Universidade de Aveiro
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Continuous improvement of the logistics processes of an automotive company

Melhoria contínua dos processos logísticos de uma empresa automóvel

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Relatório de Projeto apresentado à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Engenharia e Gestão Industrial, realizado sob a orientação científica da Prof.ª Doutora Carina Maria Oliveira Pimentel, Professora Auxiliar do Departamento de Produção e Sistemas da Escola de Engenharia da Universidade do Minho e coorientação da Prof.ª Doutora Helena Maria Pereira Pinto Dourado e Alvelos, Professora Auxiliar do Departamento de Economia, Gestão, Engenharia Industrial e Turismo da Universidade de Aveiro.

“The world we have created is a product of our thinking; it cannot be changed without changing our thinking”

Albert Einstein

o júri

presidente

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agradecimentos

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palavras-chave

Indústria Automóvel, Logística, Melhoria Contínua,VAVE, *Lean*, Ergonomia, *Standardized Work*, Digitalização.

resumo

Atualmente, as empresas competem cada vez mais pelo seu lugar no mercado. Para se manterem competitivas, procuram, constantemente, a produtividade e a melhoria contínua, recorrendo para tal à filosofia *lean* e à digitalização.

Estima-se que, quando um produto chega ao consumidor final, cerca de um terço dos seus custos totais são logísticos. É, assim, fulcral, melhorar os processos logísticos.

O presente projeto foi desenvolvido no departamento de melhoria contínua de uma empresa da indústria automóvel, em cooperação com o departamento logístico, tendo como principais objetivos a análise e melhoria dos processos logísticos da empresa e a digitalização dos documentos utilizados.

O projeto focou-se, portanto, na melhoria contínua no âmbito da logística, dividindo-se em quatro iniciativas/casos de uso: projeto de melhoria da produtividade, ergonomia, seguimento de ações de melhoria em processos logísticos e a transição de standards de trabalho em papel para o formato digital numa aplicação informática comercial.

Com recurso a distintas metodologias internas e externas (VAVE, PDCA, *standardized work*, ergonomia, BPM) foi possível desenvolver diversas melhorias nos processos já existentes e propor novas soluções, tendo por base a simplificação e melhoria de ficheiros e estruturas previamente utilizados, bem como a gestão visual.

Relativamente ao projeto de melhoria de produtividade, este dividiu-se em três partes: melhoria do processo de simulação de ações, implementação das ações em si propostas (matéria-prima, produto acabado e transportes) e a criação de um *dashboard* para a apresentação de resultados provenientes das ações de produtividade.

A iniciativa de ergonomia focou-se na melhoria do processo subjacente aos estudos ergonómicos logísticos e à criação de um *dashboard* para análise de resultados obtidos através dos estudos ergonómicos desenvolvidos.

No que toca ao seguimento de ações de melhoria em processos logísticos, foi feita a transição de um ciclo de *Deming* em papel, para o formato digital, sendo ainda criado um dashboard que permite analisar as ações por diferentes categorias.

Já a vertente de standards de trabalho foi focada na transição para uma nova aplicação digital (mlean®), bem como na formação e acompanhamento dos colaboradores.

Os objetivos do projeto foram atingidos, com o reconhecimento da empresa de que o trabalho desenvolvido adicionou valor aos seus processos.

Por fim, foram identificadas várias oportunidades de melhoria para consideração futura.

keywords

Automotive Industry, Logistics, Continuous Improvement, VAVE, Lean, Ergonomics, Standardized Work, Digitization.

abstract

Currently, companies increasingly compete for their place in the market. To remain competitive, they are constantly looking for productivity and continuous improvement, using the lean philosophy and digitalization.
It is estimated that when a product reaches the final consumer, about one third of its total costs are logistical. It is therefore crucial to improve logistics processes.
This project was developed in the continuous improvement department of a company in the automotive industry, in cooperation with the logistics department, with the main objectives of analysing and improving the company's logistics processes and digitizing the documents used.
Hence, the project focused on logistics continuous improvement, being divided in four initiatives/use cases: productivity improvement project, ergonomics, follow-up of improvement actions in logistics processes and the transition of work standards in paper format to digital format in a commercial computer application.
Using different internal and external methodologies (VAVE, PDCA, standardized work, ergonomics, BPM) it was possible to develop several improvements in the existing processes and propose new solutions, based on the simplification and improvement of files and structures previously used, as well as visual management.
Regarding the productivity improvement project, this was split in three parts: improvement of the action simulation process, implementation of the proposed actions themselves (raw materials, finished goods and transportation) and the creation of a dashboard for the presentation of results from productivity actions.
The ergonomics initiative focused on improving the process for logistical ergonomic studies and the creation of a dashboard to analyse the results obtained through these studies.
Regarding the follow-up of improvement actions in logistics processes, a transition was made from a Deming cycle on paper, to a digital format, and a dashboard was also created which allows the analysis of actions by different categories.
The strand of work standards was focused on the transition to a new digital application (mlean®), as well as training and monitoring the employees on its use.
The objectives of this project were achieved, and the company recognized that this work added value to its processes.
Finally, several improvement opportunities were identified for future consideration.

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List of Abbreviations and Acronyms

AGV	Autonomous Guided Vehicles
BPM	Business Process Management
EOP	End of Production
FG	Finish Good
HSE	Health, Safe and Environment
JIT	Just in Time
JNI	Just Needed Inventory
MIFA	Materials and Information Flow Analysis
mPS	mlean® Production System
NOK	Not Okay
OEM	Original Equipment Manufacturer
PC&L	Plant Control & Logistics
PDCA	Plan-Do-Check-Act
PPE	Personal Protective Equipment
RM	Raw Material
S.W.C.	Standardized Work Chart
SAP	System Applications and Products in Data Processing
SCM	Supply Chain Management
SJM1	Plant 1 of the Company A
SJM2	Plant 2 of the Company A
SJM3	Plant 3 of the Company A (external warehouse)
SW	Standardized Work
TBC	To Be Confirmed
UAP	Autonomous Production Unit
VAVE	Value Analysis and Value Engineering
W.C.T.	Work Combination Table
W.I.	Work Instructions
WRMSDs	Work Related Musculoskeletal Disorders

1. Introduction

The current report documents the project developed in the continuous improvement department, linked to logistics, in a company of the automotive industry that produces metallic frames for seating. In this first chapter, an exposition of the motivation and contextualization of the project will be made, the company and the project will be described, as well as the intended objectives and the methodologies used to achieve them. Finally, the structure of this document will be presented.

1.1. Motivation and Project Contextualization

The present work was developed in a company of the automotive industry between October 2021 and June 2022. The company is a major worldwide supplier of the automotive industry, is located in São João da Madeira, Portugal, and produces metallic frames for seating.

Since the automotive industry is an extremely competitive sector, the company takes into consideration two major factors to keep the competitive advantage: customer satisfaction and technologic innovation. Taking this into account, and to improve its productivity, the company has implemented a project entitled VAVE (Value Analysis and Value Engineering). This project aims to improve the productivity in the process, product, and logistics through a multidisciplinary team, focusing on three key areas: raw materials (RM), finish goods (FG) and transport actions. This study focuses on the logistics improvements that can impact different areas as packaging, lot size, ergonomics, logistic process itself, transport, and inventory.

Another point that the company considers to be extremely important is ergonomics at workstations. By ensuring adequate working conditions, it is possible to reduce the number of workers' injuries, increase their satisfaction and, consequently, guarantee greater productivity. The company develops several ergonomic studies for each workstation, but when it comes to logistics, there is a specific study that is applied - Study X[1].This study evaluates the ergonomic effort of the logistics operator regarding logistical supplies and returns a result. If this result is not favourable, it is necessary to take actions to improve the conditions of the workstation.

One of the responsibilities of the continuous improvement department is to follow improvement actions that arise, always ensuring the involvement of all necessary stakeholders. For actions to evolve and be completed, teamwork and close follow-up of actions are essential.

Lean thinking and continuous improvement take a critical part in the company, so standardized work is a main pillar to achieve better results and be able to analyse opportunities of improvement. Having this in mind, and considering the impact of the digital technologies, the company is transforming the way of implementing and auditing the standardized work - transitioning from

[1] Due to confidentiality reasons, the real name of the ergonomic study will not be mentioned.

paper format documentation to digital, using mlean® - an application developed upon the request of the company.

Concluding, four main research questions arise in the scope of this project:

1. What is the impact of VAVE actions on the company?
2. How can the ergonomic analysis process in logistics be improved?
3. How can the process of following up improvement actions related to logistics be improved?
4. How to implement standardized work in a new digital tool?

1.2. Company Description

In the current section, the company is presented. Due to confidentiality reasons, the name of the company will not be stated, as well as some information related to the company like suppliers, clients, parts numbers, and names. To simplify this question, the company where the project was developed, will be named "Company A".

As mentioned before, the company belongs to one of the major worldwide suppliers of the automotive industry. The group to which the company belongs was created in 1997 and has three hundred plants worldwide, in thirty-five countries. The group not only comprises the manufacturing sector, but also has thirty-nine Research and Development Centres.

In Portugal, there are six manufacturing companies, one central services facility and one Comfort & Trim Systems Division. The project was developed precisely in one of the six manufacturing plants which is located in São João da Madeira and produces metallic frames for car seating.

The mother company of the group was created in 1951. It was later in 1962 that the production of car seats began, with the first exportations of car's components taking place in 1973. Even though over the years there were multiple changes, it is possible to state that the Company A was truly created in 1998.

Nowadays, Company A has around 800 workers, 26 projects that use 934 raw material parts that result in the 362 finish good parts. It can produce 50000 parts/day in the maximum capacity and works with 130 suppliers and 32 clients (see Appendix A, Figure A.1).

The main productive operations of the Company A are welding, assembly, and painting.

To better understand the complexity of the company flows and logistics operations, it is important to explain that the Company A is divided in two buildings in SJM – SJM1 and SJM2 – that are linked by an elevator for materials and by stairs for people. Moreover, there is also an external warehouse, SJM3, about 12km away from São João da Madeira.

Figure 1 displays an overview of the flows between the different plants and the customers. These flows can be summed up as follows:

- The plant SJM1 is considered the mother-plant and receives raw material (RM) directly from the supplier or from SJM2 by elevator. Only 10% of raw material is directly unloaded by the supplier in SJM1. The rest 90% of the RM that is necessary in SJM1 comes from SJM2 by lift.
- A small percentage of RM, around 2.5%, goes from SJM1 to SJM2 by elevator.
- The plant SJM1 is constituted by production cells and the painting sector and produces painted seats.
- A major part of SJM2 is dedicated to the mass storage of raw material, which was the original purpose of this building. However, with the growth of the Company A, the consequent introduction of new projects and lack of space in SJM1, it was necessary to change SJM2's layout and introduce production cells in this building.
- SJM2 produces unpainted backrests using laser welding which requires a clean environment. Since the painting process is located in SJM1 and there is no convenience in mixing flows between painted and unpainted parts, it was decided that unpainted backrests should stay in SJM2. Furthermore, this decision allowed SJM1 to receive more projects.
- FG from both plants either go directly to the Company's A customers or to SJM3. In stable conditions and regular volumes, part of Finish Goods (FG) from SJM1 goes directly to 5 Just in Time (JIT) plants and part of FG from SJM2 goes directly to 2 Original Equipment Manufacturer (OEM). The other FG from both plants (SJM1+SJM2) go to the external warehouse (SJM3), in an average daily flow of thirty trucks.
- From SJM3, the FG goes directly to the company's remaining customers (5 JIT), with an average daily flow of fifty trucks.

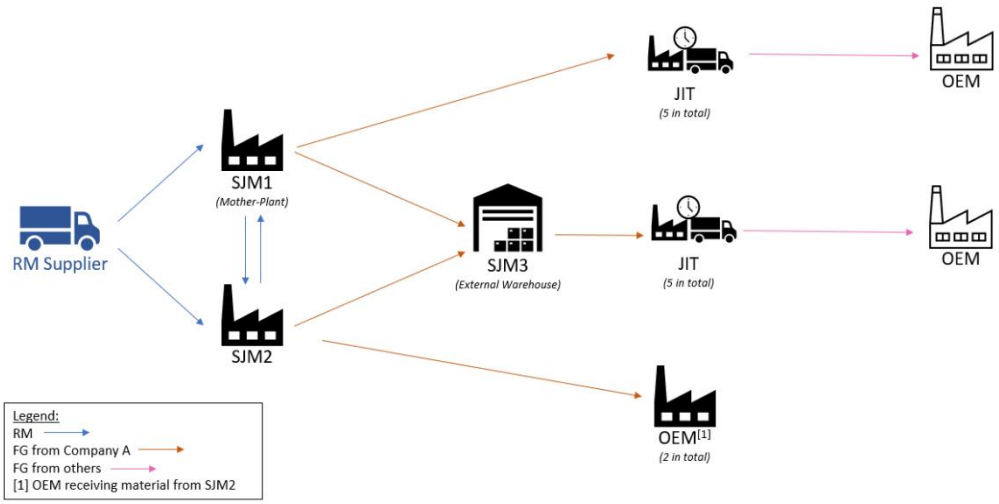


Figure 1 - Representative scheme of the flows between plants of the Company A and its customers

1.3. Project Description and Objectives

As already mentioned, the project was developed in the continuous improvement department of the Company A, more precisely with the PC&L (Plant Control & Logistics) Improvement Coordinator in constant cooperation with the company's logistics department.

The continuous improvement department is responsible not only for the continuous improvement of all the processes, but also for sharing the knowledge and promote the improvement attitude inside the company.

The PC&L Improvement Coordinator is responsible for the continuous improvement of all logistics activities, from the digitization of tools to the focus on productivity and internal (inbound and outbound) logistics. In addition, the coordinator has high responsibilities throughout the supply chain, from supplier to customer.

The present project focused on continuous improvement regarding logistics and was developed on four main aspects:

- VAVE project;
- Ergonomics;
- Follow-up of continuous improvement actions;
- Transition of work standards in paper format to the application mlean®.

Regardless of each aspect of the project, there were two common objectives that were intended to be achieved:

- Analysing the logistical processes and proposing improvements;
- Digitizing the documents used as much as possible.

Each one of the referred purposes had its specific objectives which will be presented in the following sub-sections.

1.3.1. VAVE

One of the company's projects that has the intervention of PC&L Improvement Coordinator is precisely the VAVE project. As mentioned before, this project was developed by an internal multidisciplinary team with the objective of analysing opportunities for improvement and, thus, increase productivities. This project focuses on logistics improvements that can impact different areas such as packaging, part price, lot size, ergonomics conditions, transport, and inventory.

The specific challenge presented by the Company A can be seen in two major parts: the analysis process of possible VAVE actions and VAVE actions themselves. In addition, in order to find opportunities for improvement (VAVE actions themselves), the company also wanted to analyse

possible improvements to the process of evaluating possible actions, more specifically to the Excel® file that was used to simulate VAVE logistics actions.

As such, the VAVE project was worked from both angles, with the Excel® file improvement component being the most explored.

1.3.2. Ergonomics in logistics workstations

As mentioned before, one of the biggest concerns of Company A are the ergonomics conditions in workstations. The company intends to reduce restrictions on jobs, to reduce the risk of accidents, to facilitate the work of operators allowing them to be more efficient in what concerns quality and cost and, finally, to make stations accessible to the greatest number of operators.

To evaluate the ergonomic effort existing in logistics workstations, the company uses Study X. This study considers the operations of lifting and positioning. All the steps underlying this ergonomic study are managed by the PC&L Improvement Coordinator.

Each workstation is object of a study. Study X analyses all the activities done by the operator to calculate a result (score) for the activity. Then, this result is compared with a reference score to identify the risk and to define the priority of actions to take.

As this ergonomic study is standard for the group and has already been parameterized, the precise challenge proposed by the company was to analyse the process underlying the ergonomic study and recommend improvements.

1.3.3. Follow-up of continuous improvement actions

The PC&L Improvement Coordinator is responsible for following up the logistical improvement actions, having to guarantee the involvement of all the necessary stakeholders and the correct attention to the actions that arise.

To ensure the correct follow-up of actions, it is essential that there is a good teamwork between the company's continuous improvement and logistics departments. In addition, it is also crucial that all stakeholders are aware of the actions in real time and that they fulfil their role. Thus, PC&L Improvement Coordinator meets daily with members of the logistics team - PC&L Manager, warehouse manager and logistics supervisors. Ideas and actions emerge from these meetings, which are followed up over time until they can be considered closed.

Given the considerable number of actions to be followed and the method used – Improvement cycle – Plan-Do-Check-Act (PDCA), which are operationalized on paper, the main objective of the company was to automate and improve this process, which was then the focus of this strand of the project.

1.3.4. Standardized Work

Standardized work (SW) is one of the company's pillars to capture the best way of working, making it last and then changing it through continuously improve. The company's standard documentation is based on Lean Management, which fundamentals can be found all over Automotive Industry companies which apply lean manufacturing principles (Internal document Company A, 2022).

The group to which Company A belongs defends that the standardized activities should be applied to all kind of operations and not only in production, so having standardized work in logistics is crucial.

The group also states that the digital transformation is a key contributor of the continuous improvement culture and performance, so leaving behind the paper documentation related to the SW is a requirement.

Hence, the challenge presented by the company was to create digital working standards in mlean®, which are a combination of videos that replace the photos and detailed descriptions of each task that made part of the work instructions in paper format. The goal was to create the highest possible number of logistics' standards in the digital tool. This required a large teamwork as well as an effective coordination between the logistics supervisors (responsible for setting the work standards), the improvement team (in charge of providing all the necessary support and training) and the digital department (responsible for the implementation of digital solutions in the company and for providing technical support).

1.4. Research Questions

As mentioned in Motivation and Project Contextualization, there are four main research questions to be answered throughout this project. These also have some sub-questions which are relevant. Following, the referred questions and sub-questions are summarized in topics:

1. What is the impact of VAVE actions on the company?
    a. How can the study and analysis of VAVE process actions be improved?
    b. Which sectors are impacted by these actions?
    c. What are the savings associated with these actions?

2. How can the ergonomic analysis process in logistics be improved?
    a. What are the steps taken in the ergonomic studies?
    b. How are the actions resulting from the studies followed up?
    c. Is it possible to improve the entire process involving logistics ergonomic analysis?

3. How can the process of following up the improvement actions related to logistics be improved?
    a. How is the analysis of improvement actions performed?
    b. How are so many actions managed in terms of priorities?
    c. Is it possible to improve this process?
    d. Is it possible to automate this process?

4. How to implement standardized work in a new digital tool?
    a. What are the associated benefits?
    b. What are the biggest challenges?

To ensure that the answers to these questions arose throughout the development of the project, it was necessary to outline several steps. It is important to highlight that these steps were defined with the department team (continuous improvement team), more specifically with the PC&L Improvement Coordinator, and with the logistics department team. The main steps that were taken in order to answer the research questions were then the following:

- VAVE
    - Analyse the current VAVE action simulation file
    - Update the necessary information
    - Propose improvements to the VAVE action simulation file and implement them
    - Analyse the impact that VAVE actions have on the different sectors of the plant
    - Analyse the possible savings to be obtained by implementing different VAVE actions

- Ergonomics
    - Analyse the process of logistic ergonomic study
    - Analyse all the components needed to perform the ergonomic study
    - Analyse the process of following up actions resulting from ergonomics studies
    - Propose improvements to the process underlying ergonomics studies and later implement them

- Improvement actions related to logistics
    - Engage in the daily improvement meetings
    - Keeping abreast of the improvement actions that were already underway and those that were planned
    - Analyse the process of following up of improvement actions
    - Propose improvements to the process underlying and later implement them

- Standardized work in a new digital tool
    - Analyse the current situation of the standardized work in logistics
    - Provide all the support needed and train the logistics supervisors
    - Create digital logistics work standards in the mlean® application
    - Analyse the benefits and major difficulties related to the mlean® application

To achieve these steps and answer the matching questions, different methodologies were followed – presented in the next chapter (Methodolog).

1.5. Report Structure

The current report is divided in eight chapters. This first chapter presents a brief introduction where the motivation and context that supported this project are exposed, as well as the presentation of the company and the project itself. The objectives are also defined, and the research questions are presented. Finally, the structure of this document is outlined. In chapter 2 the methodology used is explained.

A theoretical framework, supported by a literature review, is presented in chapter 3, with the aim to provide the conceptual bases that support this project.

Chapters 4 to 7 expose the work that was developed in the company. These chapters present, for each of the strand of the project, the description of the initial situation or a contextualization, and development and proposal of the improvement actions. Afterwards, the implementation of the improvement proposal is described and, finally, the results and the conclusions are presented.

Chapter 4 focuses on VAVE actions, chapter 5 on ergonomics in logistics, chapter 6 on logistics improvement ideas and chapter 7 addresses the actions proposed on SW in mlean®.

In the last chapter, chapter 8, the main conclusions and results are presented, as well as future work.

2. Methodologies

This chapter explores the different methodologies used throughout the project to answer the research questions and achieve the outlined objectives outlined in chapter 1.

At the beginning of the project, the focus was to get to know the functions of the continuous improvement department, as well as the functions of the PC&L Improvement Coordinator. For this, it was necessary to accompany employees with different functions in the logistics area: warehouse manager, logistics supervisors, material planners and customer contacts. After having acquired an overview of the continuous improvement and the logistics departments, it was important to understand which improvement projects linked to the improvement logistics team were already in the development phase, as well as those that were planned, from digitization, shop floor changes, ergonomics projects and VAVE actions.

Table 1 summarizes the different methodologies applied throughout the project. Each of them will be described in more detail in the following sections.

Table 1 - Summary of methodologies used by project strand

Project Strand	VAVE Project	Ergonomics	Improvement actions related to logistics	Standardized work in a new digital tool
Methodology used	Internal company methodology + BPM life cycle	Internal company methodology + BPM life cycle	PDCA + BPM life cycle	Internal company methodology – SW + Methodology defined by the team

2.1. Business Process Management Life Cycle methodology

When looking at the research questions and the objectives, it is possible to notice that there are some common objectives concerning the VAVE actions simulation file, the process of following the ergonomics studies and the logistics improvement ideas. For all these topics it is required to analyse the process, suggest improvements and then implement them, so it was decided to use a single methodology for these three areas (see Table 1).

The methodology chosen was the Business Process Management Life Cycle (BPM life cycle). BPM can be viewed as a continuous cycle comprising the following phases presented in Figure 2 and described below.

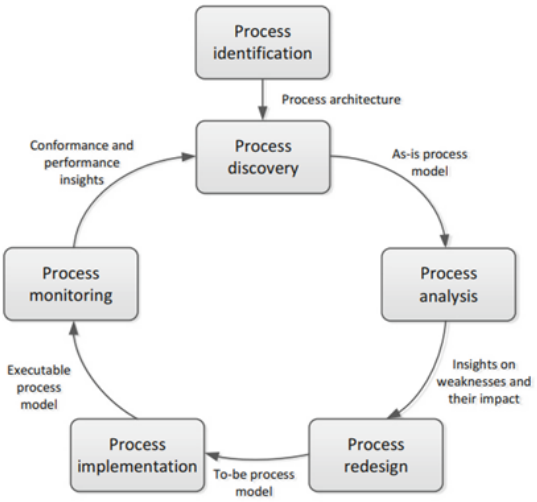


Figure 2 - BPM life cycle (Dumas, La Rosa, Mendling, & Reijers, 2018)

In the first phase, Process identification, a business problem is posed. Processes relevant to the problem being addressed are identified, delimited, and interrelated. The outcome of process identification is a new or updated process architecture, which provides an overall picture of the processes in an organization and their relationships.

In the second phase, Process discovery (also called as-is process modelling), the current state of each of the relevant processes is documented, typically in the form of one or several as-is process models.

In the phase Process analysis, issues associated with the as-is process are identified, documented, and whenever possible quantified using performance measures. The output of this phase is a structured collection of issues. These issues are prioritized based on their potential impact and the estimated effort required to resolve them.

The goal of the *Process redesign* (also called process improvement) is to identify changes to the process that would help to address the issues identified in the previous phase and allow the organization to meet its performance objectives. Hence, process redesign and process analysis go together: as new change options are proposed, they are analysed using process analysis techniques. Eventually, the most promising change options are retained and combined into a redesigned process. The output of this phase is typically a to-be process model.

In the phase *Process implementation*, the changes required to move from the as-is process to the to-be process are prepared and performed. *Process implementation* covers two aspects: organizational change management and automation. Organizational change management refers to the set of activities required to change the way of working of all participants involved in the process. Process automation refers to the development and deployment of information technology systems (or enhanced versions of existing information technology systems) that support the to-be process.

Once the redesigned process is running, the last phase - *Process monitoring* -takes place. In this phase, the relevant data are collected and analysed to determine how well the process is performing with respect to its performance measures and performance objectives. Bottlenecks, recurrent errors, or deviations with respect to the intended goals are identified and corrective actions are taken. New issues may then arise, in the same or in other processes, which requires the cycle to be repeated on a continuous basis.

2.2. Internal methodology to implement VAVE actions

There is a well-defined internal methodology of the company that the multidisciplinary team which integrates the VAVE project must follow.

Figure 3 condenses the distinct phases through which the VAVE actions pass by.

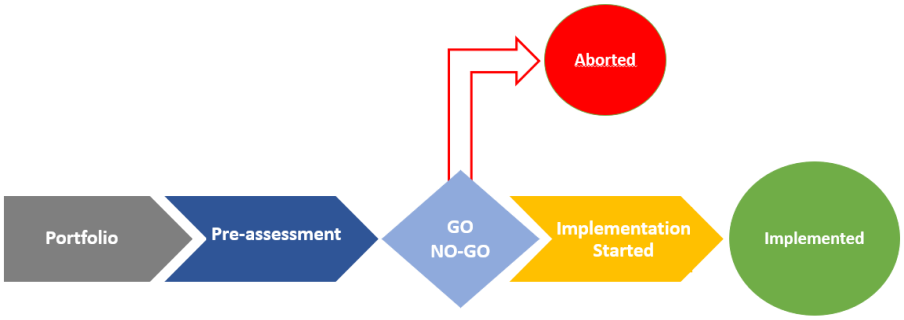


Figure 3 - VAVE Methodology (Internal document Company A, 2020)

It starts with a workshop where an Autonomous Production Unit (UAP) of the factory is analysed to find improvements ideas that can be developed in terms of product, process, or logistics. After this workshop, the project is managed by the following stages: Portfolio, Pre-assessment, Decision, Implementation Started and Implementation. In the end, after the actions are implemented, it is necessary to report the associated savings to the management control department.

In the *Portfolio* phase, the improvement idea to be worked on is inserted into a follow-up list. However, there is no type of evaluation regarding its feasibility, savings, associated costs or expected implementation time. This evaluation is conducted in the next phase – *Pre-assessment*.

Then, based on the results of the evaluation and the PDCA methodology, it is decided whether the idea will have continuity – *Decision* phase. If the decision is positive, then the improvement idea will be implemented – *Implementation* and *Implementation Started* phases. It is important to emphasize that in the *Implementation Started* phase, all steps necessary to achieve implementation are performed. In this phase, the involvement of material-planners and customer contacts is essential, and it is also necessary to perform road tests to make the decision, thus running an internal validation phase. If the result of this internal evaluation is positive, then the action moves to the next phase, but if it is negative the action does not proceed to the implementation.

It should be noted that the priority ideas to be implemented should be those that lead to greater savings and that are easier to implement.

Finally, all necessary documents are updated (like packaging agreement, saving sharing agreements or even the External MIFA – a simplified representation of the different logistical flows of a company), including savings and costs. All information and knowledge acquired with the actions are compiled in a single file that the VAVE team uses. This file serves as a basis for the analysis and monitoring of the different actions that the team follows.

Given the different scopes proposed for the VAVE analysis, this methodology is repeatedly followed for each action under study.

2.3. Internal methodology to perform logistics ergonomic study – Study X

At the company, ergonomics studies are based on two main Excel® files: the Ergo mapping and the Study X file itself.

The Ergo mapping is a single file for the company, created by the group's ergonomics manager, which must be filled in by the members who conduct the company's ergonomics studies. This file allows to record the results of ergonomics studies from all the company's workstations, define action plans and even extract the results of the studies' statuses.

The Study X file itself is also a file created by the group's ergonomics manager, which allows to evaluate the workstation under study by simply insert the data needed.

The steps for study X management at the plant level are defined by the group as follows:

1. Training in ergonomics provided to Departments' heads and to ergonomics' study pilots.
2. Identification of all workstations of the plant in Ergo mapping.
3. Identification of the ergonomics methods for each workstation in Ergo mapping.
4. Perform all ergonomics studies defined. In case of logistics, it is only the Study X.
5. Record the result in Ergo mapping.

To perform the Study X, steps defined by the group must be followed. The flowchart presented in Figure 4 demonstrates the methodology underlying the ergonomic study that is used by the company, that can be synthetically described by the following steps:

1. Observe the workstation in the shop floor
2. Perform the Study X
3. Record the result in the Ergo mapping
4. Take all the necessary actions

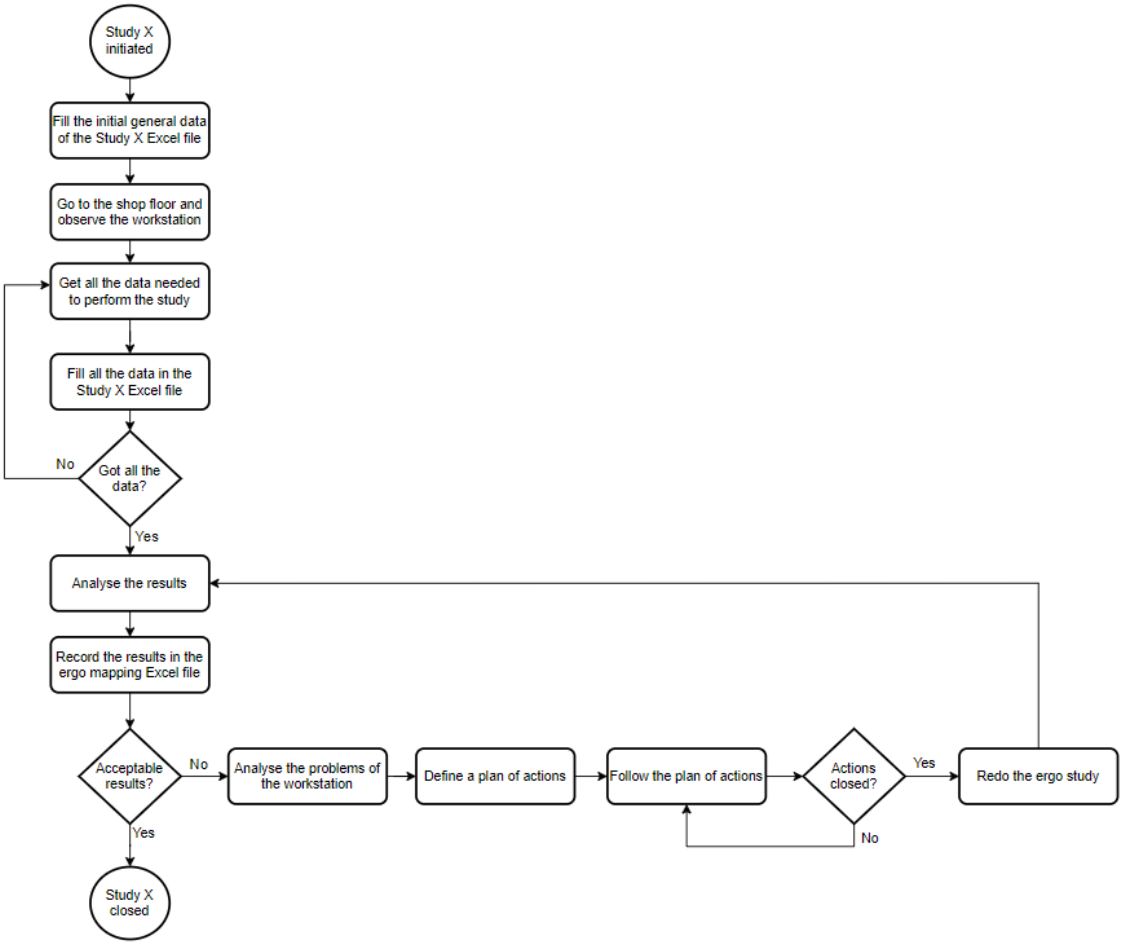


Figure 4 - Representative flowchart of the process of performing ergonomic Study X

2.4. Methodology to implement logistics improvement ideas

The main plant objective is to get customer satisfaction and continuous improvement. To achieve this objective, it is crucial for the company to hold lean management in the way of thinking through all the teams.

All the ideas of improvement managed by the PC&L Improvement Coordinator stick to the interactive process for continually improving – the well-known PDCA cycle.

PDCA is an improvement cycle based on the scientific method of proposing a change in a process, implementing the change, measuring the results, and taking appropriate action (Lean Enterprise Institute, 2022).

The PDCA cycle is known as the continuous improvement cycle or the Deming cycle. It is a quite simple sequence that serves as a guide to continuous improvement. The cycle is divided into four parts and 15 steps, as shown in the Figure 5 (Pinto, 2014).

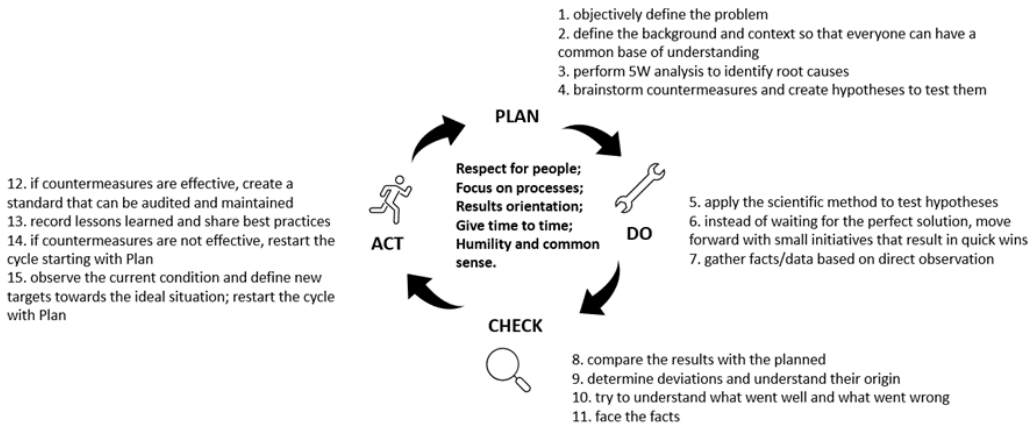


Figure 5 - Parts and steps of the PDCA cycle (Adapted from (Pinto, 2014))

The Company A follows the four stages of PDCA cycle (Figure 5):

1. Plan - determine goals for a process and needed changes to achieve them.
2. Do - implement the changes.
3. Check - evaluate the results in terms of performance
4. Act - standardize and stabilize the change or begin the cycle again, depending on the results

2.5. Methodology for Standardized Work in mlean®

Regarding the implementation of the SW in a new digital tool, two methodologies were applied, as it is possible to observe in Table 1. The first one - Internal company methodology to implement standardized work - is detailed bellow in this section. The second one - Methodology defined by the team to shift from paper standards to mlean® - was developed during the internship itself, being detailed in chapter 7 of the present document.

Internal company methodology to implement standardized work

As already mentioned, SW is a pillar of the company (Internal document Company A, 2020).

The group has an established methodology which must be followed regarding standardized work. This methodology consists of four steps as can be seen in Figure 6 and are briefly presented below.

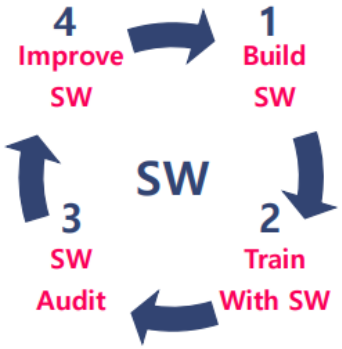


Figure 6 - Standardized Work Methodology (Internal document Company A, 2020)

First Phase - Build SW

This phase aims to have the SW built by the supervisor and/or gap leader, which is then validated by the PC&L Manager.

The SW construction phase can be subdivided into 4 moments:

1. observe current situation – on the shop floor by observing what operators are
2. really doing to understand the cycle
3. identify the best way to perform the work – select the best way in terms of safety, quality, efficiency, and repeatability
4. split cycle in elementary tasks and measure – stopwatch and split in elementary tasks
5. describe the "what" and "how" – capitalize know how in the three SW documents

From this first phase, it is expected that three major documents are obtained: standardized work chart (S.W.C.), work combination table (W.C.T.) and work instruction (W.I.).

Second Phase - Train with SW

SW is the fundamental for Gap Leader to train operators. This phase aims to explain the process with the documents from the previous phase, help the operators to observe a trained operator and finally give them autonomy to do the job and coach.

To train the operators, the Gap Leader must follow the next steps:

1. Show the line, workstation, and the process
2. Explain the "what" with the SW (W.C.T., W.I.)
3. Explain the "how" for each elementary task
4. Demonstrate on workstation

Third Phase – SW Audit

As soon as SW documents are implemented, SW audit is a routine to improve and stabilize SW conditions. This phase has two main objectives: ensure that operator respects the SW and identify improvements that can be applied to the SW.

By comparing the current way of working to the standard and filling the audit sheet, the audit allows to qualify operators and newcomers, ensure conformity to standard (Health, Safe and Environment, quality, efficiency), challenge operators towards improvement and capitalize on it.

In a very simple way, the SW audit ensures operators follow the best-defined method to run and look for any improvement opportunities (variability and wastes reduction), so it is a unique opportunity to identify improvement ideas. By the observations and measurements taken during the audits, immediate actions can be taken to correct identified issues to go back to the standard like immediately re-training the operator.

Forth Phase – Improve SW

The last phase focuses on work in waste and variability reduction and to capitalize in a new SW to ensure performance sustainability. Therefore, it is necessary to decide as a team on how this topic should be approached and implemented and defining the methodology to be followed.

3. Theoretical Contextualization

This chapter explores the main topics that underpin the project from a theoretical point of view.

3.1. Supply Chain Management and Logistics

Regardless of business domain, companies must focus on speed, efficiency, cost of production, customer service, product value and so on to be globally competitive (Vivek Singh & Ravanan, 2016). So, daily, businesses and organisations must compete for market share, which push companies into constantly seeking productivity and quality improvements while reducing costs, to stand out from their competitors (Uriona Maldonado, Leusin, Bernardes, & Vaz, 2020).

Thus, reasonable cost reduction of a production without affecting the quality level could be the best way industry can attain their maximum profit level (Vivek Singh & Ravanan, 2016). It is possible to reduce the product cost by localization of imported parts, resourcing from a different supplier, design changes, value analysis, supplier negotiations, supply chain cost review, benchmarking, competitive evaluation, alternate manufacturing process and re-evaluate customer needs (Singh, Kumar, & Arya, 2017).

The competitive capacity of a company can be implicitly related with the productivity performance of the productive factors and with the increase of innovation - translating this in the efforts of investigation and technological development (Carvalho, 2005).

In the logistics systems of automotive suppliers, production logistics processes are often linked to long lead times, and all companies are therefore trying to find suitable solutions and reduce the lead time of production logistics (Francuz & Bányai, 2022).

As the satisfaction of the final customer can be seen as of utmost importance for the successfulness of the whole chain, effective management of those processes is crucial (Jaklič, Trkman, Groznik, & Stemberger, 2006).

As Jaklič et. al (2006) refer, having efficient processes within a company may not be sufficient, so it is also necessary to have the operations of all partners synchronized. Thus, in this point of view, the integration of processes in the supply chain are required for the company to be successful in the market.

Supply chain management (SCM) can be considered one of the most important strategic aspects of any business, as it contributes greatly to creating value for the end customer. The achievement of SCM and application of lean thinking to its management can result in huge gains for companies (Pinto, 2014). In recent times, effective supply chain management has become a potentially valuable way of ensuring competitive advantage and improving organizational performance since competition is no longer between organizations, but among supply chains (Li, Ragu-Nathan, ragu-nathan, S., & Rao, 2006).

Supply chain management and logistics can be referred as the coordination and management of activities within a network of internal and external relationships. Structurally, the supply chain is defined as three or more companies linked directly to the upstream and downstream flows of products, services, finances, and information. Through these linkages, individual firms gain access to resources, develop capabilities, and impact performance. In supply chains, managers seek the capacity to interpret and understand the environment and the ability to disseminate information among partners to improve performance outcomes (Richey, Roath, Adams, & Wieland, 2021).

Logistics is considered by the different actors as the ‘‘reason to be’’ of each company belonging to a supply chain. Without logistics, no raw material can be extracted, transformed nor delivered to the final user (Perboli, Musso, & Rosano, 2018).

The Council of Supply Chain Management professionals defines logistics or logistics management as the part of the supply chain that is responsible for planning, implementing and controlling the efficient and effective forward and reverse flow and for the operations of storage goods, services and related information between the point of origin and point of consumption in order to meet customers' requirements/needs (Crespo de Carvalho J. , 2020).

Currently, logistics is considered by many authors, one of the key elements of business success, being a strategic process, since it adds value, allows differentiation, creates competitive advantage, increases productivity and makes the organization profitable (Moura, 2006) (Crespo de Carvalho J. M., 2004). A powerful logistical system is key to success in supply chain management (Crespo de Carvalho J. M., 2004).

Logistics can have an operational and strategic interest for organizations: in operational terms, making products and services available in the desired places and times, at the lowest possible cost; in a strategic sense, when managed as a core competence, enabling service differentiation or lower cost operation (Moura, 2006).

To the extent that logistics is associated with the management of the flows of products and information, it is possible to say that it intervenes in practically all organizations (Moura, 2006).

The main logistics activities for most organizations are transport, storage, stock management, packaging and information. The interaction between these activities and the resources used – human, technological and financial – is usually seen as a critical factor for logistical success (Moura, 2006) (Kain & Verma, 2018).

According to Crespo de Carvalho (2004), logistics is to open windows, to bring doubt where there is certainty and to live and live with change. Thus, it can help to triggers new thinking mechanisms, to combine induction, deduction, and creativity, to generate alternative patterns, to create scenarios, causing a new order to emerge at the end. The author also defends that logistics is and will be strategic to the company, just as logistics is, and will be increasingly focused on the mindset achieved by human capital in companies (Crespo de Carvalho J. , 2020).

3.1.1. Logistics costs

Logistics costs can comprise a significant and relevant proportion of business costs: depending on the method applied and the industry in question, their share of company turnover in developed economies tends to be at least 10 per cent (Engblom, Solakivi, Töyli, & Ojala, 2012).

According to Moura (2006), the logistical costs of a product when it reaches the final consumer can represent up to 30% of the total cost. So, logistics comes, in a way, to open a new window in the way of looking at competitiveness (Crespo de Carvalho J. , 2020).

Christopher (2005) states that, for a vehicle manufacturer, logistics costs represent about 12% of a vehicle's material costs. The author considers that, in a vehicle, 85% of the costs are in material and the added value of the component suppliers is only 15%. Within material costs, the value added by the component supplier is 60% and of these, around 80% arises from general and indirect expenses. Logistics costs such as transport, storage and stock represent 30% of general and indirect costs (see Figure 7).

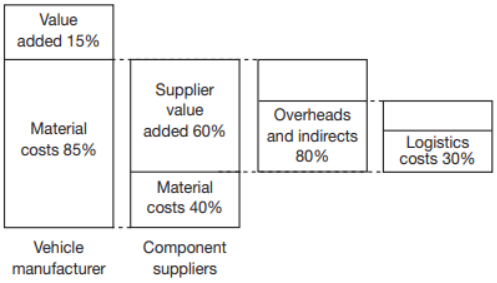


Figure 7 - The impact of suppliers' logistics cost on the cost of a car (Christopher, 2005)

Back in 1996, to Thomas & Griffin (1996) had mentioned that transportation typically accounts for half of logistics costs. According to Crespo de Carvalho (2004), organizations are beginning to realize that inventory represents between 25-30% of their value in a year. Thus, it is important to look for cost reduction opportunities in these two logistics activities.

In the analysis of an action to reduce logistics costs, logistics must be seen as an integrated system and the analysis' objectives must be clearly present, since an action in one activity can impact on others (Ross, 2010). So, logistics cost management is associated with specific challenges, since increasing the quality of logistics services for customers may often come with increased logistics costs. On another hand, reducing the costs of one logistic component may causes an increase or decrease in the costs of another logistic component, which can result in different total logistics costs (Muha, 2019).

3.1.2. Productivities

A logistics system, from a procedural point of view, can be seen as a group of activities whose goal is to convert a set of inputs into outputs of value to the customer. In this context, productivity ends up becoming the output per input unit of the logistics process.

However, creating value for the customer is not enough. Companies must also create value for workers and capital holders. In other words, they must be productive while meeting and, perhaps, exceeding the demands created by the market (Crespo de Carvalho J. M., 2004).

Productivity and profitability are two key indicators in evaluating the performance of organizations.

Productivity depends not only on the efficient way in which an organization produces its goods and/or services, but also on the effectiveness of what it produces, being determined by needs and market demand.

Profitability, on the other hand, has its direct expression in the monetary factor, depending on variations in both the prices of the goods/services produced and the prices of operating factors.

In strictly operational terms, it can be considered that productivity is identified with the measure of economy of means. Thus, it is said that there is an increase in productivity: when a higher level of output is achieved with the same or lower inputs or when the same output is achieved using fewer inputs (Carvalho, 2005).

3.2. Continuous Improvement

The concept of continuous improvement has long been considered as one of the most effective ways to improve performance and quality in organizations, ensuring the superior quality of products and services and the implementation of a permanent improvement culture (characterized by dissatisfaction and the constant search for better results) (Pinto, 2014).

Continuous improvement has increasingly been seen as an important complement to more radical, step-change forms of innovation. It involves a company-wide process of enabling a continuing stream of focused incremental innovation. It has found application in the area of quality improvement, but the principle can be applied to many other divisions of business performance. Although simple to define, the achievement of such activity and its maintenance over the long term can be a major source of difficulty many times (Bessant, Caffyn, Gilbert, Harding, & Webb, 1994).

Continuous improvement is based on continuous evolution. Gradually, improvements emerge, giving everyone time to adjust and learn. Every small increment given towards continuous improvement can be supported by a continuous improvement cycle (PDCA cycle, see Figure 8) and this cycle is constantly repeated. The PDCA cycle was already described in the section Methodology to implement logistics improvement ideas.

According to Pinto (2014) continuous improvement of processes, products and services can only begin after practices are standardized.

Figure 8 - Continuous improvement based on the PDCA cycle (Adapted from (Pinto, 2014))

Continuous improvement is therefore seen as a way of thinking according to which people work together to improve the performance of their processes, bring performance closer to reference values and, continuously, monitor and respond to customer needs and expectations (Pinto, 2014).

3.3. Lean Thinking

In today's world, industries are often very dependent on the effectiveness of the interactions with their environment to survive in the market. This dependency can be included in the relationship between organizational culture and the values of that culture (Prayuda, 2020).

In today's competitive globalized market environment, almost every industry strives to improve its performance through modern manufacturing techniques and advanced management philosophies. Lean manufacturing is a manufacturing technique that aims to eliminate waste from the root level to obtain productivity improvement and customer satisfaction (Vijay & Prabha, 2021).

Throughout the years, many companies applied lean production to improve the productivity and competitiveness against the global competition and economy decline over the past decades (Chen, et al., 2013). Lean manufacturing is a management approach to manufacturing that strives to make organisations more competitive in the market by increasing efficiency and decreasing variability through the elimination of non-value-added steps in the process (Jiunn-Chenn & Taho, 2015). When it comes to lean thinking, standardization is frequently used in enterprises (Czifra, Szabó, MÍkva, & Vaňová, 2019).

The philosophy of lean thinking has its roots in Toyota Production System, created by Taiichi Ohno (1988), who, in turn, was inspired by other scientists and engineers that had been working on the topic of operations and quality management in the automotive sector since the 1940s (Pinto, 2014).

The expression "lean thinking", as a concept of leadership and business management, was first used by in 1996. Since then, it has been applied worldwide to refer to a philosophy of leadership and management that aims to systematically eliminate waste and create value. According to Womack and Jones (2003), waste refers to any human activity that does not add value. However, Pinto

(2014) proposes that the concept of waste should be broadened to include not only human activities, but also any other type of activities and resources that are misused and that contribute to increase costs, time and to decrease customer satisfaction or other interested parties in the business.

The aim of lean thinking can be seen as to revolutionizes the way organizations thinks and behaves. The belief in change and continuous improvement paves the way for the correct application of lean thinking practices and underpins the dynamics and process of continuous improvement (Pinto, 2014).

According to Pinto (2010), the lean thinking philosophy opens new windows of opportunity for organizations to adapt and develop in an increasingly complex world. In 2014, the same author went even further, asserting that lean thinking can be an effective antidote to crisis.

3.3.1. Value and Waste

Value can be defined as everything that justifies the attention, time, and effort people dedicate to something. Some authors state that only value justifies the existence of an organization, and it is intended to satisfy all interested parties (stakeholders) (Pinto, 2014).

Waste refers to all activities that do not add value. These activities consume resources and time and make the products or services available in the market more expensive than they should be. Thus, it can be concluded that competitive advantage can be measured by the value that organizations create and by what they ask for in return (Pinto, 2014).

In Lean Manufacturing, there are 3 M's (MURI, MURA, MUDA) for waste. MURI corresponds to overloading people and machines, causing irregularities in the process and drastically decreasing the productivity and efficiency. MURA consists of the uneven application of resources and discrepancies in business operations which leads to oscillations in production that results in diverse types of waste. And finally, MUDA, are the activities that do not add value to the product or service for the customer (Internal document Company A, 2022).

The seven best-known waste categories were identified by Taiichi Ohno (1988), as follows: waste of overproduction, waste of time on hand (waiting), waste in transportation, waste of processing itself, waste of stock on hand (inventory), waste of movement and waste of making defective products. Figure 9 resumes the concepts related to each category of waste.

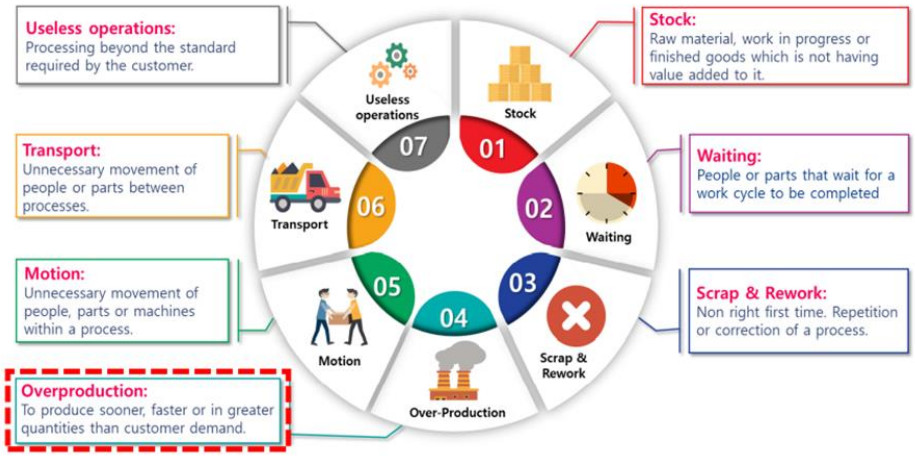


Figure 9 - Seven major types of waste in any plant (Internal document Company A, 2022)

3.3.2. Visual Management and Dashboards

Visual management, also referred to as visual control, is a process to support increasing the efficiency and effectiveness of operations by making things logical and intuitive. It is, therefore, a tool that ends up making processes simpler, less dependent on computer systems and formal procedures.

One of the defining characteristics of human beings as a species is that their interpretation of the world is visual. In this way, promoting visual management can facilitate the communication and information necessary for decision-making processes (Pinto, 2014).

This tool has been increasingly studied and applied in various professional contexts, especially in industries that seek continuous improvement of processes and operations (like food and automotive industries), thus giving rise to the concept of visual factory. Visual factories are places where production and management are believed to be most effective due to the implementation of a visual approach to information exchange (Braglia, Castellano, Gallo, & Romagnoli, 2019).

Some of the advantages of using visual management are improving workflows, improving compliance and safety management, reducing barriers in information flows, identifying waste, encouraging self-management, increasing transparency and facilitating the interpretation of information by all (Singh, Kumar, & Arya, 2017).

To visualize multiple graphics and visuals at the same time, a visual management tool called a dashboard can be developed. It consists of a single screen where it is possible to monitor all the necessary information in a clear and immediate way. Its development must be process and business centred, since, just as a car dashboard provides all the information needed to operate the vehicle, a business dashboard must enable the management of a company's operations and making strategic decisions (Few, 2006).

According to Eckerson (2011), a dashboard is a set of three perfectly integrated tools: one for monitoring, one for analysis and one for management. Monitoring displays information using timely and relevant data, usually from graphical elements. Analysis allows to explore data in multiple dimensions and different levels of detail to draw conclusions. Management communication encourages and facilitates communication between executives, managers, and other employees by providing detailed information and helping in decision making.

Some features of dashboards are comparison with past data, forecasting values or goals to be achieved. They also allow the disaggregation and aggregation of hierarchical data and deepen an element to its source data (Sharda, Delen, & Turban, 2018)

3.3.3. Standardized Work

According to Azevedo et al. (2019), standardization and documentation can lead to reduced cycle times, to gain efficiency and to make less movements, which directly affect transport and inventory wastes. Standardized work is then seen as crucial to achieve success in reducing waste. To implement and preserve it, there is a need to plan a training program that includes the workers in continuous improvement (Canales-Jeri, Flores-Perez, Rondinel-Oviedo, & Collao-Diaz, 2022).

To standardize means to make the same, regardless of who makes or uses it. Thus, standardization guarantees a solid ground for continuous improvement, allowing to build on top of it a stable and continuously improving system of operations (Pinto, 2014).

A tool in the productive context is the methodology of standard work, which aims to standardize the sequence and execution of activities at each workstation. This ensures that procedures are conducted in the same way, regardless of the employee involved (Azevedo, et al., 2019).

So, it can be said that standardized work is the reference to work, providing for every job a detailed and timed description of the best repeatable succession of several elementary tasks, including what is being done and how it is done (Internal document Company A, 2022).

Standardized work is seen as an important topic, because it is usually one of the first steps taken by companies with the aim of adopting a lean philosophy (Marksberry, Rammohan, & Vu, 2011), despite organizational culture representing a crucial role on the successful implementation of SW (Shafeek, Bahaitham, & Soltan, 2018).

Company A uses three main documents for standardized work: standardized work combination table, standardized work chart and work instruction.

The Work Combination Table (W.C.T) describes the work sequence with a timetable combining manual work, walks, and, when relevant, automatic machine times. W.C.T. shows the meeting of man/machine. It gathers all the “Elementary Tasks” necessary to produce a part in the best conditions: safety, quality and efficiency. Check-do-check tasks are also included. Periodical tasks

are also systematically identified (for example “check the HSE points of the forklift at the beginning of the shift”) and include key points with their explanation.

The Standardized Work Chart (S.W.C) is helpful for visual check as it describes the work sequence of elementary tasks, the position and moves of the operator , as well as line feeding systems. S.W.C. helps to identify the waste of motion and “way-back” motion.

A Work Instruction (W.I.) describes for each elementary task the most efficient way to produce a part in the easiest and best conditions: safety, quality, and efficiency. It includes the specific ergonomic and safety rules for the workstation, as well as the Check-do-Check tasks and the reaction rules. It explains “WHAT to do” but the most important aspect is that it describes “HOW to do it right” (Internal document Company A, 2022).

It should be noted that standardized work is more easily taught, improved, documented, audited, and transferred (Pinto, 2014).

3.3.4. Lean Supply Chain Management

Lean thinking describes the way a supply chain should work. A lean supply chain is characterized by having been subjected to a process of a detailed analysis of all the facts that existed in it, following a process of fluidization of all the dominant flows of information, materials, people, and money. Waste in a supply chain can be measured in unnecessary time, inventory, and costs.

The goal of a lean SCM can be seen as the satisfaction of the five R (5R) of logistics, namely: “the right stuff”; “in the right moment”; “under the right conditions”; “in the right place”; “in the right time”. The activities that support the 5R can generate value from the customer's perspective.

Although waste in the supply chain is difficult to identify, it is possible to pinpoint 7 types (see Figure 9) (Pinto, 2014).

3.3.5. Lean People

Lean people refer to the people in an organization who live and develop the lean thinking philosophy in a natural way, developing and maintaining the lean thinking philosophy in organizations. They are seen, therefore, as the most important and decisive factor in this type of organization, much more important than the technological factor or the knowledge of lean solutions. However, creating lean people can be a challenge.

All people in an organization can be lean learners. The journey for improvement has no end and everyone must learn and apply it constantly.

Training and coaching are critical aspects in creating and maintaining lean people. The investment made in this direction is amply rewarded by the greater participation and contribution of

employees. Creating and developing lean people must be understood as a permanent challenge within each organization and one of the most powerful ways to create competitive advantages.

At the base of the training of lean people are two facilitating tools: the PDCA cycle and the scientific method. The performance of people in a lean environment must be guided by habits of continuous improvement, based on simple, standardized and formally established procedures: proactivity, win-win, perceiving and being perceived, teamwork and KATA (a methodology that uses repeated, consistent practice and scientific thinking to train the skills that enable a person to make rapid, incremental improvements every day, and which describes the foundational continuous improvement philosophy and culture exemplified by Toyota) (Pinto, 2014).

3.3.6. The commitment to change

The environment that surrounds the business is unique, turbulent, and unstable, characterized by changes at all levels. However, change can bring challenges and opportunities (Crespo de Carvalho J. M., 2004).

Innovation is perceived as an important research area because innovations are expected to aid organizations to successfully adapt to and continue to exist in volatile business environments (Emsley, 2005).

According to Gallivan (2001), the crucial variable in organizational adoption is that it is not innovation use or user adoption per se that is of concern as the outcome of interest, but rather the extent to which the organization uses the innovation and its effects on processes, structures, and cultures within the organization. Therefore, it is important to highlight the extent of organization adoption of innovation processes rather than whether the organization adopts the innovation (Ramli, Sulaiman, & Mitchell, 2012).

It is well-known that companies are witnessing a time of continuous changes due to the irruption of digital technologies that are causing a transformation in the way the market and businesses operate in general. This can generate a disruptive effect with respect to traditional procedures in terms of the way products are produced and exchanged, and, also, how business is carried out and benefits are obtained for producers and customers (Llopis-Albert, Rubio, & Valero, 2021).

Pinto (Pinto, 2014) considers that the faster things change, the faster productivity and performance can be improved.

3.4. Value Analysis and Value Engineering

For creating value, organizations must be competitive. Hence, it is essential that organizations continuously manage their costs and maintain better quality products that meet customers' changing needs and desires. If these are not achieved, organizations may not be able to survive nor sustain their position in the competitive market. Therefore, industries must increasingly display

competitive characteristics which should stimulate the use of cost reduction and prevention techniques such as Value analysis and Value Engineering (VAVE) (Ramli, Sulaiman, & Mitchell, 2012).

Value Analysis can be seen as an activity that typically occurs jointly between purchasing and method engineering that focus on the value of a product. This activity can be defined as a process of systematic review that is applied to existing products design in order to obtain better and optimised commercial output (Vivek Singh & Ravanan, 2016).

Value Engineering relates to a systematic and multi-disciplinary team approach usually adopted by organizations to solve problems in terms of value of product or service from the consumer's point of view. As such, it can be considered as an innovative tool that enables companies to sustain their business performance. Value Engineering aims to achieve the essential business functions at the lowest overall cost while maintaining customers' optimum value assurance (Ramli, Sulaiman, & Mitchell, 2012).

As already mentioned in the two previous chapters, VAVE system can be applied for enabling product improvement and achieving cost reduction (Vivek Singh & Ravanan, 2016).

3.5. Ergonomics

Despite the changes that automation solutions have created, several tasks and activities are still performed manually in industrial settings. Manufacturing contexts – characterized by complex products comprising hundreds of different parts and a high variety of assembly, lifting, and handling tasks – may require a high level of flexibility not provided by a robot. In addition, humans have cognitive and physical skills that are very difficult to replicate. In such contexts, tasks repetitiveness, hazardous or awkward postures, heavy loads and other ergonomics risks can negatively impact workers' well-being, causing Work Related Musculoskeletal Disorders (WRMSDs). WRMSDs refer to all health problems of the locomotor apparatus and all forms of ill health disorders or injuries induced by work circumstances and performances. Consequently, it is necessary to sustain workers' physical and cognitive well-being by reducing ergonomic risk through human oriented production systems and workplaces design.

There are two main consequences related to WRMSDs: they directly affect workers' well-being, and productivity decreases due to absenteeism or higher turnover rates (Battini, et al., 2022).

Therefore, organizations must focus on achieving efficiency in their processes, maintaining the well-being of their workers (Sylla, Bonnet, Colledani, & Fraisse, 2014).

4. Case Study – VAVE Actions

The present chapter focuses on the project aspect related to the VAVE actions regarding logistics. After a brief contextualization, two main topics will be addressed - the Excel® file used to simulate the VAVE actions and the VAVE actions themselves (with some examples). Afterwards, the results and their analysis will be presented and, finally, the main conclusions will be drawn.

It is important to mention again that, due to confidentiality issues, there is information that cannot be disclosed.

4.1. Brief contextualization

As already mentioned throughout this report, logistics productivity is extremely important for the company, which makes the VAVE company's internal project essential.

This VAVE project has participants from different departments (such as production, continuous improvement, purchasing, engineering and logistics), constituting a multidisciplinary team. This team meets biweekly to discuss the evolution of the actions that each pilot (member of the team) is following, and the results are saved in a single file that the team shares on Microsoft Teams®.

Regarding logistics, VAVE actions are managed by the PC&L Improvement Coordinator. These actions can be divided into three major areas of focus each with their distinct categories (Table 2).

Table 2 – Three major areas of logistics VAVE actions and their categories

VAVE logistics main area	Categories
RM (Raw Material)	Supplier transference, eliminate the repack, stack ability, change packaging, return empties, ergonomics, increase parts, lot size, paint
FG (Finish Good)	Stack ability, change packaging, return empties, increase parts
Remain	FG – packaging, RM - lot, RM – packaging, RM – transport, FG – transport, others

These VAVE logistics actions require teamwork between the PC&L Improvement Coordinator, material planners and client contacts, so two biweekly meetings take place – one dedicated to FG actions and the other dedicated to RM. Regarding transport actions, these involve the transport team and there is a weekly meeting.

Each department manages its actions internally, simulating the actions that arise to obtain the necessary data and then fill in the team's single file. In the case of logistics, PC&L Improvement Coordinator makes use of an Excel® file that was created based on the previous AZALEA project (predecessor project of VAVE that focused only on logistical gains), to perform the simulations of each VAVE action and monitor its evolution.

To ensure that the single file followed by the multidisciplinary team is not too long and difficult to follow, the PC&L Improvement Coordinator only transfers to this file actions that are already in the phase of development. *Implementation Started*. It should also be noted that while in the logistic

simulation file each action is analysed individually, in the multidisciplinary team single file the actions can be grouped if they all refer to the same supplier. For example, if the action is “to increase N parts in 4 references from supplier X”, then in the individual file of the PC&L Improvement Coordinator there will be four lines of actions, while in the single file of the team there may be only one line.

For linking purposes, each VAVE action that goes to the team's single file has a unique code that must be followed in the simulation file.

The highest priority actions are always those that generate the greatest savings. However, there is an exception - those that affect the working method, such as ergonomics actions that always involve a reduction in the number of pieces per package (due to the weight above 12kg, which is an ergonomic condition that will be better explored in the next chapter) and, normally, do not generate savings.

Lastly, the relationship and agreements with the supplier and customer are points that have to be taken into consideration, as it may not make sense not to take a certain action if a change in both the production project and the supplier is planned.

At the end of each month, the savings data must be shared with the Plant Controller so that the month-end data can be updated. So, ensuring that the simulations of the actions are well performed and that the associated savings are correct is crucial and involves great responsibility.

4.2. Simulation File – original version

The VAVE logistics simulation file is extensive and gathers information from the company's system regarding packaging, suppliers, customers, inventory, transport, and components.

Considering the amount of data that the file used (translated in ten Excel® worksheets), in a first phase (Process Discovery) it was necessary to make a detailed study of where each information came from and how each field of the simulation was calculated.

The original Excel® file that was used at the beginning consisted of several tabs, each with specific objectives (see Table 3).

The calculations were already parameterized according to the company's requirements and conditions (Table 4) and some visual management was already used (Figure 10 to Figure 13).

Table 3 - Worksheets and its main objectives (original file)

Worksheets	Main objectives
Main Page	Automatically compiles data from other worksheets; calculates the total savings associated with each action; follow-up of actions (list of actions). It is divided into 5 categories: general data, packaging, transports, full year saving and decisions.
Inventory	Database for inventory saving calculations
Transport	Simulates and calculates savings from changing the transportation mode.
Parts price	Calculates and stores the annual impact of a price/part change.
Packaging	Packaging database.
Supplier	Supplier database and world map with all the suppliers' locations marked up.
Customer	Customer database and world map with all the customers' locations marked up.
Decisions	Compiles all the information necessary for decision making; records the decision, as well as the responsible and the date.
Savings	Dynamic table that allows you to present the status of actions and savings by supplier
Suppliers & Customers Maps	Global view of the location of suppliers and customers; used for brainstorming sessions

Table 4 - Company's parameters and their explication

Parameter	Explication
Number of days per year	240
Weight/Box	Packaging weigh itself + (Part weigh * Number of parts per packaging)
Quantity/Pallet	Nº packaging (boxes) per pallet * Quantity per packaging
Weight/Pallet	Pallet weight itself + (Weight/Box * Nº packaging (boxes) per pallet)
Company's truck	13.6 meters long + 2.4 meters wide + 3 meters high 24000 kg weight limitation
Nº pallets/year	(Quantity of components per pallet / Daily needs) * Number of days per year
Nº trucks/year limitation=volume	Nº pallets per year / Nº volumes in the truck
Nº trucks/year limitation=weight	(Nº pallets per year * Weight per pallet) / Maximum weight of the truck

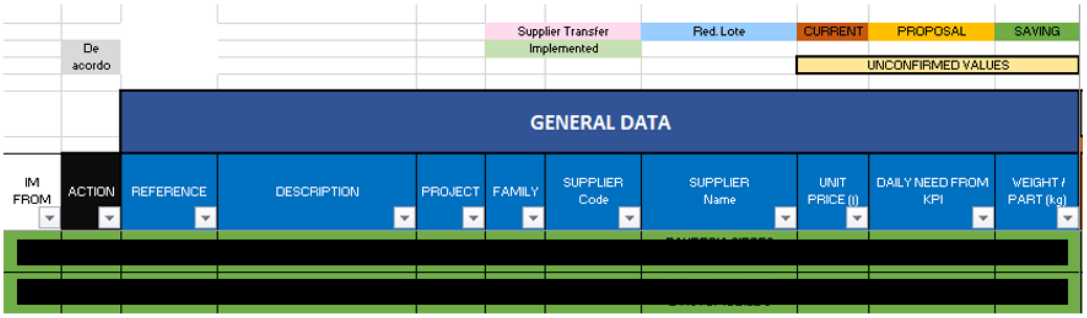


Figure 10 - Original file Main Page (General data)

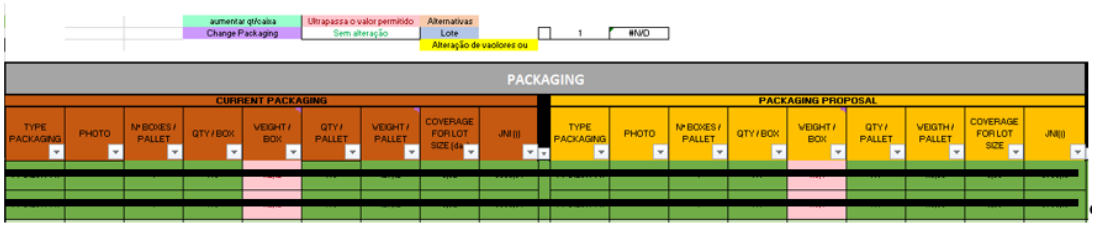


Figure 11 - Original file Main Page (Packaging)

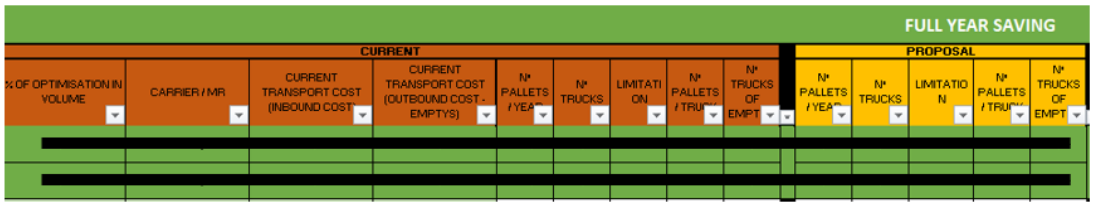


Figure 12 - Original file Main Page (Transports)

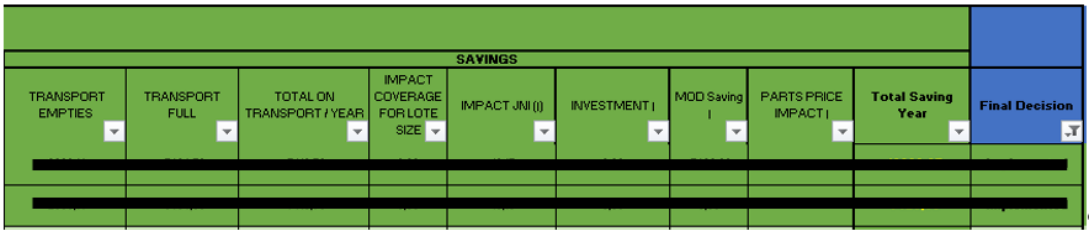


Figure 13 - Original file Main Page (Year Savings and Decision)

4.3. Simulation File – new version

The aim of creating a new file version was to simplify it, enrich it and, if possible, make it more automatic.

Throughout the project, working on this VAVE simulation file was a constant task, with a total of 7 sequential versions of the file being prepared (it was in version 3 at the beginning – original file – and at the end of the project it was already in the tenth).

Bearing in mind that the final version, version 10, is one of the results of the work performed during the internship, the focus will be precisely on it. Anyway, it is considered that version 5 was the one that brought the first major changes and that served as the motto for the following changes. For this reason, during the project, a summary table of the changes made in version 5 was created and passed on to the PC&L Improvement Coordinator (see Appendix B, Figure B.1).

In the cyclical process of improving the simulation file, it was necessary to always keep in mind some aspects: organization, simplification, visual management, data correction, data analysis and automation.

The parameters mentioned in Table 4 were maintained and in some cases adapted to the current situation that the company was going through. It was also necessary, in a first phase, to update some databases, such as transport costs, daily needs forecast for the year in question, details of

packaging, list of suppliers and customers and even the routes. It was also essential to delete all the sheets that were not relevant or that no longer made sense, integrating the information in the main sheet as much as possible, most of the calculations being done on this sheet. Version 10 of the file then consisted of the following main worksheets:

Table 5 - Main worksheets of the version 10 of the file

Worksheet	New or Adaption?	Main objectives
Index	New	Organize the file and the information. Allows to navigate through the tabs by just clicking.
RM_2022	Adaption	Main page for RM VAVE actions. Allows to perform the simulations needed. It is divided into 9 categories: general data, packaging (current and proposal situations), transports, full year saving, decisions, dates, comments, contact and auxiliar dates for the graphics.
FG_2022	New	Same logic as RM_2022, but for FG actions simulation. It is divided in the same 9 categories mentioned above. Worksheet completely new, so it was necessary to adapt it to the data.
Resume_remain actions (2022)	New	Allows to simulate and follow-up the remain actions regarding transportation for example. In the beginning, this information was in a separate file.
PC&L_RM	New	Resumes the data regarding RM actions to send to the PC&L Manager. Used as month-end report (Report 1).
PC&L _FG	New	Resumes the data regarding FG actions to send to the PC&L Manager. Used as month-end report (Report 2).
Plant_RM	New	Resumes the data regarding RM actions to send to the Plant Controller. Used as month-end report (Report 3).
Plant_FG	New	Resumes the data regarding FG actions to send to the Plant Controller. Used as month-end report (Report 4).
Dashboards	New	Allows to analyse the data in a visual way and compares the previous month to the actual one. Used as month-end report (Report 5).

Other worksheets related to databases were also created, maintained, or adapted: supplier, customer, System Applications and Products in Data Processing (SAP) extractions, 2022 budget volumes for RM and FG, packaging, and photos (see Figure 14).

Figures 14 to 21 show the worksheets of the version 10 that were created in order to perform the tasks described in Table 5, as well as an example of the dashboard that was created to resume the information and make it more visual.

Figure 14 - Index Worksheet

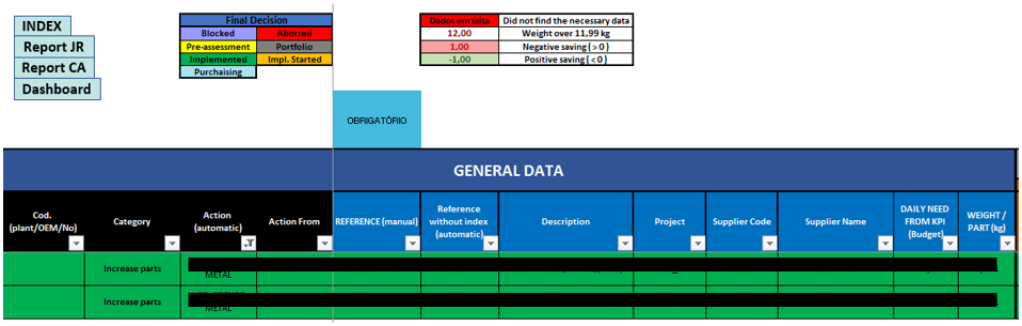


Figure 15 - RM_2022 General data

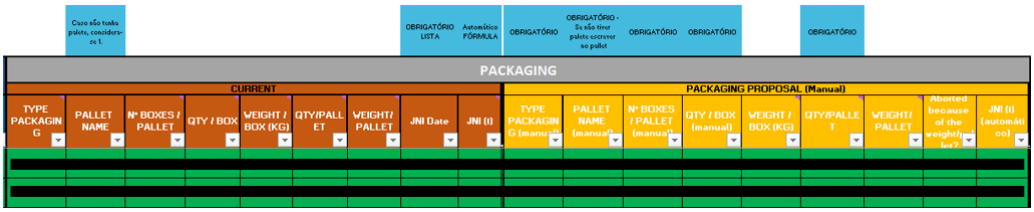


Figure 16 - RM_2022 Packaging

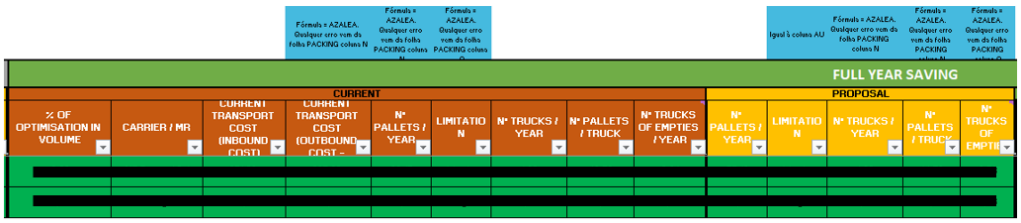


Figure 17 - RM_2022 Transport

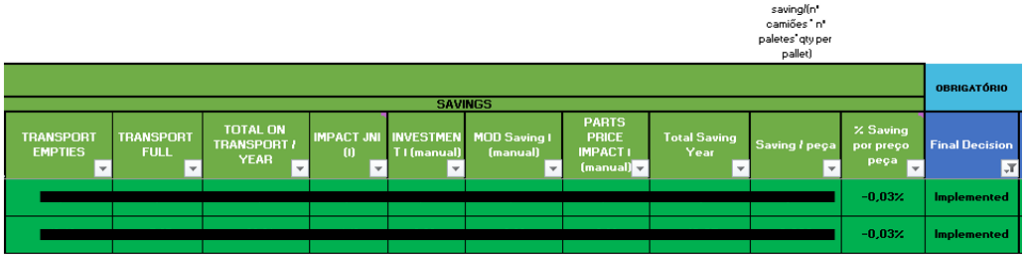


Figure 18 - RM_2022 Full year saving and decisions

OBRIGATÓRIO	OBRIGATÓRIO	AUTOMÁTICO	AUTOMÁTICO	AUTOMÁTICO			Abertura		Fecho	
Opening Date (idea initiated)	Closing Date (idea implemented or abandone	Action closed?	Mês - Auxiliar	Ano - Auxiliar	Comments	Contact	Ano abertura	MÊS ABERTURA	Ano Fecho	MÊS Fecho
10/01/2022	10/01/2022	yes	janeiro	2022			2022	janeiro	2022	janeiro
10/01/2022	10/01/2022	yes	janeiro	2022			2022	janeiro	2022	janeiro

Figure 19 - RM_2022 Dates, comments, contact and auxiliar dates for the graphics

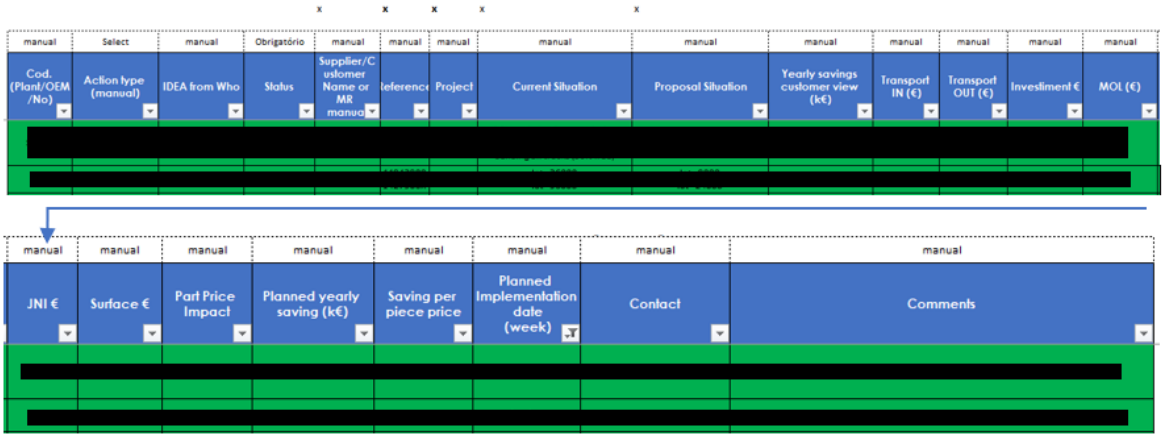


Figure 20 - Resume_remain actions (2022)

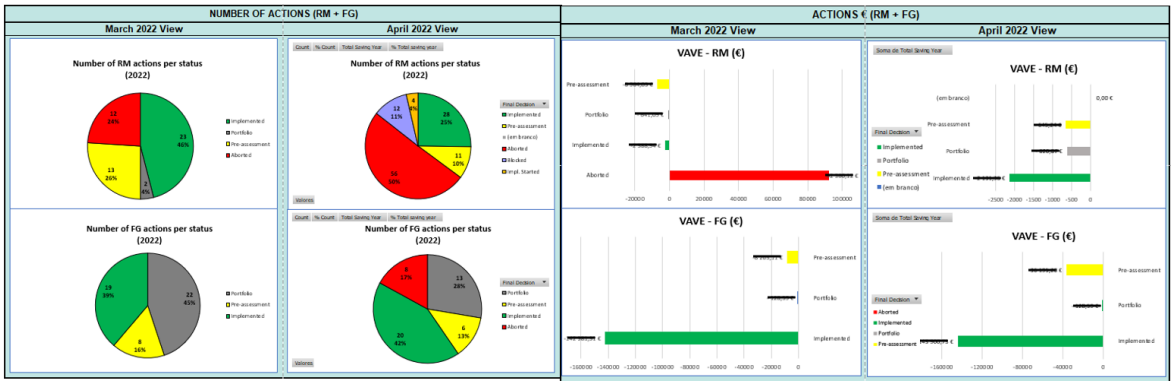


Figure 21 - Example of the dashboard created

In the new version it was also relevant the implementation of visual management through colours, which provides help regarding the fields. Figure 22 demonstrates what has been implemented.

Final Decision	
Blocked	Aborted
Pre-assessment	Portfolio
Implemented	Impl. Started
Purchaising	

Dados em falta	Did not find the necessary data
12,00	Weight over 11,99 kg
1,00	Negative saving (> 0)
-1,00	Positive saving (< 0)

OBRIGATÓRIO

Figure 22 - Colour codes applied and helping notes in the version 10th of file

Some fields were added to facilitate the analysis of actions and to avoid certain errors. Examples of this are the fact that specific categories of action types were added for RM and for Remain (Table 2), if the action should be aborted due to the weight of the pallet – given that the forklifts used have a load limit and new formulas were also inserted regarding the saving per piece and the

percentage of saving per piece price. As far as the final decision is concerned, it was limited to the fields of a drop-down list and, depending on its status, the colour line changes. Although the remaining calculations were maintained, it was crucial to simplify the formulas and add criteria and alerts in case there was any kind of error.

Excel® macros were also used to allow a more simplified navigation within the file through buttons with hyperlinks.

Version 10 of the file also allows to automatically send the FG action report to the PC&L Manager (Figure 23) via email. This solution was achieved by building a macro in Excel® (see Appendix C). By clicking on the “Send report” button (Figure 24 right highlighted in pink), a copy of the sheet is created and attached to an email with the recipients, subject and body text filled in as can be seen in Figure 25.

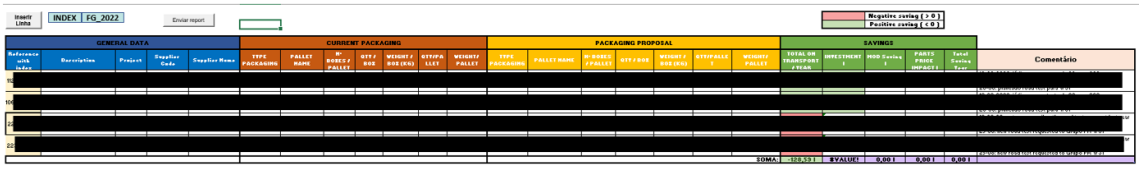


Figure 23 - FG VAVE actions report that is send to the PC&L Manager

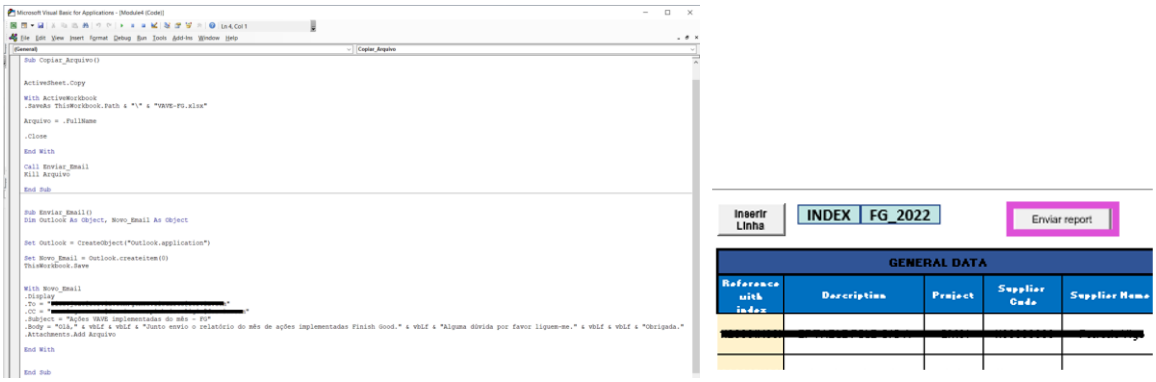


Figure 24 - Excel® macro built to send the FG VAVE actions report by email (left), with associated button to send the email (right)

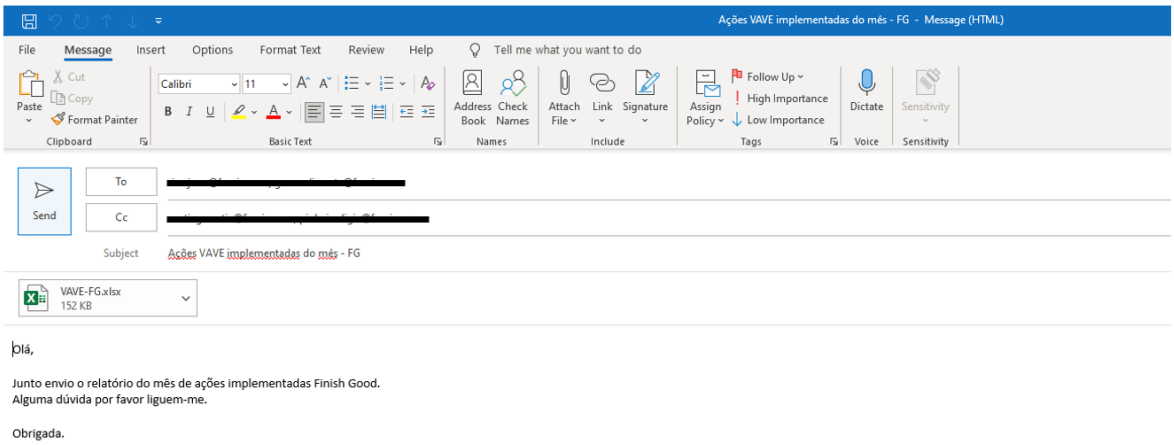


Figure 25 - Email sent when the "Send report" button is clicked

4.4. Implementing VAVE Actions

As already mentioned throughout the chapter, VAVE actions are seen as something of great importance in the company and may even constitute a competitive advantage factor. These can be of different types as explained in the Table 2 and involve a great complexity of calculations during the simulation phase. In addition, they involve several decision phases and people.

Throughout the project period, it was possible for the trainee to integrate the VAVE team and to monitor all the steps taken in the management of actions. It was then possible to perceive that the project can only works with great effort and teamwork and that the flow of communication and information is fundamental.

During this period, many actions were monitored, and many others were implemented. Although the company does not allow to share sensitive information, it was allowed to share some examples of actions that were implemented, and these are described in Table 6.

Table 6 - Some examples of logistics VAVE actions implemented during the project

Type of action	Action category	Description	% Saving per piece price
RM	Increase parts	Increase the number of pieces per box. Go from 67 pieces/box to 74 pieces/box.	- 0,03%
FG	Increase parts	Increase the number of pieces per container of FG. Go from 26 pieces to 28 pieces.	- 14,15%
Remain	RM Transport	Modification of a specific route in order to optimize the return of empty containers.	- 0,20%
Remain	RM lot	Change the batches of two specific finish good references from 36000 to 9000 and from 96000 to 24000.	- 0,002%
Remain	Transport	Change stacking on truck from 1 to 2.	- 0,11%

During the project period, 166 logistics actions of VAVE were monitored, using the new file format just presented.

4.5. Results and Discussion

As the VAVE actions analysis process itself is defined by the company (Process Identification), the focus was on the internal management of logistics actions, more precisely on the Excel® file used to carry out the simulations.

After the initial phase of understanding how everything worked, it was concluded that it was possible to change and improve the file. Some changes or innovations were considered critical and beneficial, such as:

- Creation of a colour code through conditional formatting, so that better visual management is possible and, at the same time, allows alerting to situations that deserve special attention.

- The review of the fields related to packaging and pallets used. The type of pallet and its weight were not parameterized, so it was essential to include this information to avoid errors in the calculations.
- The inclusion of the criterion of maximum weight per pallet that the forklift can handle. Whenever it reaches 700 kg (), the action is automatically put in the "aborted" status.
- The weight limit per box will be controlled in the simulations. According to the company's ergonomics rules, no box that includes manual handling must weigh more than 12 kg. In the new version of the file, whenever this occurs in the simulation, the weight/box field is highlighted in red.
- The inclusion of a new formula for calculating the percentage of savings per piece price that allows for a more detailed analysis and response to requests from the Plant Controller.
- The new simulation sheet for FG VAVE actions and the merge of the remain actions in the same file.
- The creation of dashboards and the structure of reports.
- The automatic sending of the reports created.

The referred VAVE actions involve several departments (like logistics, sales, quality) of the company and represent a possible great source of savings.

To allow a deeper analysis and discussion of what was done concerning the VAVE actions themselves, it is important to show the size of the sample of actions that were examined.

Based on the new VAVE simulation file and the actions found in it, it is possible to conclude that in 8 months,166 logistics VAVE actions were monitored. Of these, 94 regard to RM, 33 to FG and 39 to remain actions (see Table 7).

Table 7 - Number of logistics VAVE actions per category and status (October 2021 to June 2022)

Nº Actions October 2021 - June 2022								
Category	Nº Total	Portfolio	Pre-assessment	Impl. Started	Purchaising	Blocked	Aborted	Implemented
RM	94	0	10	2	0	8	50	24
FG	33	0	0	0	0	5	4	24
Remain	39	0	10	0	0	15	10	4

As it is possible to analyse through the table, even though the number of implemented actions is relatively high in general, the number of blocked and aborted actions is considerable. The category of FG was the only one where the number of implemented actions was higher than the sum of the blocked and aborted actions.

All ideas that arise must be simulated, but they do not always pay off in terms of savings or changes that may exist at the project or supplier level, what justifies the high number of aborted actions. The action may still be advantageous to the company, but the supplier/customer may not accept

or demand money for such changes. In other words, it is always necessary to take a careful balance of what is worth insisting on.

Blocked actions are problematic because they prevent the natural evolution of actions and consequently the company's possible savings. It is therefore critical to analyse the root causes for these situations and eliminate or minimize these causes and, consequently, the blocked actions.

Taking into consideration the questions raised in section Research Questions, it is possible to state that all were answered positively and that the objectives were met. Even so, it is recognized that it is always possible to improve the file, so this task should continue, as the continuous principle states.

4.6. Concluding Remarks

The VAVE project is considered an asset by the company, as it allows to explore improvement ideas from different perspectives that can lead to large savings. When creating something of such responsibility and importance for the company, it is essential that the actions are managed carefully and meticulously. For this, it is crucial that there is a good teamwork, the information and communication flow efficiently and that the calculations are correctly made.

Knowing the complexity of the subject, it was vital to go through a first phase of knowledge about the subject and the file used to simulate the logistical actions of VAVE. It was also essential to integrate the follow-up meetings of the actions and get to know the team.

During the project some limitations were felt. A recurring one is that as the process involves several steps and a lot of people, sometimes the company's collaborators motivation decreases, and, consequently, the actions take longer to be implemented. Additionally, due to lack of response from some necessary actors, actions were considered blocked, and it could take months to change this state. Another blocking factor was the lack of defined criteria for decision-making by the logistics team.

A known limitation of this approach is the fact that the information taken from the system (SAP) is not always updated, which can lead to estimation errors.

As a future work, several intervention actions of different typologies are proposed and briefly described next.

Regarding the Excel® file itself, it is proposed to continue the work of simplifying it as much as possible, placing all actions, or at least those of RM and FG, in a single list. It is also considered that it would be worthwhile to make the reports more automatic, being able to make greater use of Excel® macros or even apply Power BI. Something that would make everything easier and lead to fewer errors would be to find a way to directly link the file to the system, thus avoiding constantly doing SAP extractions and having to manually update the formulas in the file.

Regarding the teamwork between PC&L Improvement Coordinator, material planners and customer contact, it works well. However, it is sometimes difficult to obtain availability from the logistics team, so it is essential to work on their motivation and involvement in the process.

It is also considered that the blocked actions could be fewer if there were defined criteria or rules regarding the final decision of certain actions, such as ergonomics actions. It is seen as essential to define clear criteria together with the PC&L Manager so that it is not necessary to ask for his/her decision so often.

Although the decision of the parameter of the impact on the Just Needed Inventory (JNI) - ideal stock to have in the factory from the reception of components to the moment of their use in the production lines- to be given by a material planner is established, this ends up blocking actions or delaying the simulations. It is then proposed to study with the material planner a more effective way of managing this information.

Despite all the limitations mentioned and the future work presented, it is considered that the objectives were met and that it was possible to improve a lot the simulation file, with very positive feedback from PC&L Improvement Coordinator.

Finally, it is concluded that integrating the VAVE company's internal project was a great source of learning, allowing the application of various knowledge acquired throughout the academic course.

5. Case Study - Ergonomics in Logistics

The present chapter focuses on the study of ergonomics in logistics. After a brief contextualization and the description of the initial situation, the main topics will be addressed – the improvement proposal made and implemented. Then, the results and their analysis will be presented and, finally, some conclusions will be drawn.

5.1. Ergonomics in logistics – Brief Contextualization and Initial Situation

The ergonomics conditions of the workstations are a constant concern of Company A, with a well-defined target - to obtain the best possible results and always look at the stations that, at first glance, seem impossible to improve as permanent challenge.

The group to which the Company A belongs has well-specific parameters and rules regarding ergonomics conditions. Concerning the logistics activities in the company, they have different types of load handling as it can be seen in the image below (Figure 26).

Figure 26 - Material handling in logistics (examples) (Adapted from (Internal document Company A, 2003))

When these physical operations are performed in an inappropriate way in terms of ergonomics, they can imply risks, mainly lumbar injuries for the workers. To prevent this, there are rules defined by the group that must be followed:

- there must not be any manual handling of any load over 12 kg
- the height of the load (between the location of the hands and the floor) must be between 500 mm and 1500 mm.

The Study X is an ergonomic study designed by the group to assess the ergonomics conditions when handling loads, mainly boxes in the context of logistic activities. This study contemplates the operations of lifting and positioning, and its result is based on three parameters: height of locations of the loads (storage, train/trolley, and line), weight of the loads and the frequency of manipulation of the loads. In the end, a result is obtained, and it is possible to identify the priority of actions to take (Figure 27). If there are loads that break the rules above, the result will always be *"Not acceptable"* (requiring more or less immediate mitigation actions – purple or red, according to Figure 27).

FEAL SCORING	INTERPRETATION		PRIORITY OF ACTIONS
GREEN	Low effort	Acceptable	No actions required
ORANGE	Hight effort	Acceptable	Analyze improvement actions
RED	Very high effort	Not Acceptable	Actions required
PURPLE	Critical effort	Not Acceptable	Inmediate actions required

Figure 27 - Study X possible results, its interpretation and priority of actions (Internal document Company A, 2003)

A critical point to correctly perform the study is to select properly the type of manual manipulation for each part (Figure 28).

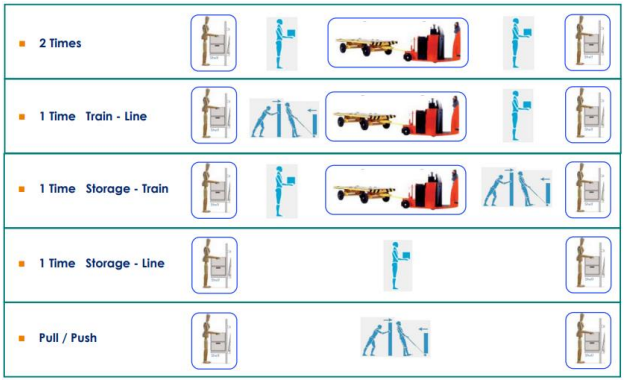


Figure 28 - Types of possible manual manipulation (Adapted from (Internal document Company A, 2003))

Ergonomics studies are therefore important and the objective set by Company A is to have all studies completed by the end of 2022. Although these studies are not conducted by the PC&L Improvement Coordinator (they are carried out by an external person), the role will be responsible for managing the entire process, outline an action plan and follow it.

In a very summarized way, the PC&L Improvement Coordinator defines which station has to be studied, explains it to the external person, who in turn conducts the study and sends it to the PC&L Improvement Coordinator. If there are no doubts, then the result can be recorded in the Ergo mapping (Excel® file) by the external person. In case of further needs, the PC&L improvement coordinator may contribute directly to the study (*e.g.,* providing further data and insights, visiting the shop floor with the external person, …).

At the beginning of the project, the communication flow between the PC&L Improvement Coordinator and the external person was mostly done via email and the ergonomics studies were stored in a folder on the company's internal network to which only people within the company had access.

All the information that the external person needed was obtained on the shop floor and through an Excel® table provided by the PC&L Improvement Coordinator with data on the parts and frequency of handling.

The recording of ergonomic study results and the necessary actions were then recorded in an Excel® file created by PC&L Improvement Coordinator that followed the structure presented in Figure 29.

Action Plan - Follow Up 2021								
GAP/Station	Location	result	Action Descritpion	Pilot	Forecast Date	Implement Date	Forecast Result	Status / Comentários
[redacted]	SJM2	Red	Implement the kitting	[redacted]	W52		Green	
[redacted]	SJM2	Orange	Implement the kitting	[redacted]	W50		Green	
[redacted]	SJM2	Red	Implement the kitting	[redacted]	W02 2022		Green	
[redacted]	SJM2	Red	Implement the kitting	[redacted]	W04 2022		Green	
[redacted]	SJM2	TBC	[redacted]	[redacted]	TBC		TBC	[redacted]

Figure 29 - Structure of the original file (Action Plan follow up - ergonomics)

As shown in Figure 29, there are the following columns: *Gap/Station*, *Location*, *Result* (the actual one), *Action Description*, *Pilot*, *Forecast Date* (to implement the proposed actions), *Implement Date*, *Forecast Result* and a *Status/Comments* area.

5.2. Improvement proposal

As already mentioned, the Study X is standard for the group and has already been parameterized, so the challenge proposed by the company was to analyse the process underlying the ergonomic study and suggest improvements. For this, it was necessary to get to know the process, receive training in ergonomics and integrate the ergonomics team (constituted by Health, Safe and Environment – HSE – members, the PC&L Improvement Coordinator and the external person).

When analysing the process, something immediately came out - the external person did not have access to the folder on the network where the ergonomics studies were kept, and the communication flowed via email. It was proposed to create a team in Microsoft Teams® including the external person and the members of the Health, Safe and Environment department (HSE) to facilitate communication. Additionally, the studies were managed there, ensuring that everyone had access to the folders (Figure 30 and Figure 31).

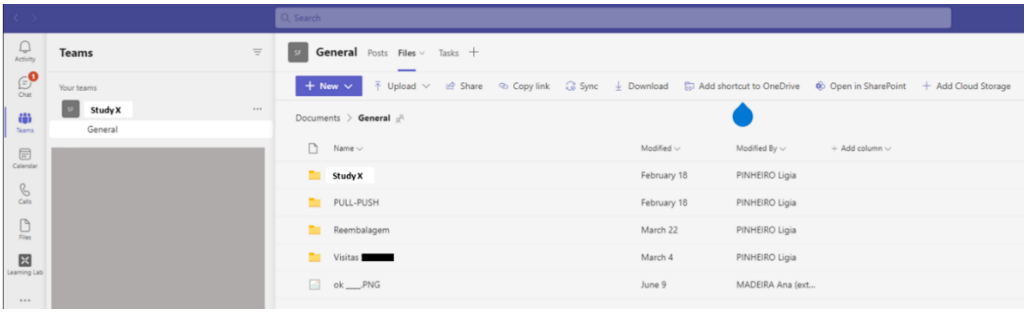


Figure 30 - Team created in Microsoft Teams® and Folders

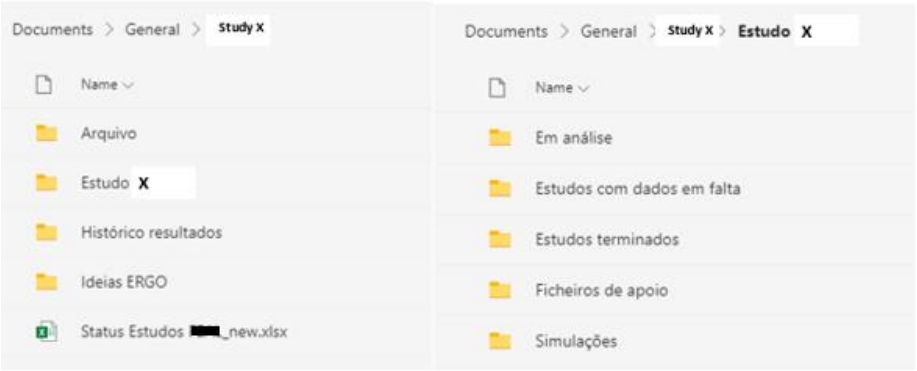


Figure 31 - Organization of the folders in Microsoft Teams®

In addition to this type of improvement in the communication and organization of studies, it was also intended to improve the action tracking file that the PC&L Improvement Coordinator used.

Certain needs were considered, such as:

- recording the history of the results of the studies, making it possible to analyse their evolution;
- define categories of actions and, depending on those, automatically assign the pilots;
- create a colour code and legend;
- define a result target for the following month and for the end of the year 2022;
- automatically define the containment action for each study, among others.

To meet these needs, several versions of the file were created (eight in total). The eighth version, which was fully closed in May 2022, includes all the points mentioned above and will be described below.

For a better organization of the file, an index was created to allow easy navigation between the various worksheets that constitute the file (Figure 32). The file structure is the one shown in Figure 35, following the colour codes shown in Figure 33. Regarding the categories of actions created, these can be observed in Figure 34.

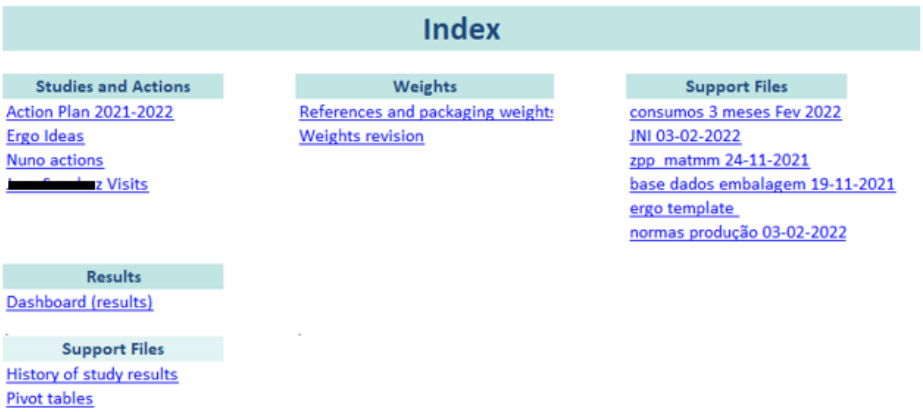
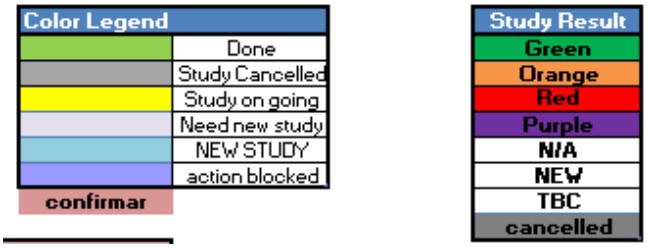


Figure 32 - Index created for the file



Color Legend	
	Done
	Study Cancelled
	Study on going
	Need new study
	NEW STUDY
	action blocked
confirmar	

Study Result
Green
Orange
Red
Purple
N/A
NEW
TBC
cancelled

Figure 33 - Colour code and legend followed in the new file

Problem type	Pilot
Production rack	[redacted]
Heigth supermarket rack	[redacted]
Part weight	[redacted]
Heigth descentralized picking	[redacted]
Heigth central picking	[redacted]
Ton/h	[redacted]
Heigth trolley store	[redacted]
Heigth train store	[redacted]
Review the [redacted] study	[redacted]
New study	[redacted]
SAP update	[redacted]

Figure 34 - Action's categories and pilots

			Previous Study		Actual study					
GAP/Station	Location	Cancelled? (Y/N)	Previous Result	Previous Result Date	Actual Result	Actual Result Date	year	month	New or Revision?	Link to actual study
	SJM1	N	Red	26/04/2022	Purple	12/07/2022	2022	jul	New	https://laureci a.sharepoint.c om/:x:/s/S- FEAL/EIybAa NOQnlQjN3T VLDz8SABAg KgDA7beVEci 4hzY93Dbg?es EIhgDoE

Action Plan - Follow Up 2021 2022

Problem/Action Descritpion							
Reference	Problem Type	Weigth/Heigth problem	Action Description	Blocked?	Pilot	Forecast Date	Implement Date
		1640 mm (line load)	1640 --> 1500 mm			jul/22	
	Part weight	12,49 kg	ação VAVE	Yes			
	Part weight	12,49 kg	ação VAVE	Yes			
		line load 1660 mm	1660 --> 1500 mm			jul/22	
		storage unload 1545 mm	1545 --> 1500 mm			jul/22	
		stor. Unload 1610 mm	1610 --> 1500 mm			jul/22	
		line load 1570 mm	1570 --> 1500 mm			jul/22	
		line load: 1600 mm	1600 --> 1500 mm			jul/22	
		line load: 1600 mm	1600 --> 1500 mm			jul/22	
		line load: 1600 mm	1600 --> 1500 mm			jul/22	
		stor. Unload 1600 mm	1600 --> 1500 mm			jul/22	

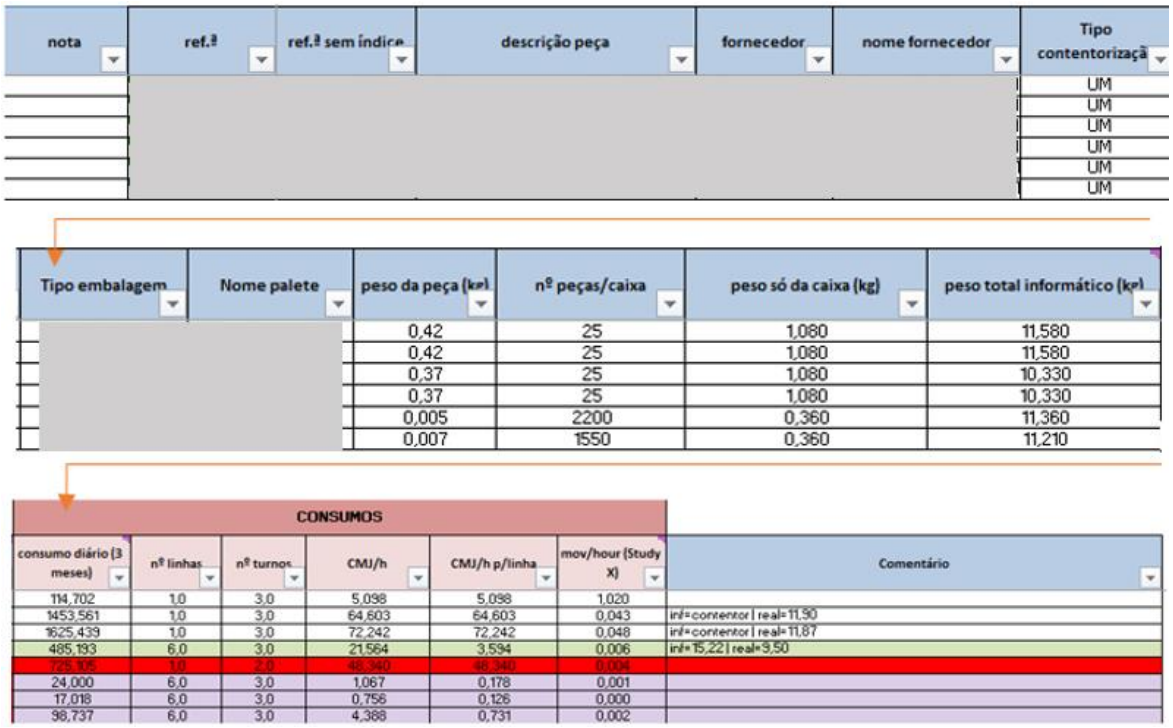
MAIO

Next month expected result	Improvement?	Next month expected result achieved?	Forecast FEAL Result end of 2022	Forecast FEAL Result achieved?	Status / Comentários	Cointainment Action
Red	Não		Red	N/A		Forbidden

Figure 35 - Structure of the new file

For the construction of this new version of the file, conditional formatting, pending lists and rules defined together with the PC&L Improvement Coordinator were used.

Two points that were still verified in the initial situation were that the table given by the PC&L Improvement Coordinator was not fully updated and that there were often weights that were not correct or updated in the system (they did not follow the step of implementation of VAVE actions, for example). Therefore, there was the need to create a new table (inserted in this new file shared in Microsoft Teams®) that included all the necessary information and that was updated whenever necessary (Figure 36).



nota	ref.ª	ref.ª sem índice	descrição peça	fornecedor	nome fornecedor	Tipo contentorizaçã
						UM
						UM
						UM
						UM
						UM
						UM

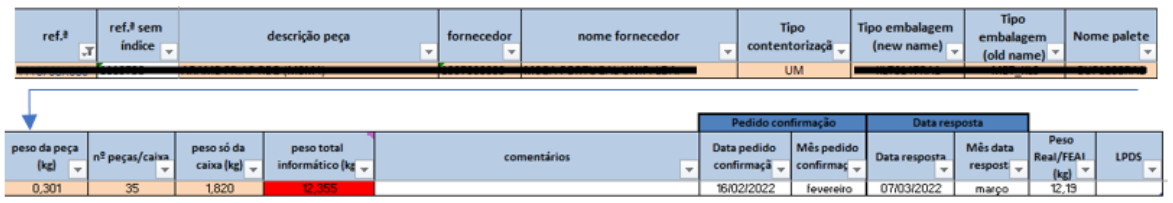
Tipo embalagem	Nome palete	peso da peça (kg)	nº peças/caixa	peso só da caixa (kg)	peso total informático (kg)
		0,42	25	1,080	11,580
		0,42	25	1,080	11,580
		0,37	25	1,080	10,330
		0,37	25	1,080	10,330
		0,005	2200	0,360	11,360
		0,007	1550	0,360	11,210

CONSUMOS						
consumo diário (3 meses)	nº linhas	nº turnos	CMJ/h	CMJ/h p/linha	mov/hour (Study X)	Comentário
114,702	1,0	3,0	5,098	5,098	1,020	
1453,561	1,0	3,0	64,603	64,603	0,043	inf=contentor | real=11,90
1625,439	1,0	3,0	72,242	72,242	0,048	inf=contentor | real=11,87
485,193	6,0	3,0	21,564	3,594	0,006	inf=15,22 | real=9,50
725,105	1,0	2,0	48,340	48,340	0,006	
24,000	6,0	3,0	1,067	0,178	0,001	
17,018	6,0	3,0	0,756	0,126	0,000	
98,737	6,0	3,0	4,388	0,731	0,002	

Figure 36 - New table structure

For end of production (EOP) situations the line is marked in red, for weights above 12 kg the total weight cell is in red and for situations where there was a change in the packaging or weight confirmation the line is marked in light green.

The confirmation of weights proved to be something necessary and recurrent, so a list of all references that weighed more than 12kg was made and supervisors were asked to collaborate to provide the actual weights, confirming the number of parts per package.

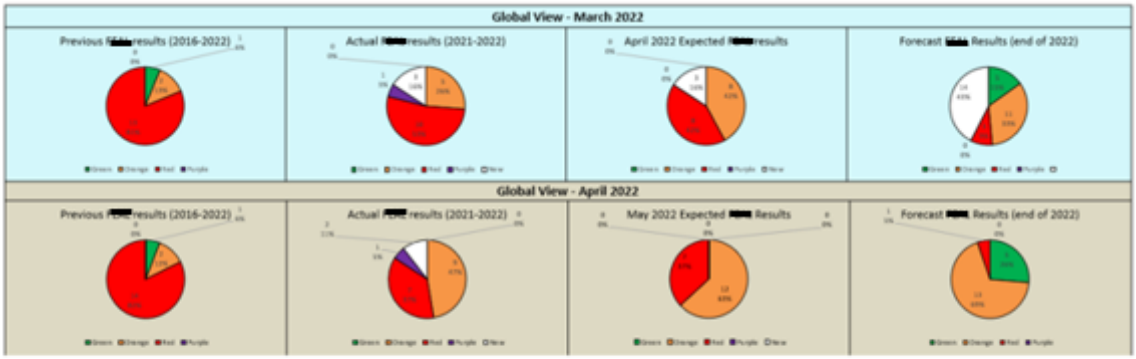


ref.ª	ref.ª sem índice	descrição peça	fornecedor	nome fornecedor	Tipo contentorizaçã	Tipo embalagem (new name)	Tipo embalagem (old name)	Nome palete
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	UM	[redacted]	[redacted]	[redacted]

					Pedido confirmação		Data resposta			
peso da peça (kg)	nº peças/caixa	peso só da caixa (kg)	peso total informático (kg	comentários	Data pedido confirmaçã	Mês pedido confirmaç	Data resposta	Mês data respost	Peso Real/FEAI (kg)	LPDS
0,301	35	1,820	12,355		16/02/2022	fevereiro	07/03/2022	março	12,19	

Figure 37 - Table built to follow-up the weights

To be able to analyse the ergonomics studies' results more visually and be able to compare the statuses, a dashboard was created. This also started being shared at the end of each month with the Deputy Plant Manager and the PC&L Manager (Figure 38).



Global View		
	March	April
Green	0	0
Orange	5	9
Red	10	7
Purple	1	1
New	3	2
TOTAL	19	19

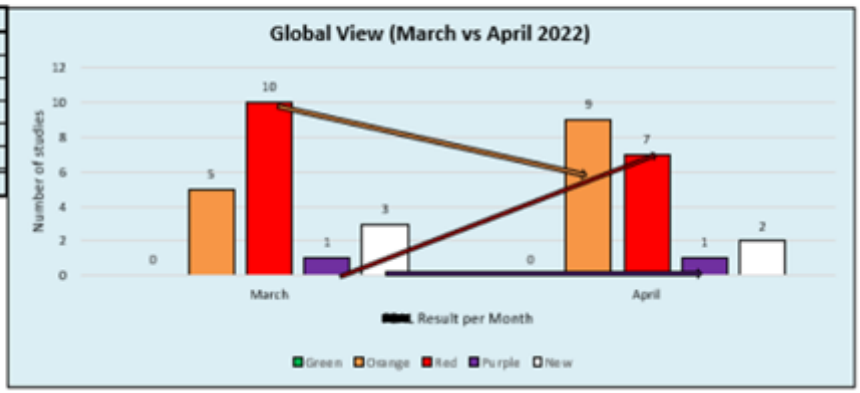


Figure 38 - Dashboard created for the Study X follow-up

5.3. Ergonomic Improvement – Best practices

As mentioned before, the Ergo mapping turns out to be the mother file when it comes to ergonomics in the group to which the Company A belongs. In this file, created by the Ergonomics Manager, there is an action plan to follow according to each company, so Company A has a unique action plan that must follow. Whenever an action is closed and is considered a good practice, it is shared with the other companies in the group, being considered a *best practice*. This can also happen when the Ergonomics Manager visits the companies and sees something that he/she considers positive and that should be applied by the other companies.

In the scope of the project, two best practices regarding ergonomics in logistics' field were identified and shared. The first was related to the improvement of ergonomics conditions, by implementing a roller to avoid having boxes at floor level (which does not follow the ergonomics rules of heights). The second was related to a visual help to guarantee the maximum ergonomic height in picking (see Figure 39 and Figure 40).

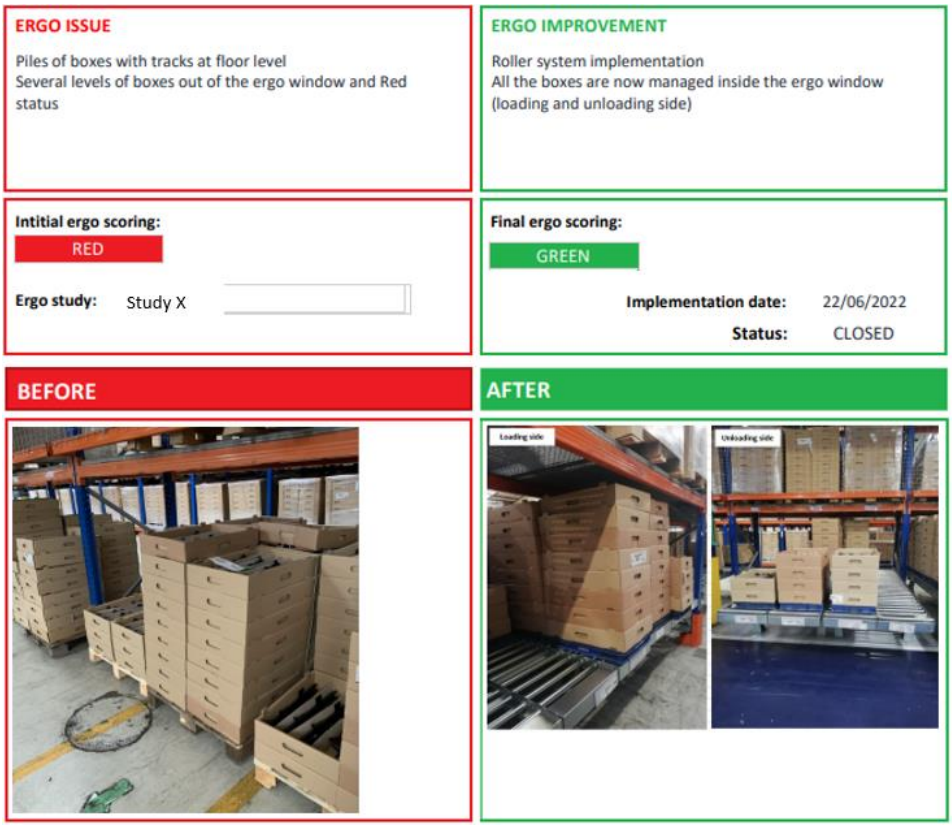


Figure 39 - First best practice (better ergonomics conditions)

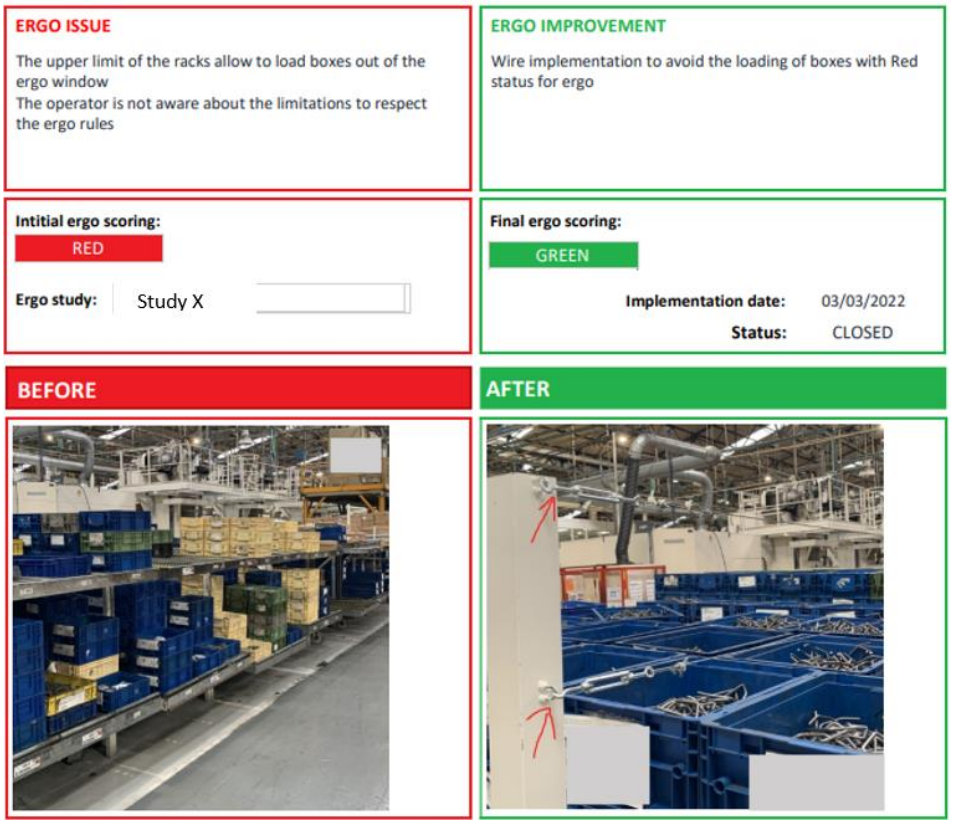


Figure 40 - Second best practice (visual help)

The second-best practice was not limited to what is shown in Figure 39. To better signal the cables and even avoid accidents, another visual help was added, and the cables were coated with red and blue sleeves. The first cable – blue – is used to place needed identifications, whereas the second cable – red – is used to signal the ergonomic height limit, serving as a warning to employees that they cannot fill boxes above that limit (see Figure 41).

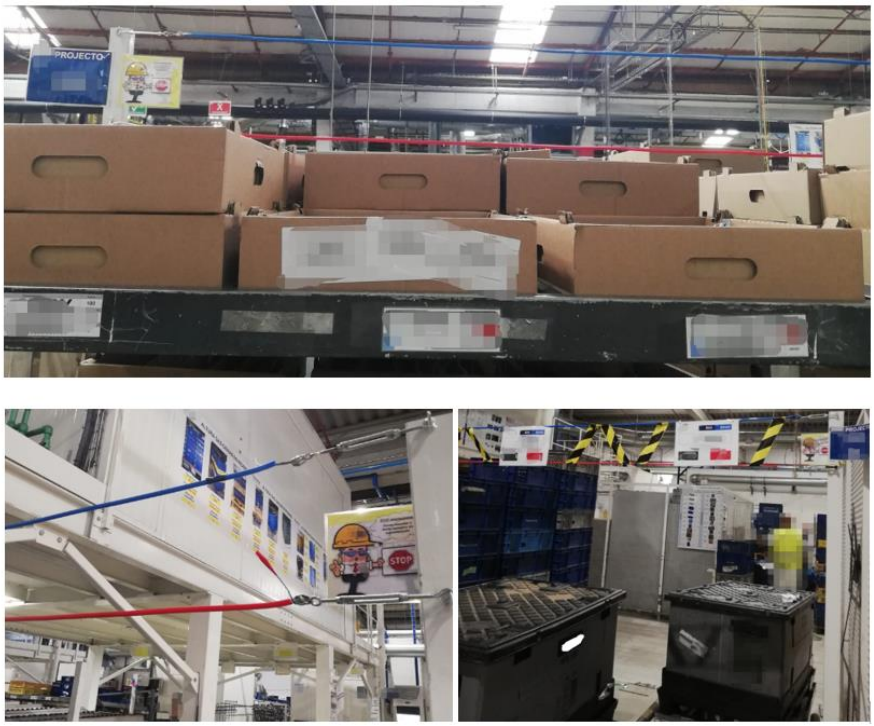


Figure 41 - Implemented height limiters

5.4. Results and Discussion

It can be said that ergonomics is undoubtedly a crucial factor for the Company A and that it is only achieved with teamwork, availability, and commitment from everyone.

As seen in section 5.2 Improvement proposal, having a good flow of communication is essential to improve ways of work. Ensuring that all members of the ergonomics team had access to documents was also crucial, since those are themselves tools to develop daily work, sources of information and live pieces of communication. The move from e-mail to Microsoft Teams® as a means of communication and storage has enabled just that.

The way PC&L Improvement Coordinator managed the action plans was already seen as positive, however it did not respond to all the needs, so it became a major necessity to update and improve the supported Excel® file used.

Having all the necessary information in a single file shared with the team and updated whenever necessary was a change in mindset that was considered advantageous to enable a more collaborative and proactive work.

The issue of weights at the computer (SAP extraction) versus real level proved to have a significant impact on ergonomics studies and showed that there is a need to update the information in the system so that there are no errors resulting from the wrong information.

Height limiters are not yet implemented in all factories, but there are some issues that should be carefully analysed. Although in general the employees comply with the rules, there are still NOK situations in which materials are stored above the red limit (Figure 42).

Figure 42 - Height limiter NOK situation

It is considered that it was possible to answer all the questions raised and that in general the objectives were met, however there is still work ahead.

5.5. Concluding Remarks

Contrary to what is seen in other environments, ergonomics proved to be really respected in the Company A, with the group pushing to achieve the goals defined for the end of the year.

Improving ergonomics conditions at a logistical level depends on several factors, the first being a team committed to this objective, carrying out studies and outlining and following the necessary actions.

Throughout the project some limitations were felt such as the lack of time of the team due to other situations that end up becoming a priority. The fact that there are frequent changes in projects and on the shop floor did not make it easier either, as ergonomics studies must always be updated and reflect the real situation of the workstation.

There was not much space available for the picking area, so it meant that over time it was necessary to increase the height of the racks to guarantee the necessary supply capacity. However, with the efforts of PC&L Improvement Coordinator, this situation is being corrected. Nevertheless, due to lack of time or availability of internal suppliers, it is not happening at the expected rate, often being a blocking point to improve positively in ergonomics studies.

It can be pointed out as future work the continuation of ergonomics studies and consequent monitoring of actions, being crucial to achieve a faster correction of more critical situations such as

the height of the racks. It is still important to continue working on the improvement of the Excel® file for tracking actions, allowing to send the report automatically or even analyse the data via Power BI.

Regarding weights above 12kg, there are different points that should be analysed in the future. One of them is to pass the information to the colleagues responsible for the implementation of the projects that it is not at all allowed to have packages above 12 kg. Another point is to ensure that the information in the system is correct, thus avoiding errors in ergonomics studies and even wrong VAVE actions.

Finally, training the employees on the importance of ergonomics and to effectively follow correct ergonomics practices is fundamental, showing that everything is being done is for their welfare. Otherwise, the actions identified in the studies will not be effective because their actors will simply not be applying them as correctly as desired.

6. Case Study – Logistics Improvement Ideas

This chapter focuses on the project aspect related to the logistics improvement ideas and their follow-up. Thus, a brief introduction of the actions will be made and the initial situation at the beginning of this project will be presented. Then, improvement ideas for the follow-up process will be addressed and, finally, the results will be presented and analysed, and conclusions will be drawn.

6.1. Improvement ideas and actions

Recognizing, implementing, and tracking improvement ideas is one of the great goals of the continuous improvement department. As already mentioned, regarding logistics, this ultimate responsibility lies on the PC&L Improvement Coordinator.

Company A is large and has several buildings (see Figure 1). Logistic flows are then complex and require constant monitoring. In addition, the use of various means of transport (such as trolleys, petit-trains, forklifts, wagons, lateral forklift, stacker, elevator) ends up making flows and their management even more complicated.

Another situation that has been challenging for the logistics department is the lack of space in the plant. This is mainly due to the growth in factory production because of the increase of customer demand.

It is then crucial to evaluate the company's logistic areas, their flows, come up with ideas for improvement and implement them. This requires effort and successful teamwork between the logistics and continuous improvement departments. For this purpose, and as previously mentioned, there is a daily meeting with all people involved, either on the shop floor or in the office.

The actions that are discussed and followed can have different origins and typologies, from repairs, changes in flows, changes in picking, changes in layout, new means of transport, creating identifications in a different way, and so on.

6.2. Initial Situation

As previously explained, the PC&L Improvement Coordinator has daily meetings with the logistics elements (PC&L Manager, warehouse manager and supervisors). To ensure communication with as many supervisors as possible, these meetings often take place in the morning and in the afternoon (around 30 minutes each meeting) to accompany both shifts.

These meetings mostly take place on the shop floor so that certain ideas or actions can be verified in real time.

When the project started, the meetings took place mainly in SJM1 shop floor in an area called “e-TOP5 Logistics” (Figure 43). Various support materials are located in this area (*e.g.*, electronic boards). SJM's daily logistics meetings take place in this area.

Figure 43 - Logistics e-TOP 5 area in SJM1

In these meetings, several issues related to the logistics area of the three plants (SJM1, SJM2 and SJM3) were discussed among the team and recorded on a paper board (Figure 44). For each action, a pilot and a target resolution date were defined to monitor the evolution in the following meetings.

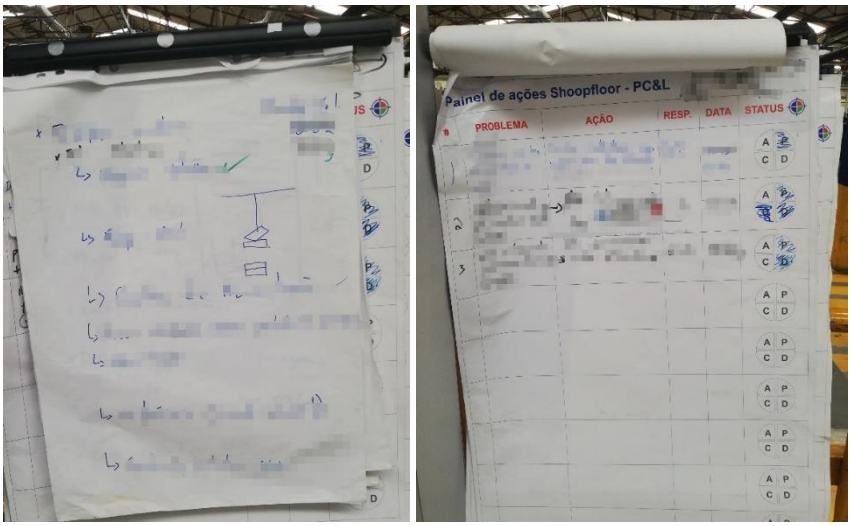


Figure 44 - Paper boards used to record the topics discussed on the meetings at the beginning of the project (left: first version, right: second version)

Despite the monitoring of the actions following the PDCA methodology, the first board used (Figure 44, left) ended up becoming obsolete. So, the team started to use another paper board that reflected the PDCA methodology, making it possible to aggregate the actions by category and to indicate which phase of the PDCA cycle was (Figure 44, right).

6.3. Follow-up method improvement

Although the actions' follow-up method presented earlier may seem effective at first glance, over time it proved to be neither practical nor the most appropriate. This happened because:

- it did not allow a real-time update of the actions (as it would be always necessary to go to SJM1, which was not practical;
- the space for the action's description was limited;
- it did not facilitate the data analysis;
- with the increase of the number of actions, it became difficult for the team to monitor all of them;
- it proved to be a significant waste of resources, such as paper and markers.

As a result, the idea of digitizing the process arose, so that the actions could be followed in a file that all team members could consult and edit and that could be opened on the digital boards of the "e-TOP5 Logistics" area. The digitization was implemented together with the PC&L Improvement Coordinator by means of creating an action tracking file in Microsoft Excel®. Regarding the actions that were digitized, only those that had not yet been implemented were considered in the file.

The structure of the file itself was defined from another file that had already been built together with the PC&L Improvement Coordinator (see Appendix D, Figure D.1) – albeit the focus of that being mainly on repairs or personal actions within the scope of logistics.

This new file for following-up logistics actions was saved on the company's internal network in a folder that allowed viewing the file on the "e-TOP5 Logistics" digital board and to which all team members had access.

The first created version of the file followed the format shown in Figure 45:

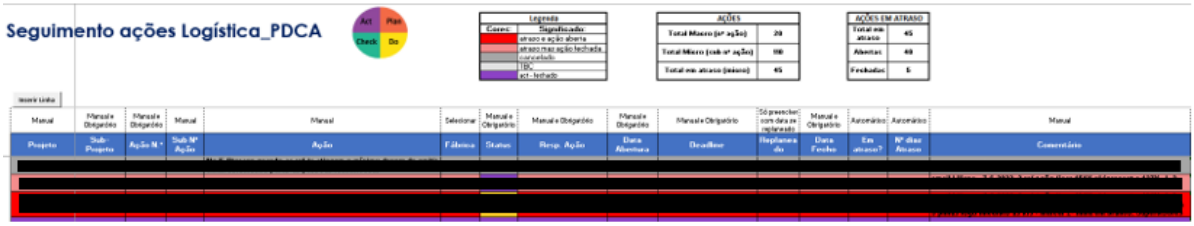


Figure 45 - First version of the logistics actions follow-up file

Each action could be categorized by project and sub-project, by its number and sub-number. It was also possible to select which plant(s) it was referring to (SJM1, SJM2, SJM3 or a combination of each/all of them), the status of the action (*Plan*, *Do*, *Check* or *Act*). Besides, it was possible to assign an owner for the action, indicate the opening date, the target closing date and, if necessary, the replanning date. Once the action was closed, it would be necessary to fill in the closing date field. Based on the dates entered, it automatically appeared if the action was overdue and, if so, by how many days. In addition, there was also a field for comments.

To make visual management easier, it was essential to apply conditional formatting based on different criteria and create a colour legend.

Table 8 summarizes the colour used for each type of situation, the field where it was applied, as well as the associated criteria applied to know if the action was overdue.

Table 8 - Colour meaning, its application and the criteria associated

Colour	Meaning	Applied to	Criteria
	Status = Plan	Status column	-
	Status = Do	Status column	-
	Status = Check	Status column	-
	Status = Act	Status column	-
	Dates TBC	All line	-
	Action Cancelled	All line	-
	Action still open and overdue	All line	Delayed action (current date beyond the deadline) and still no closing date
	Overdue closed action	All line	Action closed, but closing date beyond deadline

Knowing that it was important to perform some type of data analysis, two small automatic tables were created (Figure 46), which allowed checking the number of open actions at the macro level (by action number) and at the micro level (by sub-number) and the number of actions that were overdue.

AÇÕES	
Total Macro (nº ação)	20
Total Micro (sub nº ação)	110
Total em atraso (micro)	45

AÇÕES EM ATRASO	
Total em atraso	45
Abertas	40
Fechadas	5

Figure 46 - Automatic tables created to perform data analysis of the file

By way of example and by analysing the figure, it is possible to conclude that 20 macro actions were being followed which turned into 110 micro actions and, of these 110, 45 were overdue. Of these 45 overdue actions, 5 had already been closed and the remaining 40 were still open.

Over time, it became clear that the file was effective, but that it did not reflect all the actions taken by the PC&L improvement manager and that often had to be discussed with the team. In addition, there were certain missing fields regarding the desired detail in the follow-up of actions and data analysis was not as extensive as intended.

It was then necessary to create a new version of the file to fulfil these needs (Figure 47 to Figure 50). For this second version, the file became available in Microsoft Teams®, being shared with all participants (PC&L Manager, warehouse manager, supervisors, and logistics improvement team).

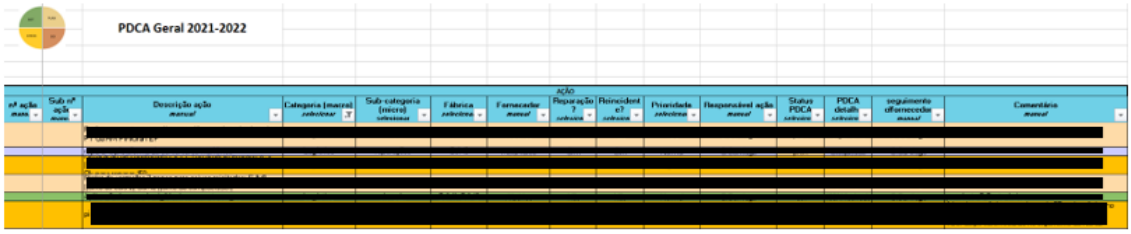


Figure 47 - General PDCA 2021-2022 (action area itself)

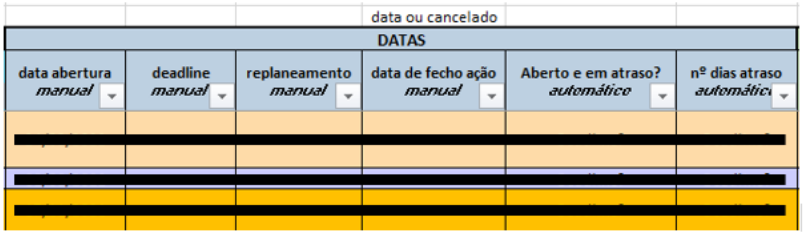


Figure 48 - General PDCA 2021-2022 (dates area)

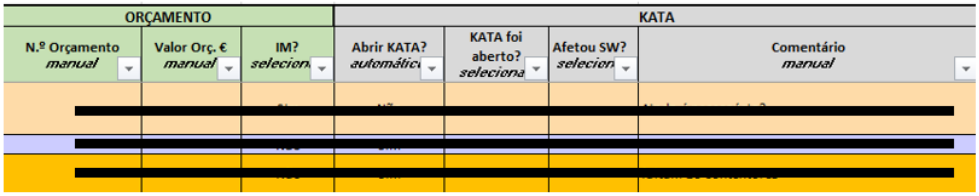


Figure 49 - General PDCA 2021-2022 (budget and KATA areas)

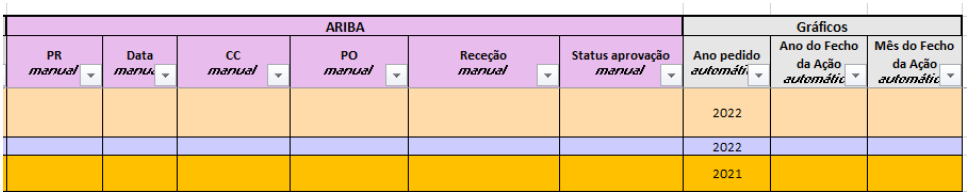


Figure 50 - General PDCA 2021-2022 (ARIBA and graphics areas)

This second version, called *General PDCA 2021-2022*, includes several categories of actions that resulted from the combination of the different PDCAs that the PC&L Improvement Coordinator followed: autonomous guided vehicles (AGV), external warehouse, ergonomics, logistics, actions related to the handbook requirements, HSE, improvement, logistics and new projects. Each category has specific sub-categories that can be changed at any time. For example, the *Logistics* category has sub-categories such as: layout, repairs, identifications, exterior, equipment, picking, elevator. This version also incorporates new areas of interest that were not included in the previous version like the supplier, if it is a repair, if it is not the first time it happens, the priority, a new category for PDCA (detail) (Table 9), who is the responsible for the follow-up with the supplier and also new areas regarding the Budget, KATA, ARIBA (SAP module that allows to process the payments) and graphics.

Table 9 - PDCA categories and sub-categories created by the team

PDCA category	PDCA sub-categories (created by the team)
Plan	Go/no go; Budget; Blocked; Stand by; Cancelled
Do	On-going; Blocked; Stand by; Cancelled
Check	In test; Blocked; Stand by; Cancelled
Act	100% closed; Blocked; Stand by; Cancelled

Even so, this second version still did not have any kind of dashboard where it was possible to graphically evaluate the progress of actions, so it was necessary to build two more versions. Version 3 allowed to observe the general overview of closed actions (Figure 51) and the progress of closed actions through the months (Figure 52) and version 4 also allowed to see the number of actions per category and their cost per month (Figure 53).

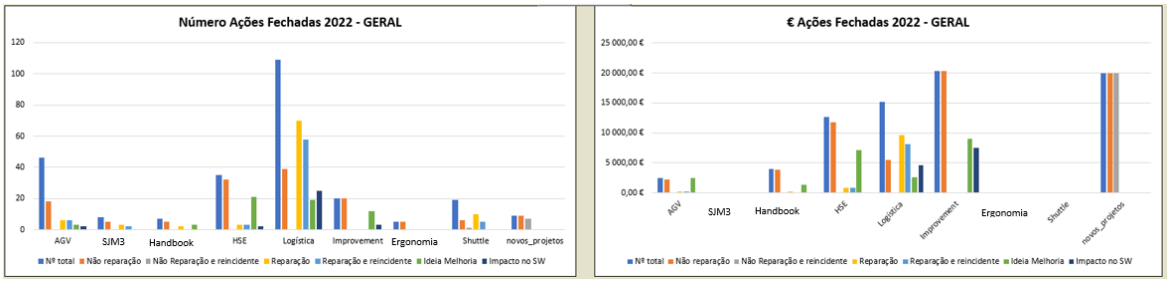


Figure 51 - Closed actions general overview *(not real data)*

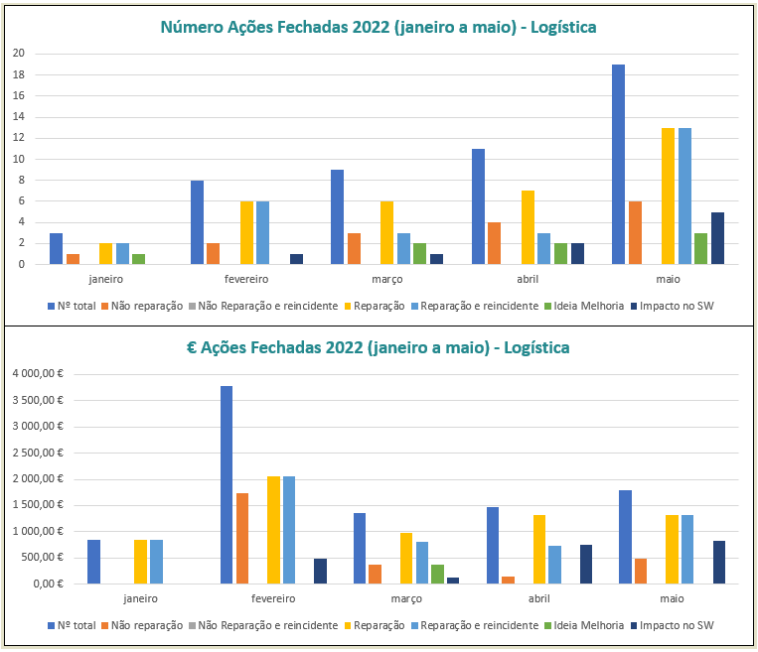


Figure 52 - Progress of closed actions through the months - example of logistics actions *(not real data)*

Number of Actions Closed 2022 (may)							
Category	Total Number	Non repair	Non repair but recidivist	Repair	Repair and recidivist	Improvement idea	Impact on SW
AGV	1	1	0	0	0	0	0
CEF	0	0	0	0	0	0	0
FES	0	0	0	0	0	0	0
HSE	10	10	0	0	0	7	0
Logística	19	6	0	13	13	3	5
Improvement	2	2	0	0	0	2	1
FEAL	0	0	0	0	0	0	0
Shuttle	0	0	0	0	0	0	0
novos_projetos	0	0	0	0	0	0	0
Total	**32**	**19**	**0**	**13**	**13**	**12**	**6**

€ Number of Actions Closed 2022 (may)							
Category	Total Number	Non repair	Non repair but recidivist	Repair	Repair and recidivist	Improvement idea	Impact on SW
AGV	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
CEF	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
FES	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
HSE	1 867,25 €	1 867,25 €	0,00 €	0,00 €	0,00 €	1 242,25 €	0,00 €
Logística	1 791,90 €	476,90 €	0,00 €	1 315,00 €	1 315,00 €	13,50 €	835,00 €
Improvement	590,00 €	590,00 €	0,00 €	0,00 €	0,00 €	590,00 €	245,00 €
FEAL	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Shuttle	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
novos_projetos	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Total	**4 249,15 €**	**2 934,15 €**	**0,00 €**	**1 315,00 €**	**1 315,00 €**	**1 845,75 €**	**1 080,00 €**

Figure 53 - Number of actions per category in the money associated in a specific month *(not real data)*

A fifth version, the final version, was still created. The novelty in this version was the sequential numbering of actions (highlighted in pink in Figure 54).

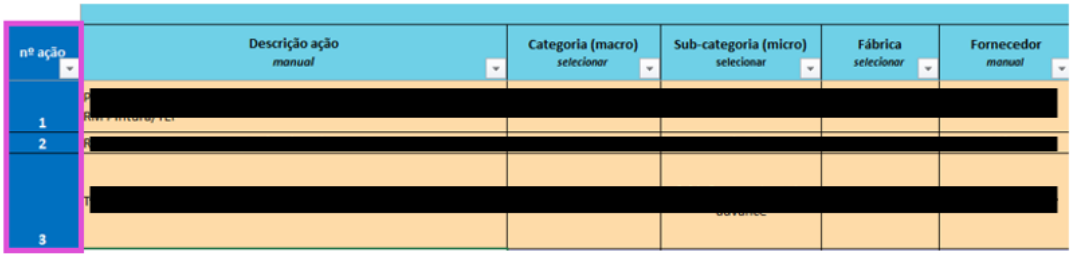


Figure 54 - The novelty in the structure of file version 5

The last version of the file (fifth), continued in line of the previous ones in terms of structure, visual management (Table 10), and the calculation of the delay of the actions.

Table 10 - Colour meaning, its application and the criteria associated (file version 5)

Colour	Meaning	Applied to	Criteria
	Status = Plan	Status column + Line	-
	Status = Do	Status column + Line	-
	Status = Check	Status column + Line	-
	Status = Act	Status column + Line	-
	Dates TBC	All line	-
	Action Cancelled	All line	-
	Action Blocked	All line	-
	Action still open and overdue	All line	Delayed action (current date beyond the deadline/replanning) and still no closing date
	Action on the limit of overdue	All line	Action still not closed and on the limit of becoming overdue (date=deadline/replanning)

Once the dashboards were created, they were shared monthly via email with the Deputy Plant Manager and the PC&L Manager.

6.4. Results and Discussion

To allow a deeper analysis and discussion of what was done in this initiative, it is important to show the size of the sample of actions that were worked on.

Based on version 5 of the action follow-up file and the actions found in it, it is possible to conclude that in the project period (8 months), 296 actions were followed. Of these, 14 were cancelled, 168 were closed and 114 were still open (Table 11).

Table 11 - Overview of number of actions between October 2021 and June 2022 *(real data)*

Nº Actions October 2021-June 2022			
Total Nº	Cancelled	Closed	Still open
296	14	168	114
100%	4,73%	56,76%	38,51%

Five versions of the follow-up file were mentioned. The differences between each version are highlighted in Table 12.

Table 12 – Novelties incorporated in each version of the file created

Version	What is new	Comments
1	Digitization of the paper action plan (Figure 44).	First version of the file.
2	Number of actions; Colour scheme; Categories and sub-categories; Supplier and the responsible for the follow-up; If it is a repair and if it is recidivist; Priority; Sub-category for the PDCA; Automatic messages in case of missing dates; All area dedicated to the budget; All area dedicated to KATA; All area dedicated to ARIBA; All area dedicated to graphics' data; File in Microsoft Teams®.	Compilation of several PDCAs that were followed by the PC&L Improvement Coordinator. Introduction of more areas of detail. PDCA sub-categories defined by the team according to their needs. All information in a single file.
3	Graphics: general overview of closed actions and the progress of closed actions through the months.	First dashboard created.
4	Number of actions per category and the money associated in a specific month.	New data analysis.
5	Sequential numbering of actions.	Automatic. Allows to recognize an action only by its number.

All these versions and changes reflect the needs felt by the team during the time and the use of the digital file.

By observing the previous table, it is possible to see that version 1 was the beginning of digitization, leaving the paper behind, and the version 2 constitute a big shift of mindset regarding the

meticulous follow-up of the actions. In addition, it is also possible to observe that version 3 and beyond allow to perform data analysis through dashboards (graphics and tables).

Some changes must be highlighted due to their importance:

- Digital file:
    - The digitization of the file allowed the monitoring of actions in real time at any time, no longer having to go to SJM1 to monitor the actions. In addition, it allowed for a more effective and efficient follow-up of actions.
- One single file:
    - The combination of all PDCAs in a single file allowed the PC&L coordinator to have the information in one place, thus facilitating the follow-up of all issues under its responsibility. In addition, it also facilitated communication with the team, as it is not only the actions of the logistic category that must be discussed with the team.
- *Action* category:
    - Due to the high number of actions, it was essential to categorize them, allowing at any time to filter by category and to perform an analysis by area.
- *Supplier*, *Owner of the follow-up*, *ARIBA* area:
    - Many of the actions depend on internal or external suppliers (for example repairs). Having all the information summarized in the file made it easier to follow up on actions with suppliers, including the status of budgets and requisitions that are managed in ARIBA (a program from the SAP forum).
- Action priority:
    - Managing so many actions without any sort of priority list is very difficult and error prone. It was therefore crucial to create a field that allowed assigning a priority to each action. The list of priorities defined was as follows: critical, very urgent, urgent, normal and To Be Confirmed (TBC).
- Repair/recidivism:
    - It was noticed that over time the number of actions related to repairs and relapses was high. It was therefore crucial to follow up on these types of situations to then carry out a deep analysis and get to their root causes and consequently intervene.
- PDCA sub-categories:
    - With the number of actions increasing and the use of the file, it was noticed that often the 4 categories of the PDCA were not enough, since they did not provide the desired detail. Thus, together with the PC&L Improvement Coordinator, the

categories presented in Table 9 were defined, which allowed for a more in-depth follow-up of the actions.

- Dates:
    - Keeping track of the opening dates, deadline, replanning and closing dates proved to be beneficial and essential, allowing an automated analysis of overdue actions.
- *KATA* area:
    - KATA is something intrinsic to the company. It was then found to be advantageous to introduce this new area into the tracking file. PC&L Manager has defined that a KATA should be opened whenever the action is a relapse, or the budget exceeds a certain monetary value.
    - The introduction of the field related to SW was also considered an advantage , as actions may or may not have an impact on SW and having an idea of this type of situation is fundamental.
- Microsoft Teams®:
    - Initially the Excel® file was on the company's internal network so it could be opened on e-TOP5, but this raised some questions: whenever someone opened the file, no one else could edit it at the same time. Furthermore, sometimes the file was opened on the e-TOP5, and nobody was using it, so it would be necessary to physically move to the digital board and close it. Considering this, the file was moved to Microsoft Teams®.
- Graphics and dashboards
    - Something that did not exist until version 3 of the file was a data analysis regarding the actions taken by the improvement and logistics team. It is considered that this was a crucial step, also allowing the monthly sharing of results.

In the section Research Questions, some questions, and objectives regarding the were pointed out. It is possible to confirm that it was possible to answer all the questions and achieve all the objectives defined at the beginning of the project.

6.5. Concluding Remarks

The focus of the chapter was thus on digitization, moving from an action plan in paper format to an action plan in digital format.

As it was possible to verify, several changes were necessary in the way of working and thinking and only with the fifth version of the file was it possible to conclude the project regarding the research questions and objectives defined at its beginning.

It is considered that the implementation of the digital file brought a lot of benefits, allowing an easier management of actions (which was fundamental given the high number of actions) and a detailed analysis of the data. In addition, it allows the entire team to have access to the plan at any time of the day. This digital file further emphasizes the importance of the work that is developed in terms of continuous improvement.

Despite all the benefits presented and considering that the objectives have been met, it is considered essential to continue the work developed and encourage the entire team to make use of new technologies.

One of the limitations felt throughout the project was precisely the resistance to the use of the file in Microsoft Teams®. An example was the fact that the updating of the actions' status was mostly done by PC&L Improvement Coordinator , with no intervention of the supervisors due to lack of initiative. It is thus seen as fundamental in the future to motivate the team and encourage it to take a more active role in terms of following up on actions.

Changing the file from the internal network to Microsoft Teams® raised an aspect that became an obstacle - the inability to open the file in "e-TOP5 Logistics" screen. This issue should also be considered as future work.

Other aspects that can be improved in the future are the dashboards and the process of sending monthly reports. As it was developed for VAVE FG report for the PC&L Manager (Figure 25), sending this report could become more automatic, for example through Excel® macros. Another alternative that is considered interesting to apply in the future is the use of Power BI.

Finally, it is concluded that this area of the project was of great learning, demonstrating the true importance of teamwork, continuous improvement, and its impact on the logistics area.

7. Case Study – Create digital work standards in mlean®

This chapter focuses on logistics work standards and their transition to the mlean® application. Thus, the initial situation and the contextualization in terms of the software characteristics will be addressed, as well as the transition from paper to digital format, which means the implementation itself of SW in mlean®. The approval loop for the standards will also be explained. Then, the results will be presented and analysed, and conclusions will be drawn.

7.1. Initial Situation and Contextualization

As already mentioned, standardized work is one of the pillars of the lean philosophy adopted by Company A, so it is mandatory that work standards for each workstation exist and are followed.

At beginning of the project and until February of 2022 the logistics work standards were all in paper format. These had to have clear details, to be meticulously described and to contain all the necessary photos to show the correct way of working and OK/NOK situations.

Technological evolution is also one of the company's main goals, so one of the main targets is to reduce the use of paper documents, digitizing various processes.

One of the technological solutions implemented in the company to meet this objective is precisely the mlean® Production System(mPS). This is a fully integrated and complete system, with web and mobile supports, that digitizes and centralizes continuous improvement process right from the shop floor.

mPS allows businesses to manage production processes, schedule tasks, track metrics, preventive maintenance checks, routine safety inspections, working instructions and more (see Figure 55).

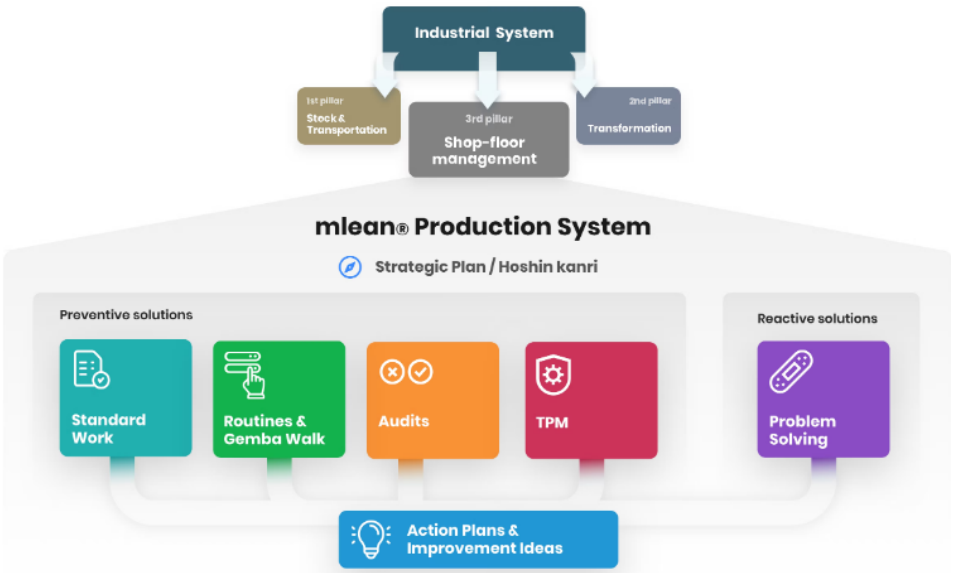


Figure 55 - mlean® Production System different resources (mlean®, 2022)

Hence, the *mlean® Production System* is a suitable software to digitize documentation related to the continuous improvement of manufacturing operations, for any industry requiring management of the shop floor.

The focus of the project was precisely on SW for which two applications from mPS were needed – *Visual Standard* and *Standard Work Audit*.

On one hand, *Visual Standard* allows to:

- Create and keep video standards up to date;
- Trace work as standards and production tasks changes, define the main sequences of process, and add video content plus multimedia annotations;
- Maximize team's capabilities with a training system that gives them autonomy and flexibility;

Linking to the company's internal methodology for implementing the standardized work (Figure 6), this application essentially serves the first phase – Build SW – and the second phase – Train with SW.

On the other hand, *Standard Work Audit* application allows to:

- Keep a close eye on the standards. Verify that collaborators follow the safety rules and perform all the operations to accomplish all key points.
- Tackle the most problematic workstations due to cycle-time variability. By sampling cycle times over time, it is possible to discover where more wastes are located.
- Validate the operator in the workstation in line with the SW and to analyse if it is reasonable to keep him/her in the position.

Linking to the company's internal methodology for implementing standardized work (Figure 6), this application essentially serves the third phase – SW Audit – and the fourth phase – Improve SW

Visual Standard then aims to replace paper documents, with standards being constituted by videos, removing the need for such detailed descriptions as on paper. However, it is necessary to ensure that all requirements keep being met, that all relevant points are mentioned and that all necessary extra documents are attached.

7.2. Creation of digital work standards

The transition from paper format work standards to the mlean® application was something completely new for the company. Therefore, it was necessary to create a methodology to be used in order to achieve the desired success in this important issue. It was then essential to discuss as a team which steps should be followed to make the transition from paper to digital format. It should

be noticed that the teamwork involving various departments was considered crucial since the beginning.

To implement the new approach on how to make work standards in digital format, it was essential, first, to receive training on the mlean® application, since the improvement team would act as a liaison between the logistical supervisors (responsible in a first phase of perform the standards) and the digital team. In addition, it was defined that the improvement team would be responsible for supporting colleagues, both in terms of standards' construction and in terms of the use of the application (see Table 13).

Table 13 summarizes the referred steps, as well as their responsible ones, to be able to have a SW in the application throughout the development of this project.

Table 13 - Steps of the methodology created in order to have SW in mlean®

Steps	**Description**	**Responsible**
1. Get training on the application	Receive training from the digital team	PC&L improvement team
2. Define the pilots for logistic	Define the pilots who will perform the SW regarding logistic in mlean®	PC&L Manager + PC&L Improvement Coordinator
3. Prepare the training for the logistics pilots	Make a questionnaire[2] to the logistics supervisors (logistics pilots) to prepare the training	PC&L improvement team
4. Provide training to logistics supervisors	Provide complete training not only on SW itself but also on how to do them in the application	PC&L improvement team
5. Define the SW to be carried out, distribute them, and define a target	Define which SW to be implemented, assign to supervisors, and define the target in terms of implementation dates	PC&L Manager + PC&L Improvement Coordinator + Warehouse Manager
6. Perform the SW	Depending on the assigned SW and the target data, perform the SW in the mlean® application	Logistics Supervisors
7. Give support	Give all the necessary support both at the SW level itself and at the application level	PC&L improvement team
8. Give technical support	Provide all the necessary technical support and serve as an intermediary between the company and the external company that developed the application	Digital team

Points 7 and 8 occur constantly throughout the entire project implementation process.

Despite the new approach, the role of standardized work in the company must be kept. This translates in including four elements in the new registry: work instruction (now in video format),

[2] See Appendix F, Figure F.1.

work combination table (as attachment), work chart (as attachment) and the standardized measurement of cycle time sheet (as attachment).

Although the presentation of the application and the training in terms of standards were given simultaneously by the digital team to the production and logistics departments, the use of the application took place firstly on the production side. This was mainly because the cycle times of logistics activities are much longer than the cycle times of production. For example, while tracking the supply cycle of a certain logistics workstation can take 20 minutes, assembling material at a production station can be 1 minute or less.

An advantage of this approach was the learning gotten from the production standards and from the difficulties or achievements that were reported by the production team (which allowed to build Table E.1 – see Appendix E). This was also crucial to adapt the training to give to the logistics' team supervisors in the following step.

The actual creation of the standards in the application started after the training phase.

At the beginning, it took several attempts to understand the best approach to follow when it comes to using the application itself and how to adapt it to the logistics situation that has long cycle times.

The logistics area is constantly changing, due to market volatility and in constant adaptation to production. So, one of the first steps taken was to understand if the standards that had been selected existed in paper format. It was concluded that for some cases they existed, but they were not updated, and for other cases they did not exist.

Based on this, the recommendation given to supervisors was that they should first make a draft with the elementary standard operations and share it with the improvement team and the warehouse manager (see Appendix E, Figure E.1).

After exchanging ideas among the stakeholders, the logistics supervisors could then move on to the already known process of time measurement (an activity that they already performed in the past) and then on to the application.

Regarding the use of the application itself, the suggestion given was to start by inserting the elementary tasks of the process, insert their descriptions and only then insert videos illustrating those tasks. This suggestion was due to the feedback received from the production department, which found it easier to start by outlining the process and only then picturing it, according to the drawn sequence.

Something essential to keep in the description of operations is the route and type of task that the employee must perform. Therefore, the suggestion given was to always have a description such as "The operator moves from X to Z and performs Y". This is because the SW must answer the questions "What?" and "How?".

It became clear that the elementary tasks in the application could join several small tasks that, in paper format, were separated.

An important point for logistics was that the videos would not have to show repetitive tasks within each elementary task. For example, if the supply of N racks falls within the first elementary operation, but this has a time of 20 minutes, then the video would not be that long. The supervisor only needs to record a first supply, for example, and then associate the correct time with the elementary task. For that, the video must be clear and have all the proper annotations.

Another important point to follow was that before starting the recording of the videos, an assessment of the surrounding space should be made, ensuring the correct working conditions (standard conditions), and approach the operator who would be filmed. Only people who had given proper authorization could be filmed.

To ensure better results, it was essential to explain what was happening to the shop floor collaborators, what the objective was and to review the standard before recording it.

Whenever necessary, the videos should be repeated to ensure that they were perceptible and clearly demonstrated the correct way to perform the operations.

Having recorded the videos, then they would be saved in mlean®, associating each video to each operation, and add all the necessary data: extra information, efficiency, safety, and quality points. All these points allow the insertion of evidence (like videos, photos, or PDFs) which turns out to be an asset. Other information associated was the necessary Personal Protective Equipment (PPE) and the ergonomic level of the workstation.

Based on the time measurement sheet and the selected cycle time (2nd best time within 3 to 4 measurements, according to Company A's requirements), it would be necessary to ensure that the times of operations in mlean® corresponded to the measured times.

After entering the times of each operation in mlean®, the application gives the total cycle time by summing up the times of each operation, so it is mandatory that this time and the cycle time of the time measurement sheet are consistent.

To have a complete standard, it is still necessary to have the work combination table (as in the work chart). These documents continue to be built as before, in Excel® format, and then they are added to the standard in mlean® as attachments in PDF format, for example. Once again, it is also necessary to ensure consistency between times and operations.

A point that cannot be forgotten is the periodical operations. These are also represented in the application by video, description, and key points. The difference is that they are in a separate field, being separate from non-cyclical operations.

For each periodical task it is possible to select or create a frequency criterion, for example "at the beginning of the shift" and associate a time. However, this time is not included in the cycle time.

Although the documents W.C.T., S.W.C. and standardized measurement of cycle time sheet continue to be made as before, there is no longer the need to have them in paper format at the workstation. Hence, whenever they are updated, these updates can be made on the computer and then saved in the mlean® in the "Additional Information" area.

7.3. Approval Loop

The company has always had a standards approval loop to ensure that standards meet all requirements. Thus, any standard to be approved must, in this case, go through the several logistics departments (supervisors, gap leaders of all shifts and logistics' manager), HSE, quality and continuous improvement.

Only after all departments have approved the standard, with the continuous improvement department being the last in the approval loop, the standard ready for the next phases of auditing and improvement.

Table 14 present the different points that should be considered when approving a standard.

As it is possible to see in Table 14 there are several requirements that must be met for a standard to be approved. In addition, it is also possible to observe that the PC&L Improvement Coordinator is the person who should verify all these requirements, being therefore the last person in the approval loop.

Although it is not reflected in the Table 14, all logistics supervisors and gap leaders for each shift are also in the approval loop depending on the workstation. This can be explained by the fact that, according to Company A Handbook, SW is built by supervisor and/or gap leaders and validated by the respective manager.

If someone in the loop rejects the standard, then it reverts to draft status and must be changed so that the reason for rejection is corrected.

As soon as SW documents are built and approved, SW audit is a routine to improve and stabilize SW conditions.

Table 14 - Points to analyse when approving a standard and person in charge

	Department/Person in charge to check the point			
Point to analyse	**Logistics PC&L Manager**	**HSE HSE Manager**	**Quality Plant Quality Manager**	**Continuous Improvement PC&L Improvement Coordinator**
Videos in general	X	X	X	X
Operations' descriptions	X	X	X	X
Extra information points	X	X	X	X
HSE, efficiency and quality points	X	X	X	X
Specific HSE points		X		X
Specific quality points			X	X
Specific efficiency points	X			X
5S compliance	X	X	X	X
Documents in the extra information area				X
Version of documents				X
Consistency of operations and times	X	X	X	X
Well selected PPE	X	X		X
Reaction rules in NOK cases	X			X
Ergonomic level		X		X
Compliance with all handbook requirements				X

7.4. Results and Discussion

As already mentioned, one of the first and most important steps to adopt mlean® was to train logistics supervisors, as these were the pilots chosen by the PC&L Manager for the first phase of implementing the tool.

To ensure that the training was suitable for the group of people and that it was focused on the main points, an anonymous questionnaire was developed in advance for supervisors and the warehouse manager (see Appendix F, Figure F.1).

Although the warehouse manager is not responsible for the elaboration of the standards and is not part of the approval loop, it is important that he/she has knowledge of the mlean® application, as he/she is responsible for the supervisors and plays a role of constant help and guidance regarding the standards.

As seen in Table 15, all the people involved in the training already had some work experience, were aware of what a work standard was and were receptive to the training. However, even though all of them had already prepared some work instructions, regarding the elaboration of the remaining

documents (measurement of cycle time sheet, W.C.T., S.W.C.) the results were dispersed. Furthermore, only one person had already contacted with work standards in mlean®. It thus became evident that the training would have to be focused not only on the application itself, but also on the concepts related to the standards and in particular the documents that constitute it.

Table 15 - Questionnaire results

				Elaborated standard elements					
Role in the company	**nº years in the role**	**Knowledge in standardized work** *(from 1 to 5, being 1 the lowest and 5 the highest)*	**Already elaborated a standard**	**Standardized measurement of cycle time sheet**	**W.C.T.**	**S.W.C.**	**W.I.**	**Already elaborated a standard in mlean®**	**See training as a positive thing**
Supervisor	2,5	4	Yes	X	X		X	No	Yes
Supervisor	5	3	Yes		X		X	Yes	Yes
Supervisor	7	4	Yes		X	X	X	No	Yes
Supervisor	10	3	Yes				X	No	Yes
Supervisor	8	5	Yes				X	No	Yes
Warehouse manager	5	3	Yes		X	X	X	No	Yes
number of people = 6	average = 6 years	average = 4	all yes	1 person	4 people	2 people	all	only 1 yes	all yes

In the section Research Questions, some questions and objectives regarding the implementation of SW in mlean® were pointed out.

It is possible to conclude that all the questions were answered, however only partially. To fully answer the questions, it would be necessary that the project to last longer.

Until the end of the project, only one logistics standard was fully developed and approved. Nevertheless, it did not progress to the following audit and improvement phases. For this reason, it is considered that the first question raised has not been fully answered.

Throughout the project it was possible to analyse some benefits of the transition to digital (such as the fact that it eliminates paper waste, being something more visual and dynamic to train new operators and greater ease of communication between departments) and some challenges (such as being something totally new, the fact that the application is not fully adapted to logistics, more free time is required to make a standard and a greater level of attention and detail is needed). However, considering the short period of time for the application to mature during the project period, it cannot be considered that the last two questions can be given as fully answered, since it is believed that with the use of the application more challenges arise as well as more benefits.

In this way, it is considered that the first objective has been fully achieved and the other ones have been partially achieved, since being a new tool to deal with, for the initiative to continue, it is necessary to provide support during a considerable time.

Resistance to change and lack of comfort with the application were obstacles to the registration of more standards. To have more sense on the real challenges and benefits of the application, it would be required to have more standards fed into it, as well as more time, in order to analyse its effects in a medium/long term. In addition, it is considered that it would be important to broaden the range of people who develop the standards in the application.

7.5. Concluding Remarks

Transforming an ingrained method into something totally new always brings challenges and undoubtedly involves a change of attitude, which can cause resistance from the people involved. However, without this change of mindset, it is not possible to evolve.

It is known that the automotive industry is demanding and has suffered a lot of instability in the last years. These economic constraints, associated with a lack of personnel in the company, created greater pressure on supervisors, causing them to have less time to perform some of their functions, such as those related to work standards. These were considered as less priority tasks, being relegated by critical ones with short-term impacts.

Also due to market instability, internal logistics processes end up suffering, making it sometimes difficult to comply with standards or adapt those that exist on paper to the new realities.

The non-existence of standards in old format (paper), or their outdating, and the lack of contact between supervisors and standard's documents made the transition to the digital tool more time consuming, requiring constant monitoring and support by the improvement team and the warehouse manager.

The fact that the application is very focused on the production area did not help either, as several questions arose along the way about how to adapt to the logistics situation. Therefore, these questions must be followed by the digital team.

Another issue that led to some uncertainty was how to guarantee that the application can fulfil all the mandatory requirements present in the Company A Handbook.

Despite obstacles just mentioned, it was possible to obtain a fully approved logistics standard that can be considered a benchmark, not only for Company A, but also for other companies in the group that are also starting their journey in the digital transition.

It is considered that to be able to draw more conclusions, it would be advantageous to follow the project for a longer time, waiting for the maturation phase of the application.

Regarding future work, it is possible to conclude that it is essential to encourage and motivate this new way of working and thinking, never neglecting teamwork. In addition, it is considered that it would be an added value to include the warehouse manager in the approval loop, as he/she is the person with the most experience in the area and who closely monitors supervisors and gap leaders.

Regarding gap leaders, it is considered that it would also be advantageous if they had a more proactive role in this transition and if they also had the same training as supervisors. In addition to standards being their responsibility, it would be a way to free up supervisors in terms of time and to integrate the new method, creating a more cohesive team to overcome resistance to change.

Another point that can be implemented in a future phase of greater maturation is to carry out a weekly report on the status of the standards, ensuring that there is a close follow-up of the evolution.

Finally, it can be concluded that the transition to the digital tool has brought doubts and resistance to change, and challenges have been encountered since the first step. However, it was recognized by the majority of the people involved that it is a necessary step to take and that with its maturation it can bring a lot of benefits.

8. Final Conclusions and Future Work

In this last chapter, the conclusions related to the developed project and a critical reflection are presented. Additionally, its limitations and proposals for future work are also addressed.

8.1. Final Conclusions

This report reflects the work developed over 8 months in an automotive company, focusing on aspects under the broad theme of continuous improvement – VAVE, ergonomics, improvement actions and work standards.

After a first phase of adaptation, it was essential to be integrated into the various projects monitored by the PC&L Improvement Coordinator and to be in constant contact with the logistics team, both in the office and on the shop floor.

It was concluded that logistics plays a key role in the supply chain and that logistics decisions impact the company and sometimes its partners. In addition, it was also possible to perceive that it is not possible to evolve without continuous improvement and that it encompasses all the areas in the company, being a transversal topic.

Throughout the project, many VAVE actions were blocked by some of the stakeholders, which increased the time and effort involved in implementing ideas. Simple ideas often became the most difficult to implement due to some lack of communication with suppliers or clients.

Ergonomics was of great value to the company, so it was a privilege to be part of the team. Despite all the work carried out, it is recognized that there is much more to be done such as the compliance between the information data in SAP and the real data.

The follow-up of actions and the PDCA logic are intrinsic, verifying the real impact that improvement actions can have on the company. Following up on these actions involves a lot of effort and teamwork, but it is essential to overcome obstacles and evolve.

The standardized work is something completely implemented in the company, but the digitization of documents to the mlean® tool was undoubtedly a new challenge. Resistance to change was an initial obstacle, but it is believed that with time everything will become simpler. Unfortunately, it was not possible to develop this topic as much as expected to evaluate the benefits of using the application and its true potential.

Despite some limitations felt, the final balance is very positive, and it can be said that in general it was possible to answer all the questions identified at the beginning of the project and achieve the proposed objectives:

- Analyse the logistical processes and propose improvements;
- Digitize the documents used as much as possible.

Overall, it was a successful project that allowed to see in real context the importance and impact of continuous improvement, more specifically in the logistics area. None of this would have been possible without the teams from the continuous improvement and logistics departments, especially from the PC&L Improvement Coordinator. The fact is that Company A focuses not only on money and savings, but also in staying innovative, improving the conditions of workstations and continuous improving of the processes.

Finally, it is possible to acknowledge that the ideas identified and explored throughout the project can be applied to other components and processes, and there is also the possibility of being used as a reference for other industries.

8.2. Future Work

Based on the various points mentioned throughout the concluding remarks of each of the case study chapters, it is possible to notice that:

- Regarding VAVE, following a high number of actions involving many people can become an obstacle, and that blocked actions are a problem that should be avoided. It is, therefore, considered important to improve the interconnection of information and data, making the process as simple and automatic as possible.
- Despite ergonomics being a constant concern in the company, there are blocking points that should be avoided, such as the existence of outdated information and the lack of availability from suppliers to make necessary changes on the shop floor. It is also advisable to train all operators in the field of ergonomics, so that they really understand what the changes made mean and that they can and must contribute with ideas themselves – they are the ones carrying out their job tasks daily. The conclusion of the implementation of height limiters is also considered as a priority for the future.
- Performing an action follow-up is essential, but it is almost humanly impossible to manage so many actions at once. In addition, the overall management of the follow-up is performed by a single person, which causes a lot of pressure. The lack of time or resources on the part of suppliers to quickly respond to the issues raised also limits the evolution of actions. It is advisable that in the future the company encourages teamwork in this follow-up and that the use of technology (in this case the digital PDCA) by everyone is strongly encouraged, leading to a more continuous improvement culture.
- Regarding the work standards in *mlean*®, the two biggest limitations felt were the resistance to change on the part of the employees and the fact that the application was not adapted to the reality of logistics. It is therefore recommended that the company continues to develop this work, motivating people, and that the digital team try as much as possible to obtain solutions for the needs raised.

As technological developments are so important in the automotive sector, it is considered extremely important to digitalize as much as possible the processes described throughout this report and to automate the other ones that are already digitalized. Data analysis through graphics and tables proved to be advantageous, so it is advisable to apply this mindset whenever it is possible, making use of dashboards and reports.

Continuous improvement proved to be one of the great pillars of the company, so it should never be neglected or forgotten.

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Appendices

Appendix A. External Current MIFA of the Company A (October 2021)

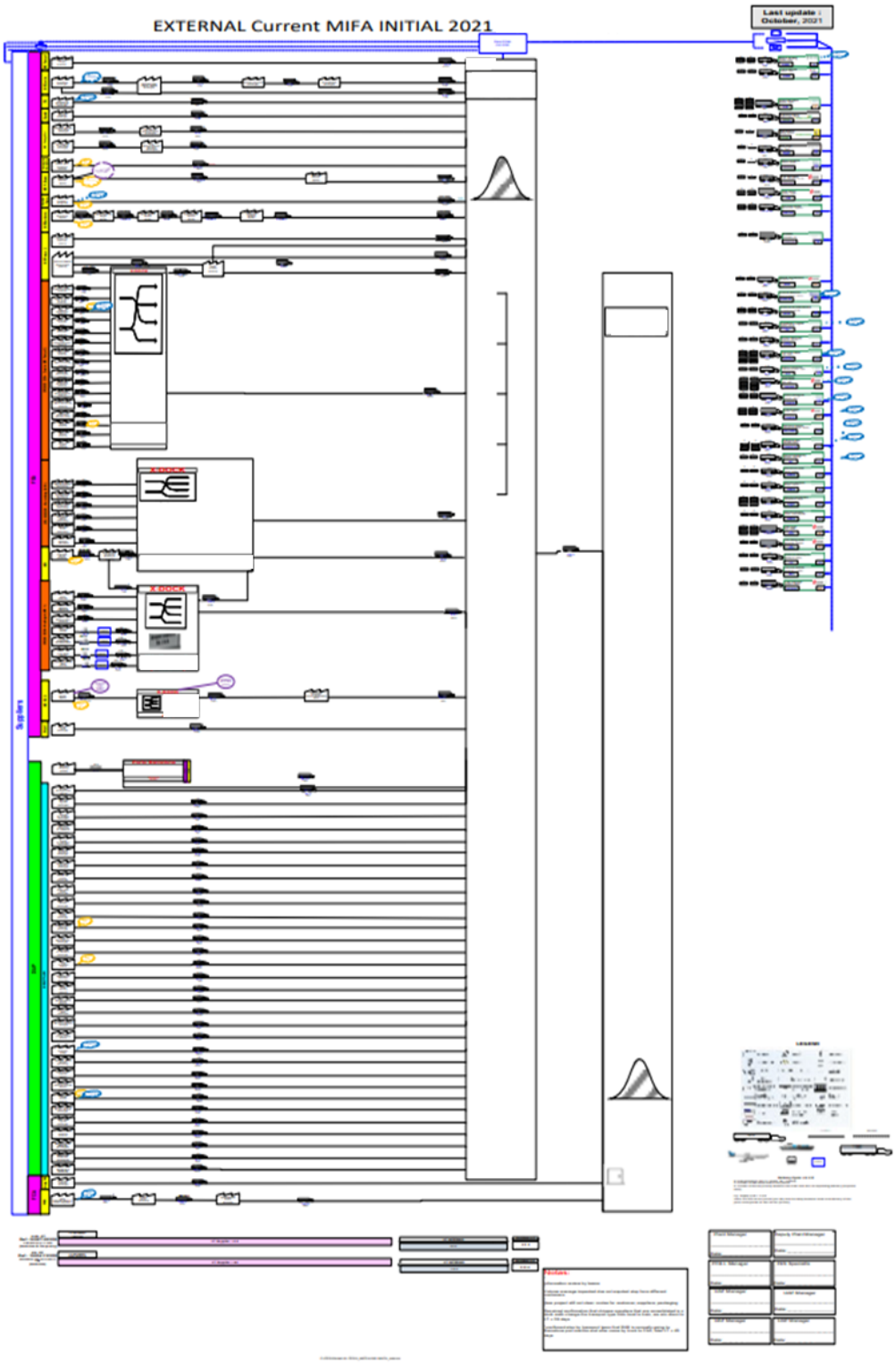

Figure A.1 - External Current MIFA Initial 2021 (October 2021) (Internal document Company A, 2021)

Appendix B. Table of changes made in VAVE simulation file version 5

Table B.1 – List of changes made in VAVE simulation file (version 5)

Coluna/Área	Antes	Novo	Motivo/Explicação
Reference	Continha ref com índice e servia de base para procv todos no JNI	Reference without index	Esta coluna é automática, ou seja: pega na refª que se encontra na coluna Reference e tira-lhe o índice. É com base nesta nova coluna que os procV no JNI vão ser realizados. Assim evitam-se os erros na pesquisa.
Todas que iam ao JNI	Faziam pesquisa num JNI de 2/12/2020 ProcV com refª total e com verdadeiro Não assinalava visualmente quando não encontrava refª	Fazem pesquisa num JNI de 26/11/2021 ProcV com refª sem índice e com * Assinala a texto vermelho "Not Found"	Dados atualizados Para evitar erros e fazer uma pesquisa mais correta. Assim, pesquisa sem ter em conta o índice e o * serve para assumir uma pesquisa que tenha qualquer coisa à frente daquela refª (sem índice) que nos interessa. Melhor gestão visual e assim também se consegue fazer filtro.
Todas que iam ao zpp_matmm	Faziam pesquisa num zpp_matm de outubro 2020	Fazem pesquisa num zpp_matmm de 24/11/2021	Dados atualizados. Pesos todos em KG.
Todas que iam ao zpp_pack	Faziam pesquisa num zpp_pack de outubro 2020	Fazem pesquisa num zpp_pack de 19/11/2021	Dados atualizados
Daily need from KPI	Dados com base no JNI	Dados com base no budget (folha nova no ficheiro)	Dados mais reais, uma vez que o JNI varia com bastante frequência. Esta nova folha do budget contém uma média das médias diárias dos consumos de cada referência.
Type packaging	Não distinguia se a referência tinha ou não palete e fazia a pesquisa sempre na mesma coluna do zpp_pack	Distingue se a referência tem palete e, de acordo com isso, faz pesquisa na coluna certa do zpp_pack	Com esta nova solução foi possível evitar problemas nas pesquisas dos pesos e quantidades de peças por caixa/palete. O zpp_pack está organizado de forma algo peculiar e foi muito importante realizar estas alterações para que houvesse uma clara distinção do tipo de embalagem utilizada.
Pallet name	Não existia	Criação desta coluna e caso não use palete mensagem	Para que seja mais fácil distinguir se a referência em causa usa ou não palete e para ser possível chegar ao peso da palete depois na coluna weight/pallet. Caso a referência não use palete mesmo, mensagem de "no pallet".
Nº boxes/pallet Qty/box	Era confuso Era confuso	Pesquisa correta no zpp_pack Pesquisa correta no zpp_pack	Agora, a pesquisa é feita de forma correta no zpp_pack e, caso a refª não use palete, então assume quantidade = 1. Agora, a pesquisa é feita de forma correta no zpp_pack, tendo em conta se a refª usa ou não palete.
Qty/pallet	Era confuso	Cálculo correto + comentário na coluna	Mesmo que a refª não utilize palete, este campo tem de ser preenchido. Então, como se considera 1 palete nestas situações, a sua quantidade acaba por ser a quantidade por caixa.
Weight/pallet	Dados desatualizados	Atualização de dados	Agora a pesquisa já é feita de forma correta no zpp_pack de acordo com o facto de ser ou não necessário adicionar o peso da palete. Além disso, os pesos das paletes foram todos colocados no zpp_pack, mas de forma manual (através da consulta do mm03 no SAP), dado que atualmente não existe uma extração de SAP com os pesos das paletes.
Current Transport Cost (inbound)	Dados do ano passado 2020-2021	Dados em atualização	Criação de nova coluna na folha packing para atualizar os dados relativos a este ano. → ainda em processo (com base nos documentos enviados por Nuno porto e no MIFA)
Current Transport Cost (outbound)	Dados do ano passado 2020-2021	Dados em atualização	Criação de nova coluna na folha packing para atualizar os dados relativos a este ano. → vai haver nova atualização em fevereiro, pelo que isto vai ser atualizado nessa altura (Nuno Porto ficou de avisar)
Saving – Impact JNI (€)	Retirava informação de outra folha	Fórmula diretamente no BOP	Fórmula aplicada diretamente no BOP em vez de ir a outra folha (esta outra folha foi apagada).
Saving/peça	Não existia	Criação	Esta nova coluna surgiu da necessidade da PC&L coordinator ter de dar estes dados. Adicionei coluna com a fórmula desenvolvida pela PC&L coordinator.
Saving por preço peça	Não existia	Criação	Esta nova coluna surgiu da necessidade da PC&L coordinator ter de dar estes dados. Adicionei coluna com a fórmula desenvolvida pela PC&L coordinator. Além disso, assim é mais fácil perceber que ações atacar em primeiro lugar, pois, como é óbvio, não se atacam as ações todas ao mesmo tempo &tem de haver prioridades).
Photo Database	Fotos no próprio BOP	Criação de folha que serve de base dados para fotos Criação de botões	Desta forma a folha BOP em si não fica tão pesada e existe uma base de dados que vai sendo alimentada à medida que é necessário, pois nem sempre é preciso ver as fotos do current e do proposal. As referências colocadas nesta folha foram retiradas do JNI de 26-11-2021 Na folha BOP existe um botão que dá diretamente para a folha da base de dados e depois, nesta, existe um botão de voltar que vai dar diretamente ao BOP novamente. Desta forma, torna-se tudo mais automático e fácil. 
Cores das linhas	Células pintadas manualmente	Cor da linha varia automaticamente consoante final decision	Para ser um processo menos manual e ajudar visualmente → através do código de cores utilizado é possível perceber ao longo de todo o ficheiro em que ponto se encontra cada ação
Legenda	Não havia legenda	Criação de legenda	Ajuda visual para que seja claro para toda a gente o esquema de cores.
"Títulos" + ref	Não estavam congelados	Congelados	Assim, ao percorrer o ficheiro, consegue-se ver sempre a refª, os títulos das colunas, a legenda e as notas. → Ajuda visual
Comentários nas colunas	Não existiam	Adição de comentários importantes	Tendo em conta que o BOP é um ficheiro complexo, com estes comentários é possível consultar em qualquer momento notas que são importantes como: explicação de alguns procV/outras fórmulas, como são feitos alguns cálculos, etc.
Notas a azul	Não existiam	Criação de notas nos topos das colunas com uma cor chamativa	Desta forma, é possível ver a qualquer momento notas que se consideraram importantes ao longo da construção do ficheiro, em como algumas boas práticas que devem ser aplicadas. Serviu, ainda, para assinalar as colunas que dependem de informação retirada da folha PACKING (folha manual construída em 2020/2021 pela PC&L coordinator e que, atualmente, pode já não estar 100% atualizada). Esta folha é a única que, ao momento, poderá causar assim alguma discrepância em cálculos. No entanto, devido à urgência deste ficheiro, não foi possível criar de novo uma folha deste género.
Células manuais	Não estavam sinalizadas	Sinalização	Desta forma fica claro para todos o que deve ser inserido manualmente.
Final decision - purchaising	Esta opção não existia	Criação de nova categoria	Esta nova categoria surgiu da necessidade que a Cátia sentiu ao longo do tempo a utilizar o VAVE.
Formatação condicional	Não estava atualizada/presente em todas as células	Atualização da formatação condicional	Para que a formatação desejada seja aplicada a todas as células desejadas.
Not Found	Erros não eram todos sinalizados	Erros sinalizados com Not Found	Desta forma é possível identificar logo as células onde houve algum erro nas suas fórmulas.

Appendix C. Code used to create the macro in Excel® to send the report automatically via email

```
Dim Arquivo As String
Sub Copiar_Arquivo()
ActiveSheet.Copy
With ActiveWorkbook
.SaveAs ThisWorkbook.Path & "\" & "VAVE-FG.xlsx"
Arquivo = .FullName
.Close
End With
Call Enviar_Email
Kill Arquivo
End Sub


Sub Enviar_Email()
Dim Outlook As Object, Novo_Email As Object
Set Outlook = CreateObject("Outlook.application")
Set Novo_Email = Outlook.createitem(0)
ThisWorkbook.Save
With Novo_Email
.Display
.To = "..."
.CC = "..."
.Subject = "Ações VAVE implementadas do mês - FG"
.Body = "Olá," & vbLf & vbLf & "Junto envio o relatório do mês de ações implementadas Finish Good." & vbLf
& "Alguma dúvida por favor liguem-me." & vbLf & vbLf & "Obrigada."
.Attachments.Add Arquivo
End With
```

Appendix D. Excel® file structure for logistics actions plan follow-up

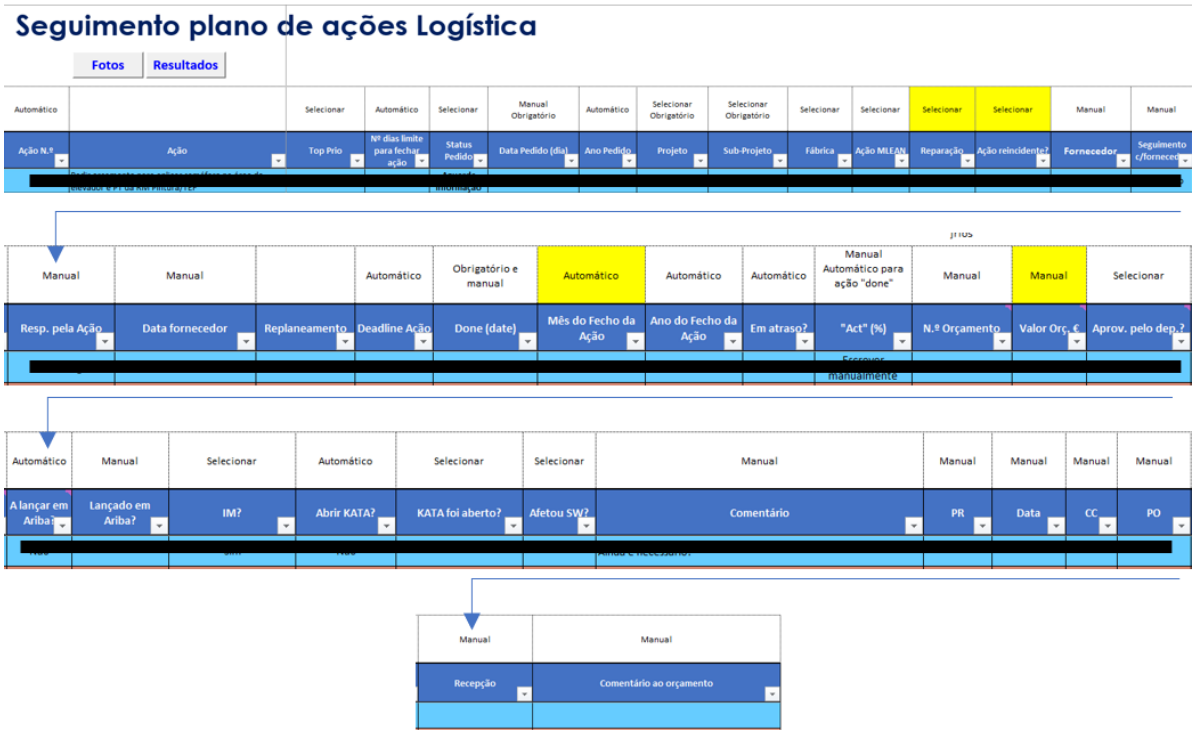

Figure D.1 - Excel® file structure for logistics action plan (elaborated with the PC&L Improvement Coordinator)

Appendix E. List of recommendations to build a work standard in mlean®

Table E.1 - List of recommendations to better build a standard in mlean®

Topic	Recommendation
Division of operations	Before recording/adding the videos, create the operations division.
	Analyse on the shop floor what employees do and analyse how to best perform the division of operations.
Person who will be recorded	Ensure that the person is aware of the situation, that gives permission to be recorded, that feels comfortable and know the standard in question well.
PPE	Ensure that all PPE is being used in accordance with safety rules and what is on the station's safety sheet
Surrounding environment	Ensuring that 5S and HSE requirements are met, and that the equipment involved is in good condition.
	Alert people around what is going to happen and ask for their understanding.
Filming	Preferably use the iPad, record horizontally whenever possible, avoid talking, record collaborator from the back especially when they are just walking, film all relevant details. It is also advisable to shoot several video clips and not an entire cycle at once.
Operations	Ensuring the normal rhythm of operations and the correct sequence of operations, being understandable all the steps taken.
Descriptions	Always follow the logic of “The operator moves from X to Z and performs Y”, being as concrete as possible.
Extra points and evidence	Add all relevant and necessary points regarding extra information, HSE, quality and efficiency. Whenever possible, include evidence (photos/videos).
OK/NOK situations	Ensure that OK/NOK situations are explained, as well as what reaction rule to take if there is a NOK point.
Documents	Ensure that all necessary documents are attached: W.C.T., S.W.C and standardized measurement of cycle time sheet.
Consistency	Ensuring consistency between all the elements that make up the standard.
Loops	There is no need to record operations that are constantly repetitive. It is enough to have just one loop.

Appendix F. Previous questionnaire made to prepare the training in standards in mlean®

Formação mLean – Standard de Trabalho (SW)
04/04/2022

Por favor, responda às seguintes questões, de forma que as sessões de *coaching* sejam o mais produtivas e adequadas possível.

1. Qual a sua função na empresa? SUPERVISOR

1.1 Há quantos anos se encontra nessa função? 2,5 ANOS

2. De 1 a 5 como avalia o seu conhecimento acerca da temática standard de trabalho? (1 – nenhum conhecimento, 5 – bastante conhecimento)

○ 1 ○ 2 ○ 3 ⊗ 4 ○ 5

3. Já alguma vez elaborou um standard de trabalho em papel?

⊗ Sim ○ Não

3.1. Se respondeu "Sim" à questão anterior, que elementos elaborou? Selecione apenas os elementos que elaborou.

- ⊗ Mínimos repetitivos
- ⊗ Tabela Combinada de Tarefas (TCT)
- ○ Esquema Elementar de Tarefas (ETE)
- ⊗ Instrução de Trabalho (IT)

4. Já alguma vez elaborou um standard de trabalho no mLean?

○ Sim ⊗ Não

4.1. Se respondeu "Sim" à questão anterior, como avalia a sua experiência?

5. Vê esta nova formação como algo positivo?

⊗ Sim ○ Não

5.1. Se respondeu "Não" à questão anterior, porquê?

Figure F.1 - Example of a questionnaire filled in by one of the supervisors