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"REDESIGNING THE WAREHOUSE FLOW THROUGH VALUE STREAM MAPPING AND WORK SAMPLING: THE CASE OF VERALLIA SPA"

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ABSTRACT

Background: from a cost center to a weapon of competitive advantage, the role of the warehouse has changed drastically over time. To be functional in terms of adaptability to new production processes and market trends, improvement in warehouse operations is a prerogative. Value stream mapping, a widely used lean tool, allows waste to be identified and minimized by improving the flow of materials and information within a process. While Work Sampling, a statistical method of measuring time, helps to detect how much time workers spend on tasks productively (or unproductively).

Purpose: in the following paper, we attempt to investigate the leading causes, effects, and solutions to the problems of a finished goods warehouse in a manufacturing plant where the upstream process, the productive one, follows the push logic. Specifically, we aim to identify waste in handling finished goods in the Lonigo warehouse (Verallia Group) by integrating value stream mapping with work sampling as a timing tool. In addition, the study aims to identify the root causes and propose countermeasures to help minimize the identified wastes.

Method: the paper follows a case study design with a predominantly qualitative nature. A deductive approach using the literature was adopted for the methodological research. Direct and participant observations as well as semi-structured interviews are the data collection methods that were used both in mapping the process in the warehouse and in conducting the work sampling study.

Findings: Based on the current VSM and the results of the WS study, wastes in form of waiting, transportation, underutilization of space, and over-movement were identified. In examining these wastes, layout and methods were identified as the main areas for intervention. Several countermeasures were proposed to maximize the space saturation index and update some outdated management storage methods. In particular, standardizing the management process for non-conforming products and eliminating the "lot separation" storage method bring improvements to the internal flow of materials. The redesign of an area of the temporary warehouse and the D section of the definitive warehouse, together with the introduction of a wall rack to exploit the cubic capacity of the packaging warehouse area, represent concrete opportunities in terms of efficient use of space.

Finally, the study has shown how lean tools can be used to improve processes in a manufacturing warehouse that is supplied with a pure push logic.

Key words: *Lean, Lean warehousing, Value Stream Mapping, Root cause analysis, Waste, Layout, Work Sampling, RFID system.*

List of Abbreviations

HU - Handling Unit

TU – Transportation unit

VSM – Value Stream Mapping

VA – Value Adding activties

NNVA – Necessary Non Value Adding activities

NVA – Non Value Adding activities

FIFO – First In First Out

WS – Work Sampling

JIT – Just in Time

RFID – Radio-Frequency Identification

MHE - Material Handling Equipment

TAG - Touch and Go

ABC – Analysis ABC

MTS – Make to stock

RCA - Root cause analysis

VIM – Verallia Industrial Management

WCM – Word class manufacturing

NC – Non Conformity

F31 – Furnace area 31

F32 – Furnace area 32

TVA – Total value added time

TNA – Total value non added time

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CH 1: INTRODUCTION

1.1 BACKGROUND

A golden rule of logistics is, "*The best warehouse is the one that does not exist*." This assertion is valid because maintaining a warehouse imposes costs on the company, i.e., costs of personnel employed, costs of maintaining equipment, and costs represented by inventory. What differentiates the warehouse from a mere cost center, as it has historically been viewed, and actually makes it a source of competitive advantage is the willingness to implement *continuous improvements*. The challenge is to adapt it to new production systems and customer requirements, all under the constraint of financial sustainability. The Lonigo plant (Verallia Group) is taking up this challenge through a logistics project to make the warehouse more efficient in terms of human, space, and equipment resources.

A widely used concept for industrial improvement, first in manufacturing - Lean Manufacturing - and then in logistics - Lean Warehousing - is *Lean*. Its goal is to eliminate waste and, ideally, reduce costs. Waste is any activity that does not add real value to the customer (Liker & Meier, 2006).

For this study, a framework that uses VSM in combination with Work Sampling was used. VSM provides a macro-level view of the processes under investigation. The goal is to track all non-value added activities to bring the total lead time as close as possible to the value-based lead time. The WS is a time measurement technique used to determine the work time distributions of an operator in his various tasks. Since warehouse operations have poor traceability because they depend more on human activity, unlike the production process which is more mechanical, it is an appropriate environment to use it.

In this paper we present the project carried out at Verallia SPA aiming to achieve improvements in logistics performance by considering all non-value added activities in the warehouse process of the Lonigo plant. It is also shown how some lean techniques can be used to highlight improvement opportunities within a warehouse supplied according to the *push logic*[1]. In addition, an explanatory analysis is provided on the application of a time measurement method, Work Sampling, suitable for the analysis of complex environments with non-standard work logics.

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[1] Push Flow: It denotes a flow in which material is pushed downstream without regard to whether there is a need or not.

1.2 CASE COMPANY: VERALLIA SPA

Verallia SPA is a multinational company specializing in the manufacture of glass packaging for food and beverage products. From a strategic unit of the Saint-Gobain Group, it became a standalone corporation in 2015 and was listed on Parigi Stock Exchange in 2019.

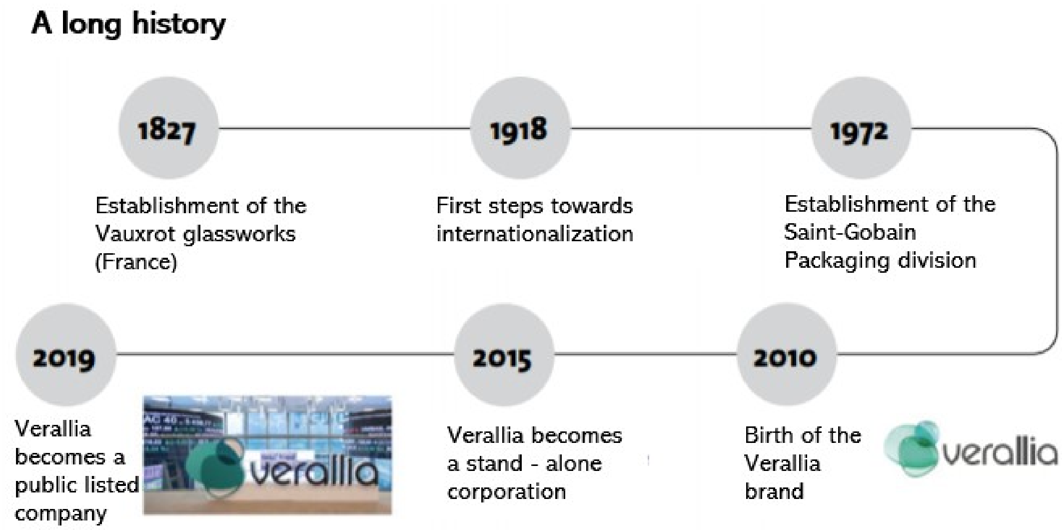

Figure 1: The main milestones of the Verallia Group (source: *www.verallia.com*)

With a history of more than two hundred years, see *Figure 1*, today Verallia covers a leading position in the production of glass containers: Number 1 in Europe, Number 2 in Latin America, Number 3 worldwide, 32 production sites in 12 countries, 16 billion containers produced between bottles and jars, 1.500 new references, more than 10 thousand customers in the food and beverage industry.

The brand's principles and values revolve around the desire to offer "healthy glass" and, above all, to do so in an environmentally sustainable way. In this direction, considerable resources are invested in research and development to ensure the best environmental performance and reduce CO2 emissions as much as possible.

Table 1: Verallia in figures (source: *www.verallia.com*)

The division Verallia Italy, originally known as Vetr.I. and then assimilated into the Verallia Brand with the purchase by the Saint-Gobain Group, employs more than 1.100 people in 6 plants, all located in Northern Italy (see *Figure 2*) and with different characteristics: Dego and Carcare are the ones that can produce the largest number of shapes and colors at the same time. Lonigo is a leader in the use of recycled glass, Villa Poma is technologically advanced and important for the food and beer industries. Pescia is the main plant for the production of single-dose containers and a valid reference for molded oil products. Gazzo Veronese stands out for its customization and design.

Figure 2: Location of the 6 Italian plants of the Verallia Group

1.2.1 Lonigo Plant

The plant in Lonigo (Vicenza), founded in 1973, specializes in the production of AG and blue-white glass (see *Figure 3*). The geographical position in the Vicenza area, famous for its wines, is functional to be close to the main customers: Wine, sparkling wine and beer producers. Together with the plants in Gazzo Veronese and Villa Poma it forms a strategic pole for the coverage of the Triveneto area.

The peculiarity compared to other Italian plants is the recycling of glass through an adjacent center, Ecoglass. Glass is the only raw material that can be reused without losing its properties.

Figure 3: White, green, AG and blue glass bottles

The complex covers a total area of 98.000 square metres, divided between the production section and storage areas (see *Figure 4*).

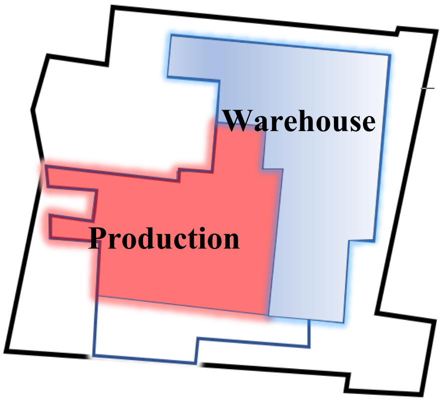

Figure 4: Picture of the Lonigo plant and its composition

The production process - simplifying - starts from 2 furnace and develops into 10 production lines. The upstream part of the process, called HOT - zone, includes the process of transforming the raw material into bottles by means of moulds and their firing. In the downstream part, in the COLD - zone, the products are controlled and palletized. Each pallet is labelled with an ID code and a TAG for the RFID system used in the warehouse.

The plant's finished product warehouse is the tail end of the production process. The products transit in the form of pallets, with different heights, through the use of two roller conveyors in the receiving phase, while all the remaining movements - unloading, sorting and loading - are carried out through the use of forklifts. Technically, in terms of internal operations, it's a

manual warehouse. By type of product handled, the warehouse can be defined as "all in one", meaning that the product arrives and leaves the warehouse in the form of a pallet, the handling unit (HU).
In the warehouse, 4 macro areas can be identified: reception area, temporary warehouse, the definitive warehouse and packaging area (as input). The flow analysed concerns the temporary and definitive warehouse. The distinction, which will be discussed in more detail in Chapter 3, considers the temporary warehouse as an intermediate storage area for finished products with batch-based production. The definitive warehouse includes the shippable products with cataloguing A, according to the ABC[2] analysis. Other finished products, classified B and C, are transferred to remote warehouses.

The references passing through the warehouse are about 100 types of products, identified with an 8 million code, while the final finished products, identified with a 9 million code, are more than 170. The 9 million codes are more since the type of pallet and packaging varies depending on customer demand. Basic Pallets can be:

- high, with more than 6 levels of products,
- medium, consisting of 4 or 5 levels and
- low, consisting of less than 3 levels.

The warehouse is owned by Verallia SPA, but the management of the processes is entrusted to an external company, ROL Logistics Srl. The workforce consists of 9 forklift drivers on a daily basis: 2 operators in charge of receiving the products, with a daily organization of 3 shifts of 8 hours each, 2 operators with sorting function and 5 with loading function.
The equipment used includes 2 different types of forklifts with different transport capacities.

Surface	Plant 98.000 sqm, Internal warehouse 16.000 sqm
Type of warehouse	Finished product Warehouse, Type manual and all in one
People	9 operators: 2 unloading, 2 sorting and 5 loading
MHE	2 types of forklifts
TU	High pallets with more than 6 levels
Products	>100 references (8M), >170 final finish products (9M)

Table 2: Lonigo warehouse in figures

[2] ABC analysis: A method used to categorize items into three classifications based on activity levels. The concept is most commonly applied to inventory, with the "A" classification identifying high consumption items, the "B" classification identifying medium consumption items, and the "C" classification identifying low consumption items.

1.2.2 Verallia Industrial management, VIM 2.0

Verallia Industrial Management, now developed into version VIM 2.0, represents the Group's operational excellence system. VIM 2.0 is a further development of WCM[3] tailored to the needs of the Group. Its special feature is the horizontal approach, which allows it to be easily adapted to the needs of the individual plants. At the base of VIM 2.0, which form the pillars, there are 7 bottles that summarize the most important group's key drivers with their respective best practices (see *Figure 5*).

Figure 5: The 7 pillars of VIM 2.0

The goal of VIM 2.0 is to help the entire Verallia organization achieve and maintain a significant level of performance for all stakeholders, develop people and implement a continuous improvement mindset. Overall, the macro-objective of VIM 2.0 is to increase Verallia's competitiveness by achieving consistent industrial excellence over time.

Behind a solid reality, there is a mission, solid values and objectives. See the *Table 3.*

VALUES	• Care for customers • Respect for people, laws and the environment • Empowerment and accountability • Teamwork
MISSION	Every day, Verallia enables people to enjoy beverages and food with healthy, attractive and sustainable glass packaging.
OBJECTIVES	• Become the supplier of choice for glass packaging • Achieve top industrial performance and excellent financial results • Developing the diversity and talent of teams • Contribute to environmental protection and community development

*Table 3***:** Values, Mission and Objectives of the Verallia Group (source: *www.verallia.com)*

[3] World Class Manufacturing is the philosophy of being the best, fastest, and least expensive producer of a product or service. It implies the continuous improvement of products, processes and service to stay at the forefront of the industry and provide customers with the best choice, regardless of where they are in the process.

1.3 DISCUSSION OF THE PROBLEM

The production of glass is characterized by a high volumetric load related to the intrinsic nature of the product, glass bottles, and the production process, of push type. In a push system (or make-to-stock (MTS)), production and distribution decisions are based on forecasts (Ghini, 2013). The result is a highly stressed warehouse, mainly because in the glass industry production is an inflexible variable where any inefficiency in the logistics flows will cause the product to stop its journey and eventually be scrapped.

In addition to the already demanding flow of materials that must be managed, there is also the need to manage quality defects that require further processing.

In summary, with a push and non-stop system, it is essential to maximize the efficiency of the logistics process. Considering the quality and fragility of the product, fewer touches of the transport units, the pallets, are an important reduction of the risk to be borne. Therefore, the efficiency of the finished product management process is key. Added to this is the need to contain costs, which are already strained by the flow of forced transfers to remote warehouses. It also follows that the saturation index of available spaces must be maximized as much as possible.

The company implements a continuous improvement process in the warehouse. When implementing a lean transformation, before focusing on the way employees work, one should look at the processes as a whole and understand what does not add value (Pavanato, 2020). To achieve this, the analysis of information and material flows is essential. A widely used tool that is also very effective is the VSM. However, there are a number of limitations as well as real challenges in applying it to a warehouse that is supplied with push logics. These elements form the basis for the analysis to be explored in the following paper.

1.4 ORGANIZATION OF THE THESIS

The project aims "*to improve material handling processes in the Lonigo warehouse"*.

Material handling deals with the techniques used to move, handle and store materials with or without machinery. In materials management, effective planning and control of processes is critical. There are a number of key elements in good materials management, such as space utilization, load unitization, safety, minimizing overall movement, and environmental concerns.

In order to narrow down the situation, while observing and outlining the main peculiarities that a warehouse of a glass manufacturing company presents, the following 2 questions are addressed:

- *RQ1:* What non-value added activities can be eliminated within the warehouse process at Verallia Lonigo Plant?
- *RQ2* : How can the existing resources of the warehouse be used more efficiently?

To the primary objective of proposing possible countermeasures suitable to valorize the resources in the warehouse, it is also intended to contribute to the academic search for the identification of variables that characterize a warehouse with finished products supplied by a production process with push logic and continuous cycle.

To facilitate the reading of the thesis, see *Figure 6*, each chapter contains a theoretical introduction to the topics considered, followed by the practical application to the case study, the main conclusions and finally a summary of the most important information.

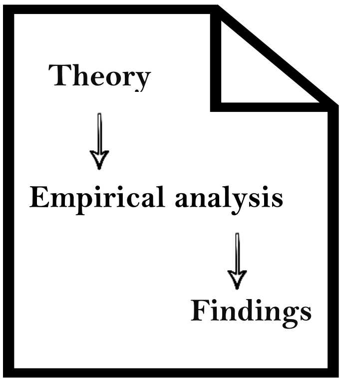

Figure 6: Chapter structure

An overview of the research methods used and the methods of data collection and analysis is provided in Chapter 2. Chapter 3 provides a theoretical overview of the lean warehousing concept and the analysis of the current status of firm's warehouse. Chapter 4 highlights the criticalities by categorizing them into the wastes theorized in the Lean model. Chapter 5 discusses the main area of intervention: layout and methods. Finally, Chapter 6 includes conclusions and consideration of the research.

1.5 LIMITATIONS

The monitoring and research activities were conducted during the period of the blockade imposed by Covid, with the risk that the observed processes were slowed down due to the global economic blockade.

The paper lacks the implementation part, for reasons related to timing. Basically, considering the PDCA model, the paper only addresses the PLAN part (see *Figure 7*). However, this is the most important and costly in terms of time and organization (Martin et al., 2013)

In terms of application, it has chosen to limit the analysis to the warehouse internal logistic process which can be classified as receiving & putaway, sorting, picking & loading.

The solutions to be used are those that are simple and directly applicable without much economic effort, in line with the conditions discussed at the beginning of the project and with the philosophy of striving for perfection: "*small but steady changes*".

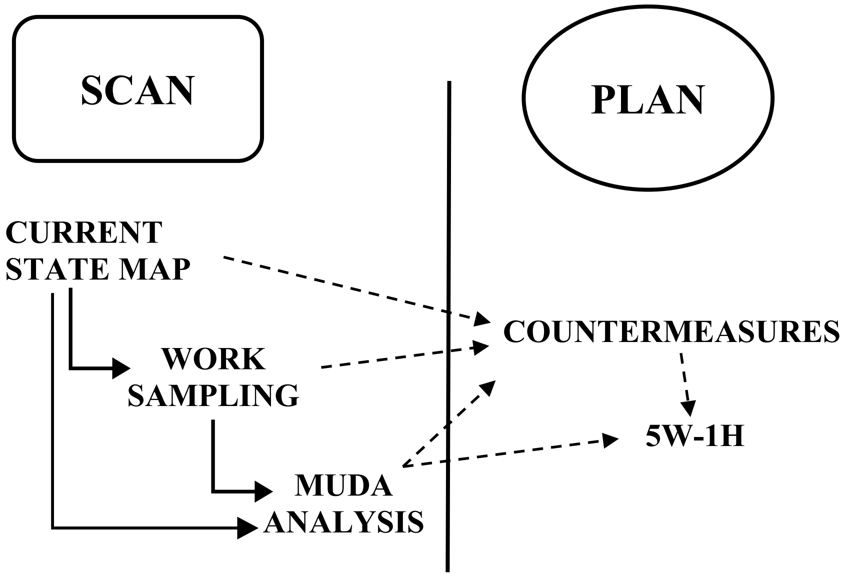

Figure 7: The PLAN phase structure of the project

CH2: METHODs

2.1 RESEARCH DESIGN: CASE STUDY

At the base of any research there is a methodology, which is the set of procedures used to identify, select, process, and analyze information. The methodology is the joint outcome of theory and research design (Patricia Leavy, 2017). Adler and Clarck (2011) define theory as an "account of social reality based on data but going beyond that data". Robert Yin (2007) describes research design as a logical plan to get from here - *a set of questions to be addressed* - to there - *some conclusions about those questions*.

The objective of the paper is to study the process within the Lonigo plant warehouse. The core was to identify the inefficiencies, allowing a better use of key resources – people, space and equipment. Thus, the case study research design was considered appropriate for 2 main reasons: Among the different forms of research design, case study is most appropriate when the researcher wants to answer the "how" and "why" (Robert Yin, 2007). Moreover, it is a method of research ideal to study a case in depth and get a holistic and realistic perspective.

When conducting a case study, there are no standard procedures for data collection and analysis. A qualitative case study research was conducted. The values underlying the qualitative method are the importance attributed to people's subjective experiences. Informal communication with front line employees was centrale in order to gain a deep understanding of the process being analysed. Moreover, the qualitative method, which is mainly based on interviews, document analysis and observation, results to be the most used in research dealing with logistics since 2000 (Karatas-Cetin & Denktas-Sakar, 2014).

Using theory as a starting point aligns with the method known as deductive research approach. In the initial phase of the project, a critical review of the literature was conducted in order to obtain a background knowledge of the warehouse features as well as to identify the most appropriate framework to develop the project.

Method	Choice
Research strategy	Case study
Research approach	Deductive
Data collection	Observation, semi-structured interviews, measurements, internal documents, existing data.
Data analysis	Qualitative

Table 4: Methodological choices of the study

2.2 DATA COLLECTION

To obtain an accurate and complete picture of the area of interest, it is important to collect and measure data from a variety of sources. This process is referred to as data collection.
By using multiple sources, the validity of the data can be increased and thus a more complete and robust analysis can be conducted.
Bryman and Bell (2007) distinguish between primary and secondary data collection. The former refers to all data collected directly by the researcher. Secondary data is described as the collection and use of data collected by someone else.

In the project, primary data was collected from unstructured interviews, direct observations, measurements of processes, and informal conversations with staff. The physical presence in the plant allowed to spend many hours in the warehouse to gain an understanding of how it works. A crucial aspect when collecting data was to involve personnel with diverse area of expertise and responsibility. Therefore time was devoted to identify the right persons to interview and to involve in the VSM activity.
Secondary data was collected through different types of internal sources such as company reports and documents illustrating existing standard working procedures, if any.
The literature review was a valuable resource. The focus has fallen mainly on academic texts addressing issues such as the role and functions of the warehouse and VSM as a flow analysis tool. The choice of texts was strongly influenced by the initial field observations, in particular the partial criticalities observed.

Data collection methods used in the study	
Observations	Direct and participant observation in the cognitive phase of processes and data collection in VSM and WS
Interview	Semi-structured interviews and non-formal conversations during periodic Gemba Walks.
Secondary data	Use of reports and company documents on existing work standards. Helpful resources for identifying data needed for the VSM.

*Table 5***:** Data collection methods: Observations, Interview and Secondary data

2.2.1 Observation

Observation is a method of data collection in which information results from observing the phenomenon under study as it is. By phenomenon, a project or a program is meant. The purpose of observation is to obtain real-life experience that supports understanding of how something behaves or appears.

Based on the involvement of the researcher, an observation can be either direct observation or participant observation (Robert Yin, 2007). Participant observation involves immersion in the subject's environment over an extended period of time. In other words, the researcher conducting participant observation seeks to learn what the life of an "insider" is like while inevitably remaining an "outsider" (Mack et al., 2005). The major advantage of participant observation is that it provides access to information that is not available to scientific inquiry and offers the opportunity to perceive reality from the perspective of a person within the case study (Robert Yin, 2007). On the other hand, one of the problems of this methodology is that the participant observer easily becomes a follower of the group under study and the way people behave in an observation situation may not resemble their normal behavior.

For this study, both direct and participant observations were critical to understanding how the operations in the warehouse flow. The observations made, along with a review of the literature, contributed to the formulation of the research questions that needed to be addressed in greater depth. Once VSM and WS were established as concepts in the framework, observations were again required. Both WS and VSM involve observation and investigation of the current state.

2.2.2 Interviews

Interviews are sources of information, usually obtained through a person-to-person conversation. However, the conversation must have a specific purpose (Merriam & Tisdell, 2016). It is an effective method when the researcher is interested in information that relates to people's experiences or past events that can no longer be reproduced.

There are different types of interviews depending on the structure: highly structured, semi-structured and unstructured interview. A highly structured interview is an oral form of written survey. Rigid adherence to predetermined questions may not allow access to participants' perspectives and understanding of the field of work. In the semi-structured interview, all questions are more flexibly worded or a mixture of more and less structured questions. In the unstructured interview, there is no predetermined set of questions and the interview is essentially exploratory.

For this study, the use of semi-structured interviews and informal conversations with managers as well as front lines involved in the processes was preferred. The questions in the semi-structured interview, were prepared beforehand following the guidelines suggested by Patton (2015) (see *Appendix 1*). *Table 6* shows the setting of the questions, intentionally generic, which creates the opportunity to ask additional questions necessary to better understand the activities within the processes.

The structure of questions asked in interviews and informal conversations
• Tell me about a time when.. • Give me an example of … • Tell me more about that … • What was it like for you when …

Table 6: Generic questions structure for interviews (Source: Merriam et al., 2016)

2.3 HOW THE PROJECT WAS CONDUCTED

In order to understand the study and gain a full understanding of how the work was conducted, a detailed explanation is provided below. The first step for this study was to determine the scope of the project. The choice of the objective must be functional to the core of the company, its mission and vision (Martin & al., 2013). Since the company wants to provide healthy, high quality glass, the integrity of the product and its transportation are key elements in achieving the goals. Reducing the number of touches and ensuring proper storage not only reduces risk but also generates financial benefits.

In order to gain a deeper understanding of the current situation in the warehouse in terms of material flows and handling, time was spent meeting staff and participating in daily operations, i.e. making direct observations. The complication here is the coexistence with an external company that has been entrusted with running the warehouse operations. As the parties have mutual interests and are linked by contractual agreements, the dialogue was mainly conducted with the managers of the third-party company present. Informal dialogues aimed at gaining clarity on the current process were also held with frontline staff.

Based on the findings, a map was created to visualise the flow of materials and information within the warehouse. A series of meetings were organised, attended by the plant logistics manager, the corporate methodology manager and the site manager (third party representative). During these meetings, the data collected was discussed in order to fill in missing information and correct any errors due to misinterpretation.

The literature review was an essential part of the project from the beginning and was started at an early stage. Greener and Martelli (2015) recommend using a literature critical review approach when conducting research projects. According to Kupiainen et al. (2015), reviewing academic literature is important for three main reasons: to aggregate and synthesize existing knowledge, to identify changes in research over time, and to provide an academic foundation for beginning a new analysis investigation.

Emarlad, ReseachGate, Google Scholar were used to search for scientific articles that provide a theoretical background that can serve as a guide. In identifying reliable sources that are consistent with the research core, Bryman and Bell (2007) recommend placing great emphasis on keywords. Therefore, we searched for empirical studies published in English that included keywords such as Value Stream Mapping, Lean Warehousing, Lean Warehouse Management, Material Handling, and Work Sampling.

In addition, it was deemed advantageous examining existing studies that address the topic Lean Warehousing and were developed using a real case study of a finished goods warehouse [Dotoli, et al. (2013), Mahfouz and Arisha (2013)].

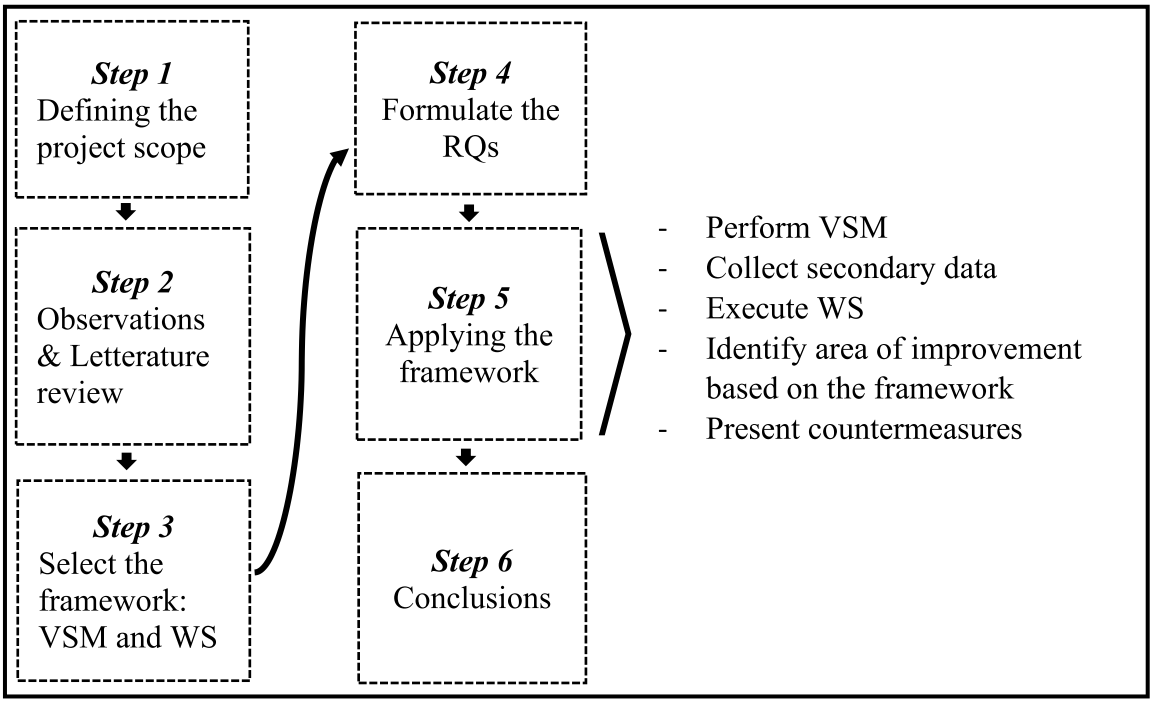

Figure 8: Flowchart of how the study was performed

The most time-consuming part of projects is usually the preliminary phase. However, good organization is critical to establishing a solid foundation for overall project management (see *Figure 8*). Direct observations were conducted to gain an understanding of how the Lonigo warehouse operates. Literature was an important resource to know the process and identify an appropriate framework to be used in the project. In line with Verallia Group's objectives and values, it was considered appropriate for the project to use the VSM to track material and information flows and to monitor more closely the activity of receiving and unloading pallets via the WS. The next step of the study was to collect the data needed for the empirical part of the study.

After performing the AS -IS map, additional information was collected. Secondary data was requested for this purpose. The company's information system - SAP integrated with the RFID system was used to obtain data and other information about the warehouse and the products stored.

To gain an understanding of the time required by workers responsible for unloading pallets from conveyors, the WS method was used. This choice can be attributed to the low standardization of this operation as operators are responsible for several functions. Once the analysis database was created, an 80/20 analysis was performed to determine the productive (or unproductive) most time-consuming activities in performing their task.

At the end of the mapping and WS investigation, a list of problems was highlighted. Critical problems were then classified in the well-known Lean waste and, through an affinity analysis, related to their area of intervention. Once the main areas for improvement were highlighted, meetings were organized with brainstorming sessions aimed at identifying improvement solutions. In this context, assuming rapid implementation and no economic impact, a number of countermeasures were formulated and detailed for possible application.

2.4 RELIABILITY AND VALIDITY

Ensuring validity and reliability in qualitative research involves conducting the research in an ethical manner.

Reliability refers to the extent to which the study can be replicated in the future with the same research design and yield the same conclusions. Reliability can be divided into internal and external reliability. The internal one is characterized by consistency throughout the project. External reliability refers to the extent to which the data collection techniques and analysis methods can be used to produce consistent results when replicated by another researcher. Validity refers to the extent to which the measurements reflect what the study intends to explore and the generalizability of the study. This can be divided into internal and external validity. Internal validity asks whether the measurements used are appropriate and whether they examine the intended phenomenon, as well as whether the analysis of the results and relationships is accurate. External validity refers to the extent to which the results can be generalized (Saunders et al., 2016).

Validity and reliability are concerns that can be addressed through careful attention to the conceptualization of a study and how data are collected, analyzed, and interpreted, as well as the manner in which results are presented.

Several steps were taken to ensure the reliability and validity of this study. These included open discussions with supervisors at Verallia SPA, to confirm the accuracy of the data collected. Interviews were conducted with several individuals with different positions as well as several rounds of interviews to avoid bias on the part of the researcher and participants. The data parameters were collected from the interviews, databases as well as the existing reports and compared to identify the differences in the parameters. If there was a difference in the data between the different sources, a discussion was held with the person responsible for the particular process to ensure that the correct data was used.

2.5 SUMMARY OF RESEARCH METHOD

What the researcher does once the different parts of the research are combined is called methodology. In this paper, the case study research design was used. The development of the project through theoretical research and observations, mixed with semi-structured interviews in the field, highlights the predominant qualitative nature of the research and the deductive approach used.

Below, *Table 7* offers a schematic elaboration of the methodology decisions.

Summary of Methodology decisions	
Design	Case study
Strategy	Qualitative and deductive
Data collection	Direct and participant observations
	Semi structured interview
	Secondary data (reports, internal documents, etc.)
Quality	Validity and reliability guaranteed through constant comparison with the internal supervisor, the organization of interviews with various parties and on different occasions and triangulation of the data collected with what was already documented in the company.

Table 7: Summary of Methodology decisions

CH 3: DESCRIPTION OF THE CURRENT STATUS

3.1 VALUE STREAM IN THE WAREHOUSE

Conceptualized by Womack et al. (1990), the term "value stream" refers to all activities, value-adding and non-value-adding, that are necessary to create a product - or service - and make it available to the customer. Within a company, different value streams can be identified depending on the size and complexity of the operation. A generalist criterion to identify these, according to Martin et al. (2013), is that "*wherever there is a request and a deliverable, there is a value stream*". In these terms, the value stream in the warehouse could be described as the chain of events from the receipt of a customer request to the shipment of the order.

Before proceeding, we think it is appropriate to briefly recall the main critical issues related to the application of the lean model to warehouse operations.

There is extensive literature (Frazelle, 2002; Rouwenhorst et al., 2000) on warehouses and the operations that characterize them. In summary, a warehouse is a planned space for the storage and handling of goods and materials (Emmett et al. 2015). The main objective of most warehouses is to facilitate the movement of goods through the supply chain to the end user (Rushton, et all, 2014). While warehouses vary in size, type, function, property, and location: Receiving, storing, stocking, picking up, replenishing and shipping are the main processes that characterize them. Of these activities, receiving, storage, and stocking belong to the inbound logistics process, meaning they deal with the flow of materials coming into the warehouse. Picking and shipping, on the other hand, belong to outbound logistics and deal with the movement of materials out of the warehouse.

The lean philosophy, whose core is founded on "*value*", has different connotations when applied to the warehouse. If the value in the manufacturing process is attributed to the transformation of the input, in the warehouse it is associated with the transformation of time and space of the product (Dehdari, 2013). Implementing the philosophy of lean manufacturing in the warehouse is not the same as implementing lean in the manufacturing process. The lean principles and practices do not change but need to be adapted to the warehouse specific processes (Dehdari, 2013). The author suggests keeping in mind the differences between the two areas, which can be summarized as follows:

- The warehouse has a more variable work cycle due to less repetitive work and larger workstations.

- Being a labor-intensive area, there is considerable variation in employee performance during work shifts.
- Fewer opportunities to monitor work performance due to variability in work schedules.
- The extended workplace layout causes more communication problems.

When applying the 5 principles of lean to the warehouse, it is necessary to put them into the perspective of the operational processes of the warehouse. A brief summary follows:

1. *Specify Value from the point of view of the customer*. Warehouse processes do not add value to the product. Value is related to the level of service provided. The goal is to deliver the products in the expected quantity, time and manner.
2. *Identify the value stream*. Warehousing activities, like transportation in general, do not create value in the eyes of the customer, so they are not willing to pay for it. Some activities as receiving, unloading, sorting, picking, and loading may not have direct value to the customer, but they are essential to the operation of the business.
3. *Make sure the flow is uninterrupted*. In its ideal form, the principle suggests the "one – piece flow". Since this is an unrealistic state, the goal must be to streamline the operational total lead time of the warehouse as much as possible to the total lead time adding value.
4. *Pull logic*. The flow of material that takes place in a warehouse can be divided into two areas: the flow of incoming products to be put away and the flow of outgoing products to be picked up and shipped to the customer. From a Lean perspective, the storage of products is similar to the concept of the supermarket, where products are picked up when a customer order arrives, and these pickups imply the need to restock these products.
5. *Perfection*. In a warehouse, perfection can be identified in the perfect order, that is, the order is delivered without damage or defects, on time and in the right quantity.

Since the goal of the project in Verallia was to make the warehouse management more efficient, it was necessary to look at the value flow that characterizes it. According to Kuhlang et al. (2011), a value stream view means looking at the operational processes, the flow of materials between processes and also the flow of information. The tool that best reflects this need is the VSM. A simple but very effective method to get a holistic overview of the state of the value streams in an organization.

3.1.1 VALUE STREAM MAPPING

A good starting point for any improvement initiative, and not only, is to create a value stream map, abbreviated VSM. Martin et al. (2013) recommend creating or revising the VSM whenever the company experiences a game-changing event. Whether it is a desire to make new investments, the threat of new competitors in the market, or a report of inefficiencies, the VSM can not only provide a clear dynamic of the current situation in the company, but also spur commitment and a sense of urgency on the part of management.

At a technical level, value stream mapping is a qualitative - *pencil and paper* - tool (Rother and Shook, 2009) that provides a framework for identifying waste and its negative impact on overall process performance and flow. According to the Lean definition, waste is anything that consumes resources (material, people, and equipment) but does not create value for the customer.

The creation process of the VSM consists of 4 main steps (see *Figure 9*). The first step of the VSM is to determine the value stream to be improved. The second step is to understand how things currently work and create a value stream map of the current state of the entire process. The third step of the VSM is to set an improvement goal by creating the future state map. The fourth step of the VSM is to develop a plan to achieve the future state by eliminating wasted time and changing processes.

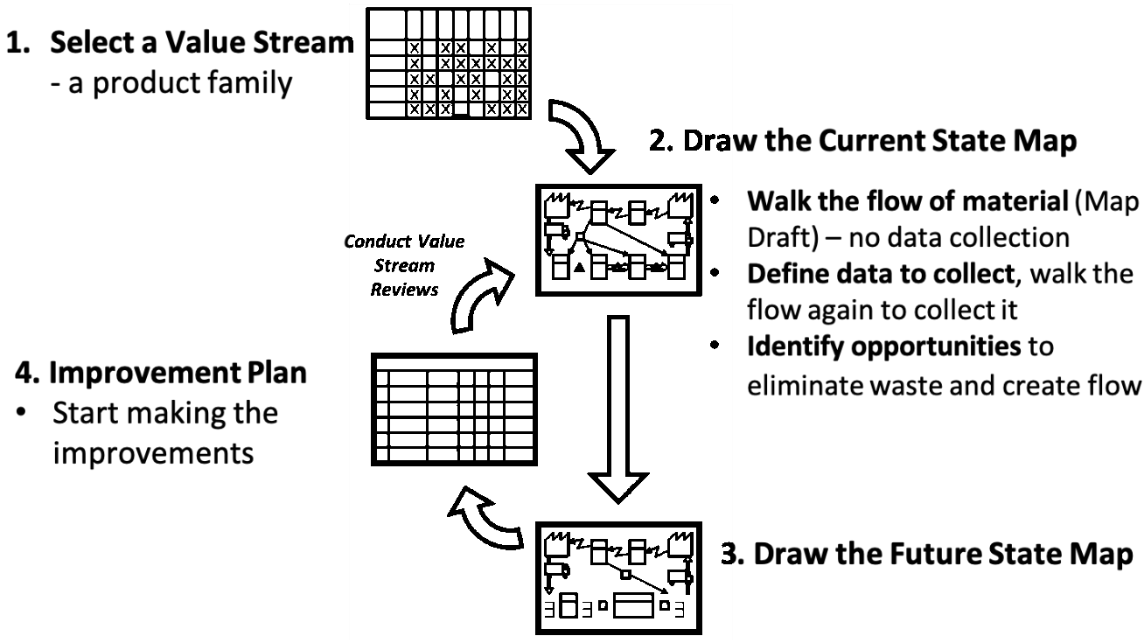

Figure 9: The 4 steps in the VSM process

The use of the VSM, in addition to its practicality, relates to the flexibility of analysis that allows. Depending on the objective, the level of analysis may vary. As a starting point, the macro level is recommended in order not to get confused by too many details (P. Lynch, 2014). The VSM can be used to map the material and information flow of an entire company from supplier to customer, or it can be used to map individual processes. In this specific case, the value stream of the finished product warehouse was drawn.

Regarding the organization and execution of the mapping, the whole process leans on the guide by Martin et al. (2013) in the book - *Value Stream Mapping: How to Visualize Work and Align Leadership for Organizational Transformation*.

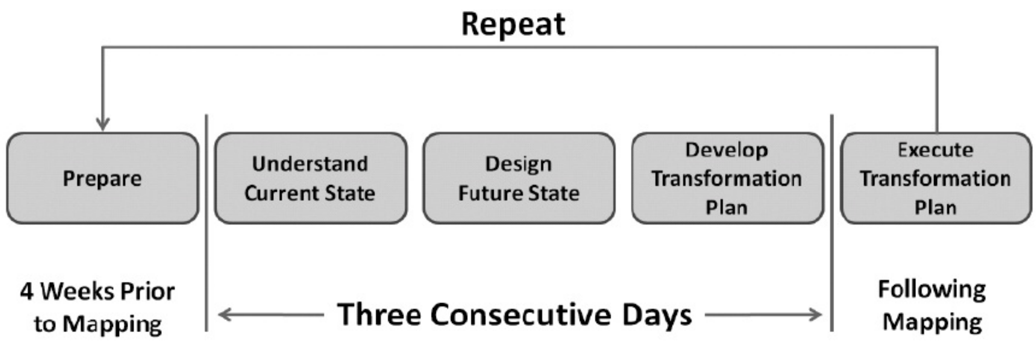

Figure 10: The “3-phase approach” model proposed by Martin et al. (2013)

The model known as the "3-phase approach" (see *Figure 10*) is based on the following procedure:

1. <u>preparation phase</u>: as extended in time as possible (at least 4 weeks) in order to be able to prepare the work in the best possible way.
2. <u>3 consecutive days</u>: with the aim of formalizing the Current VSM, Future VSM and the Transformation Plan
3. <u>Execution</u>

The initial phase is a purely organizational phase in which, in addition to deciding on the composition of the team that best matches the needs and objectives expressed by the company, the situation is studied in advance to determine the scope of the project as well as to strengthen knowledge of the same, including through direct dialog with the parties involved in the front line.
In the 3 consecutive days, the first day is dedicated to better understand the current situation. The author proposes to conduct the activity as close as possible to the work and to organize at least 2 sessions of Gemba walks. The Gemba walks, literally where the action is taking place,

will allow to observe the activity at its scale and to better tracking the dynamics and implications.
For the compilation of the current map, as well as a more detailed explanation of the phases, we refer to the book mentioned above, which is considered very exhaustive on the subject.

Brainstorming and dialogue with frontline employees are essential steps in identifying inefficiencies, waste and barriers to flow. With reference to the analysis of the map representing the current situation, Graziadei (2005) provides a guide to help identifying waste:

- Bring the total process lead time as close as possible to the value - added time. Aim to reduce the occurrence of all non-value-added processes.
- Achieve continuous flow whenever possible. The ideal form is one piece flow. If interruptions are unavoidable, prefer a pull or FIFO system as a solution.
- Apply the Heijunka system, distributing the activity over time.
- Information flows are as important as material flows. It must be a prerogative to streamline and strengthen both flows.
- Synchronize work rhythms by Takt Time, i.e., the time interval within which work must be completed to meet customer demand. Takt time is the ratio between the daily time available and the daily quantity demanded by the customer**.**

The creation of the FVSM presupposes the correction of all identified inefficiencies. In this step, the map may illustrate a goal that cannot be fully achieved - *a blue sky*, but its function is to trace the best state and the implications, even if hypothetical, on the target process.

The transformation plan, see the example in the *Figure 11*, includes all improvement activities and the people responsible for implementing them. Timelines and accurate descriptions are an extremely important detail to avoid misinterpretations and to have a clear roadmap.

Value Stream Transformation Plan

Value Stream		Progress Review Dates		
Executive Sponsor				
Value Stream Champion				
Value Stream Mapping Facilitator				
Date Created				

Identifier	Problem to be Solved or Action	Notes	Exec. Method *	Owner	Planned Timeline for Execution												Status
					1	2	3	4	5	6	7	8	9	10	11	12	
																	0%
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Figure 11: Sample template of a transformation plan

3.1.1.1 VSM Nomenclature

The VSM is an easy-to-read visual tool thanks to the use of a common set of symbols, some of which were presented in the workbook "Learning to See" published by the Lean Enterprise Institute in 2009. However, the VSM symbols are not standardized - it is possible to modify or create symbols to fit the specific needs of the organization.

The *Table 8* contains the symbols used to map the processes within a warehouse.

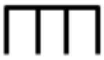
Title	Symbol	Definition
Customer & Supplier		Identifies the supplier and customer of the process
Human Operator		Represents the operators involved in the process
Supermarket		A temporary buffer used for holding assets
Inventory		Denotes the inventory level, the inventory build-up between process steps and finished goods level
ERP/MRP system		Identifies the management system used
Manual information		Manual information flow
Electronic information		Electronic information flow
Timeline		Expresses the value-added time and non-value added time for each operation in the process
Kaizen burst		Highlights problem areas that are critical to achieving value stream success.
Data Box		Summary of key information about the operations involved in the process
Activities in the process		The operations that form the process
Push Arrow		Material pushed before the subsequent process needs it
External shipment		External transport of material flow to and from the company

Table 8 - Symbols adapted, in part, from Rother and Shook, 2003.

3.1.2 Work Sampling method

When tracking improvement processes, VSM must be complemented by quantitative data. In fact, measuring throughput and the time it takes people to complete work tasks reveals more about workflow than any analytical tool (Martin et al., 2013).

In order to apply key metrics to the processes being mapped, a time measurement study must be conducted with the goal of gaining global insight into the bottlenecks/time consuming activities. A time measurement study can be conducted in two ways: Watch Measurement or Work Sampling.

In a warehouse, several people work on a particular position without strict division of tasks and the activities are interrupted for other activities. Due to these two details, Work Sampling method was considered appropriate for time study. This method, based on the statistical study of frequencies, provides information about the time of work. It consists in observing work, typically at random times, over time and analyzing the proportion of observations corresponding to each of the activities studied.

Work sampling has the advantage of being a simple, rapid, and inexpensive technique. This method is particularly suitable for measuring activities that cannot be measured by direct observations.

It should be mentioned that since it is suitable for the study of collective targets, the amount of specific details about the individual element is very limited.

For the purposes of the project, the analysis using work sampling was limited to the "unloading" activity highlighted in the VSM, i.e. the one where the greatest variability was observed. The two employees include a number of additional tasks in their daily work, such as: transporting primary inputs for palletizing and handling non-conforming products during the processes of "releasing holds[4]" and "reconditioning". The use of the chronometric method proved to be limited in this sense as there are constant changes in the activity. It was decided to use both methods to obtain more information and to check consistency by drawing. Categorizing the work into individual tasks, which were then classified according to whether they add or do not add value, provided additional information on possible areas for improvement.

[4] Releasing Holds: In Verallia, it identifies the control process for pallets that are considered unsuitable for quality reasons. This operation is used to release the remainder of the batch waiting in the storage space, by checking the integrity of all bottles on a set of selected pallets.

The following is the general procedure for performing the work sampling study:

1. Determine confidence level and accuracy level. These parameters define the error level we want to achieve.
2. Select the process or activities to be analyzed**.** The work must be divided into the tasks to be analyzed.
3. Perform an initial series of measurements. A first series of measurements, usually 100 samples, is performed randomly. As a result, a numerical estimate of the observation sample size required for the next observation.
4. Analysis with the study by sampling. The size of the sample needed to obtain a reliable statistical result is calculated. There are two techniques: The statistical formula (see *Formula 1*) or the graphical method.

$$N = \frac{z^2 . p . q}{(s . p)^2}$$

N = Amount of observation that should be done
Z = Level of confidence index
s = Expected error
p = probability of nonworking element
q = probability on working element (1 – p)

Formula 1: Number of instantaneous observations

5. Preparing the observation. This statistical method is based on a "random" collection of data. There are two possibilities: *fixed interval* or *random*.
6. Observe and collect the data**.**
7. Determine data adequacy by adequacy test. Observation data considered to be adequate when its value of N is greater that the value of N' (adequacy test), *see Formula 2.*

$$N' = \frac{z^2 . p . q}{(s)^2}$$

N' = Amount of observation that should be done
Z = Level of confidence index
s = Expected error
p = probability of nonworking element
q = probability on working element (1 – p)

Formula 2: Adequacy test

8. Analyze the data and draw conclusions.

3.2 ANALYSIS OF THE WAREHOUSE CURRENT SITUATION

The warehouse is owned by the Verallia Spa Group, but the management of its operations - reception, unloading, storage, picking and loading - has been contracted to ROL Logstics Srl. A company based in Bergamo that specializes in handling materials within the warehouse.

The internal warehouse covers an area of 16.000 sqm, divided into the receiving area, the temporary warehouse, the definitive warehouse, and packaging warehouse (input). The facility has 5 entry/exit points, outside of which are located the 7 truck loading bays (*see Figure 12*).

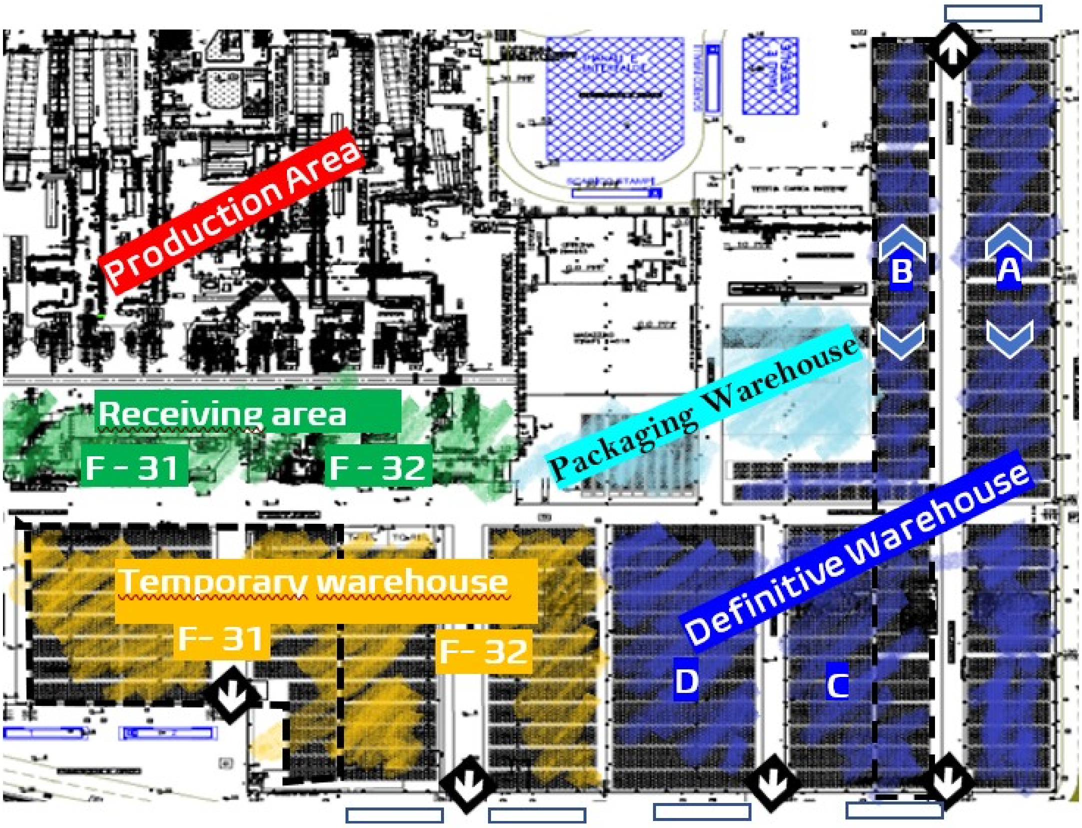


Figure 12: Warehouse current internal layout organization

The receiving area comprises 2 rollers conveyor that transport the product packed in pallet structures, the handling unit (HU). A distinction is made between the furnace area 31 (F31) and the furnace area 32 (F32). Both are characterized by the presence of a roller conveyor of different length and 1 operator in charge of emptying them. The roller conveyor F31 has a total capacity of 22 pallets, considering the whole path, while only 12 are taken directly from the forklift in the warehouse. Roller conveyor in F32 has a total capacity of 34 pallets, while only 12 are available when removed by the forklift. Both roller conveyors have only 3 removal points, which are raised from the floor (*see Figure 13*).

Daily flow averages 1250 high-pallets, with a fair split between the 2 conveyors of 625 pallets each.

Figure 13: Picking stations for pallet pairs from the roller conveyor in the receiving area

The temporary warehouse identifies the areas intended to contain pallets up to the end of the batch production. An integer distinction, exploiting the concept of spacing proximity, is the division between the area designated to F31 and that F32. A fixed (or dedicated) storage method is used: each production line has a temporary storage area. For example, line 11 has a whole span - T11 - in temporary warehouse, consisting of 4 holds (T11-1 to T11-4). The type of storage is *block stacking*, with a maximum limit in height of 5 meters, then only 2 levels of pallets above. In particular, the number of levels allowed depends on both the height of the pallet and the type and weight of the product itself.
The average stay of the lot in the temporary storage is 2.5 days. Accordingly, day 1 is the day of production, on day 2 due quality checks are carried out, if everything is in order, the movement to the final warehouse or transfer plan to an external warehouse continues.

The final warehouse has a different structure, which is characterized by 4 macro sections - A, B, C and D - with variable heights. Segments A and B allow 3 storage levels, C and D only 2, but with larger volumes, especially in the length of the holds. The form of storage is block stacking and the distribution follow the *random policy method*; the lots are deposited in the holds as they get rid of. The average number of batches present in a hold varies from 2 to 3. It must be specified that no lots of different products are allowed, only those of the same product in series. The average rotation of the final warehouse is around every 75 days. *Table 9* summarizes some key differences.

	Temporary Warehouse	**Definitive Warehouse**
Storage policy	Dedicated spaces	Random
Hold rotation	Every 2.5 days	On average every 75 days
Overall capacity	7500 pallets	19500 pallets

Table 9: Differences between temporary and definitive storage areas

3.2.1 VSM – AS IS

The process observed in the Lonigo warehouse can be broken down into the following operations: Receiving and unloading, sorting, picking and loading (see *Figure 14*). However, the sequence of operations is complex. As mentioned earlier, the large flow of product implies the need to transfer part of it to remote warehouses, about 40% of the daily production. 60 % of the daily production is destined to the factory's definitive warehouse.

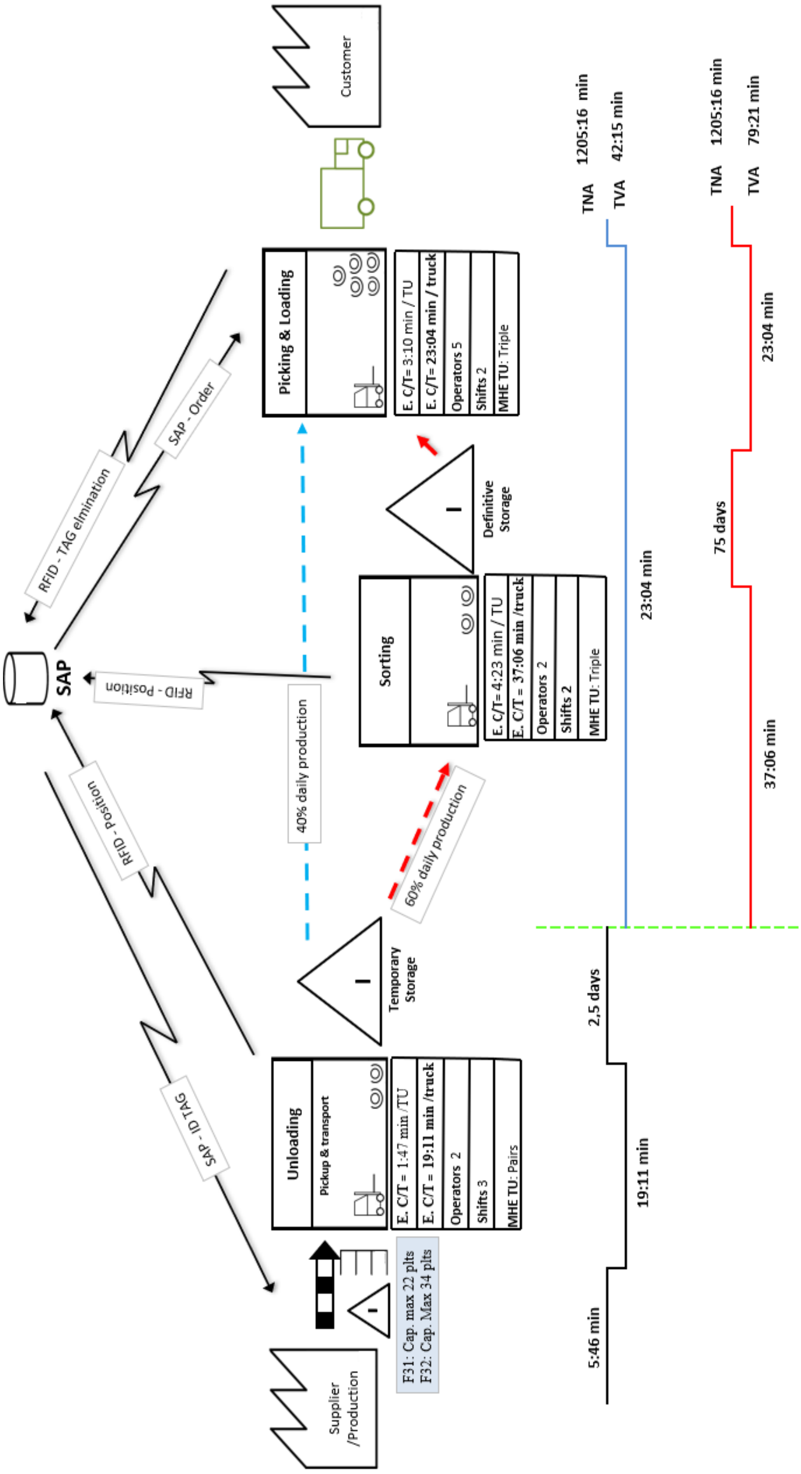


Figure 14: Current VSM of the Lonigo Warehouse

The *ends of the VSM* express customers and suppliers, respectively. The supplier in this case is internal, the production process. The customer was identified as both the end-customer and firm's remote warehouses. As mentioned before, a limitation of the following work is the focus only on the processes concerning the Lonigo plant.

The upstream production process, the supplier, follows the push logic. Production is pushed to the warehouse with a constant flow throughout the day. The daily volume is between 1250 and 1300 pallets throughout the 24-hour period. The average pallet arrival flow in the warehouse is one every 1:56 minutes. While in line with the type of forklift used to empty the conveyors, the optimal TU is 2 pallets, every 3:10 minutes a TU is ready to be handled.

The *overhead arrow* represents a process change to indicate the transition from the pure production area.

In the *receiving phase*, only a limited part of the finished products is directly accessible to the forklift drivers, while the remaining part represents a buffer waiting to be processed in the warehouse. It was equated to a supermarket. In detail, there are 3 picking stations on both roller conveyors, with the total quantity of products to be handled varying according to their length. At F31, between 3 pairs of pallets (i.e 3 TUs) can be picked, while another 3 TUs are waiting. The roller conveyor in F32 has 3 TUs for immediate picking, while another 4 TUs (a total of 8 pallets in forma of 4 pairs) are in the queue.
The transport of the pallet is expressed by the forklift symbol. Since two types of forklifts are used, the optimal capacity expressed in terms of TUs has been specified in the process box of each warehouse operation.

Two operators are assigned to the *unloading activity,* one per roller conveyor. The entire activity consists of checking the integrity of the packages as they approach the roller conveyor, picking up the pallets, scanning with the RFID system, and depositing them in the assigned area in the temporary warehouse, which follows a fixed bin storage organization. For example, line 11 has an entire area - T11 – in the temporary warehouse, which consisting of 4 holds (T11-1 to T11-4). The division into 4 holds is functional to accommodate the production batches on weekends when the transfer operations to external warehouses are not performed, nor the movement to the final internal warehouse, nor the loads.
The average effective C/T of the unloading operation was measured from the time of to the next removal from the conveyor and was 1:47 minutes/TU.

Since the 2 operators responsible for the unloading operation are entrusted with a series of secondary tasks, it was decided to go deeper by applying the WS method. A detailed description will be found in the next subsection (*3.2.2*).

40% of the daily production is immediately transferred, i.e. picked up from the temporary warehouse and loaded. For 60% of the daily products, *sorting* is required. This refers to the activity of moving the product from the temporary area to the final warehouse area. This operation is entrusted to 2 operators and is performed in two shifts daily from Monday to Friday. The operators move the finished products, which have been checked by the quality department, to the designated holds in the definitive warehouse. The average effective C/T was measured from the pickup at the temporary storage area to the next withdrawal and was 4:30 minutes for TU, composed in this case by 3 pallets seen the different type of forklift used.

Finally, the *loading phase* includes both the picking activity and the actual load. In fact, the activity takes the form of a continuous coming and going from the reference storage area to the loading yard. Five operators are employed from Monday to Friday. The average effective C/T for loading a truck with a capacity of 26 pallets is 23 minutes. The effective C/T for picking the single TU (3 pallets) and storing it in the trailer is 3.10 minutes. While the total handling cycle of a truck to be loaded, including travel time, document cheque, escort to the loading dock, and waiting time to open and close the truck trailer is 30 minutes on average.

Each operation was supplemented by a date box summarizing the following information:

- Cycle time (C/T), i.e the time interval in which the operation is completed;
- Operators: Number of people involved in the operation;
- Work shifts;
- Material Handling Equipment optimal capacity.

As far as the information flow is concerned, the use of RFID technology integrated into the SAP management system allows tracking each pallet in real time. In the transition phase from the production process to the warehouse, SAP elaborate the serial data to be included in the TAG of the pallet. In all other operations, the on-board tablet is used in all forklifts to record the change of position or code, for example in case of non-conformity of the product. The electronic information is the predominant one, although the presence of paper documentation still has a significant presence in the performance of various daily tasks.

To complete the mapping process, the timeline includes the total lead time and the total process time. The lead time is the time that elapses from the start to the end of a given process. The process time is the total time required to properly process an item within a process step.

VSM analysis allows the calculation of total value-added time (TVA), which is often associated with total process time, and total non-value added time (TNA). For the calculation of TNA durations, the average stocking time in the definitive warehouse is not taken into account as it depends on the company's commercial strategy. To ensure consistency between operations, it was decided to perform the time analysis by standardising the handling units considered to 26 pallets, i.e. the average number of pallets to be loaded into a truck, the final customer according to the limits established for the study.

Total value-added time is equal to the sum of the durations of the individual value-added activities (VA_i):

$$TVA_{direct\ transfer} = \Sigma\ (VA_i) = 42{:}15\ min$$

$$TVA_{definitive\ warehouse} = \Sigma\ (VA_i) = 79{:}21\ min$$

TNA is equal to the sum of the durations of the individual non-value-added activities (NA_i):

$$TNA_{direct\ transfer} = \Sigma\ (NAi) = 1205{:}16\ min$$

$$TNA_{definitive\ warehouse}{}^{5} = \Sigma\ (NAi) = 1205{:}16\ min$$

[5] In the formula the average stocking time in the definitive warehouse is not taken into account, since it depends on the company's commercial strategy.

3.2.2 Work Sampling results

The activity of unloading the roller conveyors proved to be the most varied in terms of the tasks assigned to the two operators responsible for emptying them. For this reason, it was decided to analyze it in more detail using the WS method (see *Table 10*). Besides the main activity of unloading the roller conveyors, the two operators involved must perform additional secondary tasks: transport the necessary input for palletizing (packages and cartons) and perform the activity of identifying and transporting the pallets for the "Releasing holds" activity.

Work Sampling study	
Title	Task analysis of the "unloading" operation in the Lonigo warehouse.
Objective	Find out how the 2 operators use their working time; calculate the proportion of working time spent on different tasks; compare the time allocation between NVA and VA; investigate potential idle times.
Sample	2 forklift drivers
Type of sampling	Fixed intervals – 15 min interval
Length of study	More than 15 days randomly selected to cover the entire week (to ensure equal representation of each day).
Data collection	Direct observation
Observations	1249

Table 10: Work sampling study

Following the guidelines presented in the above section (*CH. 3 - section 3*.1.2), the practical process was substantiated as follows:

A. The first step was to observe, with serial Gemba Walks, all the activities in which the subjects were involved. The individual activities were listed and classified into the 3 categories: VA, NVA and NNVA. Criticality in the sense that the warehouse activities do not add value to the product implied an ad-hoc categorization. A deliberate simplification was chosen by categorising the activities on the basis of non-exception and change in fiscal and temporal status of the pallets. The full categorization can be found in *Appendix 02*.

   Ways of monitoring have also been tested. The importance of adequate access points is related to the need to immediately flag the activity in which the operator is involved. Two access routes were identified. The first was in the middle of the 2 roller conveyors in direct view of the work of the 2 operators. The second, to ensure greater randomness in the observations and to prevent changes in the work of the observed subject, was a lateral access. *Table 11* shows the main parameters and information of this stage.

Roller conveyor unloading - WS Pilot		
Liv. confidenza	95%	
α	5%	
VA + NNVA	51,5%	**0,48544**
NVA	48,5%	
No. of estimated observations		**1696**
Monitoring		**848**
Routes		*Door packer - A* *Door Canteen - B*
Intervals (min)		**15**

Table 11: WS - Pilot with identification of instantaneous observations to be made, routes and time intervals.

B. Continuous tests were conducted to determine the sufficient number of observations to produce a statistically significant result. *Table 12* summarises the key data.

SAMPLING SYNTHESIS			
Roller conveyor unloading - Work Sampling study			
Liv. Confidence	95%		
α	5%		
VA + NNVA	42,6%	p - Pilot	**0,485**
NVA	57,4%	p - Real	**57,4%**
No. of estimated observations			**1696**
No. of current observations			**1249**
r - test		0,04874668	**OK**

Table 12: WS inclusive summary of sufficient observations and the accuracy test result.

C. In the final phase, data processing and analysis, the results were ordered according to the Pareto principle (law 80/20) (see *Table 13* and *Figure 15*). Thus, the proportion of time spent by the 2 operators on the complete execution of the roller unloading operation, i.e. including the secondary tasks, was measured in relation to the total working time of the shift.

	Activities	Tot Obs.	%	Min	Pareto
NVA	Pallet handling to temporary	222	18%	80	18%
NVA	Empty trolley movement towards roller conveyor	219	18%	79	35%
NNVA	Pallet pickup from roller conveyor	131	10%	47	46%
NNVA	Pallet storage in temporary area	96	8%	35	53%
NNVA	Movements for "unblocking holds".	87	7%	31	60%
NNVA	Pallet storage on the ground - roller conveyor area	57	5%	21	65%
NVA	Picking up pallets from the ground - roller conveyor area	57	5%	21	70%
NVA	Pallet Handling to Non-Compliance Areas	55	4%	20	74%
NNVA	Transport of input	48	4%	17	78%
NVA	Partial load handling	38	3%	14	81%
NNVA	F31 and F32 employee cross handling	35	3%	13	84%
NVA	Waiting	35	3%	13	86%
VA	Activities on the tablet on board	33	3%	12	89%
NVA	Empty trolley movement from roller conveyor	32	3%	12	92%
NNVA	MD56 compilation - Packaging non-compliance	23	2%	8	94%
NVA	Intercross along roadways	23	2%	8	95%
NVA	Break	18	1%	6	97%
NNVA	Lunch break	14	1%	5	98%
NVA	Temporary to permanent handling	12	1%	4	99%
NVA	Call the packer	6	0%	2	99%
NNVA	Forklift change	5	0%	2	100%
NNVA	Move to battery room	3	0%	1	100%
	Total	***1249***	***100%***	***450***	

Table 13: Analysis of WS results in terms of time spent on tasks

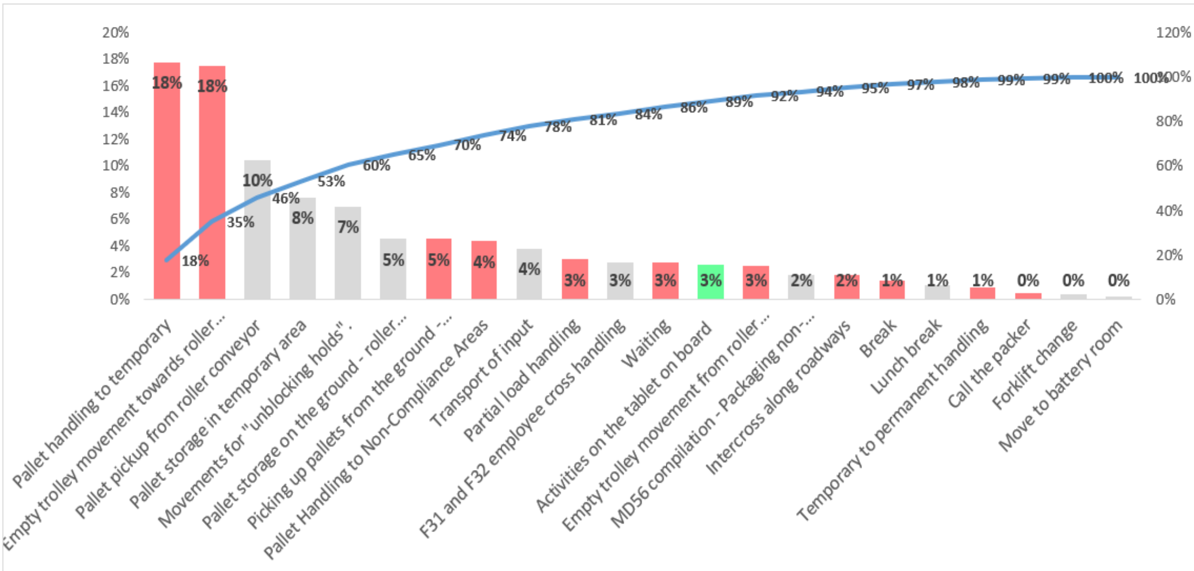


Figure 15: Graphical representation of WS results according to the Pareto principle

Based on the results (see *Figure 16*), the percentage of NVA is 57%. Taking into account the admitted relative error degree of 5%, it can be estimated that operators perform activities that can be defined as not-value adding in a range between 54% and 60%. However, we would like to point out once again that the classification of activities in the warehouse required an ad hoc formulation according to the specificities of the Lonigo plant. The percentage, in total, of VA and NNVA is 43%.

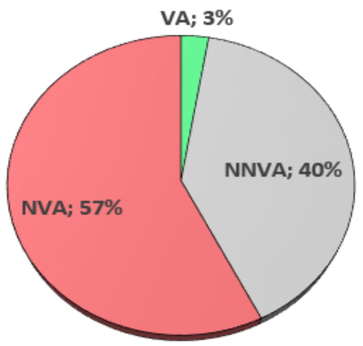


Figure 16: Distribution of observed activities based on VA, NNVA, and NVA classification

From a rapid analysis, it appears that the activities that take the most time for the two forklift operators is handling the product towards the temporary storage areas. The data shows how the operation is performed in a *simple cycle*, i.e. for 50% - outward journey - the forklift is loaded, the other 50% - return journey - the forklift is empty.

Among the non-value added items, waiting times/breaks and management of non-conforming products have the biggest impact on the time shares. In particular, the management of non-conforming products includes both the transport of the product to a specific area - the so-called "Blocking hold" phase - and the subsequent transport to the control area upon request of the controllers - the so-called "Releasing hold" phase. It has been observed that this activity involves various downtimes ranging from direct dialogue with controllers, searching for pallets with the required IDs, handling required for release and finally transport to the area due to control.

In detail, the following results can be traced for what concerns the complete operation of UNLOADING the roller conveyors:

- Deadheading for simple cycle [18% / 450 min] 80 min / shift
- Third activities carried out by the forklift drivers:
  - Total time for Quality checks ("warehouse p.v") 58 min/shift
    - Blocking Hold phase (4%/ 450 min) 27 min / shift
    - Releasing Hold phase (7% /450 min) 31 min/shift
  - Trasport of other input (4%/450 min) = 18 min/ shift

3.3 PROBLEMS HIGHLIGHTED

An immediately apparent obstacle to logistical flow in Lonigo Warehouse is the passage of finished goods in the form of batches through an intermediate area called temporary warehouse. Consequent and obligatory double handling occurs.

The problem of multiple handling is also exacerbated by the processes for dealing with quality issues, both product and packaging. In the quality control of products, as part of the process called "Releasing Holds", there are inefficiencies in terms of the time taken to clarify the IDs of the pallets to be controlled, their identification in the TQ-MENSA area, their transport to the control area and post-processing management. Overall, finding the required IDs is certainly the most time-consuming activity, as the forklift operator has to get out of the vehicle and identify the required IDs by visually consulting the pallet labels.

For packaging quality issues, there is a low level of standardisation in both the reprocessing and reconditioning processes. The first process refers to the re-palletizing of the bottles and the subsequent packaging of the pallet. The second process, reconditioning, involves removing the existing packaging and applying a new one. The main criticisms of both processes are the multiple handling, the waiting time of the pallets for the code change (from 51Y to 51) and the inefficient use of the reserved spaces - T_RICOND - for the pallets to wait for the code change. Interviews with the packaging manager revealed that an additional staff member facilitates the management of both processes and, in the case of products still in production, bypasses the compilation of paper forms, the MD56, confirming the presence of a non-compliant pallet for packaging in the warehouse. This compilation implies a forklift driver stop of 7 to 10 minutes on average.

On the equipment side, when inefficiencies were mentioned, the common variable was often the RFID system. Considering the new implementation - in 2019 - the presence of system errors, as well as the breakage of the antennas required to read the TAGs of the products, encourage improvised solutions in the management of the various operations. In the unloading operations, it was observed that the functioning forklift tended to read all the tags on the two roller conveyors, while the trolley with the non-functioning system carried out the movements to the temporary storage areas. During the sorting operations, i.e., moving the pallets from the intermediate storage area to the final storage area, the operation is performed by filling out a paper sheet certifying the movements. At a later stage, the data must be entered manually to match SAP with the physical storage situation. Another consequence that emerged from the interviews was that the average loading time of a truck deteriorated by 5 minutes for purely technical reasons. In addition, several malfunctions of the RFID devices occurred during the observations and the lack of a viable solution led to several handling manoeuvres.

The current layout, which is closely related to the physical characteristics of the warehouse, and some custom storage methods are sources of inefficiency.
The layout is constrained by the structural pillars of the facility and the low height. This is due to inefficiencies in the number of pallets each hold can accommodate, as there are on average 5 rows of finished goods. Considering that the equipment used in the warehouse carries pairs or triple as optimal HUs, the need to perform additional handling is obvious. In the activity of picking and loading, at least two maneuvers are required to form the transportation unit - 3 pallets (2+1), in order to saturate the capacity of the vehicle and reduce the number of trips, and in the unloading activity, the forklift drivers must set down the pallets and form the last row, the fifth, by inserting one pallet after another (2+2+1).
It was also found that there is a lack of space saturation in the intermediate warehouse due to the fixed (or dedicated) storage policy. Here, a whole wing of the intermediate area is reserved for 3 production lines whose maximum peaks do not saturate the capacity of the reserved space. Considering that the main feature of the fixed storage policy is to allocate a product, in the following case the output of the production line, to the same area, the excess space is a source of waste as it is chronically unused.
In final warehouse, the wastage of space is due to what is known as "lot separation", i.e. a customized type of storage. Lot separation involves a physical space to separate batches of product that are stored in the same hold. Apart from not utilizing the available space, this method poses safety risks due to less stability of pallet stacks.
In terms of space utilization, it was found that section D of the final warehouse, which is characterized by double length compared to the standard of the other storage spaces, has difficulty to rotate. The same conclusion was found in several interviews with employees as well as managers of Verallia's logistics department.
As far as the volumetric use of space is concerned, a great criticality was observed in the packaging warehouse, where the products are stored horizontally on the floor and the available cube space is not used.

Finally, the saturation of the storage area proved ineffective for the management of the so-called "Small Lots". This is an area for the pallets of leftover stock that still remain in the warehouse and occupy a full hold. Its finality is to free up the hold space of the final warehouse. An analysis carried out on the SAP platform of the company showed the presence of products otherwise assigned to the respective lots in remote warehouses, as well as non-conforming products that have been sitting around for a long time. The organization of this space usually entails making extra movements in order to be able to pick up some of the pallets, which usually results in the operators not performing the maneuver and not respecting the imposed FIFO, which means that priority should always be given to the older lots.

3.4 SUMMARY OF THE CURRENT STATE

Mapping the process in the warehouse requires a different mindset. Mapping is not performed on a production process, but on a warehouse process, which by definition does not add value to the product because no changes are made to it.

The main problems that emerge from the analysis of the current state of Lonigo's warehouse can be traced back to both the physical organisational structure of the spaces and the working methods. It is worth mentioning the blockage of the flow of materials caused by the presence of a temporary warehouse. Space, a precious resource in the warehouse, is undermined by problems related to storage methods that need to be updated and by a necessary review of the layout, which is strictly dependent on an old structure that is not in line with current production processes. The lack of standardisation has been observed in several processes, the most important being the process of reprocessing and reconditioning in terms of direct impact on the warehouse and its operations. Finally, the execution of operations with simple cycles, interruptions for technical reasons, such as the malfunction of the RFID system, and the addition of secondary tasks to the main ones, such as the management of non-conforming products, which was observed as a demanding activity from the management point of view, are sources of waste and lower performance results.

Ch 4: WASTE ANALYSIS

4.1 WASTE IN THE WAREHOUSE

The improvement process proceeds through progressive elimination of waste (Womack and Jones, 1990). Martin et al. (2013) distinguish between two types of waste. The first type is non-value added activity, also known as pure waste; it refers to activities that do not add value to the customer and are not necessary as supporting activities. Such waste should be eliminated immediately. The second type of waste is necessary non-value-added activity; it refers to activities that do not add value to the customer but are necessary for the company to continue doing business. The goal is to reduce it as much as possible if the work system cannot be changed.

The following seven sources of waste are identified in lean manufacturing: Overproduction, Transportation and Material Handling, Waiting, Motion, Inventory, Overprocessing, Defects. Add to these an eighth source: unused employee creativity. Similar to manufacturing, Bozer and Britten (2012) talk about the seven muda that lean management seeks to eliminate in the warehouse. In *Table 14,* wastes are framed in the perspective of the warehouse and the main effects and the ideal state are assigned.

Waste	Readjustment meaning in warehouse environment	Effects	Ideal status
Inventory	Any situation that leads to excess inventory and freezing of the company's assets, or stock-outs and non-optimal use of space.	High storage level, lower workers productivity	Reduce stock & buffer level to JIT
Transportation	Unnecessary movement of products, workers and MHE. Driving an empty forklift.	Labor costs and risk of damage	Minimize the distances
Waiting	Forced wait times due to unavailability of products, machines or system errors. Bottlenecks and queues in the process.	Underutilization of resource available capacities	Continuous flow, eliminate bottlenecks
Overproduction	Perform more or ahead of customers' requirements.	Long lead time	Pull system
Defects	Includes activities caused by rework due to handling and shipping of defective, damaged, mislabeled or misbranded products, errors, inventory discrepancies, or missing materials	High costs	Zero defects

Overprocessing	Using complex solutions for simple tasks; performing unnecessary steps such as labeling and inspection, moving products By more than one forklift.	High costs, low usage of resources	Follow the customers demand
Movement	Interrupting movement such as staging product before putting them away; Unnecessary movements when trying to locate equipment or products.	Poor performance	Reduce NVA motions
Underutilization of resources	Ignoring employee creativity and knowledge and overengineering a process.	Poor performance	Continuous improvements

Table 14: The 8 wastes of Lean in the context of the warehouse (source: author)

4.2 ROOT CAUSE ANALYSIS

If the deep-rooted core of the problem is not addressed, it is likely to recur (Sobek and Smalley, 2008). Therefore, at the base of any improvement process, a clear distinction must be made between the concept of "effect" and "cause".

In practise, an obvious cause is rarely the trigger (Sobek and Smalley, 2008). This also implies that the location of waste may be different from the location of discovery. Improvement investigation must go into detail until the point of origin is traced.

In analysing the root cause, there are some important points to consider, which are listed below:

- Be sure to present the cause of the problem(s) identified as it is.
- Separate symptoms and opinions from cause and effect identification.
- Consider what techniques are most useful to explain cause identification: 5 Why's? Fishbone analysis? Other?
- Identify what tests need to be performed to obtain some degree of certainty about cause and effect.
- Summarise the key findings of the root cause analysis, visually if possible.

At the group level, Verallia uses an RCA model inspired by the well-known 8D problem-solving model. It takes the form of a bilateral analysis, customer and supplier side. Experimental testing of each identified root cause and implementation of efficient solutions in standards are among its key features. The only concrete limitation found in the company's model is its standardised nature, which is extended to all problems, for example, without a real distinction between problems in production and logistics. In fact, the RCA model used follows a strong orientation towards analyses related to the production process. Also in this respect, discussions have started on adaptations to differentiate the models and make them more suitable for the scope of the analysis.

4.3 WASTE IN THE LONIGO WAREHOUSE

The critical problems raised in CH 3 - *Section 3.3* are the result of field observations and analyses conducted using the current VSM and WS results. In this section, the problems are condensed according to the Lean waste classification, see *Table 15*.

Type	Muda	Root CAUSES
Transportation	Excess travel	Truck handling method with escort to loading area.
	Deadheading	Operations carried out with simple cycles.
Underutilization of the resource - space.	Low space saturation index	"Lot separation" during storage.
		Oversized areas: "Small lots" area, T16 /T20 in temporary warehouse and section D of definitive warehouse.
		Underutilization of volumetric storage space in the packaging warehouse area.
Over-processing	NC management	Lack of a fixed management standard
Over-movement	Double Handling	Multiple movements to release pallets both during Non-Conformity process checks and for loading operations from "small lots" areas.
		Pallet arrangement for complex layout.
		Sequential operations.
Waiting	Forced stop and underperforming MHE	Technical problems caused by the RFID system
		Lack of resources for fast MHE replacement

Table 15: Waste in the Lonigo warehouse

In order to find out the sources of waste an 5W analysis was performed (see *Appendix 03*).

In some cases, the muda analysis revealed that the source of the waste is in another district but has an impact on the warehouse. An example of this is the activity of reprocessing and reconditioning. Because they follow a non-standard process, they create the following inefficiencies in the warehouse: disruption of the activity of at least one operator responsible for emptying the roller conveyors to bring the pallets to the production area. The irregularity of the process also generates the saturation of the areas reserved to receive non-conforming

products, which is in fact an obstacle when other products are to be placed there. This often leads to the need to identify a new temporary storage area for new pallets to be reprocessed or reconditioned, such as areas for "small lots". The result is a constant blocking of the flow, accompanied by repeated unnecessary movements.
Checking at different times also means that warehouse workers have to arrange for the creation of a paper document - MD56 - to be attached to the product. This takes an average of 7 minutes. From the interview with the person in charge of the packaging area, it appears that the use of the paper model is not applied in cases of immediate reconditioning of the product, which is not common today due to the lack of manpower.

4.3.1 Waiting time

As of 2019, the RFID system - radio frequency IDentification - has been integrated into the management system SAP. Despite the benefits in terms of management, both in the interview with the site manager and in the discussions with forklift drivers, RFID is a common variable that is the cause of various inefficiencies. Specifically, performance is significantly impacted by malfunctions of the associated readers. The unavailability of spare devices for the activity of unloading the roller conveyor, also considering the different type of forklifts used, is often the cause of delays related to the need to read the RFID tag on the work vehicle and then let the other complete the activity. While in the movement phase there is the need to fill in a paper form to witness the movement, the data must then be manually entered into the system.

Also, with the introduction of the RIFD system, the entire administrative system revolves around various identification codes - 51, 51Y, 01, etc. Only code 51 allows direct spendability with the forklifts equipped with RFID antennas, while code 01 is output capable but without traceability through the RFID system and therefore SAP. As a result, in the event of anomalies, clarification calls are made and the forklift driver remains in the waiting loop as he has to go through 2 figures - the site manager ROL and then the logistics manager Verallia - and cannot complete the activity.

Another cause of waiting time is the irregular flow of trucks to be loaded, resulting in uneven distribution of trucks and therefore work. Although the company provides a booking system, there are no penalties for not meeting the deadline. Therefore, delays are commonplace.
Finally, some sub-processes, such as reprocessing and reconditioning, are usually carried out at times other than current production, which requires the completion of paper forms, MD36

or MD56 relating to the quality of packaging. On average, the forklift operator must stop for at least 7 minutes to do this.

4.3.2 Over-Motion

Multiple handling is a chronic phenomenon within the warehouse. On average, a pallet in its optimal state passes through 5 touches - from picking from the roller conveyor to loading. The origin lies in the existence of a temporary storage for the finished product. This is wasteful as it stops the flow and leads to chronic double handling. However, it is now essential to deal not only with quality defects, but also to organize transfers to remote warehouses.

Sequential processes, such as pallet rework, where pallets pass through a temporary area while waiting for code, are an example of additional double handling in the form of waste. Here, for technical reasons, pallets are stored in the *T-Ricond area* after rework, waiting to be coded from 51Y to 51 by a Verallia manager. From the interview with the warehouse manager, "the function of changing the code was removed from the forklift drivers' duties" to avoid errors. On the other hand, product handling times and touches increased. As a result, these pallets go through several movements, often more than 8 touches.

Finally, Double Handling refers to the management of stocks of lots located in small areas called "small lots". The location in relation to the layout often determines the need to move them to get to the products of interest that may be in the back and not accessible.

4.3.3 Transportation

The complete use of simple handling cycles in both unloading and sorting operations. A simple cycle is an inefficiency related to the fact that loading is done in one direction only, while the return trip is done with an empty vehicle. Since the Lonigo warehouse has an L-shaped structure and the surrounding areas of the warehouse are used for outside storage, mainly for products to be tested, an empty return trip from a remote area is a waste, especially if this trip can be occupied with orders for products to be reprocessed and/or reconditioned.

The lack of preventive communication systems for NC products still on the roller conveyor means that at least 2 transport operations must be performed, towards the storage area and then back to the area reserved for pallets for quality control - TQ Mensa. This scenario is repeated every time an MD18 is issued, as the pallets from the same line that are already on the roller conveyor are part of the “Blocking hold” process, but due to lack of prior information, they are transported together with the rest of the batch. Only then are they picked up and transported to the pallet handling area for inspection.

Another cause lies in the management system of the trucks to be loaded, where the forklift driver drives an average of one empty cycle to pick up the truck from the parking area inside the plant, check the documents, and escort it to the loading dock.

4.3.4 Underutilized - resources

During the sessions of Gemba walk it was immediately apparent that the holds in the final warehouse were not saturated. The source was identified in a sort of custom storage method known as "lot separation", which involves separating batches of products stored in the same hold by means of a physical space.

The underlying cause is the pre-RFID management system, then also justified as an element to accompany the implementation of the new system.

Equated to the “honeycomb effect", the system SAP, integrated with the real-time information provided by RFID technology, was used to test the space lost by this method, which, converted to pallets, corresponds to more than 1000 pallets, i.e. 4 whole holds, which are otherwise stored in the warehouse, thus avoiding the transfer to remote warehouses.

Space, the scarcest resource of a glass manufacturing warehouse, was found to be inefficiently used at least 3 times. The management of packaging storage space, without optimal volumetric utilization. Products, in the form of raw materials - naylon and cartons - needed for pallet packaging, are stored on the floor. The result is inefficient horizontal expansion at the expense of vertical space that would otherwise be unusable. Then there is the storage section D formed by long and slow-moving holds.

Finally, the side wing of temporary space - T16, T19, T20 – resulted to be disproportionate compared to demand in the normal state. The average space saturation on a monthly basis, over an annual time frame, is only 85%.

4.4 SUMMARY OF MUDA

The problems in the warehouse described in Chapter 3 have the limitation that they are both causes and effects associated with certain inefficiencies. Therefore, a root cause analysis must be performed. After classifying the eight muda presented in the Lean model and adjusting their meaning to better reflect the warehouse environment, a number of waste were discovered to affect efficiency and effectiveness in managing warehouse operations at the Lonigo plant. Specifically, the muda analysis uncovered the following waste: waiting times, excessive movements, inefficient transportation, and underutilization of space. *Appendix 4* shows the VSM supplemented by the summary kaizen bursts of the main wastes in line with the reference operation. Below this, the Ishikawa diagram reflects the wastes and their causes, see *Figure 17*.

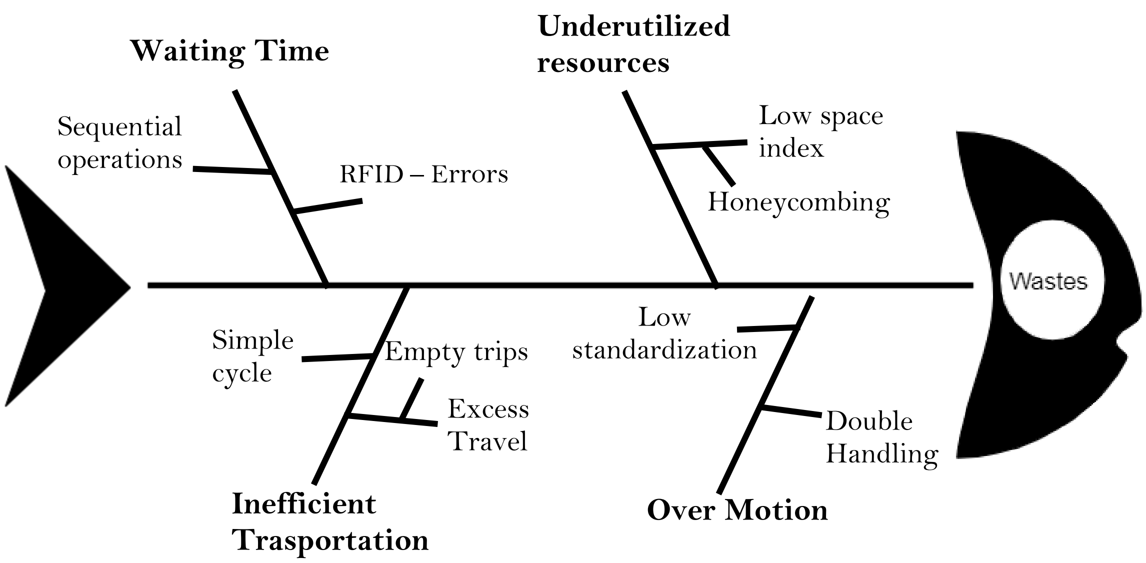


Figure 17: Ishikawa diagram summarizing the muda in the Lonigo Warehouse

CH 5: AREA OF IMPROVEMENTS

5.1 IMPROVEMENT GOALS

The aim of the project was to find solutions that could be implemented quickly and had a low financial impact. The defined objectives, also against the background of the inefficiencies identified, are to increase the productivity of operations in the warehouse and the efficiency in the use of the resource - space.

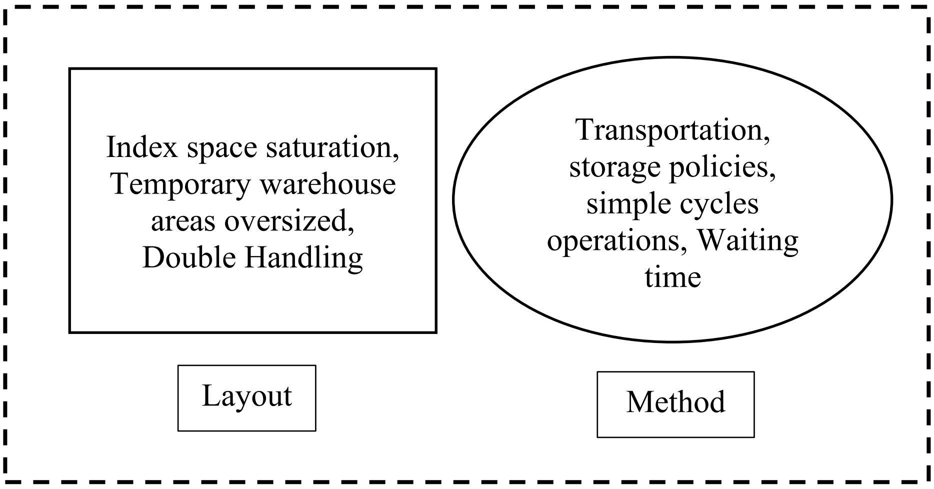


Figure 18: Affinity Diagram

Using an affinity diagram and brainstorming, see *Figure 18*, the areas which appear to have the highest potential for improvement are the *layout* and *method*. As they are functional to the improvement project and meet the objectives of rapid implementation, a series of countermeasures are presented aimed at improving the layout and changing the methods in place in the warehouse.

5.1.1 Countermeasures: Layout optimization

Redesigning the layout of the warehouse is a recurring theme in order to streamline the processes carried out, as this affects operations, overlaps between different activities, movements and withdrawals. According to Smith (2007), a proper layout allows maximizing the use of space, equipment, labor, level of accessibility and protection for all items in a warehouse.

The Lonigo's warehouse facility is obsolete, with a design volume far below current material flow. The clearest example is related to the need to transfer approximately 40% of daily production to remote warehouses, which is a large budget item in the logistics cost category.

The existing layout of the warehouse is closely related to the structure of the facility, limited by regular structural pillars spaced 6 meters apart (see *Figure 19*), and from a varying height, typically around 5 metres in the temporary warehouse, with peaks of 7 metres in the definitive warehouse.

Figure 19: Width between columns, 6 mt., and height 5 mt. in the temporary warehouse, 7 mt in the definitive warehouse

The resulting hold are inadequate for both the storage and the picking and loading processes. In fact, using forklifts with an optimal transport capacity of 2 pallets for emptying the roller conveyor and with 3 pallets capacity in the case of splitting and loading operations, replenishing or clearing out a hold that includes five vertical rows of product is impractical either way.

The first point of recommendation concerns the layout design of the temporary warehouse, which is per se a form of waste in the sense of disrupting the flow through double handling. Since eliminating, or at least act on the material flow in the area, was not a viable option, it was decided to exploit the use of the space.
The side area - T16, T19 and T20 - of the F32 – temporary warehouse is disproportionate to the actual storage needs, see *Figure 20*.

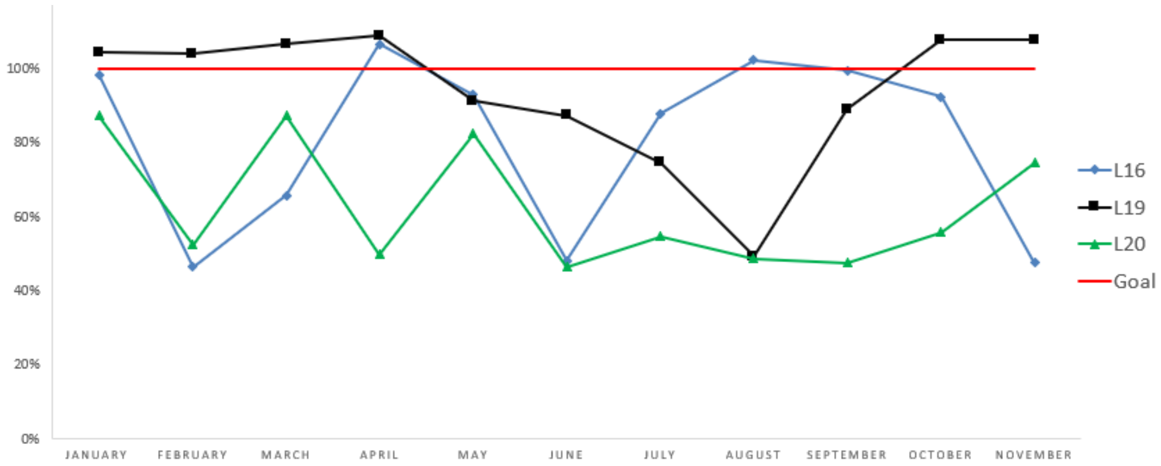


Figure 20: Graph showing saturation of dedicated storage areas by production peaks on a monthly basis for lines L16, L19, L20 in 2020.

The red line expresses the maximum capacity of the hold, 190 pallets for all three, while the other lines express the maximum monthly production peaks per line - L16, L19 and L20 - resulting from the production program. This approach to the analysis is related to the storage method used throughout the temporary warehouse - the *fixed (dedicated) storage* policy. In other words, the output of line 16 always goes to bin T16 and so on. This storage method is known for less efficient use of space because its rigidity.

The graph summarizes the trend in 2020, but overall even in 2019 and 2018, the space saturation for T16, T19 and T20 is on average below the maximum capacity (red line). In particular, it can be observed that production line L20 almost never saturates the optimal capacity for the entire duration of 2020, resulting in an obvious waste of space.

Figure 21: Example of unused space in the T16, T19 and T20 wing of Temporary Warehouse - F32

The trend shown by the whole wing of the F32 temporary warehouse area opens the solution to reduce the considered spans. Consequently, given the proximity to the D holds, the recommendation is to use the excess space to form a new roadway, which would allow the D holds to be halved. This would not only allow for greater rotation of D holds, one of the problems emerged by interview, but also to manage the greater variety of products resulting from the new trend - flexible production[6] - being driven by the Verallia Group. This inevitably leads to a greater variety of products to manage, and therefore of spaces needed for storage.

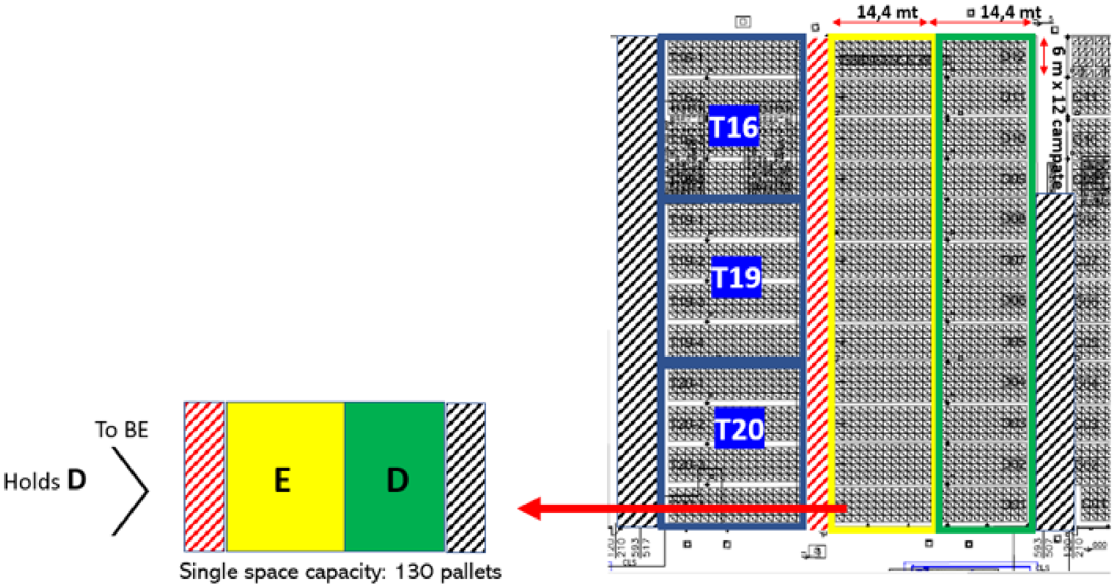


Figure 22: Revised layout of F32 - temporary warehouse and holds D.

The *Figure 22* shows the layout revised according to this new concept. The reduction of the intermediate storage areas - T16, T19, T20 - allows for a new transit route (red line). Area D, which was divided into 2 areas, is renamed Area E and D. The new access route also represents an advance in terms of the accessibility index[7], thus making the warehouse potentially more flexible, also in view of multiple access point for what concern the potential control for quality defects. In other words, the benefits relate to fewer stock transfers, and the increased rotation would ensure greater saturation of the warehouse - today the prerogative of logistic. However, it is worth mentioning that the reduction of the spaces of - T16, T19 and T20 - can lead to organisational complications under overtime conditions, as the capacity drops from 190 pallets to 160 in each space. The new

[6] Flexible production is realized through a significant increase in the number of mould changes, and therefore in the number of references produced. Today, about 15 mold changes per week are implemented.
[7] The accessibility index (AI) is an indicator of the accessibility of products without having to move other material. The closer it is to 1, the better the accessibility.

accessibility route, given the lack of a direct exit point, increases the distances traveled for storage.

In terms of layout, also reconfiguration of the packaging storage area is a second priority, especially if products can be stored in the volumetric dimension.
In this sense, a vertical rack would free up a space suitable to hold about 300 pallets of finished products (see *Figure 23*).

Figure 23: On the left the current situation of the packaging warehouse, on the right an example of a vertical rack

AS IS	TO BE	Δ
The layout of zone T16, T19, T20 of the temporary warehouse has structural imbalances. Section D has slow rotation due to its high dimensions.	Area D is segmented into 2 areas, a new accessibility route resulting from the reduction of the - T16, T19, T20 - wing.	Higher accessibility index; better saturation index; addressing greater production variability.
Lack of volumetric space utilization in the packaging warehouse area.	Install a wall rack for vertical storage.	Storage space freed up: + 300 pallet

Table 16: Summary of proposed countermeasures related to the Layout

5.1.2 Countermeasures – Method optimization

As for methods, they are often not adapted to the new storage conditions. For example, many inventory management practises did not change, even though the amount of defective product dropped dramatically over time. From an average of 200 MD18 per month to 60 at present.

The first method to be analysed, which leads to a great inefficiency in terms of space utilisation, expressed in a saturation index of about 85%, is that of "lot separation". This current storage method in the definitive warehouse is based on the physical separation of lots in the same hold, with space generally visible through half-empty walls (see *Figure 24*).

Figure 24: Pyramid structure with incomplete walls due to "Lot Separation"

Used in the pre-RFID era, and to some extent in the transition to the new system, this storage method is now proving to be completely inefficient in the use of the space as a resource.
To demonstrate the impact in terms of lost storage space, a similar procedure to the *honeycomb effect*[8] test was used. The use of the *median*[9] as a statistical estimator was chosen due to the impossibility of comparing the quantity of products in real time and the presence of a large number of products in the hold. Also due to the risk that some storage bins in the platform SAP, were not updated in real time.

[8] Honeycomb effect is the empty space that results by storing only one item in the storage area. Honeycombing most often occurs as cases or pallets are removed from the storage area.
[9] The median, in statistics, is the value separating the higher half from the lower half of a population.

	Total	Median	No plts missing		
Section A	6874	88%	857		
Section B	4963	84%	815		
Section C	2246	79%	481		
Section D	3680	88%	460		
	17763		2614	15%	Capacity lost due to "Lot Separation"

Figure 25: Results of the test on the average saturation of all 4 storage sections of the definitive warehouse.

The test results (see *Figure 25*) showed an average utilization of 85% of the storage capacity, taking into account all storage units in the final warehouse. Even though the saturation level is theoretically at a level considered excellent for managing warehouse space, the criticality at Verallia SPA is related to the reasons for implementing the RFID system. On the one hand, there was a desire to automate processes and thus avoid human errors more and more, and on the other hand, there is an immediate need to make the best use of all the spaces, which is why the use of a technology based on radio frequency was ideal.

The analysis carried out shows that this storage policy leads to a difference of more than 2000 pallets in relation to the maximum capacity of the 4 sections of the final warehouse. From the moment that maximum saturation is an ideal reference point, subsisting always conditions of non-saturation, it was conservatively agreed to certify the loss to an equivalent of 4 whole holds of the final warehouse, i.e. more than 1000 pallets.

It is also clear from the interviews that the use of this method is the cause of safety related criticism. Stacking pallets according to pyramid structures, where some walls are missing, leads to lower stability and causes some collapses in the summer season. At the flow level, the formation of separations between products increases the effective C/Ts by an average of 30 seconds per HUs pallet moved, when the first wall in the pyramid structure is formed after a new lot is transported.

While eliminating gaps created by the “lot separation” storage method made it easier to count inventory. The main drawback is the loss of physical traceability of the products, so the RFID system must work perfectly.

Precisely related to this last aspect is the concern about the loss of valuable data, such as the location and integrity in the pieces of the batches. It was decided to introduce a visual system in the form of a label, see *Figure 26*, that is quick to apply and non-invasive. The label, which is attached to the outside of the pallet stack, is not only able to track the start of the batch, but also provide approximate data on when the block will be disassembled if there are quality issues or during loading operations.

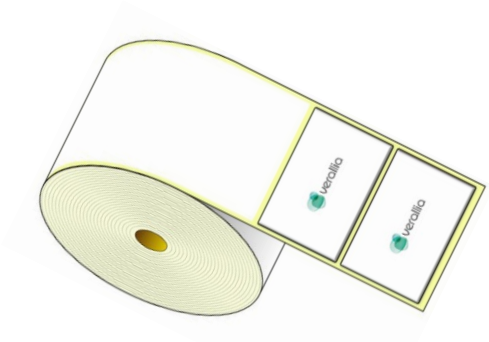


Figure 26: Adhesive labels with the logo Verallia

A second countermeasure concerns the method to manage the nonconformity code 51Y. Although quality is not the responsibility of logistics, it represents a significant inefficiency in the warehouse environment, both in terms of material flow and space requirements.
Below, see *Figure 27*, is the flow of the pallet reconditioning process that requires code 51Y to be changed to 51. Please note that the latter indicates a final product suitable for shipment while in the first one the symbol "Y" denotes a non-shippable product that needs reworking.

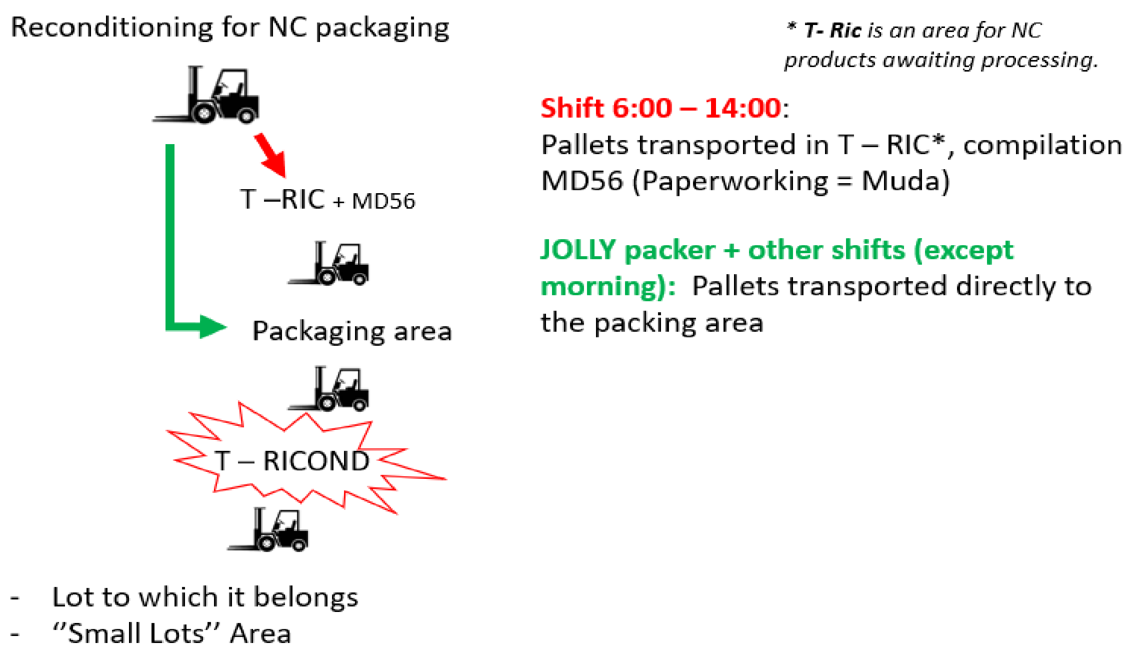


Figure 27: The operational flow in the reconditioning process

Interview with the packaging manager revealed that pallet reconditioning is not done on morning shifts, forcing logistics staff to fill out the MD56 model for all the non-conform

pallets. Paperwork is a form of waste; on average, it takes the forklift operator 7 to 10 minutes to fill out the paper template and attach it to the reference pallet. The exception comes into play when there is a jolly packer, but this is rare given the scarcity of human resources.
When the reconditioning process is complete, the pallet retraces its route on the roller conveyor and, once it returns to the warehouse, it is picked up and transported in the T_RICOND area for the Code Change step, as is the case with all post-control processes for quality-related causes. At the quality manager level, interviews revealed that checks are performed generally, not just in the designated area. From a Logistic p.v, the area T-Ricond is only useful for organizational reasons, since code 51Y cannot be dispatched and could hinder the process. However, it is also evident that in the warehouse, the T-Ricond area is often used as a temporary storage area for later processing, even though the area designated for the product has already been communicated.
To allow immediate movement near the batch to which the item belongs or the reference location for the item. It was decided to standardize the code transition as well as the overall management of the non-conforming codes with more regular procedures. It was observed that the non-conforming codes were remaining for long periods of time in areas reserved for other purposes, such as "small lots", which was both a form of encumbrance and a blockage to the normal flow of stock. This led to the proposed countermeasure of bypassing the T-Ricond area and restricting the "small lots" areas by approximately 50%, both as a means of maximizing space and as a greater incentive to control. It has therefore been agreed that 2 weekly inspections will be carried out to check Non-Conformity Codes and to suggest solutions to the site manager in time for the necessary interventions to be made. In other words, the countermeasure is related to the communication, therefore to the information flow, between the quality managers and the warehouse managers.
Integrative to the solution proposed above, in order to reduce human error, it is recommended that greater attention be paid to adequately training operators in the management of the various codes, although the interviews showed that this depends more on field experience than on adequate training plans.

Monitoring FIFO and combining cycles are other proposed methodological solutions. Combining cycles must be properly enforced whenever there is movement in a particular area of multiple interest. As an example, the two forklift drivers responsible for splitting can combine their cycles with the transport of the other inputs (nylon, cartons, etc.), since they drive near the packaging warehouse for most of the return trips, as well as for the non-conforming products located in the back of the warehouse.

The last recommendation refers to the inefficient method of managing trucks during the loading phase. Up to now, the practice has been for the forklift drivers to physically go to the stop area (for more details, see *Figure 28*) to handle the next truck after finishing a load. As the loads follow the FIFO logic, the loaded products are mainly in the definitive warehouse, which forces truck drivers to travel long distances to reach the STOP area. The operator is responsible for checking the loading document, identifying the most convenient loading point via SAP and, finally, physically accompanying the truck to the final point. This management method, in addition to the low level of ergonomics, presupposes considerable average empty distances covered daily. To give an idea, as illustrated in figure 28, the average empty distances travelled per single loading operation range between 250 and 400 metres. The same situation applies to all 5 operators who perform the loading function. The truck volumes to be handled with products located in the definitive warehouse, therefore with the loading stations furthest from the stop zone, vary between 20 and 25 trucks daily.

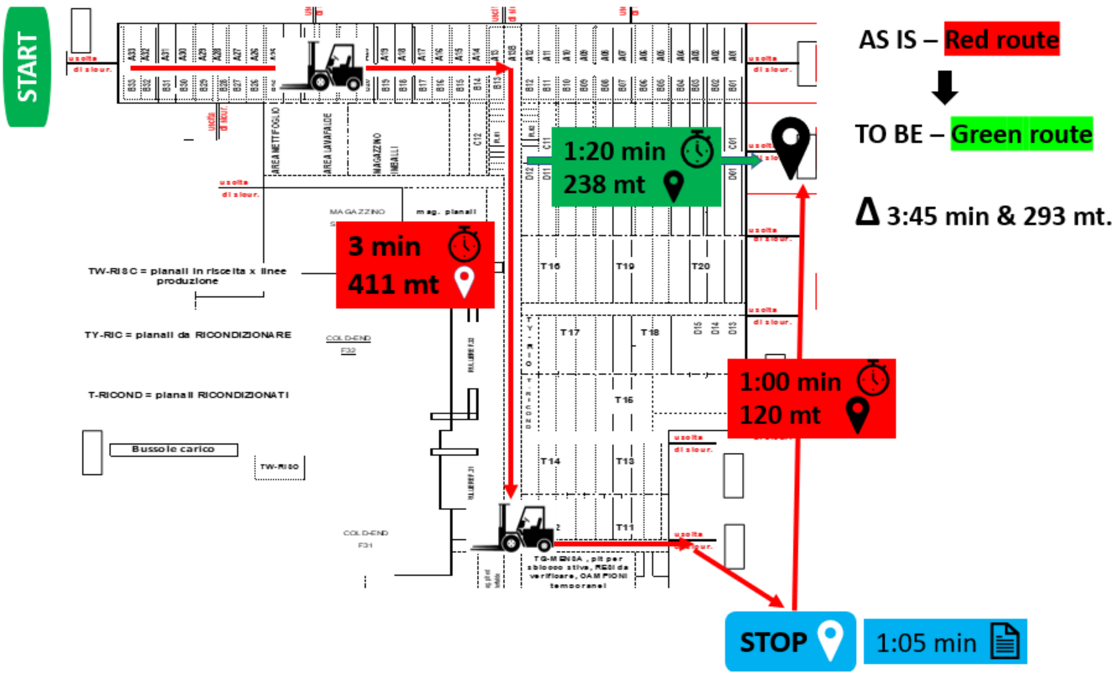


Figure 28: Current method of managing the flow of trucks to be loaded

The *Figure 28* shows a typical loading situation in the most remote part of the warehouse where a loading bay is positioned. When the operation is complete, the forklift driver travels empty to the STOP area to process the next truck to be loaded. Together with time required to consult the loading documents and the subsequent accompaniment of the truck to the pre-established lay-by constitute waste in the form of trasporation, waiting time and overprocessing. Those emphasise the need to review the management method. One recommendation is to make the process electronic to facilitate communication between the parties and provide a more workable solution. In detail, integrate the process with new information and communication systems, such as traffic lights to manage the flow of trucks waiting in the STOP zone, pop-up directly from the tablet on the board of forklifts to manage the next load and, while waiting for the truck to arrive, pre-picking operations where possible.

By way of summary, countermeasures within the methodology are provided in the *Table 17*.

AS IS	TO BE	Δ
Obsolete storage policy – i.e "Lot separation" - with empty spaces in stacked structures. Resulting in low space saturation index and increased security risk	Eliminate the "Lot separation" policy, maintaining value adding information through a visual tool.	+1000 pallets to keep in stock in the definitive warehouse, equivalent to 4 holds of the final warehouse, With a saturation index greater than 90%.
Management of non-conforming codes (51Y) results in large spaces misused (small lots), double handling and management of various codes introduced with the RFID system learned in the field.	Reduction in spaces reserved to "Small Lots" and bypassing the T-Ricond step for code change, through a double weekly standardized control and a more constant information flow between the 2 departments. Human errors reduction through training.	+ 300 pallets to keep in stock, more constant flow, increased saturation index.
Simple cycle operations and FIFO method not always respected	Combined cycles enforced whenever there is movement in a particular area of multiple interest.	Reduction of empty trips typical of the simple cycle, better management of the MHE utilization index.
Truck flow management for loading entrusted entirely to truck drivers, with one empty trip per truck and extra transportation not required.	Integrate the process with new information and communication systems, such as traffic lights, pop-up to manage next trucks directly from the tablet and pre-picking operations where possible.	Reduction of transport waste, **-** 200 m empty distances per truck, less risk of accidents, - 3 min of the total c/T of operating a truck,

Table 17: Summary of proposed countermeasures related to the Methods

5.2 SUMMARY OF PROPOSED COUNTERMEASURES

Analysis of the current situation of the Lonigo warehouse led to the identification of a number of wastes - waiting times, over-movement, transportation and under-utilization of space. In line with the company's objectives - *to improve the warehouse's material handling process* - areas for intervention were identified: *Layout* and *Methods*.

Regarding layout, which is closely related to and limited by the structure of the warehouse, the reduction of temporary area F32 (holds T16, T19, T20) and the improvement of index space utilization by exploiting the volumetric dimension of the packaging storage area were proposed. *Appendix 5* presents the revised warehouse layout considering the proposed countermeasures.

Overall, the proposed countermeasures in terms of layout bring both new storage space, +300 pallets in the packaging warehouse area through the installation of a wall rack, and an increase in the accessibility and rotation index of area D in the final warehouse. From the interviews, it was found that area D was the most voluminous and rotated the slowest. Therefore, it was decided to halve it and increase the number of holds (from 12 to 24 smaller holds), also in view of the flexibility program initiated by the Verallia Group, which will lead to an increase in the variety of products to be handled in restricted times. The new holds will be accessible via a new transit way, resulting from the restriction of excess space of F32 - temporary area.

Regarding the method, the first step was to quantify the inefficiencies related to the storage method in Verallia, called "lot speration". It involves a physical separation of the lots by a space. This not only deprives the warehouse of more than 1000 pallets, but also poses a serious risk to the stability of the stacks and therefore to the safety of operators passing by with forklift trucks. By eliminating spaces, thanks to the existing RFID system and a new visual - labeling tool, new storage space and a better saturation index (now 85%, but expandable to more than 90%) can be achieved.

Although non-conformity management is not the responsibility of the warehouse, more systematic and urgent control has been agreed, even though NC products have been deprived of some areas reserved for them, such as "small lots" and the "T-Ricond" areas. This not only results in additional space for the finished products to be shipped (+300 pallets), but also in a more continuous material flow and information flow. Furthermore, in terms of methods, it is recommended to focus on combining cycles instead of simple cycles, which reduces the inefficiency of empty runs and increases the productivity of the equipment.

Finally, a waste associated with the method used in the warehouse is the management of trucks to be loaded. Since the method FIFO is used, so that the loaded pallets are the ones that are in the defintive warehouse, forklift drivers make empty trips to receive the truck to be loaded and then physically escort it to the designated loading dock. In addition to the distances travelled, there are the risks associated with increased risk of accidents and truck downtime. The use of advanced technology - pop-ups on the tablet, voice calls along with a motion light for the truck - is one possible improvement solution.

CH 6: CONCLUSIONS

6.1 STUDY FINDINGS

Managing internal logistical processes is an issue that has become critical to competitive success in every industry and supply chain. Remarkable progress has been made in both "flow" and "quality" in warehousing, and most would agree that this progress is due to lean thinking. The proper use of available resources by minimizing losses and the ability to remove non-value added activities can be highlighted as key characteristics of Lean. The pursuit of perfection is realized through the simplification of processes and procedures. In the warehouse, for example, operations must be aligned and function optimally to increase efficiency and thus reduce costs.

When implementing a lean transformation, before focusing on how employees work, one should look at the processes as a whole and understand what is not adding value (Pavanato, 2020). In the project that concerned the warehouse of Lonigo (Group Verallia Spa), an analysis of the current situation was first carried out through a mapping process. After identifying other areas to be studied, the analysis AS - IS was integrated with information collected through a statistical measurement tool called Work Sampling. The goal was to find out how much time workers spent productively (or unproductively).
The common framework between VSM and WS led to the identification of several inefficiencies, which were categorized in terms of waste of Lean as follows: waiting, excessive movement, unnecessary transportation, and space underutilization.

The results of the project are summarized by answering the research questions originally formulated. In developing the project within the warehouse of a glassworks, some peculiarities emerged. The main challenge is to cope with the high load generated not only by the push production, but also by the high volume of products, which make the space a very precious resource. As for the mobility of the finished products, they are fragile and therefore fewer touches should always be a priority.

6.1.1 RQ1 - What non-value added activities can be eliminated within the warehouse process at Verallia Lonigo Plant?

A non-value-added activity is one that does not add value to what is delivered to the customer. In Lonigo's warehouse, non-value-added activities can be attributed to the following wastes, or muda in Japanese: Waiting time, excessive movements, unnecessary transportation, and underutilization of space.
It should also be noted that inventory, the mother of all wastes in lean philosophy, cannot be considered a true waste because the glass production process necessarily follows a make-to-stock or push logic. By contrast, a saturated warehouse in Verallia equates to lower turnover in external warehouses, which is considered positive data by management.
A similar argument must be done for a non-value-added activity per excellence, batching in the temporary warehouse areas. Batching is the antagonist of continuous flow, a source of waste because it slows down the flow of materials. At least at the management level, in the Lonigo warehouse is a good solution that allows a clear management of non-conforming products and the organization of the transfer to remote warehouses.

To identify opportunities for improvement, it was decided to focus on 2 main areas in the warehouse: Layout and Methods.
The former is directly affected by two proposed countermeasures: Reduction of temporary storage areas by compressing the T16, T19 and T20 holds, which were found to be oversized. The space thus gained, which cannot be used for other purposes, was considered as a possible new transit route allowing rear access to the D holds. The D section of the definitive warehouse was considered to be too large and the possibility of halving it and creating a new section - E - was considered. These solutions take into account the future requirements for the Lonigo warehouse resulting from the Verallia Group's commitment to make the production process more flexible. Moreover, increasing the number of smaller storage bays is a solution to increase rotation and ensure a high saturation index, as well as reduce external stock transfers - today a prerogative of logistics.
The second solution in terms of layout is to make proper use of the cubic capacity of the packaging warehouse. This results in an increase in storage capacity of approximately 300 pallets. In *Appendix 5* the revised layout is proposed.

On the method side, despite the innovations of recent years, these have often remained untouched: the introduction of the RFID system in 2019 and the radical reduction in the number of quality defects in the production process.

"Lot separation", i.e the activity of physically separating batches in the same hold, deprive the definitive warehouse of more than 1.000 pallets, according to the test, while increasing the effective C/T of the sorting operation by 30 sec/TU. The impact is also in the area of security, given the reduced stability in the pallet blocks that this method determines. Considering the presence of the RFID system, the inadequacy of the method is more than proven. For this reason, it was decided to propose its abolition and continue to keep some valuable information by means of a label on the side of the first pallet of each batch stored in the same hold.

Another inefficiency due to the methods in force in the warehouse revolves around the management of quality defects, more specifically the code - 51Y (who identifies a pallet that needs to be reprocessed due to quality problems).

The double movements due to a sequential organization of the code change procedure (from 51y to 51) and the storage of NC products in non-purposeful locations (such as the “small lot” area) suggested that the communication flow between the quality and logistics areas needed to be improved. Reducing the size of the “small lots” area by almost half and bypassing the pallet stop in the "T-ricond" area for code changes were judged to be countermeasures that would not only maximize the space available for finished product storage, but also give the quality area a sense of urgency to manage the nonconformity products present in the warehouse.

Finally, managing simple cycle operations characterized by 50% of trips without loads and a system to manage the loading trucks flow that is overly dependent on forklift operators are activities that certainly cannot be eliminated, but can be improved.

Simple cycle operations should be composed whenever activities are performed in areas of multiple interest. The management of trucks to be loaded needs to be updated with modern technology and an improved communication system. Modification of current methods, which are not very ergonomic, time consuming and characterized by bridging large distances empty, are considered as the next appropriate steps of continuous improvement of warehouse operations.

6.1.2 RQ2- How can the existing resources of the warehouse be used more efficiently?

In the warehouse, three are the key identifiable resources - space, people and MHE.

In the Lonigo's warehouse, one inefficiency is the lack of a clear standard of work in relation to the management of products to be reconditioned or reprocessed. These processes are often dictated by eventualities, such as the presence of an additional packer. In terms of warehousing, inefficiency in the management of non-conforming products leads not only to a transitional step in "T_ Ricond area" with double handling, but also to an interruption in the activity of an operator and poor management of space and equipment productivity. This highlights the need to standardize these processes. According to Bozer (2012), standardization means establishing best practices for each type of work by developing standard methods, standard process/lot sizes, and standard time frames.

In terms of space, various inefficiencies were identified in the Lonigo warehouse. It was found that the storage method known as "lot separation" affects the space saturation index in the final storage area by about 15%. In other words, a storage area equivalent to 4 whole holds of finished products, or more than 1000 pallets.
Space utilization is also affected by inefficiencies in terms of volumetric dimension, i.e. the utilization of available space even in height. In addition, arbitrary management of "jolly areas", such as small lots, leads to blockage of product flow, underutilization of storable space, and non-compliance with FIFO protocol. In the glass industry, space is definitely a very valuable resource.

Frederick Taylor (1856-1915) points out that the greatest loss due to inefficiencies is not material, but a waste of human effort. In the Lonigo Warehouse, human resource is often used for non-value added activities: Long search times for pallet IDs, filling paper forms and the need to manage loading operations by oneself are examples of human resource waste. Some methodological tools such as the elimination of double handling, the installation of established standards, and training and recall paths on rules, codes used and working procedures represent an important improvement progress.

6.2 CRITICAL REFLECTIONS

The study was conducted in a specific time period, and time constraints affect the results of the study. This means that the results may vary if the observations and time studies are conducted at different times. The limitation of the study is that it stops at the step PLAN and only considers some potential problems related to applicability and future challenges that can be expected after the implementation of the proposed countermeasures.

It should be kept in mind that within large multinational companies, as in the case of the Lonigo plant (Group Verallia SPA), some decisions are taken centrally. Regarding the scope of the study, the decisions on production and products to be transferred were the responsibility of the central hub in Dego. Thus, the outcome of the study as well as the proposed countermeasures are influenced by the time needed to contact the central managers and obtain the necessary information. Finally, the proposed countermeasures take into account not only the information directly available to an external person, but also that the changes are within the responsibility of the plant manager.

6.3 SUGGESTIONS FOR FUTURE RESEARCH

The idea of applying the Lean model to the warehouse can be associated with a seed that needs to be planted in a certain area of the warehouse. If the people around this seed take care of it, it will grow and spread throughout the warehouse. The study was conducted in the warehouse of the Lonigo plant. The warehouse is owned by the Verallia Group, but the management of operations - receiving and unloading, sorting, picking and loading - has been outsourced to a company specialising in logistics.

Given the respective interests of the parties, a next research approach is to thoroughly investigate the inertia of a continuous improvement project when the people responsible for the processes work under a different company.

At the project level, considering the identified constraints and criticisms, a future study to improve loading times is to outline viable storage and slot options for each item within the warehouse.

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Appendix 1: Interview

An interviewer can ask several types of questions to stimulate responses from an interviewee. Patton (2015) suggests six types of questions:

1. *Experience and behavior questions*—This type of question gets at the things a person does or did, his or her behaviors, actions, and activities. For example, in a study of leadership exhibited by administrators, one could ask, "Tell me about a typical day at work; what are you likely to do first thing in the morning?"
2. *Opinion and values questions*—Here the researcher is interested in a person's beliefs or opinions, what he or she thinks about something. Following the preceding example of a study of administrators and leadership, one could ask, "What is your opinion as to whether administrators should also be leaders?"
3. *Feeling questions*—These questions "tap the affective dimension of human life. In asking feeling questions—'how do you feel about that?'—the interviewer is looking for adjective responses: anxious, happy, afraid, intimidated, confident, and so on" (p. 444).
4. *Knowledge questions*—These questions elicit a participant's actual factual knowledge about a situation.
5. *Sensory questions*—These are similar to experience and behavior questions but try to elicit more specific data about what is or was seen, heard, touched, and so forth.
6. *Background/demographic questions*—All interviews contain questions that refer to the particular demographics (age, income, education, number of years on the job, and so on) of the person being interviewed as relevant to the research study. For example, the age of the respondent may or may not be relevant.

Source: Extrapolated from - Merriam, S. B., & Tisdell, E. J. *Qualitative Research: A Guide to Design and Implementation* (4th ed.), California, 2016

Specially generic wording of questions in conducting the interviews:

- Tell me about a time when . . .
- Give me an example of . . .
- Tell me more about that . . .
- What was it like for you when . .

Appendix 2: Activities classification in the WS study and the tab describing their meaning.

		Activities
1	VA	Activities on the tablet on board
2	NNVA	Pallet storage in temporary area
3	NNVA	MD56 compilation - Packaging non-compliance
4	NNVA	Pallet storage on the ground - roller conveyor area
5	NNVA	Lunch break
6	NNVA	Pallet pickup from roller conveyor
7	NNVA	Movements for "unblocking holds".
8	NNVA	Transport of input
9	NNVA	Forklift change
10	NNVA	Move to battery room
11	NNVA	F31 and F32 employee cross handling
12	NVA	Temporary to permanent handling
13	NVA	Empty trolley movement from roller conveyor
14	NVA	Empty trolley movement towards roller conveyor
15	NVA	Waiting
16	NVA	Pallet handling to temporary
17	NVA	Break
18	NVA	Pallet Handling to Non-Compliance Areas
19	NVA	Call the packer
20	NVA	Intercross along roadways
21	NVA	Partial load handling
22	NVA	Picking up pallets from the ground - roller conveyor area

Rif.	ACTION	DESCRIPTION
1	Activities on the tablet on board	The operator performs operations on the on-board tablet.
2	Pallet storage in temporary area	Manoeuvres for storing/arranging pallets in the hold (Temp. Warehouse).
3	MD56 compilation - Packaging non-compliance	Operator completes/examines paper documents.
4	Pallet storage on the ground - roller conveyor area	Manoeuvre of depositing pallets on the ground, in the "area adjacent to the roller conveyor".
6	Pallet pickup from roller conveyor	Manoeuvre of approach and lifting of pallets "from the roller conveyor".
7	Movements for "unblocking holds".	Transport of pallets from non-conformity areas to access gates to the production area (the 2 red gates).
8	Transport of input	Transport of inputs other than pallets (e.g. cartons, interlayers, etc.).
11	F31 and F32 employee cross handling	Both drivers perform picking activities from the same roller conveyor.
12	Temporary to permanent handling	Pallet transport to "final" warehouse - (At the back in relation to the rollers).
13	Empty trolley movement **from** roller conveyor	The forklift is "moving away" from the zone - roller conveyor "without" loaded.
14	Empty trolley movement **towards** roller conveyor	The forklift "approaches" to the zone - roller conveyor "without" loaded.
16	Pallet handling to temporary	Transport of pallets to holds - temporary storage.
18	Pallet Handling to Non-Compliance Areas	Pallet transport to "TQ-Mensa" hold.
19	Call the packer	Using the phone "just to call" (note IF other activity).
20	Intercross along roadways	Crossings with stop manoeuvre/changes of direction/precedence of vehicles.
21	Partial load handling	Transport of only 1 HIGH pallet/ only 1 or 2 LOW pallets.
22	Picking up pallets from the ground - roller conveyor area	Manoeuvre for picking up pallets from the ground - in the area adjacent to the roller conveyor.

Appendix 3: 5Ws analysis output

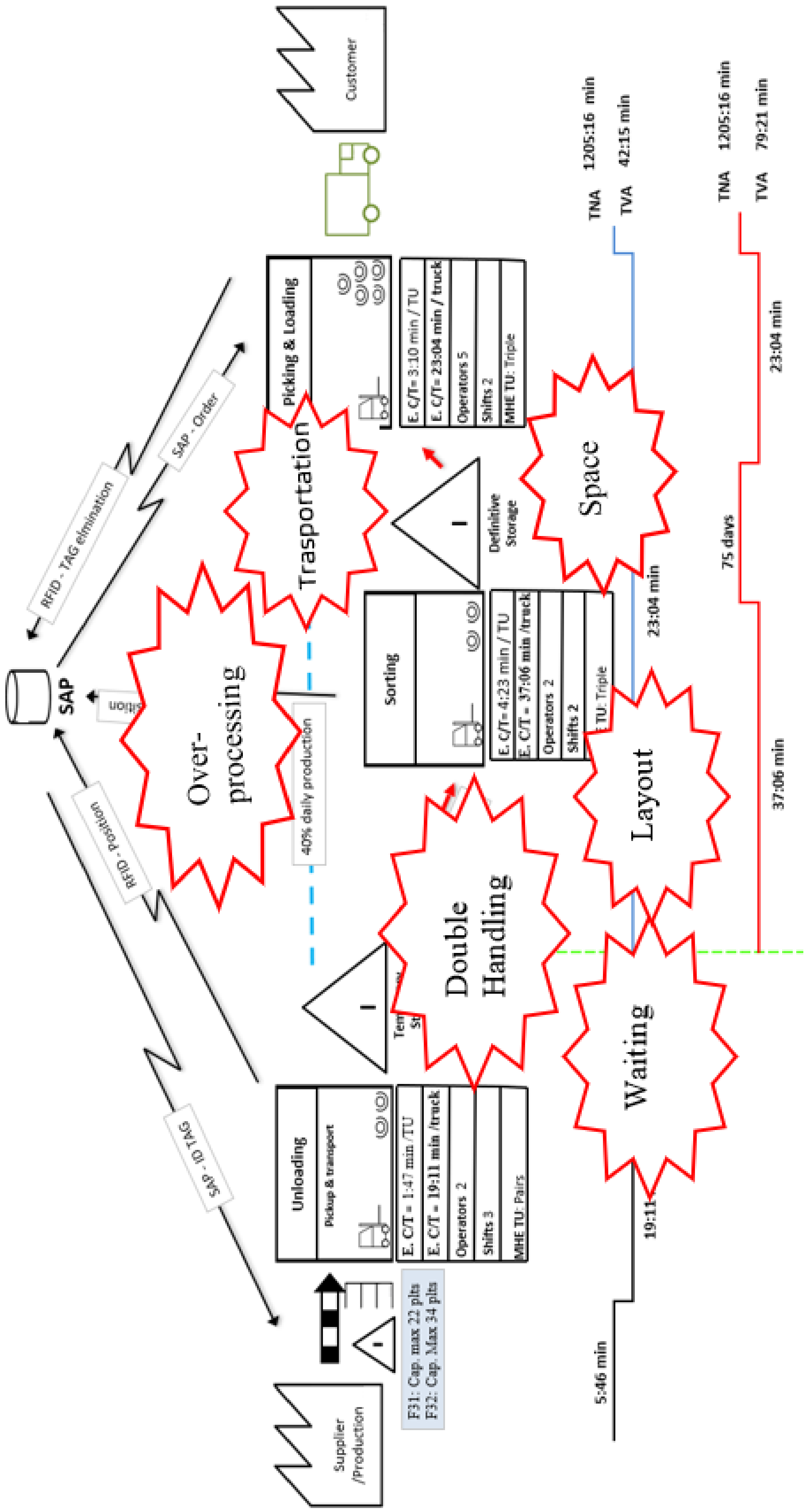
Trasportation	
What:	Excess travel and deadheading
When:	During Loading, while handling the next truck to be loaded. On receipt and sorting, the return journey is unloaded.
Where:	All operations in the Warehouse
Why:	Method of truck flow management entrusted to truck drivers. Organization of simple cycle operations.
Who:	Warehouse staff

Underutilization of resources	
What:	Low space saturation index
When:	Being stored in the final warehouse. In the management of space in the packaging warehouse.
Where:	Temporary, permanent and packaging warehouse areas
Why:	Lot separation" storage method. Failure to exploit the cubametric dimension of the space. Dedicated storage areas oversized to actual demand.
Who:	

Waiting	
What:	Slowdown in pallet handling and the work of logistics operators
When:	Frequent faults in the equipment installed on board the forklifts and connected to the Rfid system
Where:	Reception area, unloading roller conveyors and sorting operation
Why:	The RFID system has antennas mounted on board the trucks. The use of several MHEs to carry out operations and the absence of back-up or complementary equipment constrains the operation of people and machines.
Who:	Forklift drivers and site manager

Over motion	
What:	Multiple double Handling
When:	In roller conveyor unloading and sorting phase
Where:	NC areas and small lots
Why:	Sequential NC management, Layout misaligned with MHEs
Who:	Forklift drivers

Appendix 4: VSM – MUDA



Appendix 5: Revisited Layout