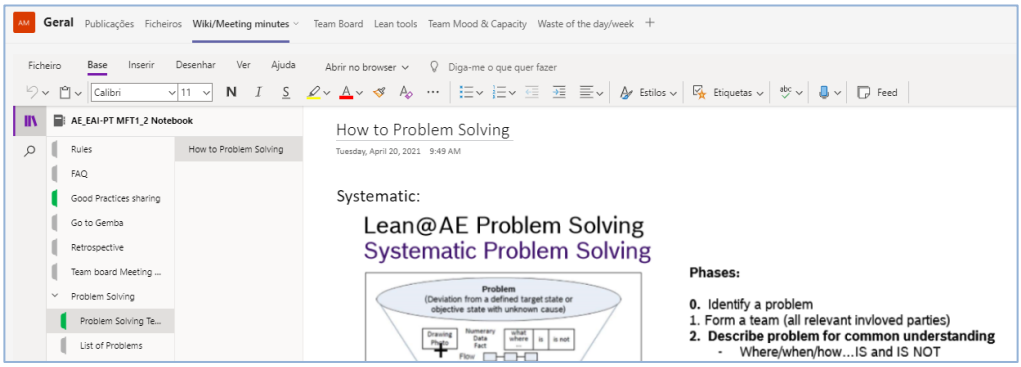


Figure 63 - Problem Solving storage on One Note

5.2.8 Good practices and Standardized Work

Good Practices could be described as accepted solutions or procedures that do not have a binding character that could be eligible for transfer. On the other hand, standardized work was a method to describe, standardize and improve binding and recurring processes and could serve as a basis for continuous improvement. This element was also considered for the Teamboard to provide the exchange of Good Practices within the team. Whenever a Good Practice was considered as proven procedure, it would be transferred to a Work Instruction.

5.2.9 Capacity Management

It was designated as a dynamic adaptation of the workload allocation due to the changing demands for the team. The capacity bucket on Teamboard would allow to allocate transparently the workload and after the implementation of the Capacity tool it would be possible to verify the long-term workload.

6. RESULTS AND DISCUSSION

Considering the status of the group during the Diagnosis Phase and the improvement ideas exposed on the previous chapter, what is the outcome? The answer to this question is in the ideas that become actions and, consequently, lead to results.

Therefore, in this chapter, it is intended to analyse the implementation of the measures proposed and their result in terms of productivity and Lean Mindset within the group.

6.1 Productivity improvement

The measures presented in Chapter 5.1 resulted in actions and sometimes in even deeper analysis in order to tackle the issues in a more concrete approach.

6.1.1 Improve Meeting Management

In order to have a deeper analysis, it was decided to perform a Process Observation to one of the project meetings within the section. The Figure 64 presents the results obtained.

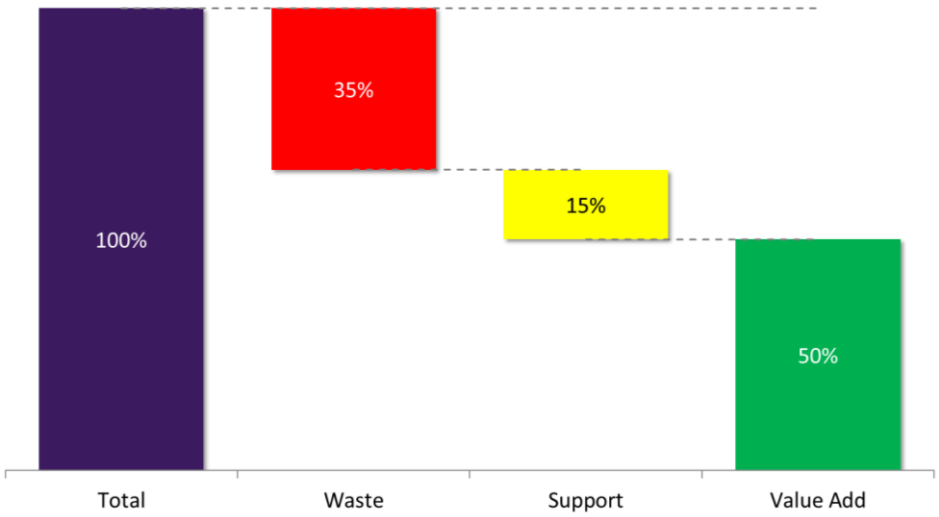


Figure 64 - Process Observation of a project meeting

It is visible 35% of waste identified mainly due to lack of agenda and some participants invited for the meeting do not have value add with their participation. It was also verified that timing has some issues such as long waiting time for the meeting to start and the duration does not match the time needed.

Nevertheless, there were some highlights identified like active moderation, preparation of the topics beforehand, create and update meeting minutes in real time with clear responsibilities for tasks and the follow-up of assigned tasks from previous meetings.

After the deployment of the template of the Agenda (see Chapter 5.1.1), it was widely spread in the plant and even other departments that haven't yet implemented Lean are using it as good practice.

The Meeting Codex brought to the team a clearer instruction of how they can handle with meetings from the request to the meeting minutes. The setup of the maximum waiting time to start the meeting was a staggering result in the elimination of waste since people no longer wait more time than defined as tolerance (normally is 3 minutes).

There was currently a perception that meetings efficiency was improving, the subject was to the point and the duration was more adapted to the needs. To assess this improvement, a new Process Observation was performed after some months of the release of this Meeting Codex.

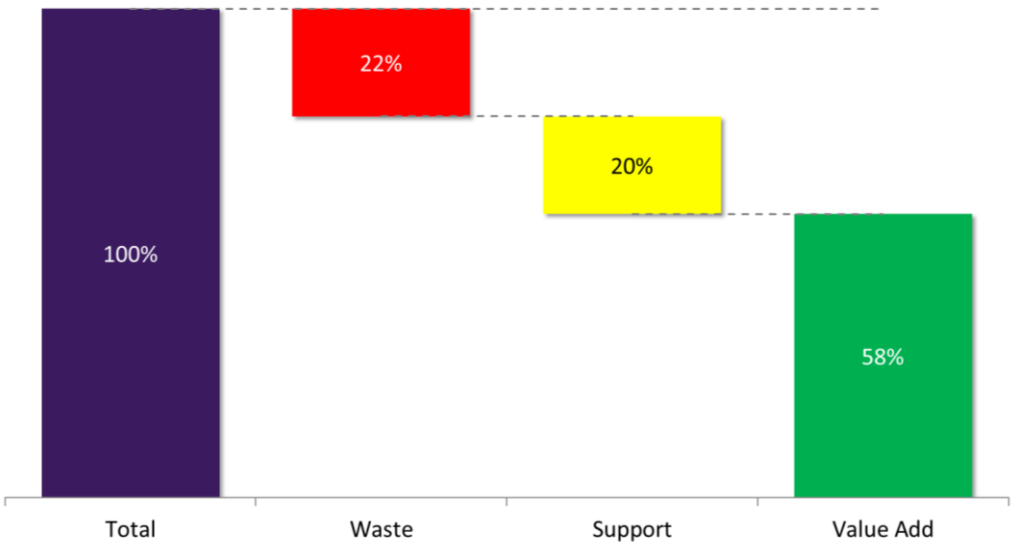


Figure 65 - Second Process Observation for a project meeting

In Figure 65 it is verified that the waste was 22%, which represents a reduction comparing to the first Process Observation in Figure 64. The participants were more aware of the time, as the agenda includes the duration of each topic it was also defined a timekeeper to guarantee the timing is fulfilled. Participants go straight to the point and whenever a topic needs further discussion out of the scope of the meeting it was addressed for clarification in other timing.

The waste cannot be eliminated due to the tolerance time (3 minutes) to start the meeting. In this case it also happened that there were technical issues with the sound in the meeting room (meeting was performed with some participants face to face and others virtually).

The implementation of this measure resulted in a total gain in productivity of 1594 hours per year: 1220 hours from reducing waiting time, 224 hours from reducing participants and 150 hours of rigidity. This represents a gain in 5,4% of TAT.

6.1.2 SMT insertions for trials

From the Problem-Solving analysis and the meetings performed with Production Department, the planning process presented overwhelming improvements. From the 4292 minutes of Lead Time during the Planning Phase represented in the VSDiA, corresponding to almost 9 days, it was estimated to reduce it to approximately half the time (2742 minutes) due to:

- Reduced waiting time from production department feedback since the prioritization was changed. So, requests performed by the group were analysed more promptly and the SMT lines were booked as soon as possible.
- Less rework from the iterations and last-minute bookings as feedback is provided on time to prepare material, verify relevant employee's availability, and prepare the programs.
- Lower over-processing because previously, to solve some issues regarding the planning, an escalation process to the managers was needed which involved more human resources and added more discussions. After the improvement measures, there was only one contact person from each department so, not only there were less information transference from side to side but also reduces the time spent by different intervenient.

Besides the improvements during the planning, it was also implemented the preparation of PCBs beforehand in some cases, but this was not always possible due to the characteristics of the trials. Sometimes the PCBs to be tested were so different from the ones used in production that the Reflow Profile needed to be performed during the trial. Of course, this continued to represent a waste for the process however, it did not jeopardize the trial.

In total it was initially expected to have a gain of 180 hours per year, which means 0,6% of TAT.

Regarding the procedure that was proposed to create, it was still under development since the due date for this activity was out of the timeframe of this dissertation. However, it was expected to contribute to the plummet of misunderstandings of the process and rework. Hence, it would provide a clearer overview of the procedures needed to perform a SMT insertion to the team, increasing the efficiency of the overall process.

Therefore, the productivity improvement was not fully estimated since the procedure was not yet concluded, and the other activities required confirmation in the long term.

6.1.3 Prioritization

Although the Excel file allowed to improve the prioritization it still required too much effort to make the estimations in comparison with the tool integrated in the Overview of Projects and activities. So, at that moment the potential gain in terms of Rigidity could not be assured since Excel is an isolated tool. Hence, whenever there would be a readjustment, it should be changed in other tools such as the time schedule to then change in the Excel for capacity management.

The solution was then to have the tool for overview of projects and activities, but it was not fully released at the time of this dissertation. The due date for the go-live of the tool was ahead of the timing for this Lean Project so, it was still under development.

However, it was expected that the tool presents some functionalities such as linking the time required for a task in a time schedule of a project with the capacity of the team member. In Figure 66 is represented the overview of the capacity for a team member that was allocated to two projects.

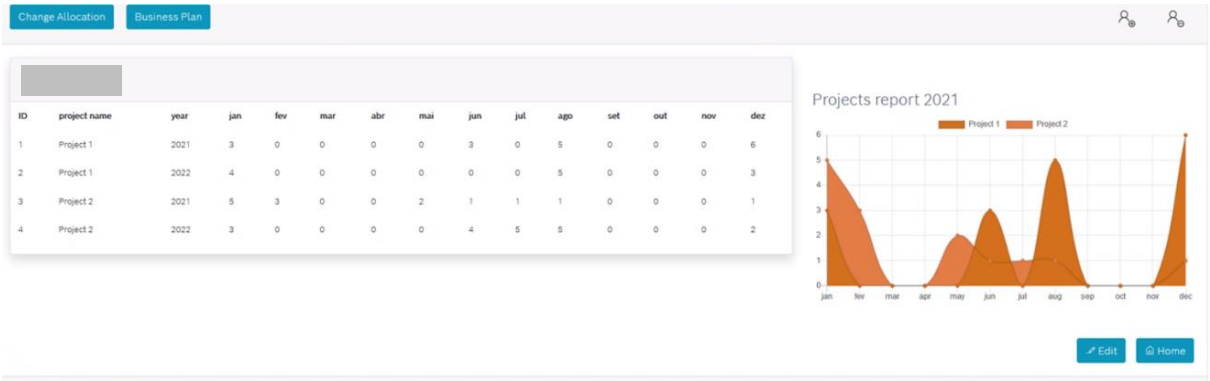


Figure 66 - Example of the function for capacity management in the Overview for projects and activities for one person

The tool would be able to provide this information automatically after establishing the schedule, considering the percentage of allocation of that person to the project.

It was expected that this tool would result in an easier identification of the capacity issues in a longer term and promote transparency regarding priorities.

6.1.4 Projects and activities management overview

As explained before, the tool for overview of projects and activities was still under development which did not allow to confirm the productivity improvement. However, it would provide a versatile tool that allows to interact online with real-time notifications and create automatic reports. The main advantage would be the visual management as the milestones from all the projects would be visible at the same time and it is possible to change views to have more details, check team members, OPL, etc.

Therefore, most of the project management activities would be concentrated in this same tool, even for the product project management. This improvement would also be of interest for the stakeholders since the information would be available in the intranet at any time. In Figure 67 are represented the advantages of the implementation of the tool for the projects and operations overview.

Figure 67 - Advantages of the tool for Overview of Projects and Operations

6.1.5 Improve information management

The organization of the folders of the department resulted in a clearer understanding of the structure since people were involved and informed about this change so, it was already reflecting their needs. It became easier to know to which group and the content of each folder and, consequently, resulted in needing less folders. Therefore, it was expected that by having less folders would result in less clicks and then reduce the time spent searching for information. This difference can be noticed in Figure 68 where is the old structure in comparison with the new one.

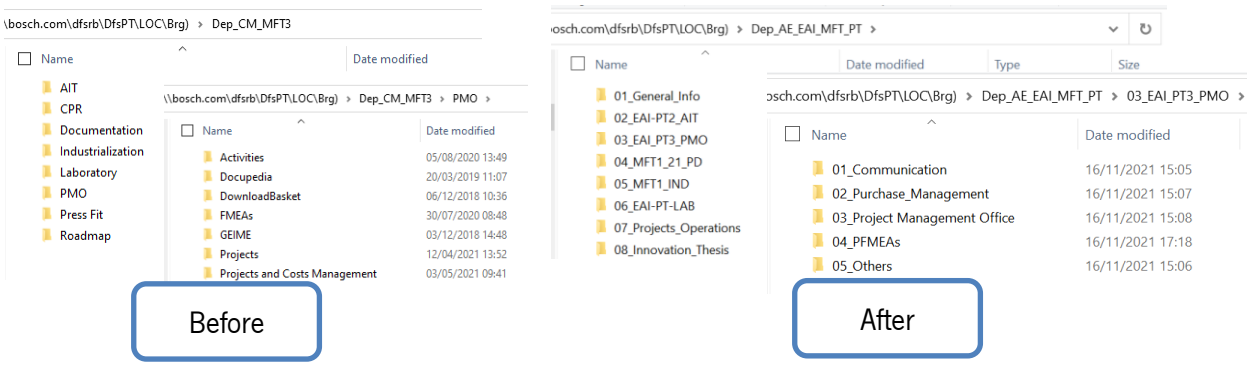


Figure 68 - Before and after re-structuring the FileShare of the department

Since this structure is new and relatively fresh in people's minds, there would be required more time to evaluate the time spent searching for information to get more reliable results.

6.1.6 Improve communication

Although most people acknowledged the benefits of the implementation of Teamboards, it was decided to evaluate the advantages and proposals for improvement.

To collect feedback from the team, the Keep-Improve-Start-Stop tool was used. It consists of a retrospective analysis of the Teamboard of the department and is represented in Figure 69. The same analysis was performed for the Teamboards of each group, but the issues were more relevant at department level.

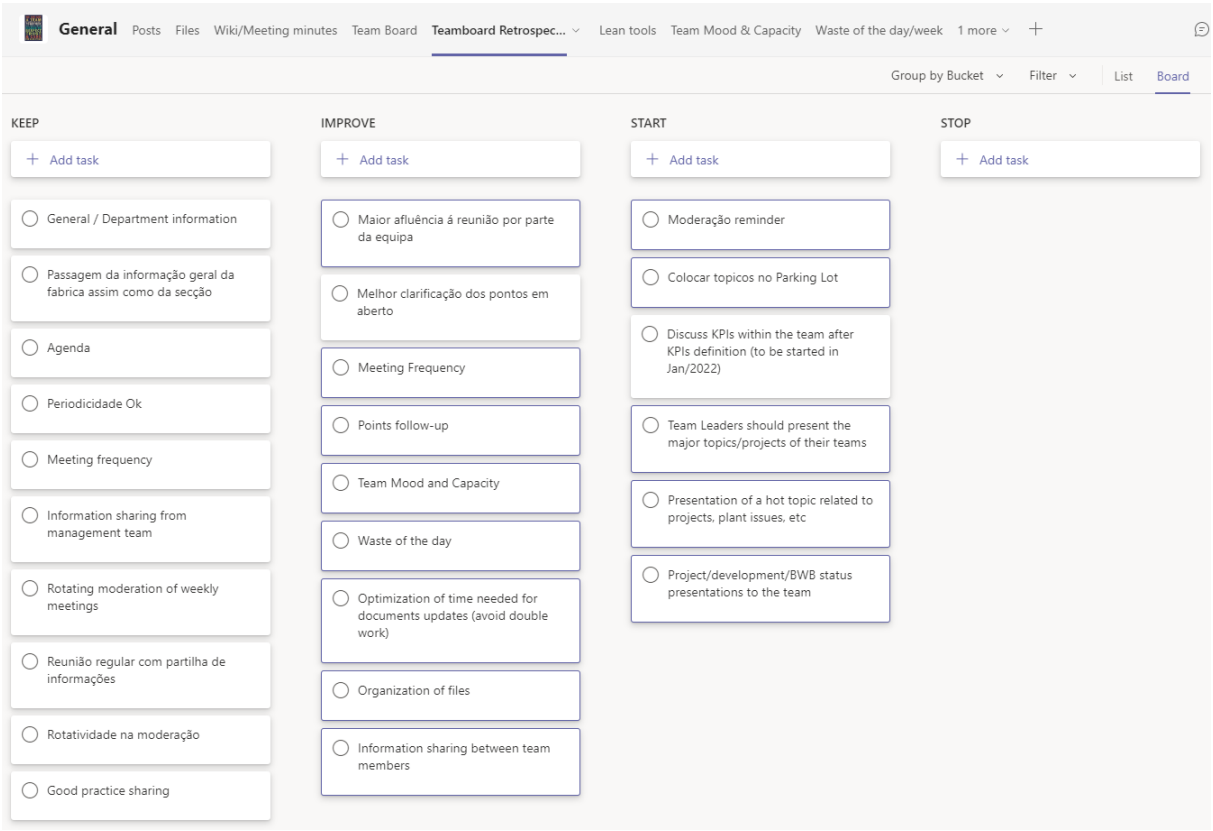


Figure 69 - Retrospective results from Teamboard

Generally, the participants were responsive so there were several topics highlighted by the team.

Although some ideas for improvement were added, people referred that the way the Teamboard was conducted (level of information, rotating moderation and agenda) and the frequency of the meeting was good, so it was proposed to keep.

In terms of improvements, it was identified some buckets and tabs that did not have the adherence and participation expected such as Team Mood and Capacity and Waste of the Day. Hence, these topics need

to be analysed and re-structured to gather more participation. Other hints include the way the meeting was being conducted in terms of time management, clarification of topics and information sharing between team members. People felt that in spite of the good participation, there were still others missing the meeting and sometimes not participative enough to engage in discussions.

As for suggestions to start implementing, it was stated that there should be a reminder of who would be the moderator of the next meeting in order to be prepared in advance and put the topics that need to be discussed in the Parking Lot. In addition, it was proposed to present and discuss other topics that the team feel as important to them such as status of projects, KPIs and other urgent topics that may be relevant to them.

6.1.7 Synthesis of results

After presenting the results from the measures proposed, in the next table (Table 7) it is presented a synthesis of the problems and respective results.

Table 7 - Synthesis of results from the project

Problem	*Status*	*Results*
Unnecessary and inefficient meetings	Concluded	Creation of a Meeting Codex and template for Agenda that enabled to reduce waiting time and improve meeting efficiency. It was also deployed the Agile Collaboration practices.
Too much waste in SMT Insertion Trials	Partially concluded	Improvement of planning process and prepare material beforehand which reduced waiting time, rework and over-processing. The procedure was still under development.
Lack of prioritization of tasks/projects/activities	Partially concluded	Tool created for Capacity Management which allows to allocate people and prioritize projects and activities, consequently, reducing rigidity. Final solution without the high effort required was still in final tests.
No current overview of different tasks and projects	Ongoing	Having a tool with the overview of all projects and activities would allow to have centralized information, available to all stakeholders without need to wait for feedback. The tool was still in final tests.
Too much time spent on searching for the correct information	Ongoing	FileShare folder structure updated with better description of folder's name. Information was identified more easily due to the reduction of folders and ambiguous names. The migration of folders was performed not long ago so, to have reliable results the final evaluation should be performed later.
Lack of organization and dedicated space for material storage	Ongoing	The workshop and questionnaire to the team was performed but the results were not still obtained in order to have a criterion for storage. Next steps would be to implement the standard in a pilot project, test it and deploy to the rest of the department.
Missing skills for all the current responsibilities or activities assigned	Ongoing	Skills and trainings needed by the team were assigned. Each team member needs to have a development plan and discuss with team leader about it and long-term business goals. The completion of Skill Matrix with this information was still ongoing to align with EAI and MFT requirements.
Lack of Digital 5S mindset	Ongoing	A workshop and survey to the team was prepared based on tools available by informatics department and costs per year spent by the department regarding information storage and SW licenses. This action was still ongoing.
Communication issues	Concluded	To improve communication within the team, the use of Teamboards to exchange information regularly was established. It was also deployed the use of Agile Collaboration tools such as Retrospective. The feedback from team members was positive.

6.2 Lean Mindset

From the Maturity Assessment presented on Chapter 5.2, different actions were implemented for the LLS elements. As it is presented in Figure 70, from the 9 elements that the group was involved, three of them already had reached the Maturity Level 4: Go to Gemba, Continuous Improvement and Problem Solving.

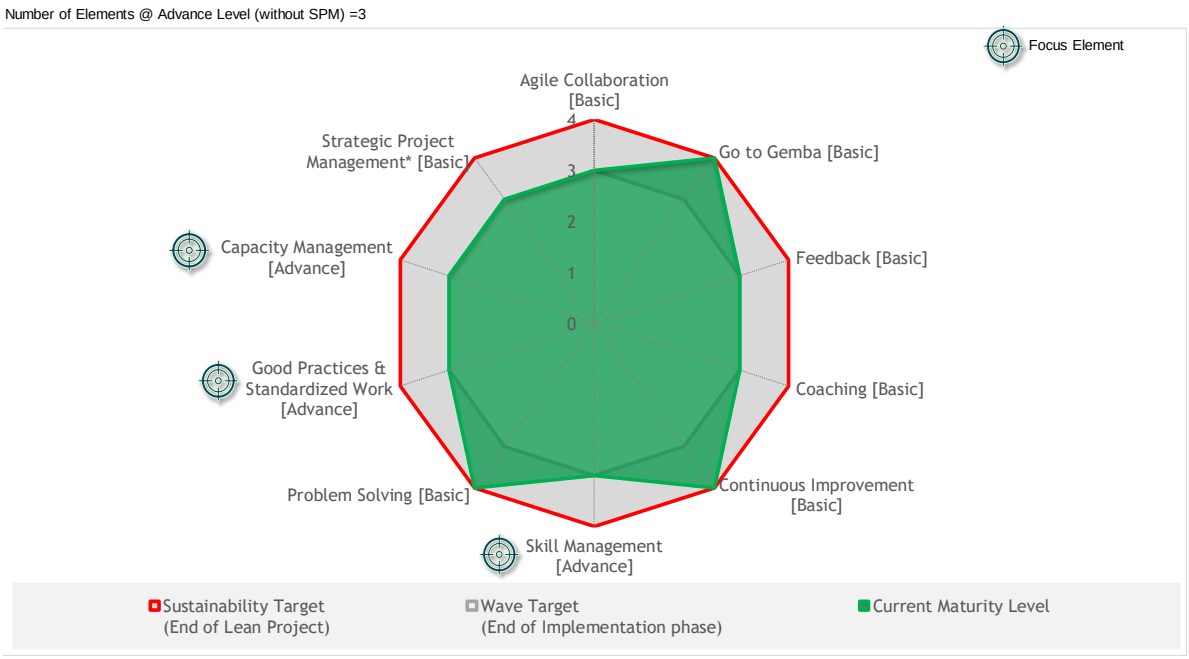


Figure 70 - Maturity Assessment of the Lean Project

These elements were consistently used during the Lean Project, new measures were derived and followed their application. For e.g., the Go to Gemba was also considered during the Design Phase to be used in some productivity measures to evaluate the development of the tasks. The same was applicable to Problem Solving and Continuous Improvement.

The other elements were on Level 3 since most of them require a closer verification. Feedback and Coaching which require regular practice to achieve the last level, were still having lack of eagerness from the team members. Although some actions such as establishing meetings or timeslots for Coaching, it would be needed more measures to promote and settle these techniques as current practice.

The remaining elements had measures ongoing so, it was expected to reach the Level 4 at the end of the project.

6.3 Overall results of the project

To assess the status of the Lean Project with the team members, a workshop was performed with both groups. The aim was to receive feedback regarding each of the LLS elements and the perception of the team about the project.

The questionnaire is presented in Appendix 3 – Results from questionnaire about Lean Project, where the same questions were made for each of the LLS elements, except for the ones that employees did not have a tool that was used by them in a daily basis (Skill Management and Capacity Management). Each question had a rating from zero to five according to the agreement each one had with the question proposed. The results are represented in Figure 71 with the average of results for each element.

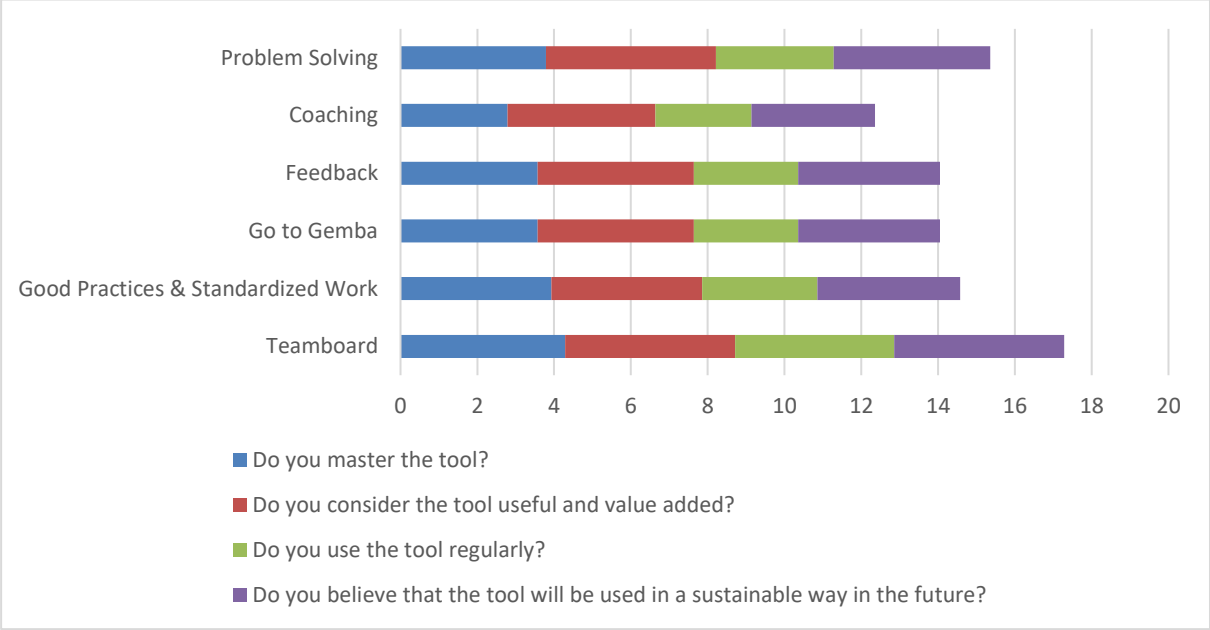


Figure 71 - Results from the questionnaire to the team regarding LLS elements

Overall, the Teamboard element had a higher score in all questions, so it can be concluded that people feel at ease with this tool and will most likely use it in the future.

On the other hand, Coaching was the one with the lowest score, especially considering the level of expertise and the regular use. The most probable cause for this score was the lack of understanding of the tool, as people had been referring in previous meetings. Coaching was perceived as a complex tool without a clear timing to use so, this may have deterred people to even try it. This could also be explained by the avoidance behaviours people have as a consequence for their irrational beliefs and anxieties (Ellam-Dyson & Palmer, 2011).

As for the remaining tools, there was still room for improvement regarding the continuous use and, consequently, the level of experience people has.

The last questions from the questionnaire were about the Lean Project as a whole, as presented in Figure 72.

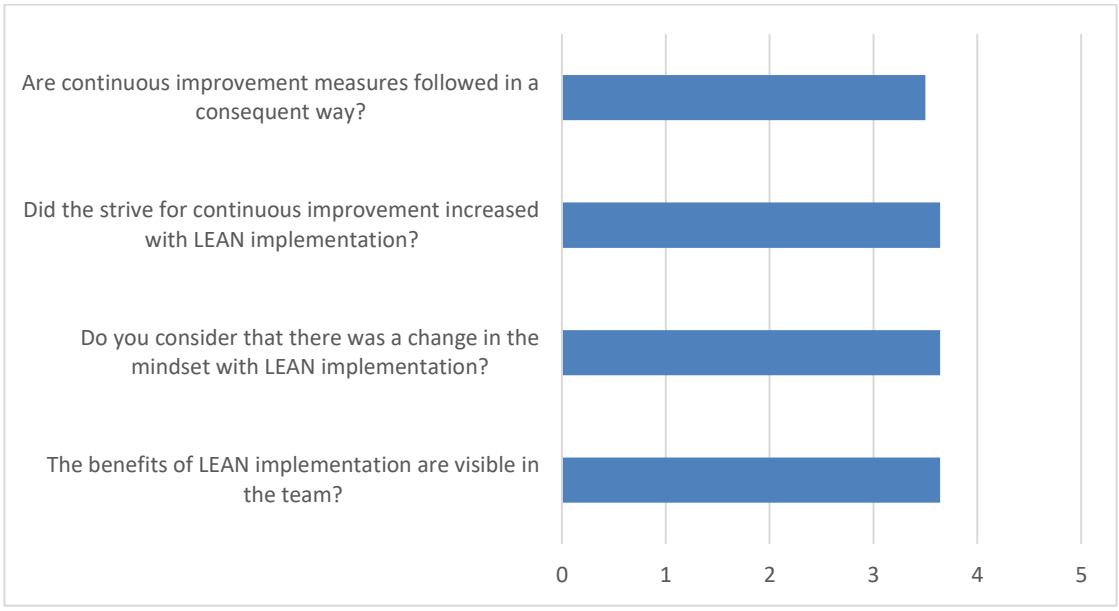


Figure 72 - Results from the questionnaire to the team regarding the Lean Project

The results show that although the average score is good (higher than 2,5), there was still a gap between the maximum value. Hence, so far, the Lean Project was at a good track since it has contributed to implement beneficial changes in the group and establish a continuous improvement mindset.

In addition, it was requested to the team to further explain these results by reflecting in what improved vs what there was still to improve. The results are represented in Figure 73 and have a label for the corresponding tool people were referring to.

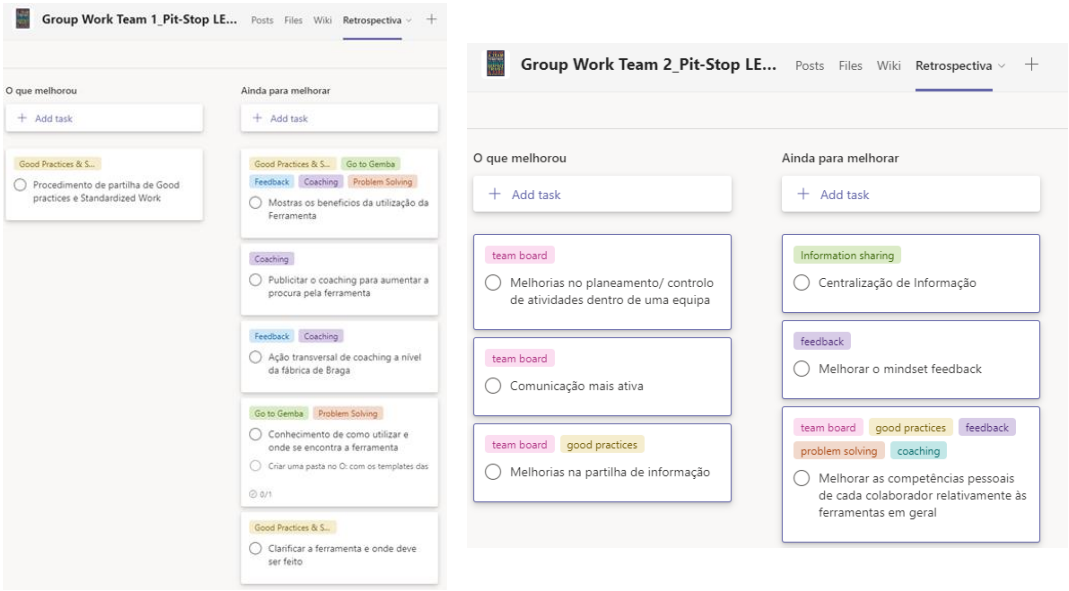


Figure 73 - Feedback from the groups about the Lean Project

It was clear from the feedback that there were improvements in communication, information and good practices sharing as well as the procedure.

However, regarding other tools that people do not feel so familiar with, they stated that their competencies and how to use them still need to be enhanced. They specifically referred to Coaching and Feedback as tools that need to be developed in terms of mind-set and knowledge.

Moreover, they felt that there was a need to centralize the information since we had different sources (Teamboard, FileShare, etc.) because the measure for the improvement of information management was still not concluded. Therefore, people were still having difficulties finding information.

7. CONCLUSIONS

This chapter presents the main conclusions of the work performed for this dissertation. A comparison between the objectives of this work and the measures implement is evaluated to verify if they were attained. It is also discussed some proposals for future work that can be essential to improve and sustain the Lean Project.

7.1 Final considerations

At the beginning of this dissertation, it was defined that the main purpose was to implement a Lean Leadership System in an indirect area, the department of AE/EAI-PT AE/MFT1.2, of Bosch Car Multimedia Portugal S.A. The implementation was conducted through a Lean Project with a systematic designed by Bosch which was divided into four phases, similar to Action Research Methodology. The project aimed to improve productivity through the elimination of wastes and establish a Lean Mindset by the Lean Leadership System. These improvements would allow the department to gain capacity to perform other tasks that are aligned with the business strategy and establish a mindset of continuous improvement.

During the Diagnosis Phase, a series of tools were applied where the wastes from different processes were identified. Some of them include waiting, rework, inventory, unbalanced work and non-utilized human talent. It was also conducted some workshops with the team to generate new ideas and get more feedback about the current situation in terms of daily work and management. From there, measures of improvement were established for the Design Phase.

These measures were elaborated into a plan with defined timings so, not all of them were initially set to be concluded during the timeline of this dissertation. Actions that require the implementation of a SW tool to proceed, are strongly dependent on trials before the release.

One of the major issues from the group, that represents more than 30% of TAT, was the meetings. The way they were conducted represented a lot of wastes especially in waiting time. The creation of a meeting codex which established rules and the template agenda helped to reduce those wastes by 5,4% of TAT.

Simultaneously, it was defined Teamboards as a tool to exchange information within the team and solve some of the communication issues. This resulted in improved information and good practices sharing and gave responsibility to team members by having rotated moderation.

Although the measures were initially established, some of them required more effort than expected and, since the implementation depends on other team members, there was not enough time available to finish them. Inventory management, update of Skill Matrix with a development plan and create awareness regarding Digital 5S require a longer timeline to implement, sustain and evaluate thoroughly.

The results from the project were visible by the team and perceived as beneficial. Indeed, the Lean Mindset had reached Level 3 for most of the LLS elements. For Go to Gemba, Problem Solving and Continuous Improvement was possible to reach Level 4 as practices were already established and used within the team and measures were derived from them.

Globally, team members gave a positive feedback about the Lean Project and had a good level of expertise and knowledge about the LLS elements. However, the elements more related with soft skills (Feedback and Coaching) still need further improvement.

In conclusion, the results were satisfactory so, it is expected that the proposals will be implemented, and Lean will be sustained in the future.

7.2 Future work

As for future work, it is expected to carefully continue to follow-up the activities proposed in order to obtain the productivity gains. It is also important to align it with an effective leadership that continuously guide and inspire team members to undergo with the project.

The LLS elements that had lower scores, Feedback and Coaching, should have more attention from the management team and have regular informal activities to promote them. As people learn more by experience, they should be faced with more situations in which feedback and coaching practices are required.

Therefore, it is also crucial that after the project ends, the Lean mindset and continuous improvement activities are maintained. It is proposed to establish a "Lean after Lean" project to sustain the mindset, although with not so tight monitoring as this one.

To sum up, with this future work proposals, it could be possible to reduce even more the wastes, promoting a continuous improvement environment and be in the route to become a learning organization.

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APPENDIX 1 – RESULTS FROM EMPLOYEE SURVEY

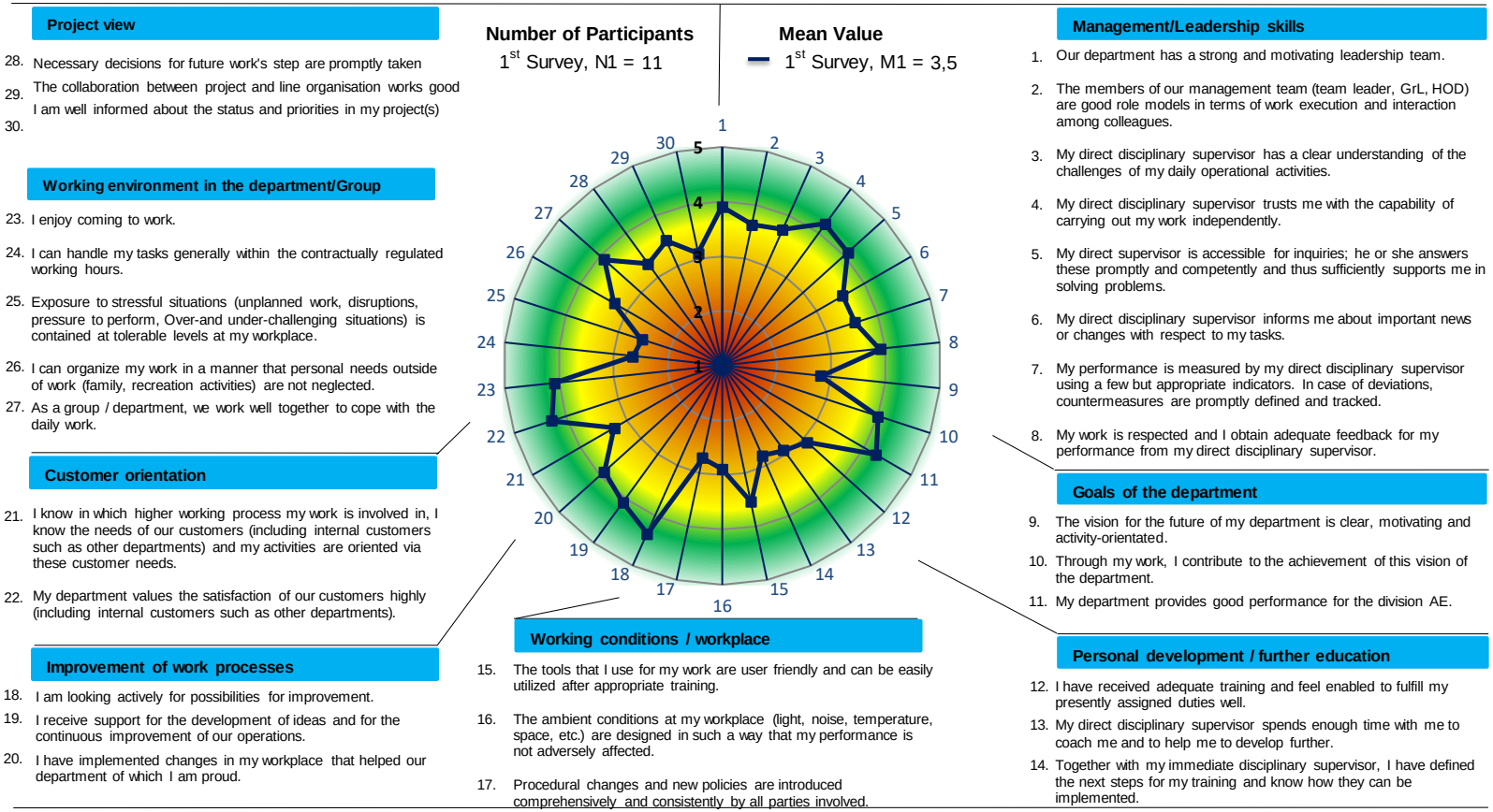

Figure 74 - Employee Survey results

APPENDIX 2 – VSDIA ANALYSIS FROM SMT INSERTION TRIALS

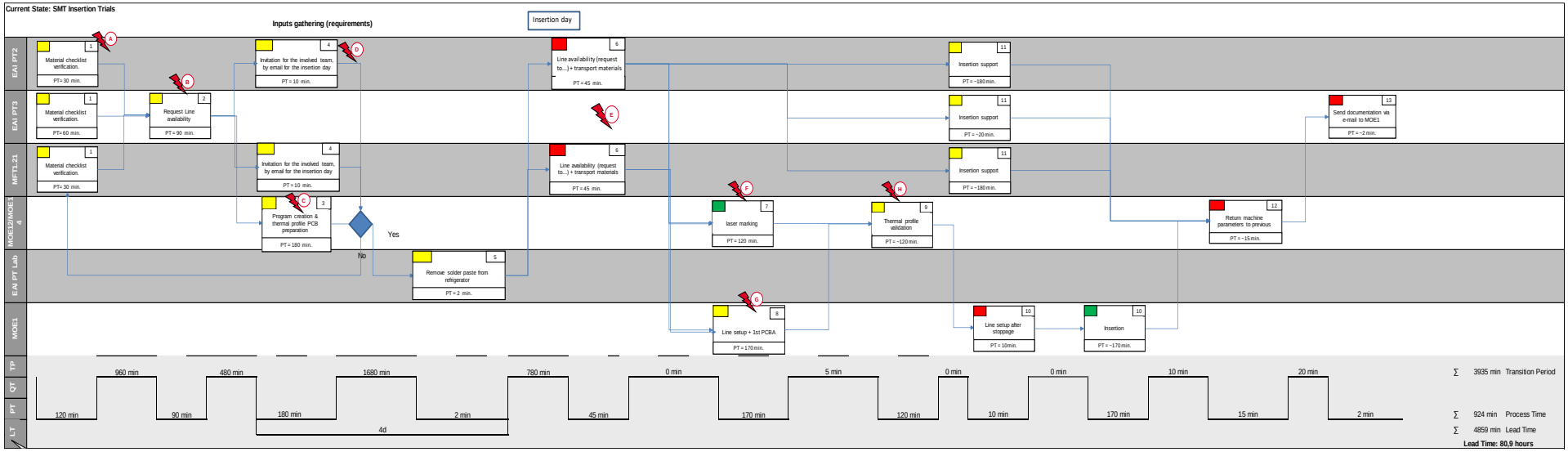

Figure 75 - VSDiA results for SMT insertion trials process

APPENDIX 3 – RESULTS FROM QUESTIONNAIRE ABOUT LEAN PROJECT

Teamboard

Figure 76 - Results from questionnaire regarding Teamboard tool

Good Practices & Standardized Work

Figure 77 - Results from questionnaire regarding Good Practices & Standardized Work tool

Go to Gemba

Figure 78 - Results from questionnaire regarding Go to Gemba tool

Feedback

Figure 79 - Results from questionnaire regarding Feedback tool

Coaching

Figure 80 - Results from questionnaire regarding Coaching tool

Problem Solving

Figure 81 - Results from questionnaire regarding Problem Solving tool

LEAN Project

Figure 82 - Results from questionnaire regarding the Lean Project