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IMPROVING INVENTORY MANAGEMENT BY MRP OPTIMISATION VIA EXCEL VBA CASE STUDY : SEWS AIN AOUDA MOROCCO

Mohamed Hamza MAROUFI

Master's Thesis

Supervisor

Asst. Prof. Dr. Fatih YİĞİT

İstanbul, 2024

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The thesis titled IMPROVING INVENTORY MANAGEMENT BY MRP OPTIMISATION VIA EXCEL VBA CASE STUDY: SEWS AIN AOUDA MOROCCO prepared by MOHAMED HAMZA MAROUFI and submitted on 10.07.2024 has been **accepted unanimously** for the degree of Master of Science in Industrial Engineering Departement.

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I hereby declare that this thesis meets all format and submission requirements for a Master's thesis.

I hereby declare that all information/data presented in this graduation project has been obtained in full accordance with academic rules and ethical conduct. I also declare all unoriginal materials and conclusions have been cited in the text and all references mentioned in the Reference List have been cited in the text, and vice versa as required by the abovementioned rules and conduct.

Mohamed Hamza MAROUFI

Signature

DEDICATION

At the end of our research project, I would like to express my deep gratitude to our professor at Altınbaş University, Asst. Prof. Dr. Fatih YİĞİT, for his guidance, advice, and encouragement towards the completion of this work.

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ABSTRACT

IMPROVING INVENTORY MANAGEMENT BY MRP OPTIMISATION VIA EXCEL VBA CASE STUDY: SEWS AIN AOUDA MOROCCO

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Aware of the role of logistics in its competitiveness, the industrial firm SEWS Ain Aouda continues to make the optimization of its management processes its main lever while ensuring the quality of delivery of final products.

Improving the management of raw material inventory is one of its main concerns. In this regard, this study project represents an attempt to enhance the management of raw material stocks by integrating VBA system into the already functional MRP system.

To conduct this study, we started by highlighting the importance of inventory management in the company's development process by identifying inventory management practices and the problems that can be generated by fluctuations in customer demands.

The literature review allowed us to address different computer tools and various inventory management methods. The data collected during this case study were useful in forming a clear idea of inventory management practices at the industrial company SEWS Ain Aouda, specialized in the manufacturing of electrical harnesses. Additionally, this study provided us with the opportunity to identify variations in customer needs.

The adoption of the order tracking approach using Excel VBA system in the MRP system, introduced in consensus with the procurement manager, enabled us to automatically

determine unnecessary orders and excess stocks. This allows managers to continuously monitor stock level variations and make appropriate decisions in case of detecting unnecessary orders. Therefore, the use of VBA can be a factor in improving inventory management at the SEWS company level.

Keywords: Inventory Management, Raw Materials, MRP, Excel VBA, Orders Revisions.

ÖZET

EXCEL VBA ARACILIĞIYLA MRP OPTİMİZASYONU İLE STOK YÖNETİMİNİN İYİLEŞTİRİLMESİ OLGU ÇALIŞMASI: SEWS AIN AOUDA FAS

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Lojistiğin rekabetçilikteki rolünün farkında olan endüstriyel firma SEWS Ain Aouda, yönetim süreçlerini optimize etmeye devam ederek nihai ürünlerin teslimat kalitesini sağlarken ana kaldıraç olarak görüyor.

Hammadde stoklarının yönetimini iyileştirmek, firma için ana endişelerden biridir. Bu bağlamda, bu çalışma projesi, mevcut MRP sistemi içine VBA sistemini entegre ederek hammadde stoklarının yönetimini artırmayı amaçlamaktadır.

Bu çalışmayı yürütmek için, şirketin gelişim sürecinde stok yönetiminin önemini vurgulayarak, stok yönetimi uygulamalarını ve müşteri taleplerindeki dalgalanmaların neden olabileceği sorunları belirleyerek başladık.

Literatür taraması, çeşitli bilgisayar araçlarını ve çeşitli stok yönetimi yöntemlerini ele almamıza olanak tanıdı. Endüstriyel firma SEWS Ain Aouda'da elektrik bağlantı kabloları üretiminde uzmanlaşmış olan şirketin stok yönetimi uygulamaları hakkında net bir fikir edinmemize yardımcı olan bu çalışma, müşteri ihtiyaçlarındaki değişkenlikleri belirleme fırsatı sağladı.

Excel VBA sistemi kullanarak MRP sisteminde sipariş takip yaklaşımının benimsenmesi, satın alma müdürü ile uzlaşı içinde tanıtılan gereksiz siparişleri ve fazla stokları otomatik

olarak belirlememize olanak tanıdı. Bu, yöneticilere stok seviyesi varyasyonlarını sürekli olarak izleme ve gereksiz siparişleri tespit etmeleri durumunda uygun kararlar alma imkanı verir. Dolayısıyla, VBA'nın SEWS şirketinde stok yönetimini iyileştirmede bir faktör olabileceği sonucuna varabiliriz.

Anahtar Kelimeler: Stok Yönetimi, Hammadde, MRP, Excel VBA, Sipariş Revizyonları.

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ABBREVIATIONS

BOM	:	Bill of Material
B/O	:	Back Orders
CST	:	Cut Strip Terminated
DHS	:	Data Harness Assembly
EDI	:	Electronic Data Interchange
JIT	:	Just In Time
MCS	:	Material Control System
MPS	:	Material Production Schedule
MRP	:	Material Requirement Planning
SEWS AA	:	Sews Ain Aouda
WIP	:	Work In Progress
WMS	:	Warehouse Management System

1. INTRODUCTION

The global automotive industry sector has been marked in recent years by an evolution of global demand addressed to the manufacturer, which has led to an amplification of the phenomenon of subcontracting, allowing many countries including Morocco to develop an automotive industry.

Aware of competitive challenges, the automotive industry in Morocco is constantly seeking to improve its profitability and strengthen its position in the market to be more competitive. In this perspective, the field of inventory management is crucial in industries where supply chain efficiency is a pillar of operational success, with the automotive industry being a perfect example. In the automotive wiring harness assembly landscape, meticulous stock control is essential to ensure that production meets customer specifications and market demands.

Technological advancements have opened a new era for inventory management. Material Requirements Planning (MRP) systems, essential for synchronizing supply with production schedules, ensure that materials are available when needed to meet production goals. Visual Basic for Applications (VBA) plays a complementary role, especially in conjunction with Microsoft Excel, enabling customized and scalable inventory management solutions.

The perspectives presented in this thesis stem from an internship at SEWS (Sumitomo Electric Wiring Systems), a leader in the automotive wiring harness assembly industry. The experience provided valuable insight into the crucial role of inventory management in meeting customer needs.

The study acknowledges that in this industry, it is often the customer who dictates stock requirements. However, changes in demand, revisions to the Bill of Materials (BOM), and updates based on evolving customer needs can significantly influence stock strategies. Therefore, the focus of this research is not to correct inefficiencies in the MRP system, as existing systems work effectively, but rather to improve responsiveness to these customer-driven changes.

During the internship, a project using VBA in Excel was proposed to align the MRP process more closely with the dynamic needs of customers. The research suggests leveraging this project to refine the MRP system to be more proactive and responsive to this variability.

This thesis explores improving inventory management through an optimized MRP approach using VBA. The aim is to highlight how strategic technological interventions can help maintain operational flexibility in an industry characterized by rapid changes and complex supply dynamics, while emphasizing the influential role of the customer in inventory needs.

1.1 PROBLEM DEFINITION

Inventory management is a fundamental aspect in the automotive harness assembly industry, where the accuracy of inventory management is essential to maintain a constant production flow and effectively respond to fluctuating customer requirements. At SEWS, where MRP systems are already effective, the challenge lies not in internal operational inefficiencies, but in managing customer order variability.

Clients such as Nissan or Renault determine stock needs, and their orders can change depending on their changing production needs or updates to the BOM. These customer adjustments can result in excess or obsolete orders, presenting SEWS with challenges such as overstocking or obsolete inventory.

The identified problem is therefore the adaptation of stock management to the changing needs of customers, which requires a thorough analysis of existing orders and a reactive decision-making process to minimize excess stocks and improve market demand responsiveness.

1.2 PURPOSE OF THE STUDY

The objective of this study is to improve inventory management at SEWS by designing a strategy that better aligns the company's MRP with fluctuating customer demands. This strategy involves conceptualizing and deploying a method that uses data analysis and process automation to ensure that stock levels are accurately adjusted to meet actual production needs, as dictated by changes in customer orders. Through a detailed examination of current inventory management practices and the integration of advanced analytical tools, the study

aims to reduce the incidence of excess inventory and improve the efficiency of the inventory management system, thereby supporting SEWS in achieving a more dynamic, flexible, and profitable operation.

1.3 RESEARCH QUESTIONS AND OBJECTIVES

1.3.1 Research Questions

The research questions we are trying to answer can be as follows:

a) What are the current stock management methods used at SEWS?

b) How can changes in customer demands impact the efficiency of SEWS's current inventory management system?

c) What specific challenges does SEWS face in managing stock levels in line with fluctuating demands?

d) How can a VBA-based tool improve the responsiveness of the MRP system to changes in customer demands?

e) What criteria should be used to evaluate the success of integrating a VBA tool with the existing MRP system in terms of optimizing inventory?

1.3.2 Research Objectives

a) Identify and evaluate the current stock management practices at SEWS.

b) Determine the impact of customer demand variability on stock levels.

c) Develop strategies to optimize stock management in response to customer demand.

1.4 SIGNIFICANCE OF THE STUDY

This study aims to make significant contributions to academic research in inventory management and practical applications in the industry. By exploring the use of VBA to optimize MRP processes, the research can provide insights into more effective inventory management practices that could benefit similar companies in the automotive sector. Furthermore, the development of a VBA-based inventory analysis tool has the potential to

streamline inventory management decision-making processes, leading to more efficient and profitable operations.

1.5 TERMS DEFINITION

For more clarity throughout the study, the following definitions are provided for key terms as they relate to the context of stock management optimization at SEWS through the integration of an MRP system optimized by VBA:

1.5.1 Material Requirement Planning

A system used to manage manufacturing processes by calculating the materials and components needed for the manufacturing of a product. It plans material supply based on production forecasts, ensuring that materials are available for production at the right time. without unnecessary excess.

1.5.2 Visual Basic for Applications (VBA)

A programming language developed by Microsoft integrated into most Microsoft Office applications. It is used to automate tasks within these applications, enhance functionality, and create custom solutions, such as the tool proposed in this study to identify unnecessary commands in the MRP system.

1.5.3 Inventory Management

The process of monitoring and controlling the ordering, storage, and use of components that a company uses in the production of the items it sells. It also involves managing the quantities of finished products for sale. The aim is to minimize costs associated with inventory while meeting customer demand.

1.5.4 Redundant Orders

Orders that have become unnecessary due to changes in customer demand or production requirements. These can lead to excess inventory if not identified and managed properly, resulting in increased storage costs and potential losses.

1.5.5 Customer Demand Fluctuation

Variability in the quantity or type of products that customers order over time. In the context of this study, it refers to changes in customer requirements such as Nissan or Renault, which impact production schedules and stock needs at SEWS.

1.5.6 Microsoft Excel

A spreadsheet program included in the Microsoft Office suite of applications. Widely used in business and financial operations for data analysis, budgeting, financial forecasting, and various other functions involving working with numerical data.

1.5.7 Operational Efficiency

The ability of an organization to provide products or services to its customers in the most cost-effective manner while ensuring the desired quality. In this study, it specifically refers to the ability to manage inventory in alignment with fluctuations in customer demand, minimizing losses, and maximizing resource utilization.

1.5.8 Resilience of the Supply Chain

The ability of a supply chain to anticipate, prepare, respond, and recover from unexpected disruptions is crucial for maintaining business continuity. Strengthening resilience involves developing strategies to ensure operations can continue smoothly under various conditions. This includes identifying potential risks, creating contingency plans, rapidly addressing issues when they arise, and adapting processes to improve future responses. By doing so, a supply chain can better withstand and recover from disruptions, ensuring minimal impact on operations.

1.5.9 Different Types of Inventories

1.5.9.1 Obsolete stock

Inventory that has become obsolete or less demanded by customers. Obsolete stock is often difficult to sell at a high price, or even impossible, and can result from an overestimation of

demand, technological advancements making products obsolete, or changes in customer preferences.

1.5.9.2 Excess stock

Levels of stock exceeding current demand. Excess inventory can unnecessarily tie up capital, increase storage costs, and risk becoming obsolete if not managed properly. It typically occurs due to overordering, errors in demand forecasting, or unexpected sales declines.

1.5.9.3 Slow-moving stock

Inventory items sell at a slower pace compared to other products. These items may still be in demand, but they take longer to sell and can result in increased storage costs. Identifying and managing slow-moving stocks is crucial for optimizing inventory levels and improving cash flow.

1.6 STUDY LIMITATIONS

The study on optimizing stock management at SEWS through a VBA-optimized MRP system presents several constraints to highlight:

First, the focus is on SEWS and its specific challenges related to fluctuations in customer demand, limiting the generalizability of the results to other organizations without significant adaptations.

Then, the effectiveness of the VBA tool depends closely on the accuracy and completeness of the data in SEWS MRP, with risks related to inaccuracies in historical data or forecasts.

Furthermore, technological limitations of Excel, such as processing speed and file size restrictions, can restrict the use of advanced analytical functions.

The adoption of the tool also requires a certain openness to change on the part of SEWS, where resistance, lack of training, or insufficient support can hinder the effectiveness of the implementation.

Furthermore, the study may not fully incorporate the impact of external market factors such as economic slowdowns or supply chain disruptions. The rapid evolution of technologies and inventory management practices may also render the findings obsolete, requiring

ongoing revisions. Finally, while the VBA tool is customized for SEWS, its ability to be adapted or expanded to other contexts without substantial modifications remains uncertain.

1.7 ASSUMPTIONS

During the study on optimizing inventory management at SEWS through a VBA-optimized MRP system, several assumptions are formulated to provide a basis for the research framework:

1.7.1 Integrity

It is assumed that the data available in the SEWS MRP system, including historical order data, stock levels, and customer demand forecasts, are accurate and complete. This integrity is crucial for the VBA tool to analyse and identify unnecessary orders effectively.

1.7.2 Stable Operational Environment

The study assumes that SEWS operates in a relatively stable environment without significant disruptions during the research period. This includes consistent supply chain operations, stable customer relationships, and the absence of major shocks in the external market.

1.7.3 Technological Compatibility

It is assumed that the existing IT infrastructure of SEWS, including hardware and software, is compatible with the integration and use of the VBA tool without requiring significant upgrades or modifications.

1.7.4 Skill Level

It is assumed that SEWS has staff with the necessary skills to effectively use the VBA tool, or that they can be trained with a reasonable investment of time and resources.

1.7.5 The Consistency in Customer Behaviour

While recognizing that customer demand may fluctuate, the study assumes that these variations fall within a predictable range based on historical patterns, allowing the VBA tool to make significant adjustments to stock orders.

1.7.6 Impact of Recommendations

The study assumes that the recommendations made, based on the analysis carried out with the VBA tool, will have a positive impact on SEWS's inventory management, leading to improvements in terms of efficiency and cost savings.

1.8 THESIS ORGANIZATION

The organization of this study is designed to provide a consistent and systematic exploration of inventory management optimization at SEWS through an MRP system optimized by VBA. The study is structured as follows:

Chapter 1: Introduction

Presents the research topic, objectives, importance, and limitations.

Chapter 2: Literature Review

Review the relevant literature on tools, different systems, and methods of stock management.

Chapter 3: Methodology

Presents the research design, data collection, and analysis methods.

Chapter 4: Case Study

a) Presentation of SEWS as the host organization

b) Implementation of the case study

c) Development and implementation of the solution (VBA tool)

Chapter 5: Conclusion

2. LITERATURE REVIEW

In the following section, we delve into the abundant scientific literature on various essential subjects that align directly with the topic of our research. Our literature review encompasses a range of critical topics, including the computer tools used in management such as Excel and VBA, as well as systems dedicated to inventory management and the methods used. We also explore warehouse activities (from material reception to storage and material shipment), with a focus on inventory control mechanisms. This review of existing research provides a fundamental understanding of the key elements underlying our investigation and sets the stage for the subsequent discussion and analysis of this study.

Inventory management is a process that ensures that stock levels are sufficient to meet customer demand and for replenishment. This process requires regular monitoring and control. Various methods and tools can be used in inventory management to add value to a business, highlighting its importance in improving business performance, reducing response times to customer demands, and achieving higher customer satisfaction.

2.1 COMPUTER TOOLS FOR INVENTORY MANAGEMENT

2.1.1 The Excel VBA Tool

According to Henry [1], Microsoft Excel is a valuable tool for inventory management in certain business contexts. Because it allows importing data from large enterprise systems such as Oracle and SAP, providing an efficient way to organize and visualize data in a simpler and clearer format. Excel's programming language, VBA, significantly extends its capabilities. It enables automating routine tasks, developing complex programs. It is important to highlight the crucial role of VBA in automating tasks in Excel spreadsheets. And its ability to create macros for repetitive tasks and its integration capabilities with Microsoft Office and AutoCAD applications.

Many companies today opt for sophisticated software solutions available on the market for key business operations, such as accounting, record-keeping, and inventory management. Despite the availability of many software options, some companies, especially startups and SMEs, prefer to use Microsoft Excel for inventory management. Excel-based inventory

management involves using spreadsheets to organize, source, sell, and store stock items. This method is still considered relevant and useful, especially for small businesses.

2.1.2 Steps of Inventory Management Process

a) Creation of a spreadsheet to record essential information.

b) Adding categories and columns for different products.

c) Entering actual products in each column or category.

Although this approach is less costly and relatively simpler than using advanced software, it has drawbacks. These include the time required, lack of automation and real-time reporting capabilities, and a greater propensity for human errors in data entry.

Effective inventory management must strike a balance between excess and limitation. Excess inventory can tie up working capital and impact the liquidity of the company, while insufficient inventory can lead to stock shortages and missed sales opportunities, ultimately resulting in reduced profits.

While some companies continue to use traditional and less sophisticated methods such as Microsoft Excel for inventory management, these approaches are often considered inadequate in the face of increasing demands and competitive pressures in inventory management. This perspective is shared by Priniotakis & Argyropoulos [2], who highlight the limitations of slower options like Excel in the current business environment.

2.1.3 The Improved Excel System

Therefore, Microsoft Excel offers an add-on called Excel Solver, which allows for quickly automating complex calculations. This is particularly relevant in inventory management, a process applicable to various sectors where control and monitoring of supplies are essential for the success of the company.

A study in India highlighted the importance of managing essential military supplies for the Indian army. The objectives of the study included:

a) Create a statistical demand forecast while maintaining effective inventory control

b) Optimize the transportation model to reduce operational costs

c) Maximize warehouse space efficiency and minimize opportunity costs through VED analysis. Microsoft Excel was used to provide solutions to these objectives.

The study by Panday & Kaur [3] demonstrated Excel's ability to effectively manage large-scale inventory management. The study results indicated that the inventory management system developed with Excel successfully achieved its objectives:

a) Reduce total stock costs

b) Decrease transportation expenses

c) Reduce potential stock management costs.

These results highlight the significant potential of Microsoft Excel in managing complex stock systems, such as those required by military organizations.

2.1.4 Integration of Microsoft with Advanced Software

The issue of significant losses in companies due to inventory management costs is a notable concern. In some cases, challenges related to supply chain network management stem from high costs and underutilization of advanced software solutions. A relevant study by Praveen [4] explored the potential of integrating Microsoft Excel with advanced software to enhance efficiency. In this study, two platforms were used:

a) Microsoft Excel to organize and prepare input datasets.

b) R Studio to run the codes and analyse the results.

In Excel, the data has been categorized and arranged in columns, using various tables, searches, and pivot table features. Linear and quadratic trends have been applied in the analysis.

The study showed that the combination of Microsoft Excel with advanced software like R Studio can be beneficial. The integration of these tools improved data entry efficiency in supply chain management. The average accuracy of the supply chain management process increased from 72% to a range of 75 to 80%. This improvement demonstrates that the

combination of Microsoft Excel and R Studio can effectively enhance the performance of supply chain networks. This finding, reported by Praveen [4], highlights the value of using both traditional and advanced software tools in tandem to optimize inventory management and supply chain processes.

The effectiveness of Microsoft Excel in inventory management and supply chain networks has been demonstrated through various methods, including ABC, VED, and ANA analyses. In a study, a web-based inventory management system named "Sprint" was developed for a telecommunications company in Indonesia [5]. While manual data entry can be slow, the study recognized the importance of Microsoft Excel alongside the existing inventory management system. Users could input data in Excel and then import or export it to the Sprint system. The integration of Excel showed significant potential in meeting the growing demands of inventory management. The study concluded that the web-based system, which collected real-time supply data and allowed for strict control and monitoring, could be effectively integrated into business operations.

Fonseca [6] emphasized that modern-era businesses can only improve by maximizing and refining their processes, which can lead to cost reductions or improved customer service. This perspective was supported by a study conducted on a cement company, focusing on stock management related to the transportation of cement in bags from warehouses and optimizing forklift operations. The study used an integer programming model, naming the process a ship loading management tool. Researchers found that Microsoft Excel was sufficient to solve this type of problem, despite its simplicity when using an integer linear programming model. This simplicity and organizational capability were deemed beneficial for stock management. To address the limitations of Excel, additional tools such as Front-Line Solver and Gurobi Optimization, which are application extensions for Excel, were used. As a result, optimization of the existing stock management system was successfully implemented, and the ship loading company was able to effectively utilize at least 50 percent of its available resources.

Dhaiban [7] notes that although programming models are widely used in inventory management, further improvements are needed to optimize the use of Microsoft Excel for this purpose. Furthermore, recent studies examining inventory management scenarios with optimal control models have generally not integrated integer conditions.

To remedy this, we resort to the use of integer programming in stock management, as discussed by Mufidah [8], a study focused on its application in large-scale vaccine supply chain management. Since vaccines are highly sensitive products, prone to expiration and requiring careful handling during storage and transportation, effective stock management is crucial. With the global vaccine market reaching revenues of $59.2 billion since the start of the Covid-19 pandemic, the need for competent stock control is evident.

Researchers have recognized the value of mixed integer programming in supervising vaccine logistics. This approach has been crucial in their review of 25 studies on vaccine allocation strategies for various diseases, including influenza, dengue, HPV, and measles. These studies, which utilized integer programming, led to a common conclusion: implementing this programming technique resulted in cost reductions of at least 20%. Furthermore, the benefits extended beyond cost savings, encompassing reduced disease impacts, improved vaccine allocation, and outbreak prevention. This research, presented by Lopes [9], highlights the significant role of integer programming in optimizing inventory management, especially in complex and high-stakes areas such as vaccine distribution.

2.2 INVENTORY MANAGEMENT SYSTEMS

2.2.1 Concept

Inventory: Includes raw materials, spare parts, work in progress, finished products, packaging materials, and general supplies" (The Editors of Encyclopaedia Britannica, 2017).

Stock control: Generally, involves the timing of when stocks need to be replenished and the quantity to be ordered (The Editors of Encyclopaedia Britannica, 2017).

2.2.2 The Challenges of Stock Management

Inventory management (IM) is a crucial factor for the financial health of a company, as inventory often represents the most significant physical asset on a company's balance sheet. It is therefore imperative to manage inventory meticulously, with well-defined replenishment rules for each item. The goal is to have the right stock, in the right place, in the right quantity, and at the lowest possible cost. Stockouts, which typically occur during

periods of high demand in the market when stocks of fast-moving items are insufficient, can result in lost sales and decreased customer loyalty.

On the other hand, excessive inventory can lead to high storage and handling costs, as well as interest on short-term loans. In addition, there is a risk of financial loss if excess materials are sold below their usual price.

The main objective of effective inventory management is to minimize total inventory costs while maximizing operational profits. There have been many cases where inventory management and planning decisions have led to success, often attributed to the development and implementation of sophisticated inventory planning models. This perspective is supported by Singh [10], who emphasize the crucial role of inventory planning models in improving inventory management outcomes.

2.2.3 The Warehouse Management System (WMS)

Warehouse management system (WMS) is a software that helps companies manage and control daily warehouse operations. Andiyappillai [11] describes the WMS as crucial in managing the warehouse's daily operations. He notes that while various algorithms are used in the WMS, their application is generally limited to executable decisions, such as determining picking paths and product placement strategies.

Andiyappillai [12] identifies the essential functions of the WMS as supervising materials from receipt to shipment, communicating real-time information on stock levels and locations of these materials to a database.

This underscores the need for a system capable of monitoring and documenting the history of material movements. Such a system is essential to provide the necessary details to identify and locate materials, as well as to determine the actual quantity at a specific location. This need is particularly felt as the warehouse, where the initial inventory control system was implemented, had no form of material flow control other than the internal shipping system.

This system only showed operators the system balance and the number of orders processed for production. Therefore, no attention was paid to or recorded the quantity and date of entry of materials into the warehouse.

Inventory management is highly valued for its potential role in improving resource tracking accuracy. However, it is not always infallible. Kenyon [13]points out that not all companies have an accurate and up-to-date system for their inventory management. Despite this, many continue to rely on it to improve resource tracking. The challenges faced by different industries in inventory management are numerous:

a) Difficulty in the retail sector: It is often difficult to consolidate a unified view of stocks across different retail channels.

b) Complexity of packaged consumer goods: The high volume of transactions in the packaged consumer goods sector can make inventory management particularly difficult.

c) Contractual obligations B2B: B2B companies often have contracts that stipulate delivery deadlines. Delays can result in penalties, adding pressure to maintain effective inventory management.

2.2.4 Interest in Inventory Management

2.2.4.1 Competitiveness and performance

A study conducted in Ethiopia by Atnafu & Balda [14] examined the effects of implementing inventory management in micro and small enterprises (MSEs), with a particular focus on its influence on competitiveness and overall organizational performance. This research, which gathered data from over 180 MSEs in Ethiopia, revealed a positive correlation between the extent of inventory management implementation and the benefits obtained by the business.

The inventory management practices examined included a range of forecasting and analysis tools such as ABC analysis, Economic Order Quantity (EOQ), Vendor Managed Inventory (VMI), demand forecasting, computerized inventory management, and Just-In-Time (JIT) inventory systems. The implementation of these practices led to significant competitive advantages, particularly in areas such as pricing, quality, and delivery. Furthermore, the study observed notable improvements in organizational performance indicators such as profitability, market share, cost efficiency, and production levels.

This research highlights the substantial impact that effective inventory management can have on the success of small businesses, demonstrating that well-structured inventory

management practices can lead to tangible improvements in both market competitiveness and internal operational efficiency.

2.2.4.2 Customer satisfaction

Sohail & Sheikh [15] conducted a study examining stock management from the perspective of raw materials to finished products. The study highlights that companies manage stocks not only for their own operational needs, but also to satisfy customers. It is essential for companies to align their stock management practices with customer demands, ensuring they can meet these demands without falling into the pitfalls of overstocking or stockouts. The study covers the entire supply chain journey, from acquiring raw materials, through the production process, to transforming into finished products. It emphasizes that throughout this journey, the security and safety of stocks must be meticulously overseen by effective stock management practices. The case study concludes that applying robust stock management practices leads to more accurate records and ensures that finished products are ready to be shipped on time. This results in increased customer satisfaction, higher revenues and profits for the company, as well as a more positive work environment for employees. Essentially, the study highlights that effective stock management is a crucial driver of overall business success, impacting various aspects, from customer relations to internal dynamics of the company.

2.2.4.3 Financial performance

A study conducted in Harare (Zimbabwe), focusing on small and medium enterprises (SMEs), revealed a significant link between inventory management and financial decision-making within companies. Muchaendepi [16] reported that a majority of the surveyed SMEs, 54 percent, acknowledged the strong positive impact of inventory management on their financial performance. In contrast, only 2 percent considered the impact to be strongly negative. Notably, 93 percent of the participating companies agreed that inventory management practices positively influence the maintenance of healthy financial performance within their organizations. These results are consistent with the previously mentioned benefits of inventory management, particularly in terms of improving cash flow within companies. Effective inventory management can lead to more profitable operations in the long term, highlighting its crucial role in the financial health and sustainability of

businesses. The study thus highlights the importance of inventory management not only as an operational tool but also as a strategic lever that can significantly influence a company's financial results.

Stock management in the Philippines is treated with the utmost importance, seen as a crucial factor in achieving successful cost control in business operations. Defining stock objectives should be done quickly and with the help of computer programs, aligning them with real needs or economic order quantities. This allows for tracking stock levels and keeping track of supplier information within the company. Seeking a reliable, efficient, and accurate stock management system not only reduces stock-related expenses but also speeds up stock-related procedures, as mentioned in (Martinez's 2020) study. Therefore, having a well-functioning stock management system is necessary.

2.2.4.4 Risk management

Some raw materials can be stored for long periods, while perishable products are kept within limits based on their usage. It is commonly recognized that careful and intelligent stock management is crucial to minimizing depreciation, theft, and stock wastage while ensuring that materials remain readily available when needed. Furthermore, additional evidence highlights those systematic and specific performance indicators are closely linked to the level of stock management practices. This connection is essential for maximizing profits and ensuring the long-term survival of any business, as these are fundamental goals for every business, as highlighted by Ardiansyah [17] in their study.

2.2.5 Warehouse Activities

Tien [18] emphasize that the main objective of materials managers is to design methods for the efficient management of stored materials. This involves focusing on the three key activities in a warehouse: material receiving, storage, and shipping.

The complexity of activities such as receiving, storing, and shipping in a warehouse is influenced by factors such as the volume of products handled and the size of the storage facility. While the systemic control involved in these activities is largely similar, it is crucial to start correctly with the receipt of materials. This involves accurately entering primary

information about incoming materials or those in the warehouse to ensure a smooth and error-free flow of information in the system. These activities are described as follows:

2.2.5.1 Receipt of materials

As seen previously, the initial phase of warehouse operations is the receipt of materials, which involves recording information about the material in the warehouse management system. Upon arrival, the products are unloaded at the warehouse receiving docks, where they are identified by a code and quantity, and then assigned to a storage location.

It is also important to organize receiving data by receiving dates and transaction references. This includes recording a unique transaction number for each receipt and/or the name of the unit from which the products are received, maintaining a detailed log of all items entering the warehouse. This practice is crucial, especially when dealing with large volumes of materials, as discrepancies can occur. In such cases, the quantity indicated on the receipt or invoice serves as the starting point for any inventory analysis, facilitating the comparison of physical counts with the data recorded in the system.

2.2.5.2 Materials storage

The second key activity in a warehouse involves material storage, which includes the correct placement of all materials in designated areas, ensuring orderly arrangement of stock, handling of stored materials, and maintaining control over physical inventory. It is crucial that all product movements, whether placed on shelves, racks, or other storage spaces, are properly recorded in the warehouse inventory records. This facilitates effective stock management. It is also important to emphasize the importance of a well-planned physical layout to make storage more cost-effective. A good layout can reduce expenses related to equipment, space, material damage, and labour in the warehouse.

Maintaining a stock with a high level of accuracy and efficient use of space per square meter is important for any business, especially during audits. This is because all stock includes products with added value and associated costs that require strict control. Inadequate stock control can have long-term negative consequences for a company, highlighting the importance of effective stock management.

2.2.5.3 Material shipment

Manual Almoxarifado [19] discusses the final stage of a warehouse's activities, focusing on the shipment or delivery of materials. At this point, the responsibility for the materials shifts from the warehouse sector to the sector receiving them. It's crucial for the warehouse to execute the delivery process in an organized manner, adhering to a pre-established schedule. This includes ensuring proper verification and obtaining a signature upon receipt during the delivery act. This process marks the transfer of material custody and is a critical step in maintaining the integrity and accountability of the warehouse's operations.

2.2.6 Inventory Control

Andiyappillai [12] emphasizes that a key objective of inventory management is to find a balance between costs and develop procurement plans that minimize the total cost while determining the optimal order quantity to replenish items. It should be noted that an effective inventory control system is essential to guide the warehouse on when to place orders or alert the purchasing department, determine appropriate quantities for material procurement, and maintain sufficient stock levels. This helps to avoid shortages as well as excessive stock accumulation in the warehouse, thus optimizing the balance between stock availability and cost efficiency. To effectively implement these controls, several factors must be considered:

a) Minimum and Maximum Stock Level Control System

b) Upper stock limit

c) Lower stock limit

d) Buffer stock level

e) Stock review interval

f) Replenishment lead time

g) Point for placing urgent orders

By using these measures, a well-regulated inventory can be maintained, ensuring a constant level of materials in storage. This approach helps prevent various issues, such as production line stoppages due to material shortages or insufficient space for material storage.

2.2.7 ABC Classification

The ABC categorization is a technique used to assign importance to items within a particular group. It organizes these items into categories based on their significance to the organization, with category A items being the most critical. This conventional ABC categorization typically employs the Pareto principle, also known as the 80/20% rule (Khanorkar & Kane, 2022).

According to the Pareto principle, generally 20% of products contribute to 80% of a company's revenue. As suggested by Naranjo [20], items in category B could generate approximately 15% of the revenue, while those in category C contribute to around 5%. These figures are not rigid but serve as a general guideline. Although category A items are crucial, they are often managed with a low level of service.

Douissa [21] identified four main categories in the context of the ABC classification. These include methodologies based on mathematical programming, approaches using artificial intelligence and metaheuristics, multi-criteria decision-making (MCDM), and various hybrid techniques. The study assumes that recommendations made, based on the analysis conducted with the VBA tool, will have a positive impact on SEWS stock management, leading to improvements in terms of efficiency and cost savings.

2.3 DIFFERENT METHODS OF INVENTORY MANAGEMENT

Inventories are considered the lifeblood of any manufacturing organization [22], and raw materials are at the heart of the company because without raw materials, the production of finished products cannot take place, which can lead to delays in the process and likely extend production and delivery deadlines. It is therefore very important for companies to use efficient and effective stock management methods for their success.

The following section explains the common methods used, namely the pull & push system, the just-in-time approach, MRP, and the MCS method.

a) Stocks are classified into three types: raw materials, work in progress (WIP), and finished goods.

b) Raw materials are ingredients used to produce finished products or final goods.

c) Work in progress refers to items in the process of being manufactured.

d) Finished goods are complete items awaiting delivery to customers.

Our work is limited to the analysis of the first type of stock, namely raw materials.

2.3.1 The Lean Philosophy and the Just-In-Time Method

2.3.1.1 The lean philosophy

Lean is a business concept that emphasizes the pursuit of simplicity and profitability, while providing exceptional quality and efficient service. Stocks refer to any stored merchandise, whether located inside or outside the factory, regardless of the storage duration. Additionally, pending orders, cross-docking, and direct shipping are part of Lean stock management systems commonly used. [23], and [24].

Lean inventory management is a methodical strategy aimed at increasing the value of a company's inventory by detecting and reducing wasteful use of resources, labor, and time. This is achieved through continuous improvement efforts aimed at achieving perfection and optimal performance [24].

Lean manufacturing focuses on measuring and reducing inventory while streamlining production to eliminate waste and increase efficiency. Initially adopted by Toyota Motor Corporation in the 1970s under the name "Kanban," these principles were developed in response to the need to conserve resources and minimize waste in Japan with limited resources at the time (Kanchan, Chandan, & Rajenthirakumar, 2016).

The use of Lean Inventory Management Systems (LIMS) is intended to enhance organizational performance by reducing expenses associated with inventory management in businesses where inventory constitutes a significant portion of operational costs [25].

2.3.1.2 The JIT method

JIT is a stock management technique that organizations use to enhance efficiency and reduce waste by acquiring items only when they are needed in the manufacturing process. This approach effectively reduces inventory costs [26].

Lean management, or the JIT approach, can be applied in various areas, such as JIT manufacturing process, JIT inventory, or a delivery scheme. The goal is to minimize stocks to the necessary minimum, ensuring they are available exactly when needed to avoid unnecessary storage costs while maintaining timely production [27].

Furthermore, the JIT method promotes zero or minimal stocks, as stocks represent tied-up capital that incurs additional costs, such as interest and holding costs, while also occupying valuable space. Indeed, excessive production or excessive storage leads to higher inventory and unused funds[28].

However, this approach presents challenges, particularly the reliance on constant and responsive supply, which can be problematic in the event of prolonged supply delays or irregular demand [29].

The adoption of a JIT system requires replenishments in small quantities to meet specific demands and minimize inventory costs. This may lead to suboptimal purchase orders and increased operational costs. Nevertheless, Lean and JIT principles remain essential strategies for businesses aiming to enhance their operational efficiency[30].

In summary, while JIT is an essential part of Lean Manufacturing focused specifically on inventory management, Lean Manufacturing itself is a broader approach that encompasses a wide range of practices aimed at improving overall efficiency and eliminating waste in manufacturing processes.

2.3.2 Materials Requirements Planning (MRP)

2.3.2.1 Presentation of MRP system

Thanks to the development of digital technology, the industrial sector has modernized significantly. Today, it has become common to use innovative tools to assist in production management. Among these solutions, we find MRP software and Enterprise Resource Planning (ERP) software.

The MRP method, first developed by Joseph Orlicky as a computerized production planning system, is applied to ensure the smooth running of production by providing users with

information on the necessary materials and their quantities to manufacture finished products, as well as when to replenish stocks.

MRP is a computerized method for managing the inventory of all materials necessary for the conversion process of a company (manufacturing or services). MRP is a system for planning and controlling materials and components that depend on demand.

The development of the MRP is logically carried out by translating the Master Production Schedule (MPS) of the finished products into net requirements for some of its components, so that this MRP can be used to calculate the quantity of materials needed and the lead time to meet these material requirements. [31].

When MRP systems were created in the 1960s, with the introduction of computer technology, inventory management software was vital. Initially developed for use in manufacturing, MRP systems were upgraded to MRP-II in the late 1980s. The integration of MRP and MRP-II for manufacturing with accounting, finance, human resources, and Customer Relationship Management (CRM) has been the goal of ERP systems since their creation in 1990.

Production planning involves defining the overall level of units to be produced to best meet the orders anticipated by the customer while respecting capacity constraints, general profitability objectives, productivity, delivery deadlines, etc. Production planning also aims to optimize the use of available resources for the manufacturing of one or more products. MRP is probably the most widespread planning model, it is a system that emerged in the 1960s which, based on firm and estimated demands for finished products and current stock levels, calculates the component requirements to meet the demand.

2.3.2.2 Key steps of the MRP process

A modern MRP system is a closed-loop system that encompasses the entire company. It tracks all activities and continuously interacts with planning and scheduling systems to ensure perfect consistency, enabling the company to remain focused on the promises made to customers and their expectations.

Novitasari [32] explains that MRP is an information system used to calculate the materials, components, or raw materials needed for the production of finished products. It is a method

to calculate how many parts or materials of a particular type are required and when they are needed. It also provides a schedule for organizing their use. This helps companies plan production and manage inventory more efficiently.

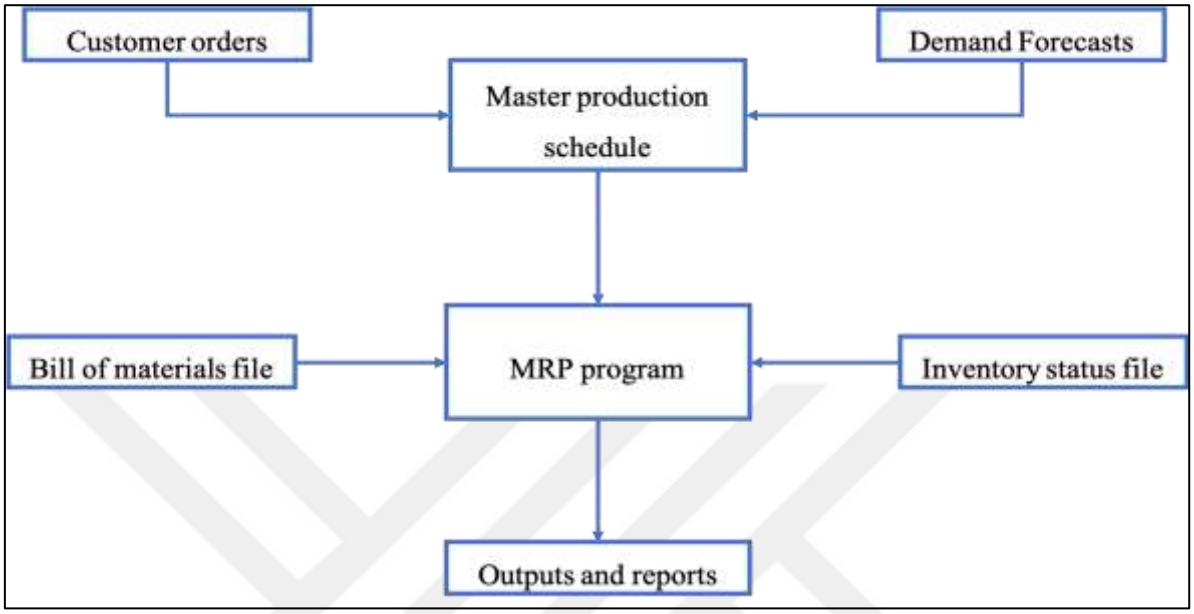

Figure 2.1: MRP System Workflow.

This planning is done following certain steps:

The key steps of the MRP process are as follows:

Precisely determine what needs to be produced

All finished products and subassemblies are the responsibility of engineering for the creation and management of the bill of materials. The bill of materials, also known as the product structure, is a hierarchical model that precisely describes what constitutes each unit. For example, there may be many subassemblies in the final product. Each subassembly may contain two or more elements, and each element may have a list of parts. The list will describe the order in which supplies will be needed, parts that depend on other parts, and the number of each type of part required.

Calculate the demand

The system determines the quantity and time interval necessary to meet the demand for finished products. The calculation considers available stock, customer orders, and sales

service forecasts. True make-to-order manufacturers primarily handle customer orders, while others focus on forecasts. Stock manufacturers use a combination of orders and forecasts to plan future production. The S&OP, which is the agreement among all stakeholders on what will be produced, is driven by this information.

Determine the quantity of supply

The MRP cycle calculates step by step the sub-assemblies, components, and materials that need to be manufactured or purchased during the planning period using the bill of materials and the MPS for all products. Then, to determine the net quantities missing for each component, the system checks the required quantities based on available stock (calculating net requirements). It determines the appropriate quantity "to manufacture or purchase" for each item using predefined parameters, such as batch sizes. Finally, it determines the appropriate start date for procurement using the procurement lead time or production lead time, as applicable, and sends this information to the Purchasing or Production Control department.

Here is what the MRP process flow looks like:

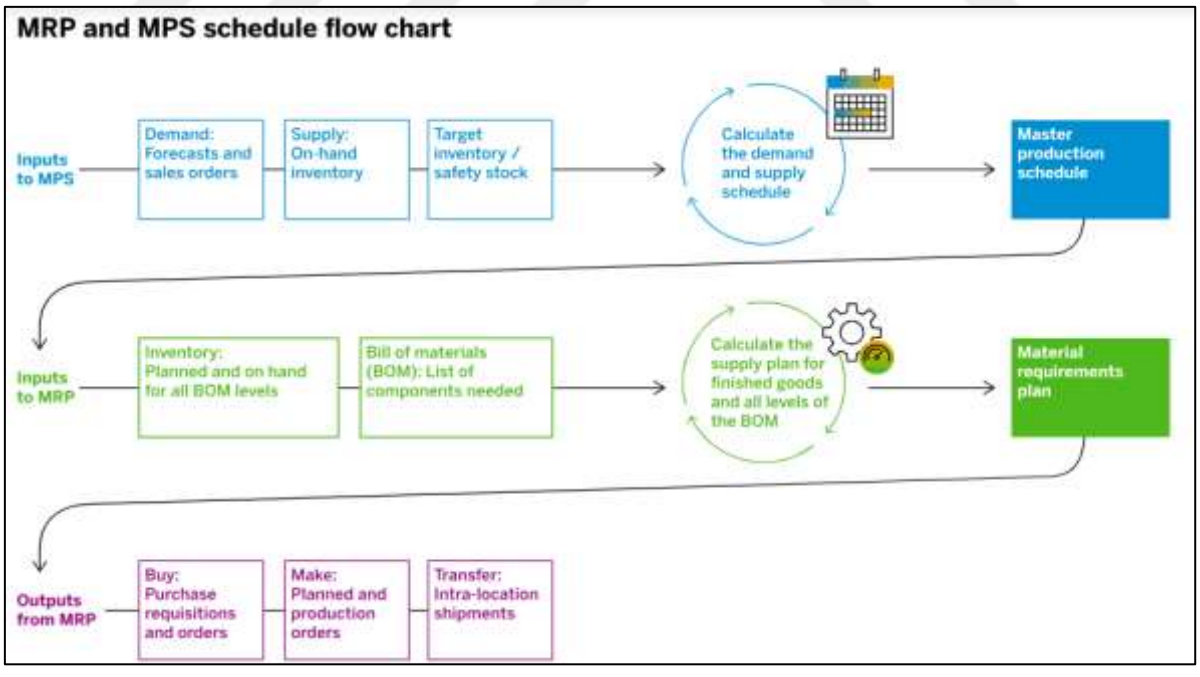

Chart 2.1: Integrated MRP and MPS Scheduling Process [32].

(https://www.sap.com/france/products/erp/what-is-mrp.html)

2.3.2.3 MRP operations

The concept of MRP has been used in the design of Enterprise Resource Planning (ERP) systems by globally renowned IT and software companies such as Oracle and SAP[33].

An MRP program is driven by a "master production schedule" that takes customer orders and demand forecasts as inputs. Customer orders feed the system with details of the finished products to be manufactured and customer information. The master production schedule, based on forecasted sales and actual demand, can propose a plan regarding the quantity, sub-assemblies, and lead time for the company.

The bill of materials is a crucial component of an MRP program. It is a list of resources required to manufacture a finished product. These resources include raw materials, components, labor, finishing work, and the exact respective quantities needed. When a customer order is received and the user creates a bill of materials for each finished product, the system can calculate the total quantity of raw materials required for production.

The stock status file is a file that keeps track of the list and level of stocks. With the stock status file, the system knows if stocks need to be replenished to meet production needs. The system automatically measures stock shortages and recommends a replenishment quantity so that there are enough materials for production to continue and to produce stocks to meet projected sales. This is why MRP is typically used in a push system.

Outputs and reports generated by the MRP system may include quotations, replenishment notes, delivery notes, and invoices. The system automates documentation and calculation processes so that users can reduce manual work and guesswork in determining replenishment amounts.

2.3.3 MCS (Material Control System) Method

MCS is the system that supports the entire material control process such as ordering, receiving, issuing, stock control, etc. It provides a function to perform MRP to calculate the order quantity using the required quantity based on the PDP, stocks, safety stocks, and open orders [34]. MRP can be run daily with high performance speed. By using a portable barcode scanner, it provides an easy and accurate issuing process.

MCS generate a valuable element of strategic management accounting and help determine the performance levels of the company and their sustainable competitive advantages (Rehman et al., 2019). Furthermore, researchers have shifted their focus from the industrial sector and applied environmental MCS to the financial sector (Hummel et al., 2020).

2.3.3.1 Objectives of MCS

a) Standardize the way materials are controlled

b) Reduce urgent orders by checking for material scarcity

c) Flexible setting of safety stocks to maintain an adequate stock level

d) Standard method of material control

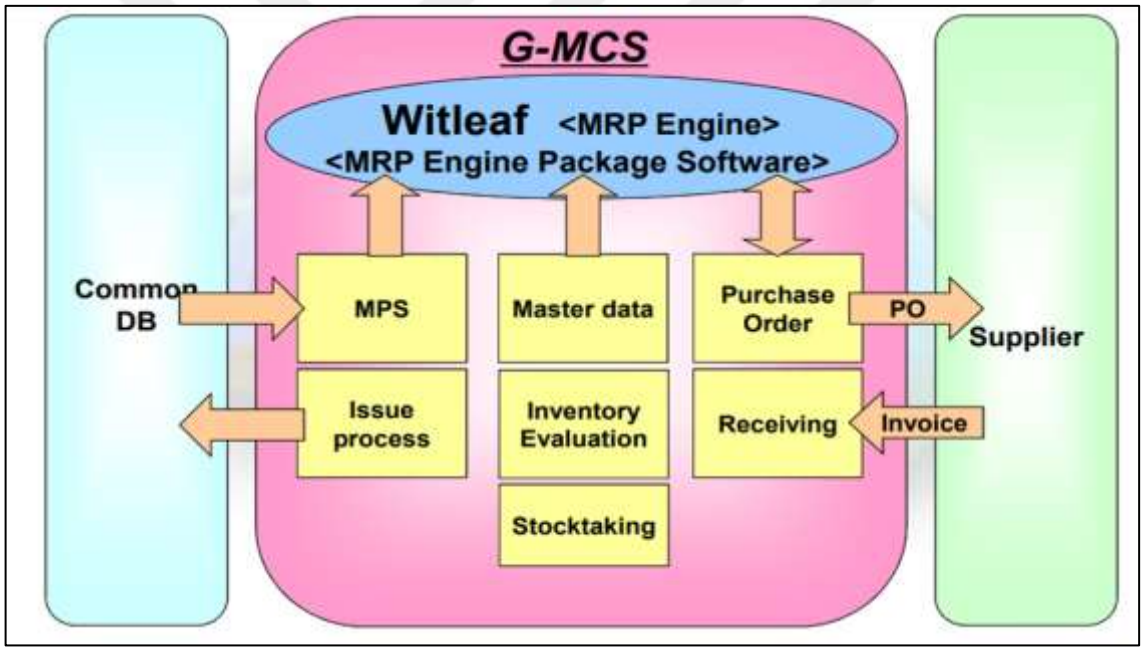

Chart 2.2: MCS with Integrated MRP and Supply Chain Workflow [32].

Traditionally, two types of material control systems have been distinguished: push systems and pull systems. In a push system, the work to be done at each workstation is determined in advance by a schedule. Each workstation is expected to adhere to this schedule, and the material is moved (pushed) from one station to another without considering the availability of the downstream resource or the level of material in the downstream buffer. The MRP system is an example of a push system, in which the production plan is dictated by the scheduled shipment date. Planned production lead times determine when the material should

be released to the shop floor, after which the material is pushed through all subsequent workstations. An MRP system is often complemented by dispatching rules, which organize the queues in front of the workstations.

2.3.4 Push and Pull Inventory Systems

Pull and push are the two basic types of inventory systems. A pull inventory approach is also referred to as a reactive system, which responds to customer demand; whereas a push approach refers to a proactive system, which utilizes "replenishment of stocks to anticipate future demand." Yang [35] study the impact of these attitudes for decision-makers on the performance of the supply chain in push and pull supply chains.

2.3.4.1 The push system

On the other hand, push systems, such as H&M stores, have ongoing production to keep products ready in their stocks or warehouses and always push items to the display shelves.

Contrary to the pull system, the push system, based on sales forecasts, produces goods to meet anticipated demand. This model is generally applied by highly profitable segments or economies of scale, with complex products and long production lead times (Industryweek.com, 2017). By employing this method, companies tend to have goods constantly available to quickly fulfill orders, but they may face high levels of inventory, resulting in various costs and even waste.

According to the recent study by Atan [36], academic literature has not yet provided a clear guideline on choosing between pure pull and push-pull strategies when considering integrated decisions at the SBP stock level and finished product PDT.

2.3.4.2 The pull system

In a pull system, production is triggered by customer orders, and materials and products are "pulled" through a logistics system. For example, a made-to-measure tailor workshop typically operates on a pull system, where tailoring only begins after a customer has placed a customized order.

The pull system is used by many Make-to-Order companies that sell customized products because excess customized products can be difficult to sell to other customers and become

waste. Additionally, a pull system also helps general companies avoid excess inventory and save resources. A pull system timely responds to a sudden drop in demand, allowing the company to adjust its production level accordingly and, consequently, reduce unsold items, save time, materials, and labor. However, this system may suffer when peak demand occurs and puts pressure on production. It is possible that the production lead time is significantly extended to fulfill large quantity orders [37].

3. METHODOLOGY

To answer the research questions, a case study will be conducted concerning an industrial company, namely the company SEWS. The methodology of this study will involve a combination of qualitative and quantitative research approaches, focusing on inventory management practices at SEWS and the impacts of changes in customer demands on the optimal functioning of the company.

The methodology is structured as follows:

3.1 DATA COLLECTION

3.1.1 The Qualitative Aspect

To understand the process and practices of inventory management at the company level, the study will be conducted using a qualitative approach, employing various data collection tools and gathering relevant information, namely:

a) Participatory observation

b) Open and targeted discussion with key individuals involved in the stock management process

c) Participatory observation of the execution of certain acts

d) Critical review of certain documents

e) Visit to different stores

3.1.2 The Quantitative Aspect

To understand the fluctuations in customer demand affecting orders and material arrivals in the SEWS MRP system, the following steps will be taken:

Perform a case study analysis focusing on the historical data of changes in customer demand and their impact on stock levels and MRP system responses.

This will involve collecting data from the MRP system archives and conducting interviews with the operational team.

a) Analysis of the MRP reports and data concerning orders at the company level

b) Manual analysis of a sample of orders for three material numbers

3.2 DATA ANALYSIS

a) For the qualitative and quantitative data collected in this study, appropriate data analysis techniques will be applied.

Qualitative data will be analyzed thematically to identify methods and practices of stock management, issues, and dysfunctions encountered.

b) The quantitative data will be analyzed using statistical tools extracted from the MRP system by examining a representative sample in terms of time and references. This comparative approach will allow us to analyze the discrepancies between existing stock levels, raw material requirements, and current orders for the given period. This method aims to identify unnecessary demands that can be postponed or canceled.

3.3 DEVELOPMENT AND TESTING OF THE VBA TOOL

3.3.1 Objectives

Evaluate how a VBA-based tool can improve the responsiveness of the MRP system to changes in customer demand.

3.3.2 Implementation of the Solution

Design and implement a VBA tool tailored to the SEWS MRP system to identify and flag potentially redundant orders. The development process will involve iterative testing and feedback sessions with the SEWS inventory management team to ensure that the tool's functionality meets operational requirements.

3.3.3 Evaluation of the Integration of the VBA Tool Through a Set of Indicators

Establish a set of performance indicators such as the collection of quantitative data from the MRP system before and after the implementation of the tool for comparative analysis.

4. MATERIALS AND METHODS

4.1 THE AUTOMOTIVE SECTOR IN MOROCCO

4.1.1 Sector Overview

The low cost and quality of its workforce in Morocco offer industrial enterprises the opportunity to establish themselves as a true ecosystem in the automotive industry. In 2018, the sector had over 183 factories spread across three main regions: Tangier (43%), Casablanca (39%), and Kenitra (7%).

The automotive sector has been a strategic sector of Moroccan industrial policy since the 2000s, experiencing annual growth in terms of job creation and exports. Over the past decade, the Moroccan automotive industry has reached sustained growth levels.

In 2021, the automotive sector was the country's main export sector (8.4 billion dollars, mainly driven by increased sales in the construction segment). Less than eight years later, Morocco is now the top exporter of cars to the European Union, surpassing China, Japan, and India, while already being the leading car producer on the African continent.

Indeed, at the end of November 2023, exports from the sector experienced a significant increase of 30.2%, reaching approximately 13 billion dollars (130.6 billion dirhams). This development is explained by the growth in sales of the construction segment, wiring, interior vehicle components, and seats.

4.1.2 Acceleration of the Automotive Sector in Morocco

This acceleration is supported by the creation of eight sectoral ecosystems. Morocco's position as a platform for the production and export of automotive equipment and vehicles is strengthened by the establishment of renowned foreign groups such as Renault, Snop, GMD, Bamesa, Delphi, Yazaki, Sews, Saint-Gobain, and more recently Stellantis (formerly PSA).

The Moroccan Acceleration Plan 2014-2020 and the new ecosystem approach it introduced have set the conditions for sustained and long-term development of companies in the sector. The new strategy strengthens the value proposition developed and further anchors Morocco's

position in the global automotive industry. Ecosystem approaches thus promote a more pronounced integration of the sector (the integration rate of the automotive industry in Morocco reached 63% in 2021), as well as a better organization of its players who gain in competitiveness, quality, and responsiveness.

Stellantis and Renault, two driving forces in the sector. At the beginning of the year 2012, Renault inaugurated its factory in Tangier. Since then, it has become the catalyst for the transformation of the entire Moroccan automotive industry. By 2022, the factory had produced no less than 2,360,000 vehicles in 10 years for over 70 destinations worldwide.

The ramping up of the industrial platform of the Renault group in Morocco has led to the launch of a major project in the automotive ecosystem: starting from 2016, agreements for the development of the Renault ecosystem were established with the aim of increasing the group's local integration rate to 65% and generating revenue of 1.5 billion euros by 2023. Moving from 26 to 76 first-tier suppliers and building on the achievements related to this agreement, the group announced in 2021 the signing of a new phase of the Renault ecosystem aiming for a local integration of 80% and a long-term revenue target of 3 billion euros.

On the Stellantis side (formerly PSA), the group signed an agreement with Morocco in 2015 for the establishment of an industrial complex with an investment of 6 billion dirhams (550 million euros) and the start of vehicle production from 2019. The Kenitra plant (50 km north of the capital Rabat) produces engines and vehicles and has an initial production capacity of 100,000 vehicles per year. It relies on the Moroccan supplier network, achieving a local integration rate of 60% from the outset and 80% in the long term.

4.1.3 The Main Industrial Companies in Morocco

Morocco aims to position itself among the low-cost countries to attract even more subcontracting and relocation activities. This is why large industrial companies have established themselves in Morocco. They can be classified according to their country of origin.

South Korea: HANDS CORPORATION; DAEDONG;

Italy: SOGEFI; MTA; PRO MAGHREB;

Japan: SEWS MAROC; SEWS MFZ; FUJIKURA; YAZAKI; JTEKT;

United States: TECONNECTIVITY; NEXTEER AUTOMOTIVE; LEAR AUTOMOTIVE MOROCCO;

Spain: FICOSA

China: CITICDICASTAL; AOTECAR;

France: LEONI…

4.2 PRESENTATION OF THE HOST ORGANIZATION

4.2.1 Overview of the Sumitomo Group

SUMITOMO is a Japanese group founded in the 16th century by Masatomo Sumitomo. This group began its activities with the exploitation and transformation of raw materials. Today, the group is heavily involved in several areas: Industry, Commerce, Finance, Telecommunication, Service, and others. Currently known as Sumitomo Electric Industries Ltd, (SEI) is a major producer of cables, materials, and equipment for the semiconductor and optoelectronic industry, providing telecommunications, power transmission, information technology, and automotive cable markets worldwide. The Sumitomo group has a global presence. Sumitomo's sites are located on all 5 continents, with over 70 sites in more than 30 countries. These are divided between production sites, research and development sites, and distribution platforms for the group's products to customers.

4.2.2 History of SEWS

In 1985, the subsidiary of the Sumitomo group, whose activities are concentrated in the automotive wiring field, took the name Sumitomo Electric Wiring Systems (SEWS). Its global network spans the five continents and ranks third in the world in the wiring sector. SEWS-Europe is part of the Sumitomo Wiring System (SWS) group, which in turn is part of the Sumitomo Electric Industries (SEI) group, specializing in the production of automotive wiring.

Table 4.1: Significant Dates in the Life of the Group [38].

Year	Activity
1990	Established Lucas SEI Joint Venture
1999	Sumitomo increased shares to 100%, thus forming SEWS-E
2000	Opened Technical and Commercial support office in Paris, France
2001	Opened factory in Deva, Romania
2002	Formed SEWS-CE Components Group
2003	Established SEWS –AWH European cable manufacturing in Hungary
2004	Opened factory in Alba Iulia, Romania
2005	Established SEWS-CE Budapest Commercial and Logistics Centre
2006	Expanded SEWS-CEH manufacturing and introduced Electronics capability
2007	Opened factory in Kenitra, Morocco
2008	**Opened factory in Ain Aouda, Morocco**
2009	Opened factory in Port Said, Egypt
2010	Established distribution center in St Petersburg, Russia
2011	Opened factory in Kenitra Freezone, Morocco
2012	Relocated Paris office to new purpose-built office
2013	Established joint venture in Yekaterinburg, Russia
2014	Opened new site in Ingolstadt, Germany
2015	Opened factory in Tarnaveni, Romania

4.2.3 The Business Sectors of Sews

The fields of activity of SEWS are diverse and can be represented in this circular infographic.

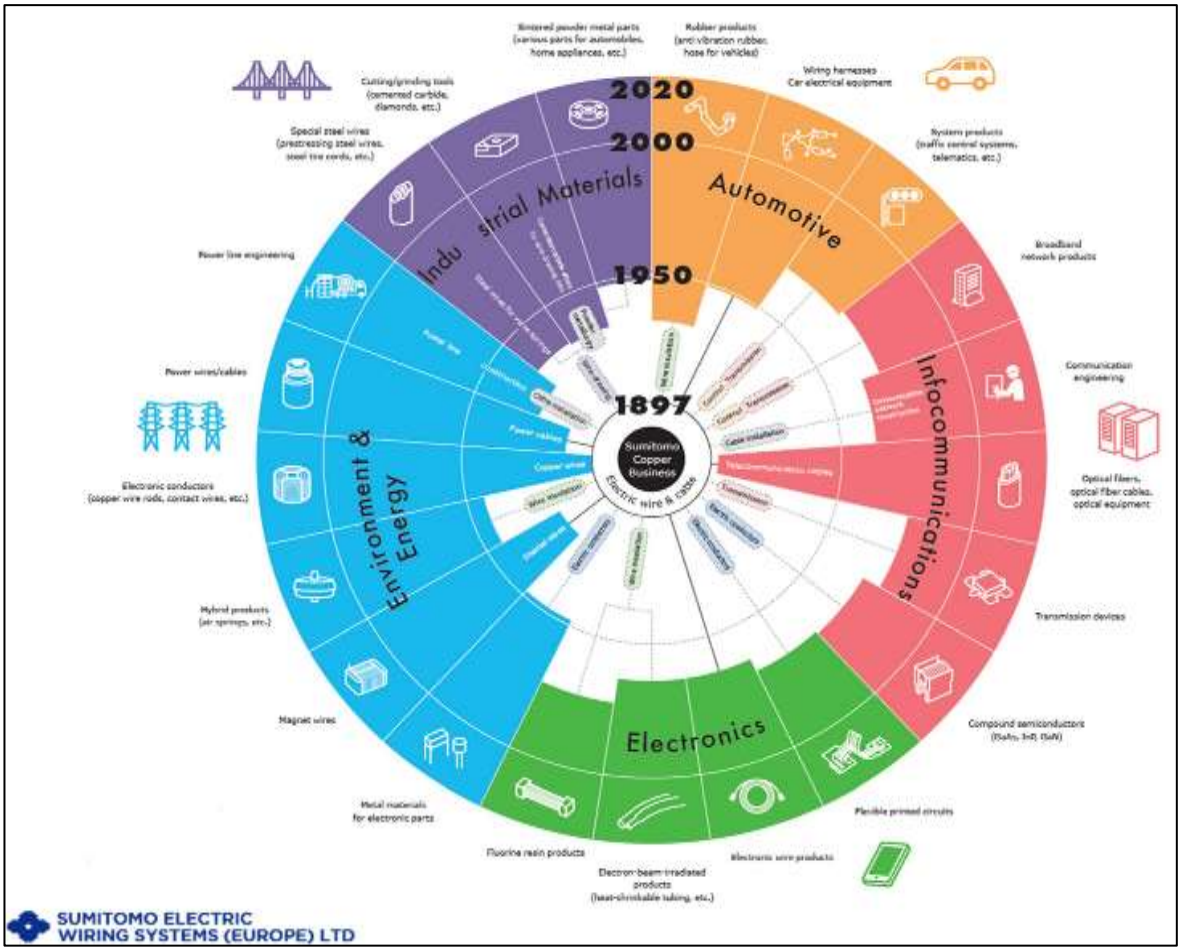

Figure 4.1: Strategic Business Domains of the SUMITOMO Group.

(https://www.sews-e.com/a-full-service-supplier/overview/)

4.2.4 Location of the Sumitomo Group's Subsidiaries

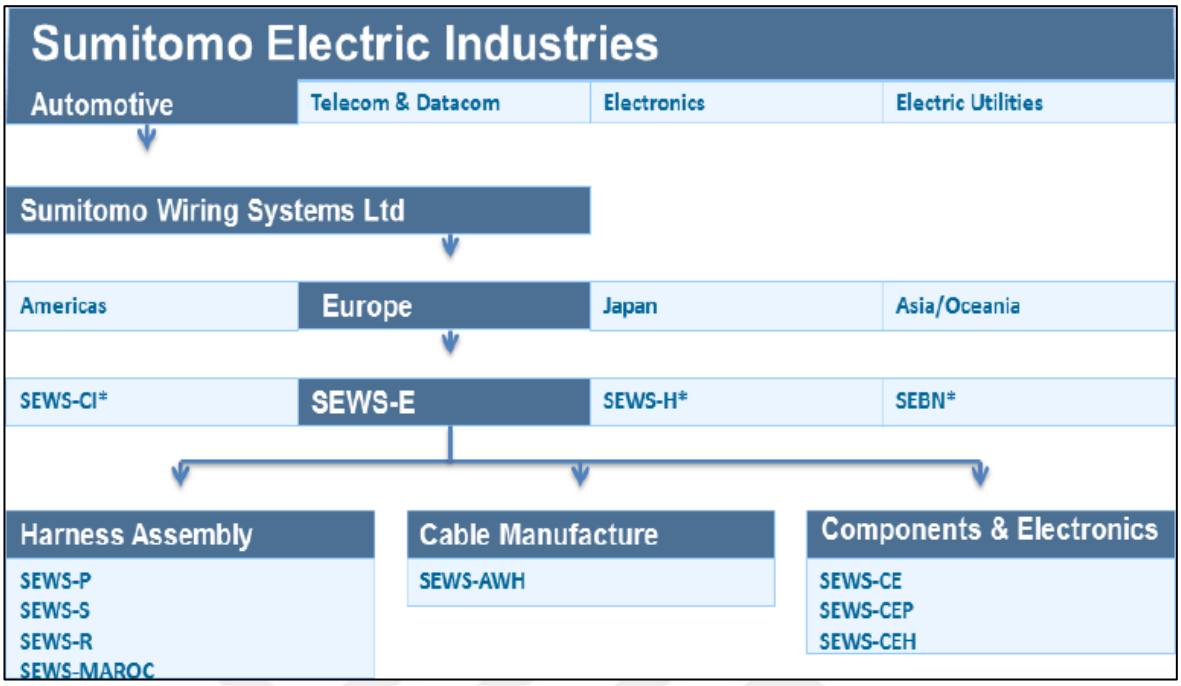

Figure 4.2: Profile of the Sumitomo Electric Industries Group.

4.3 PRESENTATION OF THE AIN AOUDA SITE

Figure 4.3: SEWS Ain Aouda.

The company Sumitomo Electric Wiring Systems, a subsidiary of the Japanese group Sumitomo Electric Industries, is represented in Morocco through 5 production sites for automotive cable harnesses, located in Casablanca, Berrechid, Tangier, Kenitra, and Ain Aouda, which collaborate with several international automotive manufacturers. Sews Maroc "Ain Aouda," established in 2009, is a limited liability company, a subsidiary of Sumitomo Wiring Systems Europe Ltd (SEWS-E) with its headquarters located in Staffordshire, UK.

SEWS-E is part of the Japanese group Sumitomo Wiring System (SWS), which itself is part of the Sumitomo Electric Industries (SEI) group. Specialized in the production of automotive wiring: "Engine" for the Renault brand and "Main" for the Nissan brand, SEWS Maroc Ain Aouda started its activity with the support of employees from counterpart companies (England (if European), Japan, Romania, and France...) thanks to their know-how and extensive experience in the field of wiring for the industry. The decision to invest in MOROCCO is primarily due to the proximity to Europe, the country's political stability, and the availability of qualified workforce.

4.3.1 Technical Data Sheet

Table 4.2: Technical Data Sheet of Sumitomo Electric Wiring Systems.

Business Name	**Sumitomo Electric Wiring Systems-Ain Aouda (SEWS-AA)**
Activity	**Production of automotive cable harnesses**
Creation Date	**2009**
Legal Status	**Limited Liability Company (LLC)**
Staffing	**3560 employees, 90% of whom are women.**
Annual turnover	**80.000.000 €**
Surface	**45150 m²**
Spoken Language	**96% French; 50% English; 1% Spanish; 1% German; 3 individuals: Japanese**
Adress	**Industrial zone, municipality of Ain Aouda, Prefecture of Skhirat Temara.**
Phone	**05 37 77 43 00**
E-mail	**Ainaouda@sews-e.com**

4.3.2 Projects Managed at SEWS AA

The SEWS AA site works with two clients: Renault and Nissan; it manages four Renault projects: X95, X61, CMF1, W09, and one Nissan project: the P32S as shown in figure 3 specifying the destinations of each family.

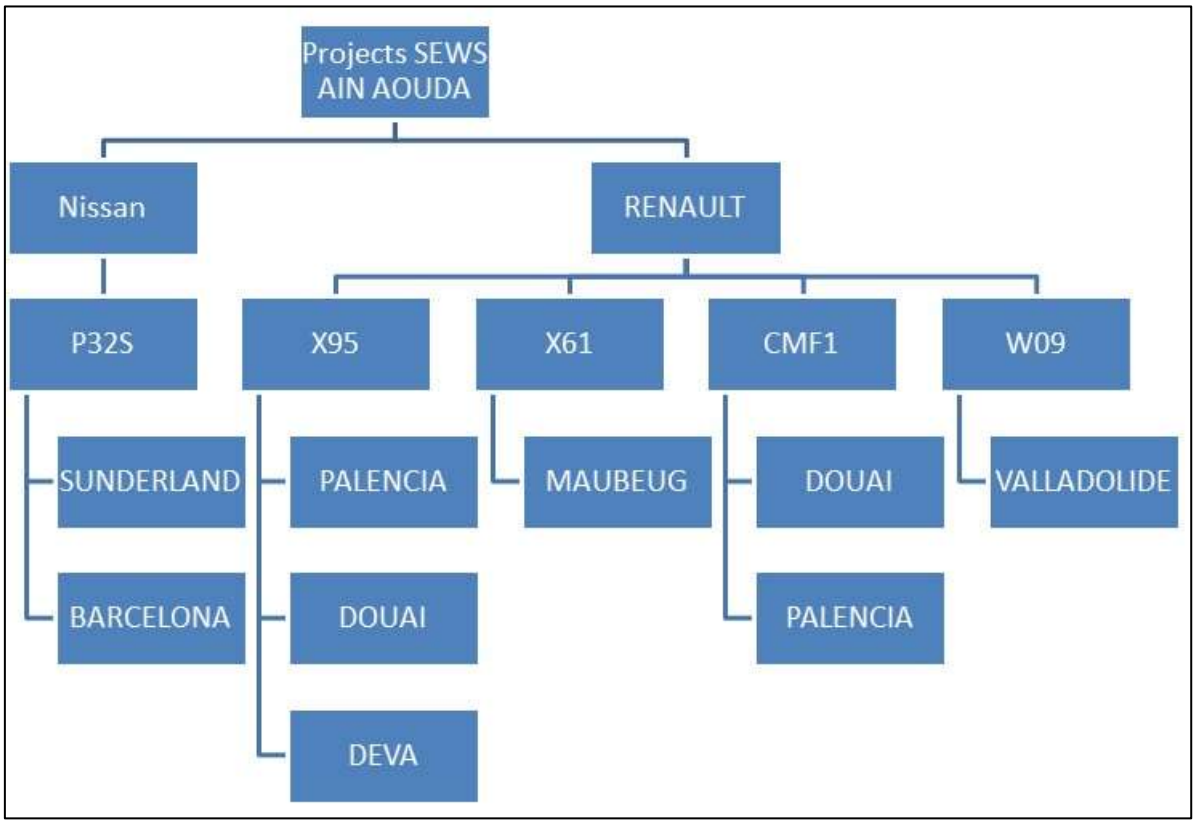

Chart 4.1: Destination of the Electrical Harnesses of SEWS AA.

4.3.3 SEWS Organizational Chart

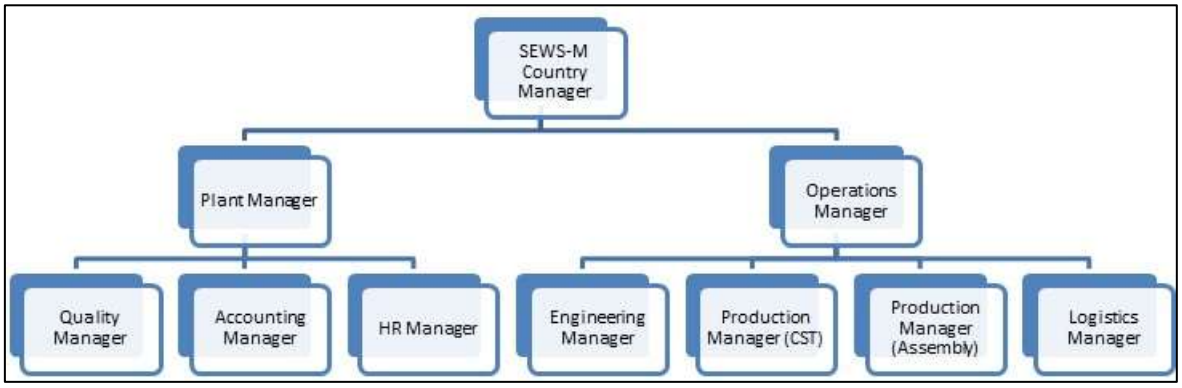

Chart 4.2: Organizational Chart of SEWS AA.

4.3.4 The Departments of Sews Ain Aouda

4.3.4.1 Production department

The main function of the production department is to ensure the production of harnesses by optimizing the available resources.

4.3.4.2 Engineering department

Upon receipt of the contractual documents for the product: Budget plan, customer plan, and bill of materials, this department validates all production documents as well as the harness assembly table layouts and prototype development.

4.3.4.3 Quality department

It ensures the provision of compliant products that meet customer requirements. It also controls the quality of the raw material upon receipt.

4.3.4.4 Department of finance

This entity is responsible, in addition to accounting, for management control insofar as it ensures the establishment of the summary budget and its control, through a comprehensive analysis of any deviations that may occur. This department supports the management in implementing the overall strategy by using advice and involvement from various departments within the company.

4.3.4.5 Department of human resources

It is responsible for personnel management, recruitment, salary management, leave management, and career management.

4.3.4.6 Logistics department

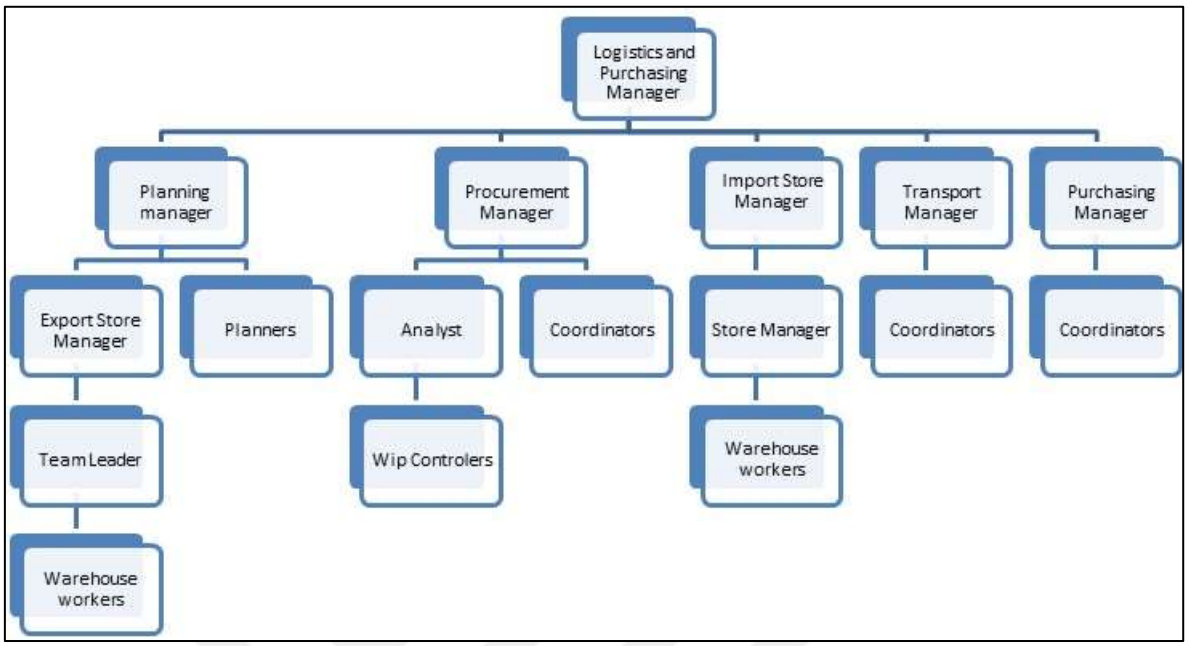

Chart 4.3: Logistics and Purchasing Department Organizational Chart.

Procurement Service

This service is based on the MRP system. Its role is to bring raw materials back to the workshop at the right time, while respecting cost, quality, and deadline.

Purchase service

The purchasing service is responsible for the indirect procurement of equipment, spare parts, office supplies, etc.

Transportation service

Manages import/export flows in coordination with all logistics service providers (transport companies, freight forwarders, ...).

The main carriers for shipping:

a) GLT

b) GEODIS

c) DHL

The main carriers for import:

a) GEODIS (Europe)

b) STC (Italy)

c) GLT (Spain)

d) YUSEN (Japan)

e) SAADANE (Morocco)

f) DHL

Store service

SEWS Ain AOUDA has two stores, namely:

a) Import: Ensures the reception and storage of raw materials and all other purchased products, as well as the supply of the production workshop with coils and components.

b) Export: Ensures the shipment of harnesses, arranges pallets by destination, and manages pallet stock.

Planning service

The planning service is considered to be the core, the active engine of the company. It deploys a highly efficient information system that provides better service to customers at lower costs and ensures the following four points:

a) Responsiveness: Speed of obtaining information

b) Completeness: Uniqueness of information

c) Communication: Sharing of information

d) Traceability: Status of goods, orders, etc.

Missions of planning service

a) Production planning and meeting customer needs while optimizing the use of material and human resources.

b) Developing the MPS and Production Planning (PDP) based on customer demand, availability of raw materials, and installed resources (capacities).

c) Constant monitoring of the PDP's execution.

d) Coordination with various company activities to define actions to address any deviations from the PDP.

e) Management of finished product stocks in Morocco and distribution centers (DC) in Europe. Ensure that 10 days of stock is available in each center.

f) Definition of schedules and scheduling of shipments and deliveries from the SEWS Morocco factory to the distribution center, while optimizing transportation costs.

4.4 IMPLEMENTATION OF THE CASE STUDY

After this presentation of the host organization of our research study location, we are commencing the actual case study.

4.4.1 The Approach

To answer our research questions, we followed the action research method, which combines a qualitative aspect with a quantitative aspect. This study aims to contribute to improving stock management at the sews company by introducing an IT solution to enhance the capacity of the MRP system in Excel.

4.4.1.1 The qualitative aspect

For the qualitative research, we proceeded with an approach that involves several aspects and uses certain tools related to qualitative studies:

Visits to various departments of the logistics department

a) Planning service

b) Procurement service

c) Transportation service, as well as the various warehouse sites.

Participatory observation

This observation involves interactively observing the activities of the various managers of these services to gather useful information, supplemented by open interviews and discussions with key individuals.

Consultation of certain documents relating to stock management

The stock files, purchase order, delivery note, receipt note, etc...

4.4.1.2 The quantitative aspect of the research

It is based on the analysis of MRP data.

4.4.2 Process

As I am an intern within the company SEWS, contacts were easy but in a prearranged manner with the relevant individuals. During my internship, the initiation of this study was decided in collaboration with the head of the procurement department, who organized meetings with the various individuals who will be addressed during this study.

During visits to the various facilities, the relevant information and data were compiled in order to present them during a meeting with the managers to receive their feedback. Alongside these observation sessions, an analysis of the MRP system was conducted on a sample concerning a raw material reference.

The results will be presented during a meeting.

4.4.3 Qualitative Data

The data collected by qualitative research tools is synthesized as follows:

Stock management at the SEWS level follows a logical and operational process and must respect certain steps. The stages of the process:

4.4.3.1 Receipt of the client's request by EDI

SEWS is an industrial design that manufactures on demand.

A client first sends the company a list of products with detailed designs and nomenclature and requests a quote from the company. After negotiation and agreement on the terms and conditions (prices, dates, delivery frequency, etc.), the client and the company SEWS sign a contract. This request is addressed with the nomenclature to the planning service department, which will proceed to estimate the quantity of materials required to meet the client's needs. The planning service will proceed with the development of MPS and PDP based on the client's needs, taking into account:

a) The availability of raw materials

b) The availability of production lines for the requested types of harnesses

c) The production periods of the requested harnesses and delivery deadlines

This procedure can be outlined in the following Flowchart:

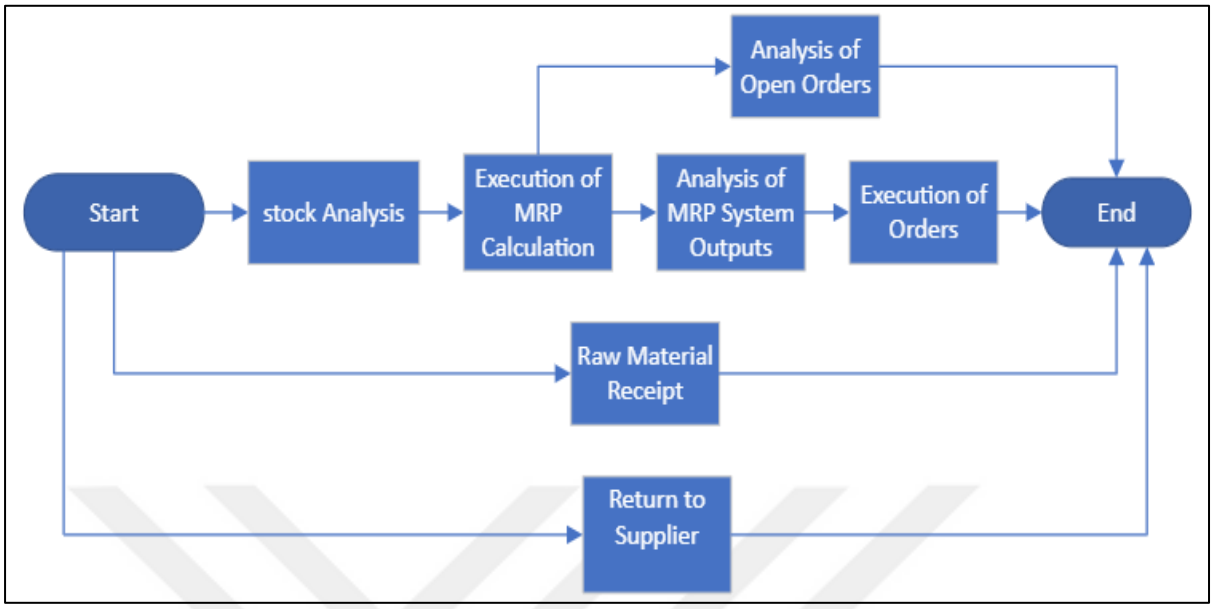

Chart 4.4: Inventory and Order Processing Workflow.

4.4.3.2 Estimation of raw material quantity

The materials requisition ordering process is based on the MRP system within the procurement department. The MRP system automatically calculates the material requirements needed to produce each unit, based on current stock levels, projected consumption, and safety parameters. This functionality reduces the risk of human errors and ensures a swift response to production needs, enabling more precise and proactive planning.

The MRP allows for visualizing future material needs over several weeks and verifying the adequacy between planned orders and actual needs, thereby avoiding overstocks and stockouts.

The orders thus defined are entered into the DHS system and are then finalized and approved. The launching of purchase orders is done through the EDI system, which is used to send orders to the supplier. It is an automated method that facilitates the process and ensures that orders are received and processed promptly. The raw material needs can be met by partner sites and by ensuring their transportation.

These suggestions are summarized in the following table:

Table 4.3: MRP Orders Suggestions.

due_date	1 whse_date	2 type	material_no	3 mod_qty	MOQ	4 Factor	5 order QTY
11/06/2016	25/04/2016	N	68105235	9000	3000	3	9000
07/05/2016	21/03/2016	N	68105238	2000	2000	1	2000
14/05/2016	28/03/2016	N	68105270	20000	5000	4	20000
07/05/2016	21/03/2016	N	68105338	12000	3000	4	12000
14/05/2016	28/03/2016	N	68105373	4000	2000	2	4000
14/05/2016	28/03/2016	N	68105450	5000	500	10	5000
14/05/2016	28/03/2016	N	68105750	12000	2000	6	12000
14/05/2016	28/03/2016	N	68105952	24000	1500	16	24000
07/05/2016	21/03/2016	N	68105974	3200	1600	2	3200
02/04/2016	20/02/2016	U	69006669	3000	3000	0	0
07/05/2016	21/03/2016	N	69105726	2500	500	5	2500
02/07/2016	16/05/2016	N	69107547	2000	100	20	2000
02/04/2016	20/02/2016	U	69130086	100	100	0	0

a) Order Arrival Date.

b) Order (TYPE) N refers to Normal Order – U refers to Urgent Order.

c) (MOQ) Minimum Order Qty.

d) (Factor) which is (mod_qty/moq)

e) (Order Qty) which is (factor*moq)

In this way, the company can maintain a smooth production flow and avoid storing excessive materials. The company reflects the JIT and Lean philosophy by relying on short and stable replenishment lead times, so replenishments are generally made when orders are confirmed.

4.4.3.3 Receipt of materials

The incoming materials ordered by the procurement department are received and counted by the warehouse team through the MCS. In accordance with the strategy described beforehand in the paragraph (Warehouse Activity - Material Reception).

Figure 4.4: The Circuit for Receiving Materials and their Storage.

The raw materials are transported by service providers for imports. The main carriers for ensuring imports are: GEODIS, STC, GLT, and YSEN.

4.4.3.4 Delivery of finished products

The finished products are delivered to customers through the transport service. The transportation of goods from the SEWS AA site to customers is carried out by a service provider. The multinational SEWS AA has entrusted this mission to 3 service providers: GLT, GEODIS, and DHL, who are responsible for all downstream logistics operations: transportation, transit, and customs clearance.

4.4.4 Quantiative Data

Quantitative data is based on the operation of the MRP system.

The quantitative study is based on the analysis of a representative sample, this analysis is done manually using the MRP system.

4.4.4.1 Presentation of MRP table

Table 4.4: Material Requirement Planning.

Material No	OLT	TLT	CLS	15-Apr-24	24-juin-24	01-juil-24	08-juil-24	15-juil-24	05-Aug-24
14009083	175	14	INV	460	460	960	1460	2460	4460
14009083	175	14	REQ	0	0	0	0	0	0
14009083	175	14	DIF	460	460	960	1460	2460	4460
14009083	175	14	B/O	0	500	500	1000	2000	1000

The table consists of several lines:

Line 1: INV: the initial quantity of materials in stock

Line 2: REQ: Production Requirement; the quantity of raw material to be used to meet the customer's bundle needs

Line 3: DIF: indicates the difference in material, (the initial quantity - the quantity to be used)

Line 4: B/O: indicates incoming orders for raw materials.

OLT: The duration of order preparation by the supplier

TLT: The duration of transport

The period between the receipt of the raw material order by the supplier and its delivery is estimated at 175 days (25 weeks) to prepare the order plus 14 days of transit. Therefore, the total duration between the sending of the order to the supplier and its arrival at SEWS is 27 weeks.

During this lengthy period, there may be changes in customers' needs for various reasons that cannot be detected after the order is sent to the supplier.

The ordering frequency is on a weekly basis.

4.4.4.2 Analysis of orders

To illustrate these variations, we take the following example, reference (14009083).

The analysis shows that during the weeks of 24-Jun-2024 to 15-Jul-2024, the following emerges:

Week of June 24, 2024

INV (Inventory): 460 units.

REQ (Required): 0 units.

DIF (Difference): 460 units surplus.

B/O (Back Order): 500 units incoming.

It appears that the incoming order of 500 units may potentially be unnecessary due to the significant surplus of 460 units already in stock.

Week of 01-Jul-2024

INV (Inventory): 960 units. (Includes 460 units previously in stock and 500 units from the incoming order of the previous week)

REQ (Required): 0 units.

DIF (Difference): 960 surplus units.

B/O (Back Order): 500 units incoming

With the addition of the 500 units from the previous incoming order to our stock, we observe a significant surplus of units compared to the anticipated demand.

Week of July 8, 2024

INV (Inventory): 1460 units. (Includes the 960 units previously in stock and the 500 units from the incoming order of the previous week)

REQ (Required): 0 units.

DIF (Difference): 1460 units surplus.

B/O (Back Order): 1000 incoming units.

Once again, we observe a significant surplus of units compared to the anticipated demand, with 1460 units in stock and no units required for immediate use, despite having an incoming order of 1000 units.

Week of July 15, 2024

INV (Inventory): 2460 units. (Includes the 1460 units in stock from before and the 1000 units from the incoming order of the previous week)

REQ (Required): 0 units.

DIF (Difference): 2460 surplus units.

B/O (Back Order): 2000 units pending.

The addition of the 1000 units from the previous incoming order to our stock has increased our surplus to 2460 units, with no units required for immediate use. Consequently, the incoming order of 2000 units could further significantly increase our surplus. It is essential to reassess our inventory management strategy to avoid excessive overstocking.

4.4.4.3 Incoming order investigation for the week of June 24 from DHS system

Objective

Identifying the reasons behind the unnecessary order for the incoming order placed during the week of June 24, 2024. To do this, we accessed the DHS system of the company

SEWS. This identification process involves several steps:

Figure 4.5: Database of Order History.

Step 1: Search for the equipment number in the order history.

Step 2: Identify the week or weeks in which the incoming orders were placed after June 24, 2024.

The following table provides information on the reference, the order launch date (P/O Date), the order arrival date (Arr Date), the transport start date (Due Date), and the order quantity (Order Qty).

Table 4.5: Material Open Order List.

Material Open Order List

Program Id : MRPFP100
Date : 18/04/2024 15:35
Order : Material No.
Section : AINA-SOCIETE SEWS MAROC

Material No.		Name		Supp. Mat. No.	Order	PO	GI	Total
P/O Date	Arr. Date	Due Date	Supplier	P/O Number	Qty.	Recv	Qty.	Recv.Qty
14009083		TER-35504457-LA		35504457				
18/12/2023	24/06/2024	10/06/2024	DELD	KNM8995	500	0	0	0
18/12/2023	01/07/2024	17/06/2024	DELD	KNM8448	500	0	0	0
01/01/2024	08/07/2024	24/06/2024	DELD	KNM9000	1000	0	0	0
08/01/2024	15/07/2024	01/07/2024	DELD	KNM9004	1000	0	0	0
08/01/2024	15/07/2024	01/07/2024	DELD	KNM8459	1000	0	0	0
29/01/2024	05/08/2024	22/07/2024	DELD	KNN0703	1000	0	0	0
				Sub Total	5000	0	0	0
							Total	

End of Report

According to this table, the incoming order of 500 units for 24/6/2024 was placed on 18/12/2023, and the duration between the order placement and the scheduled delivery date is 175 days.

Step 3: Extraction of MRP Data as of the Date 18/12/2023:

To understand the circumstances that motivated the procurement manager to place these orders, we take as an example the incoming order of June 24, 2024, which was placed on December 18, 2023.

Table 4.6: Material Requirement Planning.

Material No	OLT	TLT	CLS	18-Dec-23	03-juin-24	10-juin-24	17-juin-24	24-juin-24	01-juil-24
14009083	175	14	INV	460	460	260	260	70	-388
14009083	175	14	REQ	0	200	0	190	458	458
14009083	175	14	DIF	460	260	260	70	-388	-846
14009083	175	14	B/O	0	0	0	0	0	500

It is noted that the forecasts for the week of June 24, 2024, made on the date of 12/18/2023 show the following:

INV (Inventory): 70 units.

REQ (Required): 458 units.

DIF (Difference): -388 units.

B/O (Back Order): 0 units.

Step 4: MRP Data Analysis:

These provisions show that as of June 24, 2024, we will have 70 units of the item in stock, and the required needs amount to 458 units, creating a deficit of -388 units. This motivated the procurement coordinator to make the decision to place an order on 12/18/2023.

With a significant deficit between the available inventory and the actual needs, it is understandable that the purchasing coordinator made the decision to place an order to cover this shortage.

Step 5: Documentation of Results:

It is important to note that the actions taken were necessary to meet the anticipated production needs and to satisfy customer demands. However, as of 06/24/2024, the requirements have decreased from 458 to 0, rendering the orders unnecessary.

Therefore, we can conclude that there has been a change in customer requirements that made our orders unnecessary after they were placed.

4.4.4.4 Recommendations

Considering that the requirements have changed after December 18, 2023, and that in principle the orders are not yet ready due to the 175-day OLT duration, it is recommended to initiate negotiations with the supplier to cancel or postpone the order. This decision should be made after a thorough analysis to determine if the order has already been shipped. To do this, it is necessary to carefully examine the transit time associated with the delivery. It is also essential to assess whether the order is still in the preparation phase (OLT), during which it can be more easily modified or canceled, or if it is already in transit to our site. This approach will allow for an informed decision regarding the relevance of canceling or postponing the order, minimizing potential disruptions in the logistics chain, and optimizing resource management.

The same analysis can be done for the other weeks.

Instead of conducting this analysis manually to conclude that there is a change in needs and initiating discussions with suppliers to cancel or postpone orders, it is more reasonable to find an IT solution capable of detecting these changes that may occur and making appropriate decisions.

4.4.5 Presentation of Results and Discussion

The information collected during our participatory observation and the consultation of certain documents concerning stock management at the SEWS level, as well as the exploration of MRP data extracted from the DHS system, was presented and discussed during a meeting with the various persons involved in stock management under the responsibility of the procurement service manager.

The discussions were fruitful and constructive. They validated our conclusions and the dissatisfaction noted, such as:

a) Changes in customer needs between the order launch date and its receipt.

b) Limitations of the MRP system that cannot detect unnecessary orders in a timely manner to reschedule or cancel them.

c) Excessive raw material stock that could lead to additional costs.

d) Risk of raw material obsolescence.

All participants expressed the need for an automated computer tool to address these shortcomings and improve stock management.

4.4.6 Proposal for an Improvement Solution

During a second meeting, several solutions were presented and discussed.

3 inventory management systems were proposed, and a comparison was made among these 3 systems selected so that the most suitable one could be chosen.

4.4.6.1 Existing solutions and chosen solution

In responding to the second research question "What are the existing computer solutions for inventory control," information on existing computer solutions for inventory control was collected through computer research.

Three inventory management systems were selected for this research.

A comparative analysis of the selected systems was conducted so that the most suitable one could be chosen.

The potential solutions that were selected and compared are as follows:

Misa: software offering accounting and inventory functionalities, but with a monthly cost per user and requiring specialist assistance for maintenance.

Odoo: a more comprehensive inventory solution, also paid, and requiring technical support for maintenance.

Microsoft Excel Spreadsheets - VBA: a free option that can be customized according to user needs and maintained internally without the intervention of IT specialists.

Table 4.7: Potential Inventory Solutions.

Criteria	Misa	Odoo	Excel spreadsheet -VBA
Cost	(about USD 74)/month/user	USD 46/month/ user (Odoo, n.d.)	Free
Features/Functions	Accounting inventory	Inventory	Customizable to suit individual user preferences
Maintenance task by IT specialist	Yes, contacting service provider in vietnamese	Yes, contacting service provider in English	Self-maintaining

The comparison revealed that Excel spreadsheets - VBA is the most cost-effective solution for SEWS at present. This is due to their zero cost, adaptability, and ease of maintenance, enabling the company to manage the solution independently. Excel spreadsheets provide the required flexibility, while the VBA language allows for the automation and customization of various inventory functions and processes.

4.4.6.2 Features of the proposed inventory solution

The proposed solution should provide key features that serve the tasks of the inventory controller and business manager: creation of bill of materials, generation of quotes and delivery notes, monitoring of stock status, and inventory updates.

This functionality allows for the identification of raw material orders that can be canceled or postponed to avoid excess stock.

4.4.7 Development and Testing of the VBA Tool

The company Sewing already has an MRP system that provides us with information on material order forecasts. However, it is unable to review orders that have already been placed and consequently detect unnecessary orders.

4.4.7.1 The functions that can be performed by VBA macros

The purpose of this VBA macro is to provide a thorough and proactive analysis of pending orders in the MRP system, taking into account fluctuations in customer demands and order and transit lead times. This macro is designed to automate and facilitate inventory management decisions by identifying and flagging orders that are no longer needed or can be postponed. The key steps that the VBA will need to accomplish are the following:

Temporal analysis

The VBA will commence its analysis from the current week and will cover up to the third week of security after the total delay time (order time plus transit time). This time window is chosen to anticipate and adapt to potential variations in customer needs.

Focus on DIF value

The macro will target the DIF value at the end of this extended period, which represents the excess stock after meeting anticipated needs. This value will serve as a benchmark for assessing the adequacy of pending orders.

Smart comparison

The macro will compare this reference DIF value with the pending orders listed for the same period, going back to the week preceding the start of their transit. The aim is to verify if the ordered quantities exceed the needs determined by the DIF.

Surplus signaling

If the DIF exceeds the cumulative pending orders up to the week before transit, these orders will be marked in red, signaling that they are surplus and potentially subject to cancellation or postponement.

Visual assistance

To facilitate quick and effective decision-making, the macro will use clear visual signals, such as red highlighting, to indicate surplus orders. This will enable managers to have a clear view of the necessary adjustments to optimize stock levels.

4.4.7.2 Drafting and testing

After writing the VBA code, several tests were conducted to validate the robustness of the proposed solution. These tests included:

a) Tests with different inventory levels (DIF values) to assess the script's ability to handle normal stock variations.

b) Tests with different quantities of B/O to ensure that the script can correctly adjust recommendations based on existing contractual obligations.

c) Boundary tests, such as scenarios with no inventory, no backorders, or excessive orders, to test the script's resilience against atypical situations.

4.4.7.3 The steps for using Excel VBA

Installation of the Code

Opening Excel

Launch Microsoft Excel on your computer.

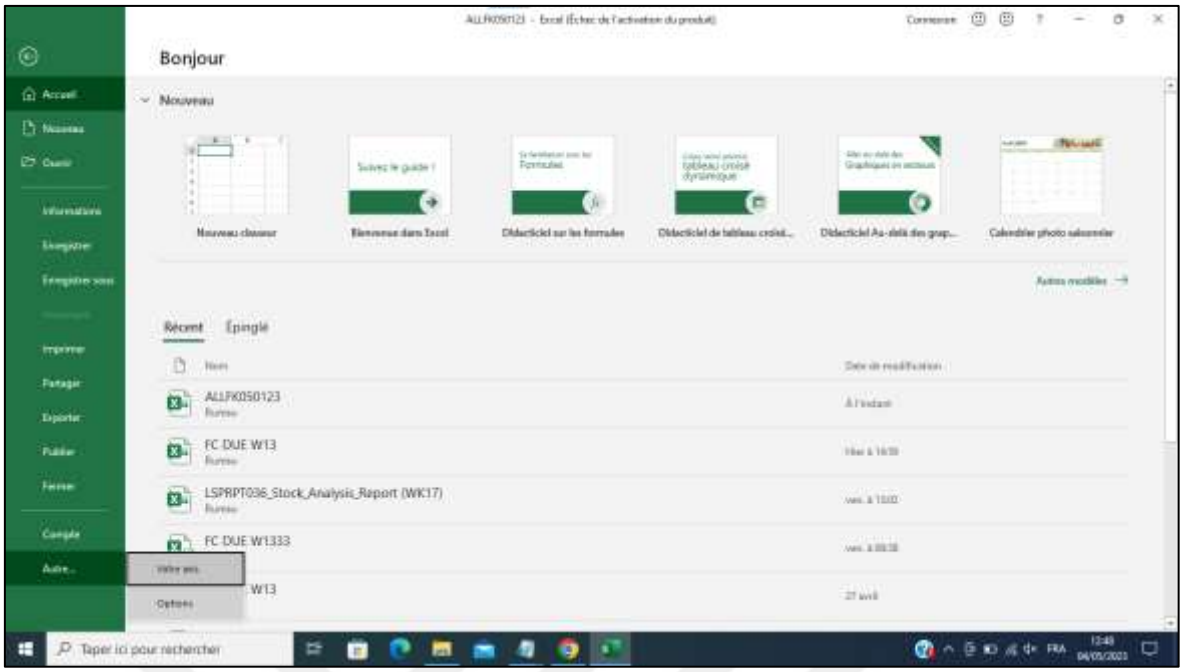

Figure 4.6: Launch Microsoft Excel on your Computer.

Accessing the VBA editor

Press Alt + F11 to open the VBA editor, which will allow you to manage and edit VBA scripts.

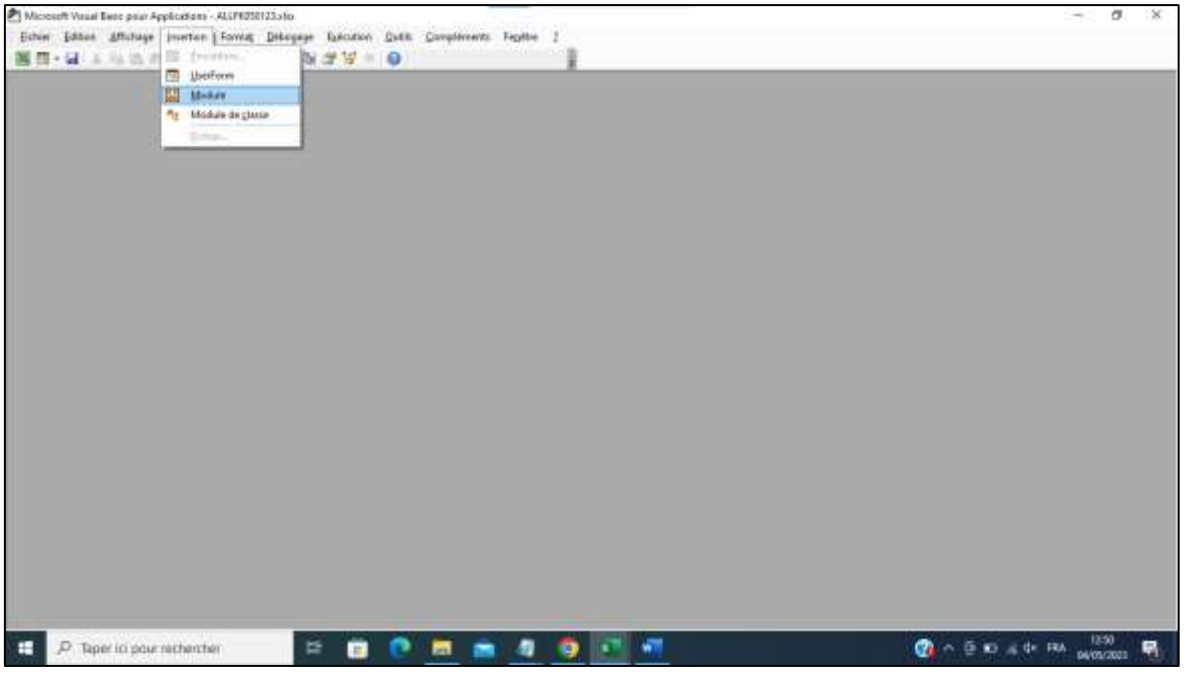

Figure 4.7: Accessing the VBA Editor.

Inserting the code

In the VBA editor, locate the workbook where you want to integrate the script. Right-click on "VBAProject (YourWorkbook)," then select Insert -> Module to create a new module.

Copy the prepared VBA code and paste it into the open module window.

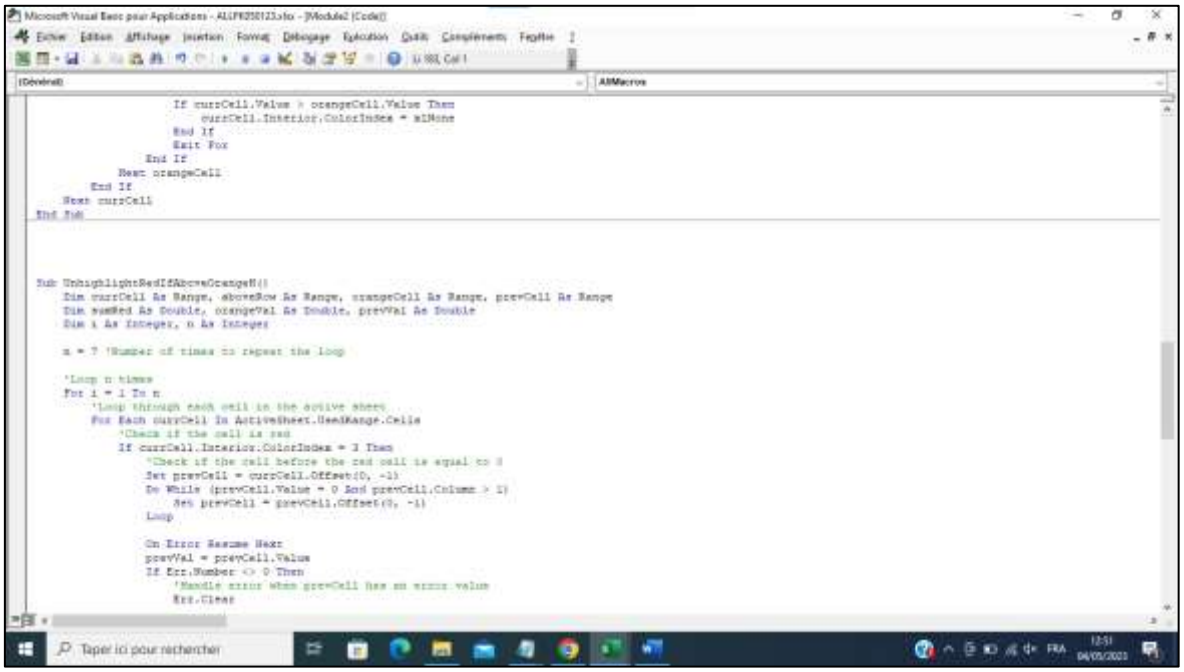

Figure 4.8: Copy the Prepared VBA Code.

Saving the script

Save the script by clicking on File -> Save or by pressing Ctrl + S.

Executing the Script

Returning to excel

Return to Excel by closing the VBA editor or clicking on Excel to switch windows.

Preparing test data

Ensure that the test data simulating the MRP environment is ready and correctly formatted in the Excel spreadsheets where the script will be executed.

Running the script

Run the script by pressing Alt + F8, selecting the appropriate script from the list, and then clicking on Run.

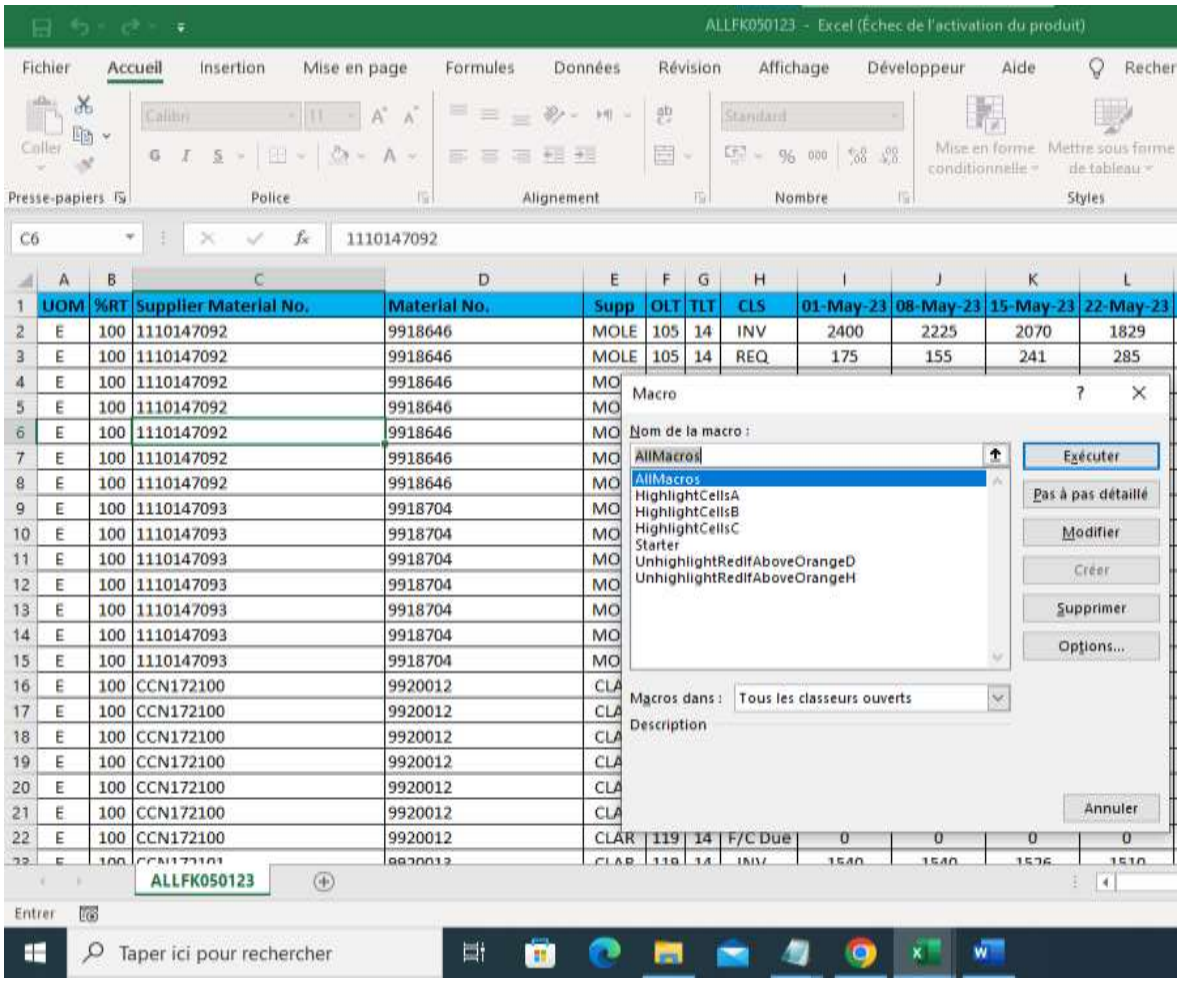

Figure 4.9: Run the Script.

4.4.8 Comparison Between Traditional MRP And MRP Optimized By VBA

Table 4.8: Classic MRP before VBA.

Material No	OLT	TLT	CLS	15-Apr-24	24-juin-24	01-juil-24	08-juil-24	15-juil-24	05-Aug-24
14009083	175	14	INV	460	460	960	1460	2460	4460
14009083	175	14	REQ	0	0	0	0	0	0
14009083	175	14	DIF	460	460	960	1460	2460	4460
14009083	175	14	B/O	0	500	500	1000	2000	1000

Table 4.9: MRP Optimised after VBA.

Material No	OLT	TLT	CLS	15-Apr-24	24-juin-24	01-juil-24	08-juil-24	15-juil-24	05-Aug-24
14009083	175	14	INV	460	460	960	1460	2460	4460
14009083	175	14	REQ	0	0	0	0	0	0
14009083	175	14	DIF	460	460	960	1460	2460	4460
14009083	175	14	B/O	0	500	500	1000	2000	1000

Analysis of the data from the two tables allows for the following conclusions to be drawn:

Traditional MRP: Traditional MRP analysis provides static information on inventory (INV), demand (REQ), the difference (DIF), and back orders (B/O). However, it does not highlight potential imbalances between planned orders and actual needs, requiring manual analysis to detect unnecessary orders.

VBA-Optimized MRP: The optimized approach utilizes VBA to enhance MRP analysis. It not only provides the same information on INV, REQ, DIF, and B/O but makes them interactive. The selected DIF is highlighted, and excess orders are automatically marked in red. This automatic identification of unnecessary orders enables supply chain managers to make immediate decisions regarding order cancellations or postponements, making the review process more agile and responsive to fluctuations in production requirements.

5. CONCLUSION

The case study that we conducted during the internships we carried out within the company SEWS Ain Aouda allowed us to address almost all the issues related to stock management and its crucial role in improving the efficiency, effectiveness, and performance of the company. Similarly, this experience was an opportunity for me to enhance my knowledge and skills in the field of management, particularly in raw material stock management.

The examination of the existing stock management practices, as well as the analysis of issues related to fluctuating customer orders, highlighted the importance of a flexible and adaptive approach. The integration of an Excel VBA-assisted system, designed in collaboration with the procurement team, demonstrated its added value by facilitating the identification of unnecessary or redundant orders, enabling regular monitoring of orders and making appropriate decisions.

In conclusion, this research work shed light on a concrete avenue for optimizing the logistical processes of SEWS Ain Aouda by introducing an innovative solution, namely the VBA tool. The adoption of VBA system in SEWS company-level inventory management can be a motivating factor for managers and staff to train and research other tools that can further improve their inventory management practices. This experience can be used in other SEWS sites in Morocco as well as other similar companies in the future. The fast change of technology and scientific research could improve the VBA system or introduce other IT tools to improve inventory management systems.

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APPENDIX A

VBA CODE

```
Sub Starter()

    'Insert new column to the right of column H and name it "CTTL"

    Columns("H:H").Insert Shift:=xlToRight, CopyOrigin:=xlFormatFromLeftOrAbove

    Range("H1").Value = "CTTL"

    'Calculate the value for the first cell in column H and fill it down

    Dim lastRow As Long

    lastRow = Cells(Rows.Count, "G").End(xlUp).Row 'Find the last row of data in column
        G

    Range("H2").Formula = "=(F2+G2)/7+5" 'Calculate the value for the first cell in column
        H

    Range("H2:H" & lastRow).FillDown 'Fill the formula down to the last row of data in
        column G

End Sub

Sub HighlightCellsA()

    Dim i As Long

    Dim lastRow As Long

    Dim rng As Range

    lastRow = Cells(Rows.Count, "H").End(xlUp).Row
```

```
For i = 4 To lastRow Step 7
    Set rng = Cells(i, "H")
    If IsNumeric(rng.Value) And rng.Value > 0 Then
        rng.Interior.ColorIndex = 6 'Highlight in yellow
        rng.Offset(0, rng.Value).Interior.ColorIndex = 45 'Highlight in orange if positive
        If rng.Offset(0, rng.Value).Value <= 0 Then
            rng.Offset(0, rng.Value).Interior.ColorIndex = 0 'Unhighlight if negative or equal to
            0
        End If
    End If
Next i
End Sub
Sub HighlightCellsB()
    Dim myRange As Range
    Dim myCell As Range


    Set myRange = ActiveSheet.UsedRange
    For Each myCell In myRange
        If myCell.Interior.ColorIndex = 45 Then
            myCell.Offset(1, 0).Interior.ColorIndex = 5 '5 is the color index for blue
        End If
```

```
    Next myCell
End Sub
Sub HighlightCellsC()
    Dim myRange As Range
    Dim myCell As Range
    Set myRange = ActiveSheet.UsedRange
    For Each myCell In myRange
        If myCell.Interior.ColorIndex = 5 Then '5 is the color index for blue
            Do While myCell.Value <= 0 'while cell value is not greater than 0
                myCell.Interior.ColorIndex = xlNone 'removes cell color
                Set myCell = myCell.Offset(0, -1) 'selects cell before it in same row
            Loop
            myCell.Interior.ColorIndex = 3 '3 is the color index for red
        End If
    Next myCell
End Sub
Sub UnhighlightRedIfAboveOrangeD()
    Dim currCell As Range, aboveRow As Range, orangeCell As Range
    'Loop through each cell in the active sheet
    For Each currCell In ActiveSheet.UsedRange.Cells
        'Check if the cell is red
```

```
        If currCell.Interior.ColorIndex = 3 Then
            'Loop through the cells in the row above
            Set aboveRow = currCell.Offset(-1, 0).EntireRow
            For Each orangeCell In aboveRow.Cells
                'Find the orange cell with color index 45
                If orangeCell.Interior.ColorIndex = 45 Then
                    'Unhighlight the red cell if it's larger than the orange cell
                    If currCell.Value > orangeCell.Value Then
                        currCell.Interior.ColorIndex = xlNone
                    End If
                    Exit For
                End If
            Next orangeCell
        End If
    Next currCell
End Sub
Sub UnhighlightRedIfAboveOrangeH()
    Dim currCell As Range, aboveRow As Range, orangeCell As Range, prevCell As Range
    Dim sumRed As Double, orangeVal As Double, prevVal As Double
    Dim i As Integer, n As Integer
    n = 7 'Number of times to repeat the loop
```

```
'Loop n times
For i = 1 To n
    'Loop through each cell in the active sheet
    For Each currCell In ActiveSheet.UsedRange.Cells
        'Check if the cell is red
        If currCell.Interior.ColorIndex = 3 Then
            'Check if the cell before the red cell is equal to 0
            Set prevCell = currCell.Offset(0, -1)
            Do While (prevCell.Value = 0 And prevCell.Column > 1)
                Set prevCell = prevCell.Offset(0, -1)
            Loop
            On Error Resume Next
            prevVal = prevCell.Value
            If Err.Number <> 0 Then
                'Handle error when prevCell has an error value
                Err.Clear
                Set prevCell = Nothing
                prevVal = 0
            End If
            On Error GoTo 0
            'If the cell before the red cell is not 0, check the cells in the row of the red cell
```

```
If prevVal <> 0 Then
    'Loop through the cells in the row of the red cell
    sumRed = 0
    For Each redCell In currCell.EntireRow.Cells
        'Check if the cell is red
        If redCell.Interior.ColorIndex = 3 Then
            sumRed = sumRed + redCell.Value
        End If
    Next redCell
    'Loop through the cells in the row above
    Set aboveRow = currCell.Offset(-1, 0).EntireRow
    For Each orangeCell In aboveRow.Cells
        'Find the orange cell with color index 45
        If orangeCell.Interior.ColorIndex = 45 Then
            orangeVal = orangeCell.Value
            'Subtract the sum of the red cells from the value in the orange cell
            orangeVal = orangeVal - sumRed
            'Check if the result is greater than the cell before the red cell
            If orangeVal > prevVal Then
                prevCell.Interior.ColorIndex = 3 'Highlight the cell before the red cell
            End If
```

```
                    Exit For
                End If
            Next orangeCell
        End If
    End If
    Next currCell
    'Reapply autofilter
    If ActiveSheet.AutoFilterMode Then
        ActiveSheet.Range("A1").AutoFilter
    End If
    'Wait for 1 second
    Application.Wait Now + TimeValue("0:00:01")
  Next i
End Sub
Sub AllMacros()
Call Starter
Call HighlightCellsA
Call HighlightCellsB
Call HighlightCellsC
Call UnhighlightRedIfAboveOrangeD
Call UnhighlightRedIfAboveOrangeH
End Sub
```