

**The School of Higher Commercial Studies**

**EHEC**

**Thesis Submitted in Partial Fulfillment of the  
Requirements for Master's Degree in Commercial Sciences**

**Major: Distribution and Supply Chain Management**

**Subject:**

**The Impact of Warehouse Automation on  
Logistics Efficiency of a Distribution Center**

**Case study: NAFTAL Commercialization Branch**

**Submitted by:**

**Mr. Abdelghani KERROUCHE**

**Supervised by:**

**Pr. Farah RAHAL**

**Professor at EHEC Algiers**

**10<sup>th</sup> Promotion**

**2022/2023**



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I would like also to take this opportunity to thank Mr. Amine BEN HADDAD, Mr. Karim BOUBERGOUT, Mr. Rachid SAIDI and all the staff members of BLIDA's distribution center for their time and good will in sharing their knowledge and expertise with me, their assistance was extremely valuable and enlightening for the accomplishment of this thesis.

## **Abstract**

In modern economy, companies are continuously seeking ways to improve their logistics operations relying on technological advancements to gain a competitive edge. Warehouses are important facilities within supply chain, thus, warehouse automation technologies have emerged as a promising solution to enhance efficiency and optimize various processes of the warehouse, such as material handling automation, automatic item identification systems and Warehouse Management Systems.

Furthermore, effective management of logistic performance is essential for companies to evaluate their current status and identify areas for improvement. Establishing a robust performance measurement system becomes imperative in this context.

The present research consists of a comprehensive literature review about warehouse automation, including basic concepts about supply chain, logistics and warehousing. The empirical part is a qualitative study realized through interviews, this study aims to analyze the benefits, challenges, and potential drawbacks of warehouse automation in improving logistics efficiency.

**Keywords:** distribution logistics, warehouse automation, performance, performance measurement.

## Résumé

Dans l'économie moderne, les entreprises recherchent constamment des moyens pour améliorer leurs opérations logistiques en s'appuyant sur les avancements technologiques pour obtenir un avantage concurrentiel. Les entrepôts jouent un rôle important dans la chaîne d'approvisionnement, ce qui fait que les technologies d'automatisation des entrepôts sont apparues comme une solution prometteuse pour améliorer l'efficacité et optimiser les divers processus de l'entrepôt, tels que l'automatisation de la manipulation des matériaux, les systèmes d'identification automatique des articles et les systèmes de gestion d'entrepôt WMS.

De plus, une gestion efficace de la performance logistique est essentielle pour permettre aux entreprises d'évaluer leur état actuel et d'identifier les zones d'amélioration. Il devient donc impératif d'établir un système robuste de mesure de la performance.

La présente recherche consiste en une revue exhaustive de la littérature sur l'automatisation des entrepôts, y compris les concepts de base de la chaîne d'approvisionnement, de la logistique et de l'entreposage. La partie empirique est une étude qualitative réalisée par le biais d'entretiens. Cette étude vise à analyser les avantages, les défis et les inconvénients potentiels de l'automatisation des entrepôts dans l'amélioration de l'efficacité logistique.

**Mots clés** : logistique de distribution, automatisation des entrepôts, performance, mesure de la performance.

## ملخص

في الاقتصاد الحديث، تبحث الشركات باستمرار عن طرق لتحسين عملياتها اللوجستية بالاعتماد على التقدم التكنولوجي لاكتساب ميزة تنافسية. تعتبر المستودعات مرافق مهمة داخل سلسلة التوريد، وبالتالي، ظهرت تقنيات التشغيل الآلي للمستودعات كحل واعد لتعزيز الكفاءة وتحسين العمليات المختلفة للمستودع، مثل التشغيل الآلي لمناولة المواد، ونظم تحديد الأصناف التلقائية ونظم إدارة المستودعات.

علاوة على ذلك، فإن الإدارة الفعالة للأداء اللوجستي ضرورية للشركات لتقييم وضعها الحالي وتحديد مجالات التحسين ويصبح إنشاء نظام قوي لقياس الأداء أمراً حتمياً في هذا السياق.

البحث المقدم يتكون من مراجعة شاملة للمصادر الأدبية حول الأنظمة الآلية في المستودعات، بما في ذلك المفاهيم الأساسية حول سلسلة التوريد والخدمات اللوجستية والمستودعات. الجزء التجريبي هو عبارة عن دراسة نوعية تم إجراؤها من خلال المقابلات، وتهدف هذه الدراسة إلى تحليل فوائد وتحديات وعيوب التقنيات الآلية في المستودعات في تحسين الكفاءة اللوجستية.

**الكلمات الرئيسية:** لوجستيات التوزيع، المستودعات، أنظمة المستودعات الآلية، الأداء، قياس الأداء.

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## List of abbreviations

<b>AGV</b>	Automated Guided Vehicles
<b>AS/RS</b>	Automated Storage and Retrieval System
<b>BSC</b>	Balanced Scorecard
<b>ERP</b>	Enterprise Resource Planning
<b>HPT</b>	Hand Pallet Truck
<b>ITU</b>	Intermodal Transportation Unit
<b>KPI</b>	Key Performance Indicator
<b>LMS</b>	Labor Management System
<b>PI</b>	Performance Indicator
<b>PMS</b>	Performance Measurement System
<b>PPT</b>	Powered Pallet Truck
<b>RFID</b>	Radio Frequency Identification
<b>ROI</b>	Return On Investment
<b>SCM</b>	Supply Chain Management
<b>SCOR model</b>	Supply Chain Operations Reference model
<b>S/R system</b>	Storage and Retrieval system
<b>TMS</b>	Transport Management System
<b>WES</b>	Warehouse Execution System
<b>WCS</b>	Warehouse Control System
<b>WCL</b>	World Class Warehousing
<b>WMS</b>	Warehouse Management System
<b>3PL</b>	Third-Party Logistics

# Summary

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# **General introduction**

The business environment has witnessed a tremendous evolution in its practices and strategies due to the changing nature of customers and the competition that is happening between organizations. Logistics, being one of the backbones of companies, has been the subject of constant improvement due to the multiple benefits it offers, despite being a difficult function to manage.

Warehouses are essential facilities within the supply chain, serving as centralized locations for the storage and distribution of goods. They play a critical role in managing inventory levels, facilitating efficient order fulfillment, and ensuring smooth logistics operations.

With the rapid advancement of technology, logistics had significant changes, especially in warehouse operations. The rise of warehouse automation technologies had a major impact on logistics performance, improving efficiency and accuracy, as it has changed the way companies manage their supply chains. By improving order fulfillment, increasing operational efficiency, and making data-driven decisions, companies can thrive in today's competitive markets.

Warehouse automation has become an increasingly popular trend in the world of logistics, and many businesses are adopting different technologies. Warehouse automation include automated storage systems, robotics, barcode scanners and Warehouse Management Systems. These different alternatives help in overcoming challenges and improve customer service levels.

The subject was mainly chosen because warehousing is one of the pillars in logistics, as it faces constant development due to daily challenges and its importance in the logistics sector, additionally this subject was chosen out of curiosity to understand more about technologies applied in warehouses.

In order to study the subject of warehouse automation, an internship was done at NAFTAL, which is a leader in the energy distribution sector, NAFTAL aims to optimize its logistic operations, particularly at the distribution center level, therefore the need to adopt modern warehouse automation technologies arise to achieve high performance and ensure company's growth.

The main objective of this research is to answer the following general problematic:

***How can the logistics efficiency be improved through the implementation of warehouse automation?***

From the above-mentioned general problematic, a set of sub-questions are generated:

1. What are the primary processes to automate within a distribution center?
2. What are the important activities to evaluate within a distribution center?
3. What are the key factors to consider when automating warehouse processes?

As a starting point, three main hypotheses were elaborated:

1. **H01:** Automating item identification and order processing can lead to improve accuracy and enhance order fulfillment.
2. **H02:** Evaluating order fulfillment and inventory management can improve the logistics efficiency.
3. **H03:** Technological complexity, existing infrastructures and software, and implementation costs are the key factors to be taken into consideration before automating a warehouse.

In order to provide answers to our questions and to test the hypotheses, we adopted a two-stage methodology:

In the first stage, we carried out a literature review based on a compilation of books, articles, university research papers and websites.

In the second stage, we carried out a qualitative study with personnel of NAFTAL while using a semi-directive interview guide to identify the impact of warehouse automation technologies on logistics efficiency and discover potential areas of improvement.

This research work is divided into 3 chapters as follows:

The first chapter is a general representation of logistics and warehousing, with a significant focus on warehouse automation technologies.

The second chapter is dedicated to performance management and measurement, treating the different approaches of measuring logistics and warehouse performance.

The third chapter is the practical part of the thesis, which we elaborated during an internship at NAFTAL in order to build up answers for this research.

**Chapter 01:**  
**Literature Review on Warehouse**  
**Automation**

## **Chapter introduction**

Warehousing is an essential part of the logistics process, and efficient warehouse operations are crucial to ensure the smooth flow of goods through the supply chain, especially, the markets has witnessed significant changes in customer demands, particularly with respect to the quality and speed of services. In this context, the integration of warehouse automation technologies has emerged as an effective solution to meet these growing demands.

The following chapter is a presentation of the previous conducted studies related warehousing in general and warehouse automation in particular. The first section treats the basic concepts related to supply chain, logistics and distribution logistics. The second section is review to the warehousing and warehouse management subjects. The last section is an introduction to warehouse automation and the different technologies applied in warehouses.

### **First section: Fundamentals of Logistics and Supply Chain Management**

Logistics and Supply Chain Management are essential concepts in modern business, therefore, this section will explore the fundamentals of these two concepts, including various definitions, types and notions about Supply Chains and distribution logistics.

#### **1. Logistics and Supply Chain concepts**

##### **1.1. Supply Chain definitions**

The term supply chain management arose in the late 1980s and came into widespread use in the 1990s. prior to that time, businesses used terms such as logistics and operations management instead. Here are some definitions of a supply chain:<sup>1</sup>

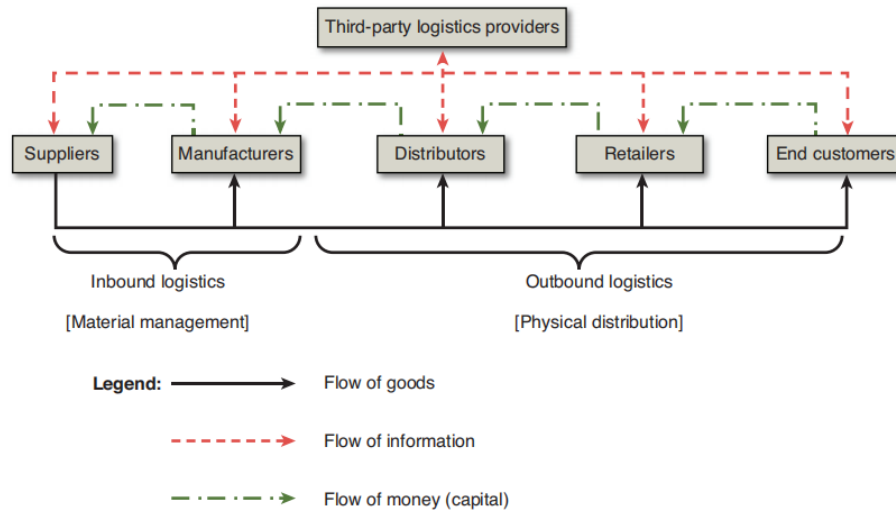
“A supply chain is the alignment of firms that bring products or services to market.” from Lambert, Stock, and Ellram, *Fundamentals of logistics management*.

“A supply chain consists of all stages involved, directly or indirectly, on fulfilling a customer request. The supply chain not only includes the manufacturer and suppliers, but also transporters, retailers, and customers themselves” from Copra and Meindl, *Supply chain*, 2015.

“A supply chain is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers.” from Ganeshan and Harrison, *An introduction to supply chain management*, 1995.

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<sup>1</sup>HUGOS (M): *Essentials of Supply Chain Management*, 4th edition, John Wiley & sons, 2018, p.03.

**Figure n°1.1: The supply chain process**

**Source:** MIN (H): *The Essentials of Supply Chain Management*, Pearson, 2015, p.02.

The figure n°1.1 shows the different stages of a supply chain, from the suppliers to the end customers, as well as the directions of the flows within the supply chain.

## 1.2. Supply Chain Management

Supply Chain Management can be defined as: “The systemic, strategic coordination of the traditional business functions and the tactics across these businesses within the supply chain, for the purpose of improving the long-term performance of the individual companies and the supply chain as a whole” from the *Journal of Business Logistics*, Vol.22, No.2, p.18.<sup>1</sup>

SCM can be viewed from several perspectives, “Supply chain management is the coordination of production, inventory, location, and transportation among the participants in a supply chain to achieve the best mix of responsiveness and efficiency for the market being served.”<sup>2</sup>

The Council of Supply Chain Management Professionals (CSCMP) defines supply chain management as “the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies”.<sup>3</sup>

<sup>1</sup>HUGOS (M): *op.cit*, p.04.

<sup>2</sup>Ibid. p.04.

<sup>3</sup>[https://cscmp.org/CSCMP/Academia and Awards/SCM Definitions and Glossary of Terms/](https://cscmp.org/CSCMP/Academia%20and%20Awards/SCM%20Definitions%20and%20Glossary%20of%20Terms/) consulted on 19/03/2023 at 17h40

### 1.3. Basics of Logistics

#### 1.3.1. Origin of Logistics

Many people believe that **Logistics** is a word but from a semantics point of view its origin was from ancient Greek and meant the “science of computation”. In fact, it is originally from combat environments and not from business or academia. It seems the ancient Greeks referred the term **Logistikos** to military officers who were experts in calculating the military needs for expeditions in war as a science, it seems the first book written on logistics was by Antoine-Henri Jomini (1779-1869), a general in the French army and later in the Russian service, titled *Summary of the Art of War* (1938). The book was on the Napoleonic art of war.<sup>1</sup>

#### 1.3.2. Definition of Logistics

Logistics was an interesting subject of research in the business field during the past decades, there is many definitions can be found:

The American Marketing Association (AMA) proposed in 1935, in *Marketing Vocabulary*, one of the first definitions of logistics: “Logistics covers the various activities carried out by a company, including service activities, during the transfer of a product from the production site to the consumption site”.<sup>2</sup>

In 1973, Heskett, Glaskowsky and Ivie, defined logistics as “Logistics is... the management of all activities which facilitate movement and the coordination of supply and demand in the creation of time and place utility”.<sup>3</sup>

According to the Council of Supply Chain Management Professionals: “Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers’ requirements”.<sup>4</sup> The definition given by the CSCMP can be considered as the most appropriate definition to the modern logistics industry.

#### 1.3.3. Types of Logistics

We can distinguish many different types of logistics depending on their purpose and methods:<sup>5</sup>

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<sup>1</sup>FARAHANI (R), REZAPOUR (S) and KARDAR (L): *Logistics operations and management*, Elsevier Science, 2011, p.03.

<sup>2</sup>LE MOIGNE (R): *Supply Chain management: achat, production, logistique, transport, vente*, 2ème édition DUNOD, p.03.

<sup>3</sup>FARAHANI (R), REZAPOUR (S) and KARDAR (L): *op.cit*, p.03.

<sup>4</sup>[https://cscmp.org/CSCMP/Academia\\_and\\_Awards/SCM\\_Definitions\\_and\\_Glossary\\_of\\_Terms/](https://cscmp.org/CSCMP/Academia_and_Awards/SCM_Definitions_and_Glossary_of_Terms/) consulted on 19/03/2023 at 18h15

<sup>5</sup>PIMOR (Y) and FENDER (M): *Logistique: production, distribution, soutien*, 5ème édition DUNOD, 2008, p.04.

- **Procurement logistics:** which allows to bring into the factories the basic products, components and sub-assemblies necessary for production.
- **General supply logistics:** which allows to provide service companies or administrations with the various products they need for their activity (office supplies for example).
- **Production logistics:** which consists of bringing the necessary materials and components for production to the production lines and planning the production. This logistics tends to absorb the entire production management.
- **Distribution logistics:** that of the distributors, which consists in bringing to the final consumer, either in large commercial surfaces, or at home through remote sales for example, the products he needs.
- **Military logistics:** which aims to transport to a theatre of operation the forces and that is necessary for their operational implementation and support.
- **Support logistics:** born in the military but has been extended to other sectors, aeronautics, energy, industry, etc., which consists of organizing everything necessary to keep a complex system in operation, including through maintenance activities.
- **After sales service logistics:** quite close to support logistics, with the difference that it is exercised in a commercial context by who has sold a good. The expression “service management” is often used to refer to the management of this activity. However, it should be noted that this form of support logistics is more and more being carried out by specialists in support who are separate from the manufacturer and user, known as Third Party Maintenance.
- **Reverse logistics:** which consists of recovering products that the customer does not want or wants to have them repaired, or to processing industrial waste, packaging, useless products from car wrecks to printer toners.

## 2. Basics of Distribution Logistics

### 2.1. Definition of Distribution Logistics

In 2003, KOTLER and DUBOIS defined distribution logistics as “the role which gathers all the activities implemented to manage in a profitable way, the flow of products and goods from their point of origin to the place of their use, according to the needs expressed by the market”.<sup>1</sup>

CLIQUET and others define distribution logistics as follows: “A set of interconnected activities whose mission is the physical transfer of finished products from the manufacturer to

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<sup>1</sup>KOTLER (P) and DUBOIS (B): *marketing management*, Pearson, 11<sup>ème</sup> édition, 2003, p.568.

the customers, the objective is to ensure that the product desired by the customer is in the right place, at the right time, in the expected quantity and at the best cost”<sup>1</sup>.

Those definitions provide a comprehensive understanding of distribution logistics and serve as a valuable foundation for further exploration, as we can define distribution logistics as the process of planning, executing and managing the physical movement of products from the production site to the point of consumption while minimizing expenses and satisfying customer needs.

## **2.2. Distribution Logistics activities**

The different activities covered by distribution logistics include:

### **2.2.1. Transportation**

Transportation is an essential activity that enables the movement of finished products from production sites to the points of consumptions, as it involves distribution network determination (routes planning, choice of routes, carrier selection, shipment tracking and choice of trans-shipment and storage infrastructures...).

### **2.2.2. Warehousing**

Warehousing is an important part of the retail supply chain. A warehouse is simply a storage space where a business owner can store their products for later order deliveries. Warehousing becomes a must thing, especially in businesses like e-commerce. Functions of warehousing are associated with the physical distribution of goods from the end of the production line to the final consumers. The most common functions of warehousing are inventory management, storage, materials handling, protective packing, and transportation.<sup>2</sup>

### **2.2.3. Handling**

Handling is “a manipulation, manual or mechanical movement of goods, for storage, shipment, or selling purposes”<sup>3</sup>, efficient handling is a critical in distribution logistics as it ensures that products are received, stored, and shipped. Proper handling reduces the risk of damage to goods, which can result in customer dissatisfaction.

## **2.3. Distribution Logistics challenges**

Distribution logistics faces several challenges:<sup>4</sup>

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<sup>1</sup>CLIQUET (G), FADY (A) and BASSET (G): *management de la distribution*, 2ème édition, DUNOD, 2006, p.287.

<sup>2</sup><https://www.businessstudynotes.com/others/introduction-to-business/explain-advantages-and-functions-of-warehousing-in-detail/> (consulted on 21/01/2023 at 1h14).

<sup>3</sup>MODEO (L) and YALAOUI (F): *Logistique interne: Entreposage et manutention*, édition Ellipses, 2015, p.73.

<sup>4</sup>RAHAL (F): *Cours Logistique de Distribution*, EHEC Alger, 2023.

- **Multiplicity of participants.** The circulation of information and goods must be well organized (control of document flows, planning of physical operations throughout the distribution network, etc.)
- **Multi-modality of transport operations.** The selection of appropriate packaging and Intermodal Transportation Unit (ITU) is crucial when using multiple modes of transport.
- **Respect of the customers' specification.** The product must be delivered in the quantity and quality requested, within the requested time.
- **Control of logistics costs.** The reduction of routes by proper route planning, optimizing the filling rate of vehicles, recourse to collaborative logistic strategies (Cross-Docking...), optimizing last kilometer costs.
- **Control of risks related to transportation.** It is important to reduce the number of load breaks during transport, to protect the goods well and to respect the transport conditions for perishable goods. Less handling means fewer risks and lower insurance costs.
- **Logistics of returns.** Organization of the collection and return of empty packaging. It requires a different set of skills and resources than the traditional logistics, from collecting and receiving the items to the inspecting phase.

#### **2.4. Distribution Logistics objectives**

The objectives of distribution logistics are multiple and include enhancing customer service, reducing costs, and improving quality. To achieve these goals, distribution logistics aims to improve customer service and prevent non-conformity of shipments. It also aims to minimize inventory holding costs, total inventory value, distribution costs, information processing costs, handling costs, and transportation costs. Additionally, the objective is to maximize non-conformity detection and prevention efforts for shipments to ensure high-quality standards are met.<sup>1</sup>

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<sup>1</sup>RAHAL (F), *op.cit.*

## **Second section: Warehouse Management**

A warehouse is an important part of a firm's logistics system that is used to store products (e.g., raw materials, parts/components, goods-in-process, finished goods) at and between the point of origin and the point of consumption. It provides information to management on the status, condition, and disposition of items being stored to create time and place utility for the firm's customers.<sup>1</sup>

This section will cover insights about warehousing including definitions, importance and main activities, as well as various aspect of warehouse management and the strategic decision to be made within a warehouse.

### **1. Definition and Role of Warehouses**

#### **1.1. Definition**

In modern supply chains, warehouses have a vital role as they are involved in multiple stages of the sourcing, production, and distribution of goods, including handling raw materials, work-in-progress and finished products, they serve as a dispatch point for the next customer in the chain and are essential in maintaining high levels of customer service.<sup>2</sup>

According to Robert Hughes, warehousing is a set of activities that are involved in receiving and storing goods and preparing them for reshipment, it is deemed that warehousing not only serve as a storage facility, but as a hub for various other activities, such as receiving, identifying, holding and assembling inventory and ensuring its availability to meet the demand thus, a warehouse acts as an integral part of logistics that stores products between the point of origin and the point of consumption.<sup>3</sup>

#### **1.2. Role of warehouses**

The prime objective of most warehouses is to facilitate the movement of goods through the supply chain to the end consumer, however different roles are performed by warehouses.<sup>4</sup>

Warehouses play a vital role in supply chain management by providing a centralized location for storing products. In addition to storage, warehouses can function as consolidation centers, where customers can receive multiple product lines delivered together. Cross-dock centers are also common, where goods are immediately unloaded from inbound transportation and loaded onto outbound transportation with little to no storage time in between. Assembly facilities are used as a final point of product assembly to minimize inventories and delay production down

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<sup>1</sup> MIN (H): **op.cit.** p.176.

<sup>2</sup>RUSHTON (A), CROUCHER (P) and BAKER (P): *The Handbook of Logistics and Distribution Management*, 5<sup>th</sup> edition, KoganPage, p.255.

<sup>3</sup>Indian Institute of Material Management: *Logistics and warehousing Management*, 2020, pp.96.97.

<sup>4</sup>RUSHTON (A), CROUCHER (P) and BAKER (P): **op.cit.**, pp.257.258.

the supply chain. Trans-shipment points transfer goods from one mode of transportation to another without the need for storage. Finally, returned goods centers are becoming increasingly important for handling returned goods due to environmental legislation and the growing use of internet shopping. Warehouses can perform a mix of these functions, and it is important to understand the specific roles they serve in order to maximize their efficiency in the supply chain.

## **2. Types of warehouses**

One of the important warehousing decisions involves selecting a particular type of warehouses that impacts cost and flexibility. Basically, warehouses are classified into one of three categories:<sup>1</sup>

### **2.1.Public Warehouses**

A public warehouse is owned and operated by a firm engaged in the business of offering space and diverse warehousing services on a “for-hire, as needed” basis. A public warehouse can take a variety of forms:

- **General merchandise warehouse.** Intended for storing any kind of products.
- **Refrigerated (cold storage) warehouse.** Intended for preserving perishable items such as grocery store items in a temperature-controlled storage environment.
- **Household goods warehouse.** Intended for storage of personal property.
- **Special commodity warehouse.** Designed for some agricultural products such as grains, salt, wool, and cotton.
- **Bulk storage warehouse.** Designed for dry products such as coal, sand, and chemicals.
- **Bonded warehouse.** Storage for imported goods. The company doesn't have to pay customs duties and excise taxes until those goods are released to the domestic market.

Public warehousing is a type of warehousing where the cost per unit of goods handled and stored is proportional to the volume of business transactions made by the user. This means that there are no large fixed costs incurred. Public warehousing offers several benefits, including the conservation of financial capital and improvement of cash flow, greater flexibility to increase to cover peak demands or decrease warehouse space as needed, reduced risk of dealing with labor disputes and natural disasters, and more professional management by a specialized commercial warehousing firm.

Despite the benefits of public warehousing, it also has its drawback. One disadvantage is the lack of control over warehousing operations, which can lead to slower customer response time

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<sup>1</sup>MIN (H): *The Essentials of Supply Chain Management*, Pearson, 2015, p.177.

and potential order fulfillment errors. Additionally, public warehousing may offer limited location choices and may present a lack of attention to a particular user.

### **2.2.Private Warehouses**

A private warehouse can be either leased or owned by the firm whose products are stored in it, and it is considered as a property of the owning firm. This gives the firm greater control over warehousing employees, operations, and scheduling customer orders, as well as the flexibility to meet specific needs (e.g., temperature- or humidity-controlled storage). Private warehouses also offer economies of scale for large-volume operations and potential financial gains from long-term appreciation in property value. On the other hand, a private warehouse can be a financial burden during a time of downsizing and strategic changes and a huge investment is tied with the purchase of a warehousing property.

### **2.3.Contract Warehouses (Third-Party)**

A contract warehouse provides a fixed amount of space and customized supplemental services exclusively for a customer for an extended period of time (e.g., six months or longer).

Contract warehousing is a type of warehousing that is customized for a limited number of customers and combines the benefits of private and public warehousing. This long-term business arrangement involves a partnership between the client and the logistics service provider, who share the risks and benefits of the operation. This approach is typically more cost-effective than public warehousing and can offer benefits such as expertise, flexibility, scalability, and economies of scale. Contract warehouses typically provide a variety of logistical services including transportation management, inventory control, order processing, customer service, and return goods processing.

## **3. Warehouse Operations**

Warehouse operations have a set of fundamental activities in common, no matter the name or the role, these functions can be defined briefly as follow:<sup>1</sup>

### **3.1.Receiving**

Receiving is the collection of activities involved in the orderly receipt of all materials coming into the warehouse, providing the assurance that the quantity and quality of such materials are as ordered, and disbursing materials to storage or to other organizational functions requiring them.

### **3.2.Putaway**

Putaway is the act of placing merchandise in storage. It includes the material handling, location verification, and product placement.

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<sup>1</sup>FRAZELLE (E): *Supply Chain Strategy*, McGraw-Hill, 2001, pp.229.230.

### **3.3.Storage**

Storage is the physical containment of merchandise while it is awaiting a demand. The storage method depends on the size and quantity of the items in inventory and the handling characteristics of the product or its container.

### **3.4.Order picking**

Order picking is the process of removing items from storage to meet a specific demand. It is the basic service a warehouse provides for customers and is the function around which most warehouse designs are based.

### **3.5.Packaging**

Packaging may be done as an optional step after the picking process. As in the prepackaging function, individual items or assortments are boxed for more convenient use. Waiting until after picking to perform this function has the advantage of providing more flexibility in the use of on-hand inventory.

### **3.6.Sortation**

Sortation of batch picks into individual orders and accumulation of distributed picks into orders must be done when an order has more than one item and the accumulation is not done as the picks are made.

### **3.7.Packing and shipping**

May include the following tasks:

- Checking orders for completeness.
- Packaging merchandise in an appropriate shipping container.
- Preparing shipping documents, including the packing list, address label, and bill of lading.
- Weighing shipments to determine shipping charges.
- Accumulating orders by outbound carrier.
- Loading trucks (in many instances, this is a carrier's responsibility).

## **4. Warehouse costs**

Warehousing typically accounts for about 20 to 30 per cent of logistics costs, while the carrying costs for the inventory within them account for a further 20 to 25 per cent. Together, these represent a very significant sum for many companies. The detailed breakdown of warehouse costs varies by the nature of the operation, but typical figures from past studies of "conventional" warehouse operations (e.g., adjustable pallet racking served by reach trucks with case picking at ground level) are as follows:<sup>1</sup>

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<sup>1</sup>RUSHTON (A), CROUCHER (P) and BAKER (P): *op.cit*, p.263.

- **Staff:** 45 to 50 per cent, with half of this often represented by order picking and packing staff.
- **Building:** 25 per cent, including rent or depreciation on the building.
- **Building services:** 15 per cent, including heat, light, power, building maintenance, insurance and rates.
- **Equipment:** 10 to 15 per cent, including rental or depreciation, equipment maintenance and running costs.
- **Information technology:** 5 to 10 per cent, including systems and data terminals.

## **5. Warehouse management**

### **5.1. Inventory management**

Inventories are raw materials, work in process, and finished goods that companies keep for different reasons such as saving time, to meet economic objectives, and as a buffer against uncertainties. The basic element of customer service for all logistics is inventory availability, and generally the most expensive logistics cost is inventory. Effective inventory management decreases carrying cost and increases customer satisfaction at the same time.<sup>1</sup>

#### **5.1.1. Inventory functions**

The following are among the many types of inventories that can be warehoused:<sup>2</sup>

- **Cycle stock** is inventory, i.e., highly predictable in its turnover and need to be replenished.
- **Safety stock** is inventory, i.e., concerned with short-range variations in either demand or replenishment. It protects against the uncertainty of demand and lead time.
- **Transit inventory** or pipeline inventory is composed of products that are in transit between producer and purchaser locations and are not ready to use or be sold. This stock is equal to the expected demand over the lead time (the time between issuing an order and receiving it).
- **Speculative stock** is inventory kept in case of material shortages, price increases, or unexpected changes in demand rather than to satisfy current demand.
- **Seasonal stock** is one form of speculative stock that is held for anticipated demand for a specific time period.
- **Dead stock** is inventory for which there is no longer demand. These inventories impose tax costs on a firm, so they should be moved out as appropriate.

### **5.2. People management**

People management is variously defined and some of the definitions are as follows:<sup>1</sup>

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<sup>1</sup>FARAHANI (R), REZAPOUR (S) and KARDAR (L): **op.cit**, p.188.

<sup>2</sup>Ibid. p.188.

- Getting people to do things.
- To achieve a task and build a team and develop individuals.

Managing work involves dealing with the four fundamental management activities: planning, organizing, directing and controlling. The planning stage is about setting objectives, preparing budgets, and plans of action are developed. The organizing stage involves determining which resources will be used and designing jobs, responsibilities, and work systems. In the directing stage, actions are coordinated with teams or groups, individuals are trained and developed, and the effectiveness of operations and people is assessed. The final stage involves monitoring performance using standards, evaluating results, recognizing problems, continually monitoring, and making improvements. These stages are crucial in ensuring that a business is able to effectively achieve its goals and objectives.

### **5.3. Storage and handling equipment**

#### **5.3.1. Storage equipment**

Storage equipment is used for holding or buffering materials over a period of time. Some storage equipment may include the transport of materials (e.g., the S/R machines of an AS/RS, or storage carousels). If materials are block stacked directly on the floor, then no storage equipment is required. Storage racks are used to provide support to a load and/or to make the load accessible, some examples of storage equipment are:<sup>2</sup>

- Block stacking (no equipment).
- Selective pallet rack: Single-deep rack or Double-deep rack.
- Drive-in rack.
- Drive-through rack.
- Automatic storage/retrieval system (AS/RS).

#### **5.3.2. Handling equipment**

To be able to decide on how to equip the warehouses with the most efficient mechanical handling equipment we need to undertake the following:<sup>3</sup>

- Define the functions to be performed.
- Review all stock items and define their handling requirements.
- Understand the travel distance and speed relationship.
- Understand the limits of the building and the structures within it.
- Evaluate staff capabilities.

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<sup>1</sup>EMMETT (S): *Excellence in Warehouse Management*, John Wiley & sons, 2005, p.231.

<sup>2</sup>Kay (M.G): *Material handling equipment*, Fitts Dept. of Industrial and Systems Engineering, North Carolina State University, 2012, p.55.

<sup>3</sup>GWYNNE (R): *Warehouse Management*, 2<sup>nd</sup> Edition, KoganPage, 2014, p.240.

- Evaluate vendors, equipment alternatives and relative costs.

Examples of handling movement equipment include: hand pallet trucks (HPTs), powered pallet trucks (PPTs), automated guided vehicles (AGVs), conveyors, forklift trucks.

**6. Strategic warehouse decisions**

Strategic decisions for warehouses may include determining the optimal location for the warehouse, selecting the appropriate warehouse design and layout.

**6.1. Number of warehouses**

There is an ongoing debate as to whether companies are going to increase or reduce the number of warehouses operated within the supply chain.

We can see from Table n°1.1 that most costs are higher if multiple warehouses are chosen, however, all of these costs can be off-set by a significant reduction in local transportation costs and improved service. In terms of inventory, we need to be able to calculate by how much we will increase or reduce our safety stockholding when we change the number of warehouses operated.<sup>1</sup>

**Table n°1.1: Comparison between many and fewer warehouse numbers**

<b>Criteria</b>	<b>Many warehouses</b>	<b>Fewer warehouses</b>
<b>Inventory costs</b>	Higher	Lower
<b>Customer reaction time</b>	Quicker	Slower
<b>Facility costs</b>	Higher	Lower
<b>Inbound transport cost</b>	Higher	Lower
<b>Outbound transport cost</b>	Lower	Higher
<b>Systems cost</b>	Higher	Lower

**Source:** GWYNNE (R): *Warehouse Management*, 2<sup>nd</sup> Edition, KoganPage, 2014, p 20.

The table n°1.1 illustrates the impact of varying the number of warehouses, from many to fewer, on multiple criteria, as the majority of costs are higher when choosing more number of warehouses, however, the customer reaction time would be quicker than having fewer warehouses.

**6.2. Warehouse location**

The first task is to identify both the general and then the specific warehouse location. The general area concerns the broad geography where an active warehouse makes sense from a service, economic, and strategic perspective. And then, a specific building site must be

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<sup>1</sup>GWYNNE (R): **op.cit**, pp.20.21.

identified. Typical areas in a community for locating warehouses are the commercial zone, outlying areas served primarily by motor truck only, and the central or downtown area.<sup>1</sup>

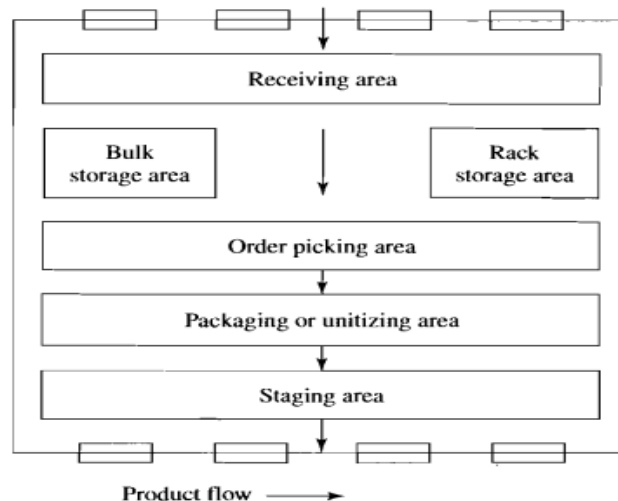
The various factors that need to be taken into consideration when choosing the location are:<sup>2</sup>

- **Layout and flow of building:** ensuring that the layout or products can be rightly fit in the given space.
- **Availability of skilled workforce.**
- **Intensity of use.**
- **Proximity to major linkage:** it involves means of transport (land, rail, water or air transportation).
- **Size:** it is important for a warehouse to accommodate inventory accordingly, and considering potential future expansions of the facility.
- **Regulations:** before buying a warehouse, one has to consider all regulations and policies in the concerned location, it becomes significant because there are certain areas or location in which it is not allowed to store certain chemical products.

### 6.3. Warehouse design

Warehouse design must consider product movement characteristics. Three factors to be determined during the design process are the number of floors to include in the facility, a cube utilization plan, and product flow:<sup>3</sup>

**Figure n°1.2: Basic warehouse design**



**Source:** BOWERSOX (J), CLOSS (J) and COOPER (B): *Supply Chain Logistics Management*, McGraw-Hill, 2002, page 399.

<sup>1</sup>BOWERSOX (J), CLOSS (J) and COOPER (B): *Supply Chain Logistics Management*, McGraw-Hill, 2002, pp.397.398.

<sup>2</sup>Indian Institute of Material Management, *Logistics and warehousing Management*, 2020, pp.102.103.

<sup>3</sup>BOWERSOX (J), CLOSS (J) and COOPER (B): *op.cit*, p.399.

The ideal warehouse design is a one-floor building that eliminates the need to move product vertically. The use of vertical handling devices, such as elevators and conveyors, to move product from one floor to the next requires time, energy, and typically creates handling bottlenecks.

Warehouse design should maximize cubic utilization. Most warehouses are designed with 20- to 30-foot (6 meters to 9 meters) clear ceilings, although modern automated and high-rise facilities effectively use heights over 100 feet (30 meters).

Warehouse design should facilitate continuous straight product flow through the building. This is true whether the product is moving into storage or is being cross-docked. In general, this means that product should be received at one end of building, stored as necessary in the middle, and shipped from the other end.

### **6.3.1. Sizing the warehouse**

There are number of critical factors influencing warehouse size. Some of these are influenced by marketplace consideration, such as the desired customer service level, size of the market(s) to be served, number of products to be marketed, demand patterns, and strength of the competition. Other factors focus on storage elements, such as the size of products, availability and type of material handling systems, labor, stocking layout, and geographical access. Finally, other factors are concerned with productivity metrics, such as facility throughput rate and exploitation of economies of scale.<sup>1</sup>

### **6.3.2. Warehouse layout**

The primary objective of a warehouse layout is either to maximize resource utilization while satisfying customer requirements or to maximize customer services subject to given resource constraints. The key warehouse resources include space, equipment, and personnel. Therefore, a warehouse layout begins with space planning that aims to estimate space requirements and to optimally allocate space according to a product's storage and handling requirements. Herein, warehouse spaces are classified into four different types: open spaces (aisles or empty areas), rack spaces, bin spaces (non-palletized items), order pick spaces. A warehouse layout decision is concerned with determining the optimal stack heights, the number of aisles, the size of staging areas, order picking lines, and reserve storage spaces necessary to perform warehousing tasks. Other important factors for the warehouse layout decision include the usage/demand rates (e.g., fast moving, medium moving, and slow moving) of stored products, similarity of products, size (e.g., load dimension and weight, stacking height), characteristics, space constraints, and inventory profiles (e.g., unit loads per stock keeping unit, cubic velocity, special handling

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<sup>1</sup>ROSS (D): *Distribution Planning and Control*, 3<sup>rd</sup> edition, Springer, 2015, pages 639 to 641.

requirements). To elaborate, fast-moving items should be stored such that the order picker's travel distance to those items is minimized. Also, it is common that items received together tend to be stored in the same area to minimize the order picker's travel distance. To ease handling, it is normal to store large-sized, bulky, heavy items close to the point of use or in the areas having the lowest stacking heights. Product characteristics such as shelf life, shape, and potential danger need to be taken into consideration for the layout because perishable, fragile, flammable, and dangerous products should be segregated to the designated storage area. Finally, to minimize vertical and horizontal honeycombing, the layout decision should consider space constraints imposed by the ceiling heights, posts and columns, floor loads, trusses, and sprinkler system. The warehouse layout can take different forms, depending on the patterns of warehousing activities.<sup>1</sup>

#### **6.4. Packaging and unit loads**

Packaging can be at different levels, such as directly enclosing the product (i.e., primary packaging), containing a number of primary packages (i.e., secondary packaging), or some form of outer packaging (normally to facilitate transport and handling). The nature of packaging is very important for warehousing operations, particularly as customers may require the goods at any of these levels. Thus, some customer orders may be for individual items (e.g., in their primary packaging), for cases of goods (e.g., containing a number of items) or at some greater quantity (e.g., a full pallet load of goods). The warehouse operations must be designed so that any of the order quantities that are offered to customers can be picked and dispatched cost-effectively.

Most supply chains are structured around the unit load concept, whereby goods are transported, stored and handled in standard modules. In warehousing, some of the most frequently used unit loads are pallets, cage and box pallets, roll-cages and tote bins.<sup>2</sup>

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<sup>1</sup>MIN (H): **op.cit**, pp.186.187.

<sup>2</sup>RUSHTON (A), CROUCHER (P) and BAKER (P): **op.cit**, pp.263.264.

### **Third section: Warehouse Automation**

Warehouse automation is a rapidly growing trend in the logistics industry. With the advancement of technology, companies are investing in automated systems to increase efficiency, productivity, and accuracy. In this section, we will cover various aspects of warehouse automation, including the types of automation technologies available, and their benefits and limitations.

#### **1. Automation in warehousing**

With the rise of e-commerce and customer expectation for faster deliveries, warehouses and distribution centers have adopted several automation technologies to run complex processes.

Groover defines automation as technology, in which a process is accomplished without humans. In automation a process is implemented using a program of instructions combined as well as a control system that executes the given instructions. An automated system usually consists of three basic elements: 1) the power to execute processes and to operate the system, 2) a program of instructions to direct the process and 3) a control system to actuate the instructions. To automate a process, an external power source is required to operate these three basic functions.<sup>1</sup>

The application of automation, computerized software and data collection devices is the most essential development in warehousing, the growth of automation in the warehouse is the result of the following drivers:<sup>2</sup>

- Growing requirements for the application of lean thinking and practices to warehousing.
- The application and adoption of sustainable business practices in the warehouse focusing on reducing energy and environment costs.
- Requirements for increased horizontal integration between the warehouse and the information systems used by other enterprise business functions.
- Integration between warehouse management systems (WMS) and transportation management systems (TMS).
- increased need to design multi-channel warehouses capable of fast-flow throughput and cost-reducing measures in the fulfillment of online order and web-based information.
- Effective scheduling, training, and management of warehouse labor through integration with labor management systems (LMS).

Effectively responding to these six challenges involves the increased utilization of technologies designed to enhance warehouse automation, deepening the planning and control of

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<sup>1</sup>KESKINEN (R): *Warehouse Automation Solutions*, Master's thesis, LUT University, Finland, 2022, p.19.

<sup>2</sup>ROSS (D): *op.cit*, pp.672-673.

warehouse functions, and providing for integration with order management and transportation software applications.

While there are many possible directions that can be pursued in warehouse automation, two critical paths stand out. The first is the use of warehouse automation tools to reduce error, increase productivity, and speed supply chain flow-through. The second path is the implementation of software suites for integrated warehouse management, labor and task planning, automation of stock put-away and order picking, and use of bar coding, robotics, and radio frequency identification (RFID).

## **2. Areas of automation**

We can distinguish three different areas: materials handling flow through facilitators, item identification, and warehouse management systems.<sup>1</sup>

### **2.1. Material handling flow-through**

This area of automation is the most visible in the modern warehouse. The overall goals of materials handling automation are to reduce materials handling, labor content, damage, and shrinkage, facilitate the flow-through of product, and integrate with other forms of warehouse automation. Applications consist of automated guided vehicles (AGVs), automated storage and retrieval systems (AS/RS), carousels, conveyors, and robotics. These systems work with warehouse control systems to drive order picking, stock put-away, inventory control, tracking item locations, storage bin utilization, stock rotation, and item movement through the warehouse.

### **2.2. Item identification**

Automatic identification systems minimize or eliminate human operator involvement in the collection of information by using optical and radio technologies that input information directly into warehousing systems. The importance of automatic identification systems in modern warehousing is twofold: (1) it minimizes or eliminates the need for human activity in data collection, and (2) it significantly increases the accuracy and speed of data collection.

### **2.3. Warehouse management systems**

As the complexity and speed of warehouse operations accelerates in today's business environment, many companies with distribution facilities are implementing computerized warehouse management systems (WMS). WMS software solutions were introduced over 20 years ago and today comprise a billion-dollar market. Over that time period they have evolved from simple back-office functions associated with inventory and shipping to today's robust systems. According to the 2013 Technology Usage Study, 50% of logistics operations are

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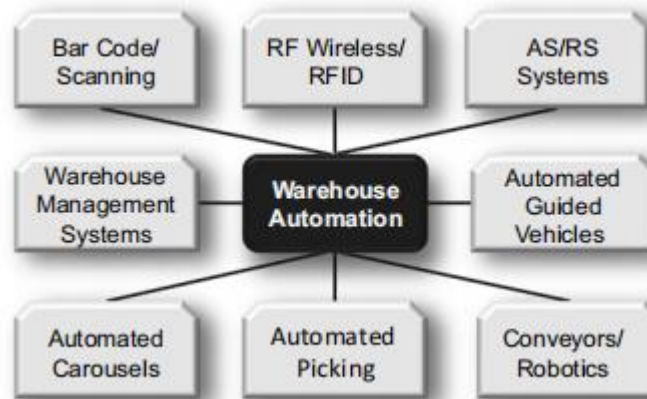
<sup>1</sup> ROSS (D): **op.cit**, pp.673-674.

currently using some form of WMS while 44 % were anticipating acquiring a WMS in the near future. About 79 % of the respondents said that their ERP systems include a WMS module.

### 3. Forms of warehouse automation

The different forms of warehouse automation are displayed in the following figure:

**Figure n°1.3: Components of warehouse automation**



**Source:** ROSS (D): *Distribution Planning and Control*, 3<sup>rd</sup> edition, Springer, 2015, p.673.

The figure n°1.3 illustrates the different forms of warehouse automation, providing a comprehensive overview of the different ways in which automation is employed in warehouses.

### 3.1. Automatic Identification and Data Capture

#### 3.1.1. Barcode scanning

Bar codes, which are becoming more widely used, are graphics consisting of wide and narrow bars that can be written and read by automatic devices. Some codes also use both wide and narrow spaces and even more than two widths.

There are many ways of composing barcodes. These are called different symbols. Depending on their symbology, these codes can be used to carry only numeric or alphanumeric information. It should be noted that the AFNOR NF 63400 standard proposes a multi-sectoral codification which should simplify many problems. Bar codes can be written correctly by all printing processes and on site by any printer, laser or thermal. Devices for reading these codes can be classified into several categories according to the reading distances they allow:

- Pens for contact reading
- Handhelds for reading at a few centimeters
- Laser guns operational from a few dozen centimeters to several meters
- Fixed laser scanners that can read beyond one meter.

All these devices need to be connected to a computer system.<sup>1</sup>

Besides the one-dimensional barcode described above, more and more two-dimensional barcodes are used. For these so called QR-codes, information can additionally be generated from the horizontal arrangement of lines, dots and areas as well as from their distances to each other. Today, the barcode in its different variants is the most common and the most standardized auto-identification technology in use.

Barcodes have become a widely used identification technique in logistics due to their advantages, including low costs per unit or label and standardized reading units. However, they do have some limitations, such as being sensitive to dirt, moisture, and mechanical impact, and only being able to be read visually. Additionally, barcodes have a limited data volume and do not allow for data addition in the process. Despite these disadvantages, barcodes remain a popular and cost-effective way to track and manage inventory in many industries.<sup>2</sup>

**Figure n°1.4: One-dimensional and two-dimensional barcodes**



**Source:** GWYNNE (R): *Warehouse Management*, 2<sup>nd</sup> Edition, KoganPage, 2014, p.147.

### 3.1.2. Radio Frequency Identification (RFID)

RFID is a technique for the contact-free recording and transmission of binary encoded information by means of electromagnetic waves. Information is transmitted between an information tag applied to the goods and a mobile or stationary scanner. RFID systems are divided into two main function groups:<sup>3</sup>

- *Transponders (tags)* as information carriers on the goods to be identified. The information stored on the transponders are just readable or rewritable, according to the type.
- A device for the recording of transponder information. Depending on the transponder type either readers or writers/readers can be used.

Since the data are transmitted via radio transmission, no intervisibility is required between the transponder and the scanner during the transmission. With regard to the power supply, RFID systems are divided into two into two basic categories:

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<sup>1</sup> ROUX (M): *Entrepôt et magasin*, 4<sup>ème</sup> édition, Edition d'Organisation, 2008, pp.249-250.

<sup>2</sup>GLEISSNER (H) and FEMERLING (C): *Logistics*, Springer, 2013, pages 200 to 202.

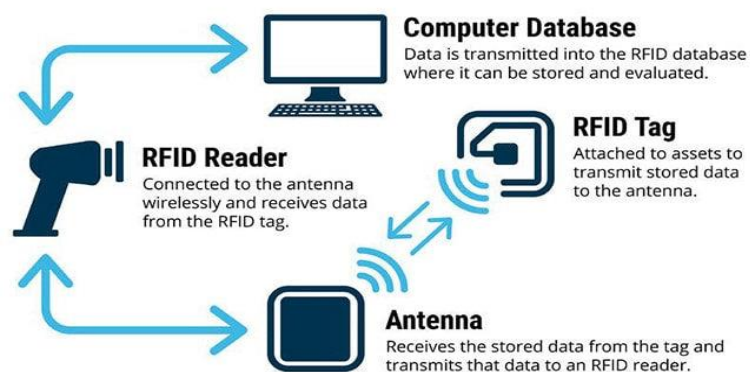
<sup>3</sup> HOMPEL (M) and SCHMIDT (T): *Warehouse Management*, Springer, 2007, p.214-215.

- **Passive transponders** are powered by a magnetic field generated by the scanner. As long as a transponder is within the range of the scanner the externally radiated alternating field generates a voltage in the antenna coil. The power is transmitted according to the transformer principle but only over short distances.
- **Active transponders** are equipped with a battery (flat or coin cell) for the chip and can independently initiate a data transmission. Owing to the internal power supply, the performance is large enough also for long distance data transmission.

RFID technology has several advantages and disadvantages. Advantages of RFID include its reusability, and ability to store a high volume of data. RFID is also writable with data during the logistics process, relatively immune to dirt, and allows for a wide range of data processing. Disadvantages of RFID include sometimes high prices for transponders, potential disturbance of receipt or sending by metallic environments, higher data volumes making control more difficult due to data protection, danger of data loss if exclusively stored externally on the transponder, as it is considered to be a complex technology.<sup>1</sup>

The following items required for an RFID system are illustrated in Figure n°1.6:

**Figure n°1.5: Basic RFID System**



**Source:** <https://blog.ttelectronics.com/rfid-technology> (consulted on 09/04/2023 at 14h25).

<sup>1</sup>GLEISSNER (H) and FEMERLING (C): **op.cit**, p.204.

The following Table n°1.2 presents a comparison between three different methods of data input and collection:

**Table n°1.2: Comparison between 4 methods of data input and collection**

<b>Technique</b>	<b>Error rate</b>	<b>Time rate</b>	<b>Cost</b>	<b>Advantages/(Disadvantages)</b>
<b>Manual entry</b>	Slow	High	Low	Low initial cost. (Requires human operator).
<b>Barcode 1-D</b>	Medium	Low	Low	High speed. Good flexibility. (Low data density).
<b>Barcode 2-D</b>	Medium	Low	high	High speed. High data density.
<b>Radio Frequency</b>	Fast	Low	High	Label need not be visible to reader. Read-write capability available. High data density. (Expensive labeling)

**Source:** GROOVER (M): *Automation, Production Systems, and Computer-Integrated Manufacturing*, Pearson, 2013, p.340.

Table n°1.2 highlights that despite the existence of error rates in automatic data collection, they are significantly lower compared to manual entry. Barcode technology offers a considerable reduction in time, while RFID systems have a huge impact on the time rate. The cost difference among the four methods is also indicated in Table n°1.2.

**3.2. Automatic material handling**

**3.2.1. Automated Storage and Retrieval Systems (AS/RS)**

AS/RS has been one of the major tools used for warehouse material handling and inventory control, since its introduction in 1950s. AS/RSs are widely used in automated production, distribution centers as well as in modern factories for work-in-process (WIP) storage.<sup>1</sup>

AS/RSs can be defined as a combination of equipment and controls which automatically handle, store and retrieve materials with great speed and accuracy, without direct handling by a human worker. This definition covers a wide variety of systems with varying degrees of complexity and size. However, the term automated storage and retrieval system has come to mean a single type of system comprising one or multiple parallel aisles with multi-tiered racks,

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<sup>1</sup> MANZNI (R): *Warehousing in The Global Supply Chain*, Springer, 2012, p.162.

stacker crane (also referred to as storage/retrieval machine or S/R machine), input/output (I/O) stations (pickup/delivery stations, P/D stations or docks), accumulating conveyors and a central supervisory computer and communication system.

**Figure n°1.6: Automated Storage and Retrieval Systems (Courtesy of Stöcklin Logistik)**



**Source:** MANZNI (R): *Warehousing in The Global Supply Chain*, Springer, 2012, p.163.

The AS/RS consists of racks made of steel or extruded aluminum structures with storage cells, stacker cranes are the fully automated storage and retrieval machines that can autonomously move, pick-up and drop-off loads. Aisles are formed by the empty spaces between the racks, where the stacker cranes can move. I/O stations where retrieved loads are dropped off and incoming loads are picked up for storage, and pick positions where human workers remove individual items. Briefly, a conventional AS/RS operates as follows: the incoming items are first sorted and assigned to the pallets or boxes. The loads are then routed through weighing station to ensure that those are within the load weight limit. For the pallet loads, their sizes should also be within the load size limit. Those accepted are transported to I/O station(s), with the contents of the loads being communicated to the central computer. This computer assigns the load a storage location in the rack, and stores the location in its memory. The load is moved from the I/O station to storage by stacker crane. Upon receipt of a request for an item, the computer will search its memory for the storage location and direct the stacker crane to retrieve the load.<sup>1</sup>

Implementing AS/RS systems is a complex and costly project that requires careful planning to avoid future modifications, after the AS/RS system is built, any modifications can be hard to carry out. The system must be designed to handle current and future needs in terms of storage capacity, picking efficiency, and input/output stations. It is also important to realize that automated storage systems are always just one part of the whole warehouse operations, and the best overall performance can only be achieved when all warehouse processes (automated and manual) work together.<sup>2</sup>

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<sup>1</sup>MANZNI (R): *op.cit*, pp.163-164.

<sup>2</sup>KESKINEN (R): *op.cit*, pp.31-32.

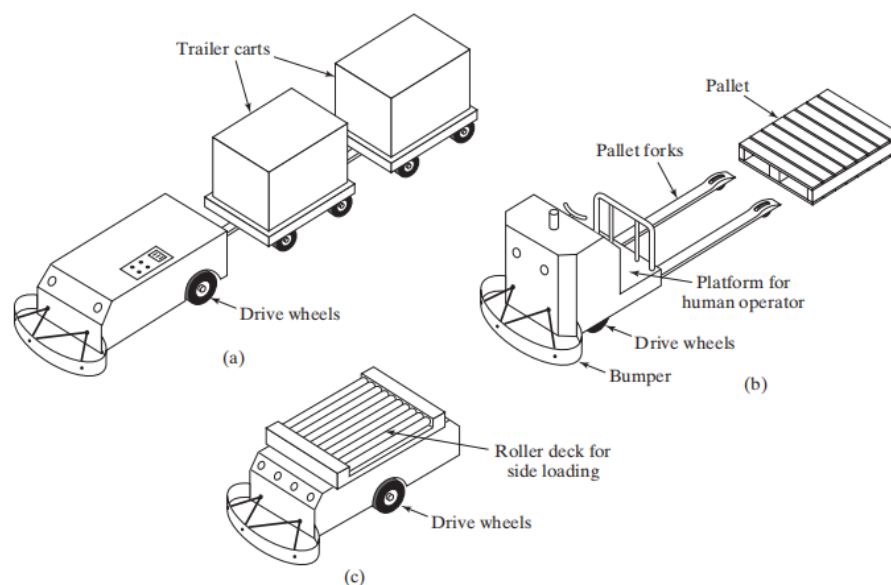
### 3.2.2. Automated Guided Vehicles (AGV)

An AGV systems is a material handling system that uses independently operated, self-propelled vehicles guided along defined pathways. The AGVs are powered by on-board batteries that allow many hours of operation (8–16 hours are typical) before needing to be recharged.<sup>1</sup>

Automated guided vehicles can be divided into the following categories:<sup>2</sup>

Driverless trains consist of a towing vehicle (the AGV) pulling one or more trailers to form a train, as in Figure n°1.7 (a). It was the first type of AGVS to be introduced and is still widely used today. A common application is moving heavy payloads over long distances in warehouses or factories with or without intermediate pickup and drop-off points along the route.

**Figure n°1.7: Three types of AGVs**



**Source:** GROOVER (M): *Automation, Production Systems, and Computer-Integrated Manufacturing*, Pearson, 2013, p.278.

Automated guided pallet trucks Figure n°1.7 (b) are used to transport palletized loads along predetermined routes. The truck is loaded by a human worker and then programmed to proceed automatically to the destination for unloading. These vehicles have load capacities of several thousand kilograms and some can handle two pallets. A special type of pallet truck is the forklift AGV, which uses forks to pick up pallets. This vehicle can achieve significant vertical movement of its forks to reach loads on racks and shelves.

AGV unit load carriers are used to move unit loads from one station to another. They are often equipped for automatic loading and unloading of pallets or tote pans by means of powered

<sup>1</sup>GROOVER (M): *Automation, Production Systems, and Computer-Integrated Manufacturing*, Pearson, 2013, p.278.

<sup>2</sup>Ibid. pp.278.279.

rollers, moving belts, mechanized lift platforms, or other devices built into the vehicle deck. A typical unit load AGV is illustrated in Figure n°1.7 (c).

Customers using this system are reporting not only a doubling of the pick rate to some 400 packages per hour, but also a 60 per cent lower error rate. Another advantage of this solution is that the picking pallet can always be adjusted to the ergonomically optimum loading height for the picker. Additional advantages include the automated transport of picked pallets on to dispatch. Each of these factors contributes to a quick return on investment. The advantages of automated vehicles are as follows:<sup>1</sup>

- computer or hand controlled
- more durable than people
- long-distance and/or high-density traffic
- fitted with security sensors and guards
- limited potential for damage
- reliable and do not cause bottlenecks.

The disadvantages are that they are initially expensive, fully reliant on the RF system within the warehouse and may require a specially designed and obstruction-free floor area.

### **3.2.3. Conveyors**

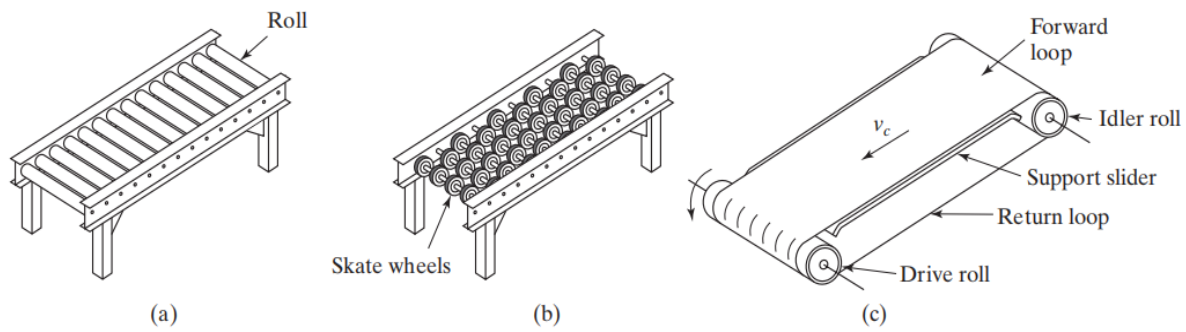
A conveyor is a mechanical apparatus for moving items or bulk materials, usually inside a facility. Conveyors are generally used when material must be moved in relatively large quantities between specific locations over a fixed path, which may be in the floor, above the floor, or overhead. Conveyors are either powered or nonpowered. In powered conveyors, the power mechanism is contained in the fixed path, using chains, belts, rotating rolls, or other devices to propel loads along the path. Powered conveyors are commonly used in automated material transport systems in manufacturing plants, warehouses, and distribution centers. In nonpowered conveyors, materials are moved either manually by human workers who push the loads along the fixed path or by gravity from one elevation to a lower elevation.<sup>2</sup>

Over time conveyer systems can provide costs saving by reducing labor costs and improved productivity through moving products and materials within the warehouse.

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<sup>1</sup>GWYNNE (R): **op.cit**, pp.241-242.

<sup>2</sup>GROOVER (M): **op.cit**, pp.284-285.

**Figure n°1.8: Types of Conveyors**

**Source:** GROOVER (M): *Automation, Production Systems, and Computer-Integrated Manufacturing*, Pearson, 2013, p.286.

A variety of conveyor equipment is commercially available. The primary interest here is in powered conveyors. Most of the major types of powered conveyors, organized according to the type of mechanical power provided in the fixed path, are briefly described in the following:<sup>1</sup>

- **Roller conveyors.** In roller conveyors, the pathway consists of a series of tubes (rollers) that are perpendicular to the direction of travel, as in Figure n°1.8 (a). Loads must possess a flat bottom surface of sufficient area to span several adjacent rollers. Pallets, tote pans, or cartons serve this purpose well.
- **Skate-wheel conveyors.** These are similar in operation to roller conveyors. Instead of rollers, they use skate wheels rotating on shafts connected to a frame to roll pallets, tote pans, or other containers along the pathway, as in Figure n°1.8 (b). Because of their lightweight, skate-wheel conveyors are sometimes built as portable units that can be used for loading and unloading truck trailers at shipping and receiving docks at factories and warehouses.
- **Belt conveyors.** Belt conveyors consist of a continuous loop, with half its length used for delivering materials and the other half for the return run, as in Figure n°1.8 (c). At one end of the conveyor is a drive roll that powers the belt. The flexible belt is made of reinforced rubber and supported by a frame that has rollers or support sliders along its forward loop. Belt conveyors are used for pallets, cartons, and individual parts.

#### 3.2.4. Automated picking Systems

The requirement for increased speed, accuracy and productivity has pointed managers towards automation as a realistic option in today's competitive automated equipment market. A high-

<sup>1</sup>GROOVER (M): *op.cit*, pp285-286.

volume item pick operation is an area where automation can have a high impact, examples of automated picking systems are:<sup>1</sup>

#### 3.2.4.1. Mini-load AS/RS systems

A mini load automatic storage and retrieval system handles loads that are contained in small containers or totes, with load weights typically falling in a range of 40 to 250 kilograms. The capacity range can go to 350 to 1,000 kilograms at the high end. The system is ideal for storing small quantities of large numbers of SKUs. ‘Slave’ trays can also be used to transport shipping cartons to reduce the amount of decanting within the warehouse. One key feature of a mini-load system is that it maximizes the cube of the warehouse, saving space whilst increasing throughput.

Dynamic slotting enables fast-moving products to be located in the most accessible locations. When a part is required, the system will identify the location and the tote or tray will be transferred to the operator, who is standing at a pick station located in front of the rows and columns of storage bins.

**Figure n°1.9: Mini-load system (courtesy of Vanderlande)**



**Source:** GWYNNE (R): *Warehouse Management*, 2<sup>nd</sup> Edition, KoganPage, 2014, p.107.

#### 3.2.4.2. Autostore

Autostore is an AS/RS system which stores goods in bins that are stacked directly on top of one another in a self-supporting aluminum grid. The battery-operated robots are controlled using a wireless system and maneuver the bins within the grid. They also transport the bins to and from workstations for goods to be decanted or picked. Bins containing fast-moving products are stored at the top of the storage system whilst slow-moving stock is stored in the lower sections. This system uses less energy than a mini-load system and is scalable.

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<sup>1</sup>GWYNNE (R): **op.cit**, pp.105. -108 & 115-117.

**Figure n°1.10: Autostore robot**

**Source:** GWYNNE (R): *Warehouse Management*, 2<sup>nd</sup> Edition, KoganPage, 2014, p.111.

### 3.2.4.3. Robotics

Robots in the form of automated guided vehicles utilized for transferring pallets within the warehouse have been in use for a number of years, but they have been a rarity within picking operations.

However, things are beginning to change and robots have been adapted to pack items into boxes and stack those boxes onto pallets in the most efficient way. The use of robots in the pick process is also beginning to increase. These are in areas where labor is scarce or very expensive, where the tasks are reasonably straightforward or where the operation is undertaken in hazardous conditions where manual handling is deemed dangerous.

Examples of the use of robotic arms fitted with suction pads and an optical reader being used to pick items from a conveyor and deposit the items into their respective containers are beginning to appear.

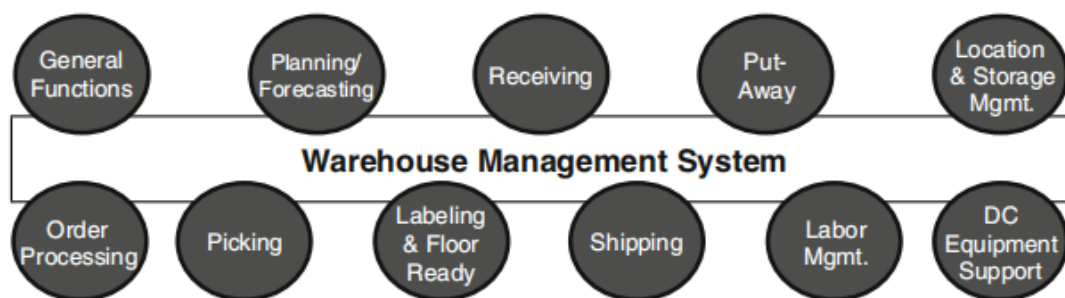
**Figure n°1.11: Robot picking (courtesy of SSI Schäfer)**

**Source:** GWYNNE (R): *Warehouse Management*, 2<sup>nd</sup> Edition, KoganPage, 2014, p.117.

### 3.3. Warehouse management Systems

Warehouse management systems provide a central information system for the control of the movement and storage of materials within a warehouse and the processing of associated transactions, including shipping, receiving, put-away, and picking. It involves the physical warehouse infrastructure, tracking systems, and the receipt, storage, and movement of goods to storage locations or to the final customer. The objective of a WMS is to optimize customer service while reducing warehouse costs. A WMS is easily linked to a firm's enterprise resources planning (ERP) system, as well as logistics transportation and supply chain process management solutions to provide companies with a totally integrated, real-time fulfillment system.<sup>1</sup>

**Figure n°1.12: WMS components**



**Source:** ROSS (D): *Distribution Planning and Control*, 3<sup>rd</sup> edition, Springer, 2015, p.675.

As illustrated in Figure n°1.12, the major WMS components consist of the following modules:

- **Receiving.** This module consists of several functions associated with supply order receiving. Often these applications are electronic data interchange (EDI) or Web-enabled. Key functions supported are in-bound order tracking, delivery scheduling, picking planning, label printing, unitization, inspection, returns, and supplier audit.
- **Warehousing.** This module contains materials handling functions, such as crossdocking, put-away, location, and storage. Critical system functionality includes palletizing, packaging, zone and random storage location selection, location capacity and utilization management, item bar coding, locator, serial, and lot control, cycle counting. The goal of these functions is to improve the accuracy of inventory storage.
- **Order management.** WMS functions in this area focus on increasing customer service by automating picking and shipping functions, shrinking processing times, and improving service accuracy. Important functionality includes order allocation, checking and grouping/batching, auto-replenishment of picking locations, pick list printing, FIFO, zone, and wave picking, product substitution, pallet layering, assembly and kitting, and scanning.

<sup>1</sup>ROSS (D): *op.cit*, pages 674-676.

- **Labor Management Systems (LMS).** An LMS enables managers to collect information about warehouse labor activity that is then compared against historical information and established standards, such as order picking and inventory receipt put away. The collected data is used to monitor productivity and optimize labor.
- **Labeling and floor ready.** Today's WMS handles complex product labeling requirements such as UPC tagging, container marking, price mark tagging, custom label design/printing, international and customs documentation, bar code labels, and RFID tags.
- **Shipping and transportation.** WMS systems integrate shipping and transportation functions directly with the ERP backbone. Key functions are shipment and load planning, trailer management, freight rating and shipping, traffic routing/scheduling, outbound appointment scheduling, transportation analysis, and in transit inventory tracking.
- **DC equipment support.** A critical WMS enabler is the capability to link warehouse equipment directly to the warehousing and business systems.
- **Billing.** WMS applications also facilitate the management of receivables billing, time reporting, surcharges, and chargebacks.

There are several benefits gained by implementing a WMS system, including increasing productivity, efficiency, and accuracy of warehouse functions, WMS applications reduce manual efforts expended on tracking locations, tracking item storage and balance accuracies, reducing stockkeeping and picking personnel, and improving order management accuracy and speed. In addition, a WMS helps in performance management through effective cycle counting, automated data collection, accountability. Finally, WMS applications enable warehouse equipment automation by integrating with business databases.

#### **4. Levels of Automation**

Four different levels are distinguished:<sup>1</sup>

- **Level 1: No or low automation.** A warehouse primarily driven by manual processes or basic decision-making automation.
- **Level 2: System automation.** Warehouses that use advanced automated decision-making, e.g., Warehouse Management Systems (WMS), to support warehouse processes. The WMS can be integrated into simpler equipment such as RFID technology, pick-to/put-to/pick-by light, and voice picking to support more efficient decision-making and picking.

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<sup>1</sup><https://www.consafelogistics.com/knowledge-center/blog/what-is-warehouse-automation> (consulted on 08/04/2023 at 14h00.).

- **Level 3: Mechanized automation.** When the decision-making is automated, the next step is to automate goods handling. This level typically includes conveyor systems and automated storage and retrieval systems. The full functionality of the WMS is likely not utilized.
- **Level 4: Sophisticated automation.** The final level of automation, where warehouses use highly automated equipment for more complex goods handling flows, such as AS/RS, conveyors, automatic sorters, AGVs (Automated Guided Vehicles), a robotic picking system, and automatic palletizers to eliminate manual movements and to streamline order picking processes. This level of automatic warehouse needs a Warehouse Control System (WCS) or Warehouse Execution System (WES) that can handle complex decision-making logic.

### 5. Issues and advantages of warehouse automation

Order picking is a time-consuming process and typically requires a lot of manual labor, especially in person-to-goods warehouses.

One way to increase productivity and reduce picking mistakes is to present the materials or information to the picker. This way the picker does not move from the picking station but instead materials are fetched with automation solutions to the picking location. The picker does not have to use time to move from storage location to another, which reduces inefficient work like search and travel, which is the most time consuming and costly operation in picking work.

Automation technologies, such as pick-by-light, pick-by-voice, and other virtual displays, is becoming increasingly popular in warehouses. The main goal of this technology is to provide hands-free and paperless information flow to warehouse workers, reducing the time spent finding the right picking location, products, and entering product codes to the ERP system, ultimately increasing productivity. The technology increases hands-free work and facilitates efficient retrieval and fast registration of picked materials with fewer errors.

Automation offers benefits such as reduced labor costs, increased accuracy, and shorter order cycle times. However, it typically requires a significant investment and may not be as adaptable to changing circumstances as non-automated solutions. Effective automation requires integration, design, and standardization.<sup>1</sup>

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<sup>1</sup>KESKINEN (R): **op.cit**, pages 19 to 21.

**Conclusion of the Chapter**

This chapter covers the fundamental concepts and principles of Supply Chain Management and Logistics, with a particular emphasis on warehousing and warehouse automation technologies. The distribution logistics is illustrated with its different activities, it is a challenging function yet a crucial element of a company's success. While various aspects of these topics are explored in different sections of the chapter, the primary focus is on providing a detailed overview and a comprehensive understanding of the different automation techniques that are currently being employed in warehouses.

To remain competitive in today's business world, companies aim to increase the overall performance of their warehouses through the integration of advanced technologies and the evolution of their facilities. The main goal of these efforts is to improve customer service levels and maintain a competitive edge. Thus, in the second chapter will explore various topics related to warehouse performance.

## **Chapter 02:**

# **Measuring Performance in Logistics & Warehouses**

## **Chapter introduction**

Performance management and measurement are critical components of modern business management. In today's competitive and constantly evolving business environment, organizations must consistently monitor, evaluate, and improve their performance to remain successful and relevant. Performance management and measurement are vital tools for organizations in various industries to effectively manage and optimize their operations.

This chapter, provides a comprehensive overview of performance management and measurement in business management which is divided into three sections. The first section discusses the concept of performance and performance management. The second section explores performance measurement systems and models used to evaluate performance. The third section treats the performance measurement models and KPIs in the context of warehouse and logistics operations.

### **First section: The Concept of Performance**

Performance and performance management are widely used terms within organizations, this section highlights the basic notions related to performance, types and performance management process.

#### **1. Definitions of performance**

The term 'performance' is defined by The Oxford English Dictionary as: "Performance. The action of performing, or something performed... The carrying out of a command, duty, purpose, promise, etc., execution, discharge, fulfillment. Often antithetical to promise... The accomplishment, execution, carrying out, working out of anything ordered or undertaken, the doing of any action or work, working, action (personal or mechanical), etc...."<sup>1</sup>

The concept of performance can be defined for a company as the level of achievement of results in relation to the efforts engaged and consumed resources. It is largely based on the concepts of effectiveness and efficiency, in relation to these two criteria, A. Bourguignon (1997) started grouping the meaning of the word performance in the field of management around these three primary meanings:<sup>2</sup>

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<sup>1</sup>SAMSONOWA (T): *Industrial Research Performance Management*, Physica-Verlag, 2012, pp.22.23

<sup>2</sup>ISSOR (Z): *La performance de l'entreprise : un concept complexe aux multiples dimensions*, in Projectics / Proyéctica / Projectique, vol. 17, no. 2, 2017, pp.95.96.

- **Success:** when performance is synonymous with success. This meaning contains a value judgement, with regard to a reference frame, which represents success from the observer's point of view.
- **Result:** here performance refers to the result of an action, the post evaluation of the results obtained without value judgement.
- **Action:** performance can mean an action or a process (the implementation of a skill that is only a potentiality).

The word is therefore “catch-all” because it includes both the idea of action and that of state (final stage or result).

According to M. Lebas, “Performance is about deploying and managing well the components of the causal model(s) that lead to the timely attainment of stated objectives within constraints specific to the firm and to the situation.”<sup>1</sup>

The AFNOR (French Standardization Association) gave the following definition: “Performance is a measure of the effectiveness and/or efficiency of all or part of a process or system (real or simulated) in relation to a number, plan or target determined within the framework of a business strategy.”<sup>2</sup>

## **2. Synonyms of performance: Efficiency, Effectiveness and Effectivity**

Performance is associated with three important concepts: Efficiency, Effectiveness and Effectivity.<sup>3</sup>

**Efficiency** is measured by the ratio of resources used by actors and the results obtained. Dohou and Berland define efficiency through some examples: "the fact of maximizing the quantity of products or services obtained from a given amount of resources: profitability (the ratio of profit to invested capital) and productivity (the ratio of volume obtained to consumed volume) are two examples of efficiency".

**Effectiveness** is "a mono-criteria, one-dimensional, simple, and very structured concept". It is defined by the achievement of objectives. Effectiveness is measured by the gap between the objectives and the results obtained. Bouquin identifies effectiveness as the ability to achieve set objectives.

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<sup>1</sup>LEBAS (M): *Performance measurement and performance management*, Int J of Production Economics, Vol. 41, Issues 1–3, 1995, p.29.

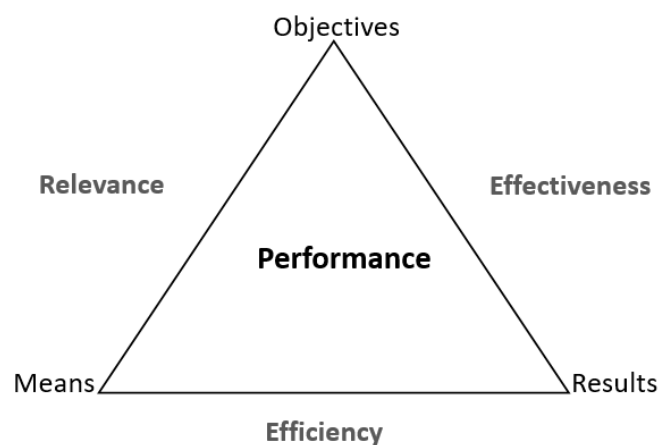
<sup>2</sup>BERRAH (L) : *L'indicateur de performance : concepts et applications*, Cépadues-éditions, 2002, p.34.

<sup>3</sup>HAMADMAD (H) : *Définition d'une expression temporelle de la performance des entreprises manufacturières*, Thèse de Doctorat en Science de Technologie et de l'Information, Université Grenoble Alpes, 2017, pp.14.15.

According to Marion and his team, effectiveness is an essential logic for evaluating performance in a company. Effectiveness is defined by a link between the objective and its achievement. "By relating the results to the objectives, effectiveness reflects the company's ability to achieve its objectives."

**Effectivity** is linked to the finality "Purpose". Le Moigne defines effectivity as: "the evaluation of the triptych (objectives - means - results), that is, by going back to the finalities that are at the origin of the system whose performance is being evaluated". Effectivity allows the link between what the company has done and what it wanted to do. The notion of effectivity can also find a kind of synonymy in the notion of "coherence" between objectives, means, and results. This is, moreover, the point of view of Marion and his team who think: "by relating objectives to means, coherence reflects the adequacy supposed to guarantee the balance of the system. By referring to the requirement of an internal coordination of the collective action, coherence reflects the harmony of the basic components of the organization that allows the evaluation of organizational performance".

**Figure n°2.1: Performance triangle: Gibert' model** (Translated from French)



**Source:** <https://www.researchgate.net/figure/Triangle-de-la-performance-Gibert-1980>

(Consulted on 19/04/2023 at 14h30).

The figure n°2.1 represents the performance triangle. This model illustrates the links between the means implemented, the objectives to be achieved, and the results obtained. The segment between objectives and results defines effectiveness and allows to know if the company is efficient enough to achieve its objectives. The segment between results and means defines efficiency and allows to know if the company is able to achieve its objectives with reduced costs and resources. The segment between means and objectives refers to relevance and determines whether the company has the right means to achieve its objectives.

### **3. Types of Performance**

Performance is considered to be a multidimensional concept as it includes the economic, social and environmental aspects of a company. Marcel Lepetit defines it as “A multidimensional, economic, social and societal, financial and environmental aim (or goal), which concerns companies as well as human societies, employees as well as citizens.”<sup>1</sup>, therefore we distinguish the following types:

#### **3.1. Strategic performance:**

Also called long-term performance, guarantees sustainability, maintaining a distance from competitors and uses a system of excellence as a measurement indicator. Several factors are necessary for achieving strategic performance, including growth, a well-thought-out strategy, strong motivation among organization members, a long-term focus, the ability to create value for customers, quality management and products, and environmental awareness.

#### **3.2. Competitive performance:**

It is linked to the competitive environment of the organization, requires the development of new forms of competitive advantages by anticipating/constructing the future rules of the game. Its materialization is not only based on the organization's actions but also on its ability to adapt and approach the competition's rules within its sector. The anticipation must be permanent in order to guarantee a sustainable performance.

#### **3.3. Organizational performance:**

Which relates to the effectiveness of the organizational structure and the way in which the company is organized to achieve its objectives, it includes various indicators such as product and service quality, employee mobilization, work climate, productivity, customer satisfaction, etc.

#### **3.4. Economic and Financial performance:**

It is essential for the survival of a company. This performance is measured by indicators such as investment and sales profitability, productivity, asset performance, and efficiency. It also includes creating value for customers, shareholders, and investors. While financial performance has long been the reference for evaluating companies, it alone no longer ensures competitiveness.

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<sup>1</sup>ISSOR (Z): **op.cit**, pages 99 to 102.

### **3.5. Commercial performance:**

Also called marketing performance, is linked to the customers satisfaction, it can be measured by quantitative criteria such as market share, profit, turnover or qualitative criteria such as the capacity to innovate for the customer, consumer satisfaction, loyalty, perception of quality and the company's reputation.

### **3.6. Human and social performance:**

It represents the social and human relationships within the company, it is affected by personnel management policies and reflects the company's attention to the social domain. Factors that affect human and social performance include the quality of collective decision-making, conflicts and social crises, employee satisfaction, turnover, absenteeism, social climate, and functioning of personnel representatives and quality circles.

## **4. Performance Management Model**

Performance management is a process which include: planning, monitoring, analyzing, improving and maintaining where each step serves as a base for the next one, this model assumes a supportive organization culture. The 5 steps can be resumed as follow:<sup>1</sup>

### **4.1. Planning performance**

Planning performance is all about establishing expectations as clear expectations provide direction. The manager and employees must determine what performance is required and how much direction is needed. Through performance management, employees should eventually become self-directed and responsible for their own results. Regular communication between the manager and employees is essential to develop a performance contract that outlines how they will work together to achieve their goals.

### **4.2. Monitoring performance**

Monitoring performance involves ensuring that expectations are being met. The second step involves agreeing on how to measure performance by using various charts and graphs that provide a visual presentation of results and then collect actual performance data to feed into charts and graphs. Observing performance is also essential. A critical partnership between the manager and employee is needed to determine what results are to be monitored and how to interpret findings, as this determines the next steps (steps 3 to 5).

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<sup>1</sup>CADWELL (C): *performance management*, Amacom, 2002, pages 15 to 18.

### **4.3. Analyzing performance**

In analyzing performance, identifying performance gaps and their causes is key to improving performance. Once performance gaps are identified, it is important to determine their cause(s) in order to figure out what can be done. Typically, such things as a lack of knowledge, some task interference, or an imbalance in consequences cause performance gaps. Correctly identifying the cause then leads to determining the best course of action to get performance back on track, this step is critical because if the wrong cause is identified it can lead to taking the wrong action to solve the problem. After identifying the cause of the gap, it's important to determine the PIP (Potential for Improved Performance) to decide if it's worth investing resources to close the gap.

### **4.4. Improving performance**

Improving performance is about implementing strategies to reduce or eliminate performance gaps. The manager and the employee must act together to get performance back on track. Choosing the right strategy can affect how long it takes to improve performance. Examples of the strategies which can be used are: providing training and development, coaching and mentoring, or developing performance action plans. Selecting the strategy depends on how accurately the cause of the performance gap was identified in step 3.

### **4.5. Maintaining performance**

The last step of performance management is maintaining good performance, which can be achieved either after monitoring performance and finding all is well or after implementing strategies to improve performance. One of the tools that can be used to help maintain performance is to develop feedback systems, formal performance appraisals are another tool for maintaining performance. The role of compensation in maintaining performance also must be considered along with the appropriate use of nonmonetary rewards and incentives. Maintaining performance ultimately leads back to the first step, thus restarting the whole process.

## **Second section: Performance Measurement Systems & Models**

Measuring performance is important to maintain control over the operations and it's a tool used to discover potential areas of improvements, this section reviews performance measurement concept, systems and highlights the importance and challenges of measuring performance in business management.

### **1. Definition of Performance Measurement**

Performance measurement is widely used in business management, therefore, several definitions can be found.

According to Neely et al, Performance measurement can be defined as “The process of quantifying the efficiency and effectiveness of action”, performance measurement is a process of assessing the actions taken by the organization through quantifying the outcomes. Neely has defined Performance Measurement Systems as follows: “A performance measurement system can be defined as the set of metrics used to quantify both the efficiency and effectiveness of actions”.<sup>1</sup>

“Performance measurement can be defined as the development and deployment of (often several) quantifiable measurements of various dimensions (e.g., cost, time, quality, innovation, customer satisfaction) which are applied to assess the effectiveness and efficiency of the performance and performance potential of different objects within the enterprise (organizational units of various sizes, employees, and processes)”<sup>2</sup>

According to Bourne and others, performance measurement (as promoted in the literature and practiced in leading companies) refers to the use of a multi-dimensional set of performance measures as it includes both financial and non-financial measures, it includes both internal and external measures of performance which quantify what has been achieved as well as measures which are used to help predict the future. It must be done within a strategic framework that aligns with the organization's goals. Performance measurement has an impact on the organization and its stakeholders, influencing their actions and decisions. It is an integral part of the management planning and control system.<sup>3</sup>

Therefore, performance measurement is an essential aspect of business organizations, as it helps to evaluate their success and progress towards achieving their goals. It is the process of

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<sup>1</sup>NEELY (A), GREGORY (M) and PLATTS (K): *Performance measurement system design: A literature review and research agenda*, Int J of Operations & Production Management, Vol. 15 Issue 4, 1995, p.80.

<sup>2</sup>SAMSONOWA (T): *op.cit*, p.38.

<sup>3</sup>BOURNE (M) and others: *Implementing performance measurement systems: a literature review*, Int. J. Business Performance Management, Vol. 5, No. 1, 2003, p.03.

quantifying and assessing the effectiveness and efficiency of business processes, products, services, and employees' performance.

## **2. The Importance of Performance Measurement**

Performance measurement has become increasingly crucial in management in recent decades, there are three primary reasons why measuring performance is vital in modern organizations:<sup>1</sup>

1. Today's businesses are very complex, which also makes them hard to manage. Performance measurement's purpose is to simplify the reality so that rational decisions can be made. That the reality is transformed to simplified numerical concepts that can be communicated and acted upon is the key to successful management.
2. Performance measures play an important role in success by giving the opportunity to evaluate performance and benchmark the results against similar organizations.
3. Performance measurement plays the role of feedback in one's organization, it facilitates the assessment whether plans were accurate or not and it shows how well the execution was carried out. These processes are of critical importance to effective and efficient performance management.
4. Implementing performance measurement in an organization will not improve performance by itself, it will however facilitate decision-making and the control over processes. The business information that is attained through performance measurement is the real value of performance measurement.

## **3. Challenges in Performance Measurement**

Despite performance measurement being recognized as a critical component of successful management, many organizations struggle with implementing and utilizing performance measurement effectively as there are several faced challenges:<sup>2</sup>

1. Measuring is often put in negative terms because people think of surveillance and pressure to perform.
2. To develop a measurement system, or a set of KPIs can be very challenging and time craving.

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<sup>1</sup>AXELSSON (P) and FRANKEL (J): *Performance measurement system for warehouse activities based on the SCOR model*, Master thesis, Lund University, Department of Industrial Management and Logistics, 2014, pp.29.30.

<sup>2</sup>Ibid. p.31.

3. Even if a measurement system is in place it has to be continuously updated to stay relevant and it's easy that the system keeps expanding and the meaning of having a few powerful KPIs are lost.
4. The complexity of developing meaningful and comprehensive performance measures for certain industries or processes.
5. The difficulty in comparing performance measures across different departments or organizations.

#### **4. Performance Indicators & Key Performance Indicators definitions**

There many definitions of the performance indicators:

According to Neely: "A performance measure can be defined as a metric used to quantify the efficiency and/or effectiveness of an action".<sup>1</sup>

On the other hand, the Performance Indicators (PI) Commission of the French Association of Industrial Management (AFGI) defines the performance indicator as: "a quantified data that expresses the effectiveness and/or efficiency of all or part of a system (real or simulated), in relation to a standard, a determined and accepted plan within the framework of a company's strategy (strategic objective)".<sup>2</sup>

Performance indicators (PI) are considered as: "An instrument to measure a predefined part of the performance of a process in order to monitor the development of this performance. A complete indicator consists of a measure, a norm, a measurement instrument and a registration technique".<sup>3</sup>

Alongside PIs, Key Performance Indicators (KPIs) are a widely used concept in measuring and evaluating organizations performance, and it can be defined as follow:

"Key performance indicators (KPIs) are those indicators that focus on the aspects of organizational performance that are the most critical for the current and future success of the organization."<sup>4</sup>

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<sup>1</sup>NEELY (A), GREGORY (M) and PLATTS (K): **op.cit**, p.80.

<sup>2</sup>HAMADMAD (H): **op.cit**, p.30.

<sup>3</sup>SAMSONOWA (T): **op.cit**, p.30.

<sup>4</sup>PARMENTER (D): *Key performance indicators – developing, implementing, and using winning KPIs*. John Wiley & sons, 2020, p.06.

**Table n°2.1: Definitions: measure, metric, PI and KPI**

Term	Definition
<b>Measure</b>	A quantifying value
<b>Metric</b>	A metric puts a measure into a certain context. The context is given by an item or an object or a set of items or objects. It defines a unit of measure and a reference unit
<b>Performance Indicator</b>	A performance indicator is an auxiliary metric that partially reflects the performance of an organizational unit
<b>Key Performance Indicator</b>	KPIs are a set of performance indicators that are selected upfront and agreed on by management to be the most representative and/or critical performance indicators. A KPI is an element of this set

**Source:** SAMSONOWA (T): *Industrial Research Performance Management*, Physica-Verlag, 2012, p.32.

Table n°2.1 provides a summary of the various terms associated with performance measurement and demonstrates the fundamental relation between the terms.

#### 4.1. Types of Performance Indicators

The performance indicators are traditionally distinguished to the following typologies:<sup>1</sup>

- **Strategic indicators:** they are related to the organization's mission and objectives, they are more complex to deal with. First, they often require internal measurements of the organization's capabilities. Strategic indicators are described as “strategic indicators or a priori indicators, which reflect the strategy deployed by the leaders”.
- **Operational indicators:** they are related to the organization's functioning itself. They generally have a relatively short periodicity and must be regularly monitored to make appropriate corrections on the ground.

Result indicators are distinguished from the Process indicators:

- **The result indicator:** evaluates the degree of achievement of an overall objective at its horizon. Result indicators, or a posteriori indicator, measure the performance of the company.
- **Process indicators:** mark the action plan by defining local objectives whose horizon is prior to that of the overall objective.

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<sup>1</sup>HAMADMAD (H): *op.cit*, p.31.

## 5. How to choose the right Performance Measures

Each company will have different priorities, a different customer base and a different method of operation. In order to choose the most appropriate measure you need to undertake the following:<sup>1</sup>

- Understand your business and its strategy.
- Decide on the objectives.
- Understand which KPIs are likely to assist in meeting the objectives.
- Align the KPIs to others within the company.
- Ensure that everyone works towards achieving the targets: nominate KPI owners.
- If targets aren't achieved, analyze the reasons why and introduce processes to enable achievement.
- If the target isn't realistic, replace it.

The measures you choose need to be **SMART**. That is, they need to be:

- **Specific.** Objectives should specify what they want to achieve. Are they clear and unambiguous?
- **Measurable.** Can we put a value on the KPI? e.g., How much, how long, how many?
- **Achievable.** Are the targets you set achievable and attainable?
- **Relevant.** Are the measures relevant to the overall goal and strategy of the company?
- **Timely.** Are the timescales realistic and how often do you measure?

You need to ensure that the data collected is accurate.

Moseley (2004) and Vitasek (2004) suggest that when introducing key performance indicators, you should:

- Use terminology that your staff understand and is meaningful to them.
- Understand what your staff need to do to improve service or reduce costs as identified by the KPIs.
- Try to use common industry KPIs so that you can benchmark your own operation against your peers.
- Review the data regularly and look for specific trends.
- Not overreact to a particular data point.
- Only introduce measures you know you can implement and measure.

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<sup>1</sup>GWYNNE (R): *Warehouse Management*, 2nd edition, Kogan page, 2014, pages 299 to 301.

- Only introduce cost-effective metrics, i.e., ensure that it doesn't cost you more to manage than the likely savings you make.
- Only introduce measures you know you can change.
- Not measure what you won't or can't change.
- Be seen to be using the data, there is nothing more frustrating than collecting data which isn't used.

## **6. Common Performance Measurement Models**

### **6.1. The Balanced Scorecard**

The Balanced Scorecard (BSC) model was developed in the early 1990's by Robert Kaplan and David Norton. It is a tool used for describing, elaborating, and implementing a vision and the strategy of a firm into fixed targets and clear set of financial and nonfinancial performance indicators.

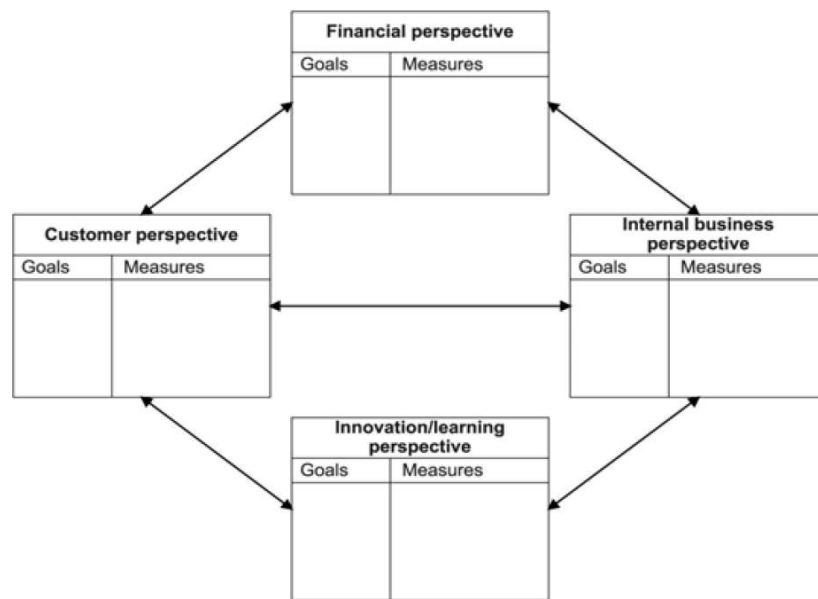
The introduction of BSC means that the goals, the indicators, and the strategic actions are assigned to concrete perspectives (Horvath et al., 2004). The Balanced Scorecard translates the mission and the organization strategy into a set of performance indicators that offers a model for the performance measurement system. The four perspectives of the BSC are:<sup>1</sup>

- 1. Financial Perspective** (How do we look at shareholders?): Controlling financial resources is very important for the success of the firm. Most of the organizations focus on financial results and ignore the other perspectives.
- 2. Customer Perspective** (How do customers see us?): Knowing what customers want in terms of quality, costs and distribution, and the most important thing, what they want in the future from the organization.
- 3. Internal Processes Perspective** (What must we excel at?): Understanding how internal processes work is very essential for the organization to achieve its goals and to know how to add the expected value to the products or services that the customers purchase.
- 4. Innovation and Learning Perspective** (Can we continue to improve and create value?): All the achievements from the customer, internal processes, and financial perspective are strictly linked to the organizational capabilities to train and develop its human resources and innovation system.

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<sup>1</sup>TAOUAB (O) and ISSOR (Z): *Firm Performance: Definition and Measurement Models*, European Scientific Journal January 2019 edition Vol.15, No.1, p.99.100.

**Figure n°2.2: The Balanced Scorecard Model**



**Source:** TAOUAB (O) and ISSOR (Z): *Firm Performance: Definition and Measurement Models*, European Scientific Journal January 2019 edition Vol.15, No.1, p.99.

The figure n°2.2 illustrates the BSC model, it provides a comprehensive framework for measuring and managing organizational performance. The BSC encompasses four perspectives: financial, customer, internal processes, and learning and innovation. These perspectives are interconnected, with objectives and measures designed to align with the organization's overall strategy. The BSC model allows organizations to track their progress and make informed decisions to improve performance in all areas.

### 6.2. The Performance Pyramid

The Performance Pyramid, also known as The Strategic Measurement and Analysis Technique (SMART), was developed by Lynch and Cross in 1992, The purpose of the performance pyramid is to link an organization's strategy with its operations by translating objectives from the top down (based on customer priorities) and measures from the bottom up. This PMS includes four levels of objectives that address the organization's external effectiveness (left side of the pyramid) and its internal efficiency (right side of the pyramid).<sup>1</sup>

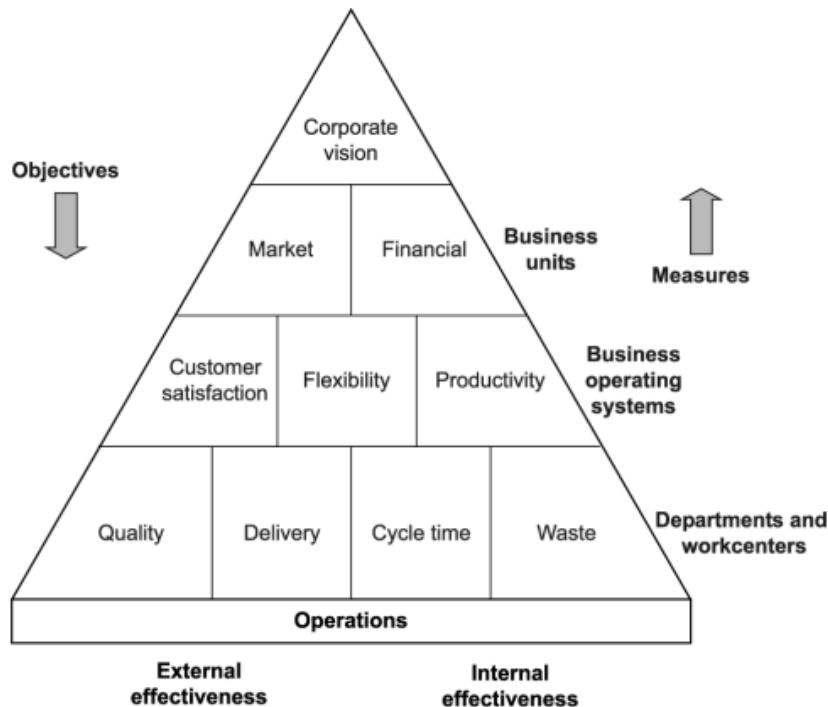
- 1. At the first level,** the development of a company's performance pyramid starts with defining an overall corporate vision, which is then translated into individual business unit objectives.

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<sup>1</sup>TANGEN (S): *Performance measurement: from philosophy to practice*, Int J of Productivity and Performance Management, Vol. 53 Issue 8, 2004, pp.731.732.

2. **At the second level**, short-term goals of cash flow and profitability are set as well as long-term targets of growth and market position.
3. **The third level** includes day-to-day operational measures (customer satisfaction, flexibility and productivity).
4. **The fourth level** includes four key performance measures (quality, delivery, cycle time and waste).

**Figure n°2.3: The Performance Pyramid**



**Source:** TANGEN (S): *Performance measurement: from philosophy to practice*, Int J of Productivity and Performance Management, Vol. 53 Issue 8, 2004, p.733.

The figure n°2.3 illustrates a diagrammatical representation of the SMART technique (Performance Pyramid).

### 6.3. The Performance Prism

The Performance Prism (Neely et al., 2002) was developed at Cranfield School of Management, United Kingdom. Prism advocates that a PMS should be organized around five distinct but linked perspectives of performance:<sup>1</sup>

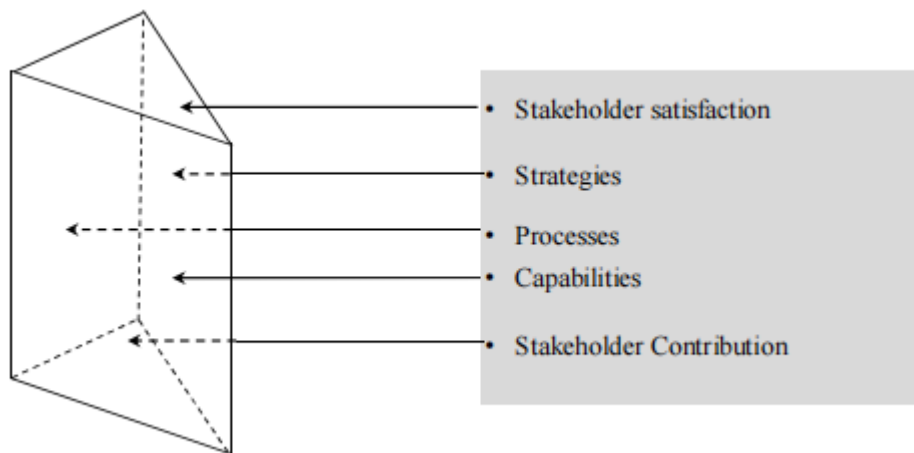
1. **Stakeholder satisfaction:** Who are the stakeholders and what do they want and need?
2. **Strategies:** What are strategies we require to ensure the wants and needs of our stakeholders?

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<sup>1</sup>LIAQAT (A): *Value-Risk based Performance Evaluation Of Industrial Systems*, Thèse de Doctorat en Génie Mécanique et Industriel, L'École Nationale Supérieure d'Arts et Métiers, 2012, pp.95.96.

3. **Processes:** What are the processes we have to put in place in order to allow our strategies to be delivered?
4. **Capabilities:** What are the capabilities we require to operate our processes?
5. **Stakeholder contribution:** What do we want and need from stakeholders to maintain and develop these capabilities?

**Figure n°2.4: The Performance Prism.**



**Source:** LIAQAT (A): *Value-Risk based Performance Evaluation of Industrial Systems*, Thèse de Doctorat en Génie Mécanique et Industriel, L'École Nationale Supérieure d'Arts et Métiers, 2012, pp.95.

The figure n°2.4 illustrates the Prism performance measurement framework. The Performance Prism authors emphasize that performance measures should not only be based on strategies, but also on the wants and needs of stakeholders, because strategy is not the aim to be reached but a tool to help managers achieve the objectives. Organizations should first identify stakeholders, their needs and expectations, and then create strategies to satisfy them. Processes and capabilities are evaluated based on these strategies, and stakeholder contribution is considered in the end.

### **Third section: Logistics and Warehouse Performance**

Logistics and warehouse performance is just as crucial as in other industries. To maintain a high level of performance in these areas, a reliable system must be established. The following section offers an overview of logistics and warehouse performance, including key performance indicators (KPIs) and systems utilized for measuring performance in these fields.

#### **1. Logistics Performance**

The contribution of logistics to the overall performance of organizations is undeniable in today's economic and social context marked by fierce competition.

Logistics performance can be defined as “The contribution of the logistic activities to the turnover and profitability of the companies, to the satisfaction of the customer, as well as to the motivation of the employees, thus, it is the capacity of the logisticians to answer and to anticipate customers’ expectations and to the creation of value for the company”.<sup>1</sup>

Logistics performance is about ensuring customer satisfaction by delivering the right products, in the right quantity, at the right time, to the right place, using fewer resources. This means controlling the operational functions established between suppliers and distributors: production, routing, warehousing, packaging and delivery to the point of sale.

Logistics performance is a measure of the relationship between the service provided to the customer and the resources consumed. Efficient logistics ensures customer satisfaction while consuming fewer resources.<sup>2</sup>

##### **1.1. Logistic KPIs**

In practice, an effective measurement system will cover all of the major operational areas within a business. some KPIs examples are as follows:<sup>3</sup>

- **Return on Investment (ROI):** it assesses the return on investment in logistics operations, considering the net profit generated and the total investment made.

**Formula:**  $(\text{Net Profit} / \text{Total Investment}) \times 100$ .

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<sup>1</sup><http://www.acharkaoui.com/la-performance-logistique-dans-les-pme-marocaines/> (consulted on 05/08/2023 at 10h25)

<sup>2</sup><http://mushimiyimana-logistique.over-blog.com/article-notions-de-la-performance-logistique-> (consulted on 5/09/2023 at 11h25)

<sup>3</sup><https://www.zoho.com/inventory/guides/warehouse-kpis> (consulted on 4/06/2023 at 10h25)

- **Transportation Cost per Unit:** this KPI calculates the average cost incurred for transporting a unit of product from one location to another.

**Formula:** Total transportation cost / Total number of units transported.

- **Inventory accuracy rate:** measures the reliability and precision of inventory records in comparison to the actual physical inventory present. The higher this KPI gets mean the inventory records are accurate.

**Formula:** (Inventory as tracked by system / Physically recorded inventory) x 100.

- **Order fulfillment accuracy rate:** This KPI calculates the number of orders that have been successfully fulfilled from start to finish, out of the total number of customer orders received. This includes orders that have been correctly delivered, on time and consisting of the right products.

**Formula:** (Orders completed without issues / Total orders received) x 100.

- **Carrying cost of inventory:** is the total amount of money a business spends on owning, storing and holding inventory. It represents how long a business can continue storing its inventory before starting to lose money and need to find a new solution for slow-moving inventory and dead stock.

**Formula:** (Total carrying costs / Overall inventory costs).

## **1.2. Logistics Performance Measurement Models**

There are several approaches to performance measurement, and in the following we present the most commonly used approaches.

### **1.2.1. The Supply Chain Operations Reference model (SCOR)**

The SCOR model was developed in 1996 by the Supply Chain Council (SCC), which is an association of supply chain practitioners. The SCOR model is a standardized methodology for describing and evaluating the processes within a supply chain.<sup>1</sup>

Four management processes form the core of SCOR:<sup>2</sup>

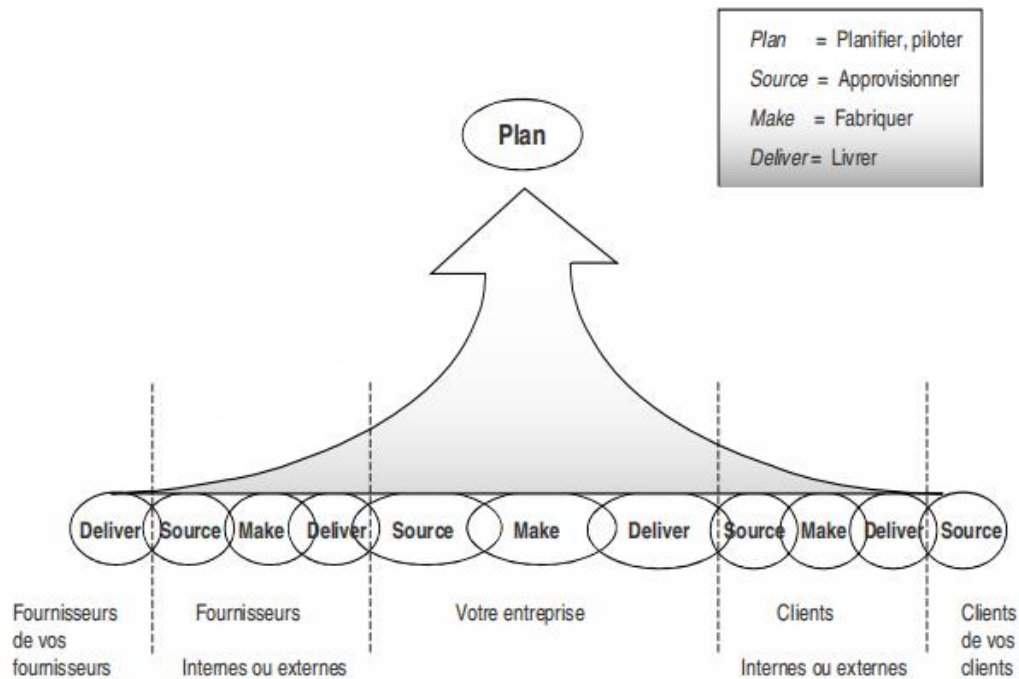
- **Plan:** to plan or pilot as the case may be (different time scale).
- **Source:** supply from an internal or external supplier.
- **Make:** manufacture, assemble, produce.
- **Deliver:** supply, reverse operation of Source.

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<sup>1</sup>ESTAMP (D): *Supply Chain Performance and Evaluation Models*, ISTE Ltd, 2014, p.66.

<sup>2</sup>PIMOR (Y) and FENDER (M) : *Logistique : production, distribution, soutien*, 5<sup>ème</sup> édition DUNOD, 2008, p.705.

**Figure n°2.5 : SCOR model core processes**



**Source:** PIMOR (Y) and FENDER (M) : *Logistique : production, distribution, soutien*, 5<sup>ème</sup> édition, DUNOD, 2008, p.705.

The SCOR model describes the operation of the supply chain in four levels:<sup>1</sup>

- **The first level** distinguishes between five generic processes: plan, source, make, deliver and return.
- **The second level** defines categories of processes that reflect the strategy put in place by the company for its operations, as well as for direct or indirect distribution, make to order or to stock.
- **The third level** details each process category identified at the second level, with their inputs and outputs.
- **The fourth level** describes the procedures specific to each company.

The model applies to all companies, in manufacturing or the service industries and it evaluates four fields: reliability of commercial performance, flexibility/responsiveness, supply chain cost and capital turn. It allows those using it to obtain a common and standardized language for use between the different actors in the chain, because the basic concepts are defined (processes, typology of processes and modes of management).

<sup>1</sup>ESTAMP (D) : **op.cit**, pages 66 to 68.

### **1.2.2. World Class Logistics model**

The WCL model was developed by Michigan State University during the 1990s. It evaluates company performance on the basis of its ability to take stock of inter organizational relationships.<sup>1</sup>

This model evaluates supply chain management performance using 68 questions. Analysis of the answers to these questions shows the level of integration of the actors in the chain and evaluates mastery of the concepts that characterize the supply chain. Following this, the results are consolidated between the companies studied within the same chain.

This model makes it possible to:

- Analyze several types of companies on the same supply chain (from the supplier's supplier to the end customer).
- Compare the practices of several actors on the same chain.
- Classify the performance of actors in terms of homogenous performance “types”.

The WCL model evaluates the integration level for the actors and their degree of mastery of the supply chain concepts. It makes external benchmarking possible.

## **2. Warehouse Performance**

Warehouse performance measurement refers to the process of evaluating the efficiency and effectiveness of warehouse operations as it involves using various metrics to assess the performance of different areas of the warehouse.

Performance measurement and metrics have also been considered to be a complex matter, and operating the measurements is often inadequately understood followed by weakly formulated definitions of what will be measured. However, when it comes to the control of a warehouse, metrics make it possible for the workforce to better evaluate and govern their area of responsibility (Melnik et.al, 2004) and thereby solve problems before it's too late.<sup>2</sup>

Warehouse performance metrics have three objectives:<sup>3</sup>

First, they enable management to establish clear and quantitative performance standards for the warehouse, be used as a benchmark guiding daily activity execution and continuous improvement.

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<sup>1</sup>ESTAMP (D): **op.cit**, pp.58.60

<sup>2</sup>AXELSSON (P) and FRANKEL (J): **op.cit**, p.40.

<sup>3</sup>ROSS (D): *Distribution Planning and Control*, 3<sup>rd</sup> edition, Springer, 2015, p.636.

Second, they enable managers to chart how effectively warehouse activities are being performed to standard. Because the rest of the organization depends on the warehouse to execute its functions and match published standards, performance measures demonstrate the degree to which the warehouse is responding to enterprise operational needs.

Third, they assist managers and associates in pinpointing problems that inhibit productivity so that constructive steps are taken to eliminate the problem from reoccurring. Finally, performance measurements provide companies with a means to plan and control the significant variances experienced in warehouse operations.

There are a number of reasons why we need to measure performance and productivity within the warehouse. We measure because we need to:<sup>1</sup>

- Ensure customer satisfaction.
- Ensure that there is a culture of continuous improvement within the operation.
- Train staff in the right areas.
- Reward staff where appropriate.

### **2.1. Warehouse Measurement Areas**

According to Ackerman (2003), we should be measuring four areas within the warehouse: reliability, flexibility, cost and asset utilization:<sup>2</sup>

**Reliability** includes on-time delivery, fill rates and accuracy. Order cycle time is probably the best measure of **flexibility** as it covers all aspects of the customer order process: how we handle the order initially, whether we have the stock available, how quickly we can process the order through the warehouse and, finally, how quickly we can deliver to the customer.

**Asset utilization** will include efficient use of warehouse space, staff and storage equipment. Warehouse utilization is normally measured in the amount of floor space utilized. However, it is more realistic to measure the cubic utilization of the building. Other companies will look at the number of pallet locations utilized against the total number of locations available.

Frazelle (2002) suggests that as occupancy rates exceed 86 per cent utilization, productivity and safety decline exponentially with each percentage point increase in occupancy. He goes on to say that warehouses managed in real time might be able to operate at 90 per cent occupancy, although this is wholly dependent on the accuracy of the system and the

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<sup>1</sup>GWYNNE (R): **op.cit**, p.294.

<sup>2</sup>GWYNNE (R): **op.cit**, pages.295 to 299.

experience of the warehouse team. For example, third-party logistics companies aim to maximize space utilization as this is a revenue stream for them, but this can lead to reduced productivity. Proper coordination of pallets in and out is crucial to avoid bottlenecks.

**Cost** measurements include cost as a percentage of sales and productivity against labor hours. One of the main things to understand is that in terms of performance measures, you need to:

- Monitor performance against the criteria that are important to your customers (delivery of the perfect order).
- Monitor performance against the criteria that are important to you (costs).

The best measures therefore are those that are aligned to and governed by customer expectations. However, they also need to be aligned to your company's resources. According to Rushton, Croucher and Baker (2010), there is a need to balance the level of customer service with the cost of providing that service. They go on to say that the cost of providing a given service is markedly higher the nearer it reaches the 'perfect service', that is, 100 per cent.

**Productivity** is part of the overall performance umbrella: productivity output such as goods and services produced in relation to inputs that include labor, finance, material and other resources.

Warehouse managers have a number of inputs and resources under their control including labor and MHE. The key to running an efficient warehouse is to make best use of these inputs. The essence of productivity measurement is the recording and analysis of the time it takes to perform each handling movement within the warehouse.

For a third-party operator, they need to know how long it takes them to undertake the different tasks associated with the warehouse in order to quote and charge their customers accordingly.

The cooperation of the staff is important, as they need to know how the measures are derived and why they are important. They must be made aware of the reasons behind the measurements, what the information will be used for and that they will also become beneficiaries of an improved operation, the measures can be individual or taken on a group basis.

## **2.2. Warehouse KPIs**

Warehouse measures are divided into two forms of indicators, quantitative measures and qualitative indicators.<sup>1</sup>

On the quantitative side, every warehouse manager has control over three prime elements of warehousing: space, equipment, and people. Simple ratios can be used to compare the actual versus maximum utilization of warehouse space and materials handling equipment. The quantitative output of people who work both in the warehouse and in the warehouse office can be compared to established benchmarks.

Quality measures may be just as important as the quantitative items. First on the list is customer satisfaction-how well has management met the expectations of the customers? Another qualitative measure is human relations. How successful is management in recruiting and maintaining a harmonious workforce? Overages, shortages, damage, and errors are referred to as "claims." They are a barometer of management's success in preserving the inventory. Safety is another measure of quality in warehousing.

Frazelle model classify warehouse performance indicators into five indicators that are used to evaluate the main activities in the warehouse. These indicators are productivity, utilization, quality, cycle time and financial indicators.<sup>2</sup>

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<sup>1</sup>ACKERMAN (B): *Practical Handbook of Warehousing*, 4<sup>th</sup> edition, Springer, 1997, pp.91.92.

<sup>2</sup>BLOMQUIST (T): *A warehouse design framework for order processing and materials handling improvement*, Master thesis in Logistics, Aalto University, 2010, pp.44.45.

**Table n°2.2: Warehouse Key Performance Indicators**

	Financial	Productivity	Utilization	Quality	Cycle Time
<b>Receiving</b>	Receiving cost per line	Receipts per man-hour %	Dock door utilization	% Receipts processed accurately	Receipt processing time per receipts
<b>Putaway</b>	Putaway cost per line	Putaways per man-hour	% Utilization of putaway labor and equipment	% Perfect putaways	Putaways cycle time (per putaway)
<b>Storage</b>	Storage space cost per item	Inventory per square foot	% Locations and cube occupied	% Locations without inventory discrepancies	Inventory days on hand
<b>Order picking</b>	Picking cost per order line	Order lines picked per man-hour	% Utilization of picking labor and equipment	% Perfect picking lines	Order picking cycle time (per order)
<b>Shipping</b>	Shipping cost per customer order	Orders prepared for shipment per man-hour	% Utilization of shipping docks	% Perfect shipments	Warehouse order cycle time
<b>Total</b>	Total cost per order, line, and item	Total lines shipped per total man-hour	% Utilization of total throughput and storage capacity	% Perfect warehouse orders	Total warehouse cycle time = DTS + WOCT

**Source:** BLOMQVIST (T): A warehouse design framework for order processing and materials handling improvement, Master thesis in Logistics, Aalto University, 2010, p.44.

Table 2.2 represents a summary of warehouse KPIs with respect to the various warehousing functions.

The financial perspective of performance measurement in warehousing usually focuses on cost-accounting, as it can be difficult to justify the profitability of warehousing. Creating an activity-based costing program for the warehouse is a common approach. Warehouses face competition from third-party logistics providers, so these measures can be used to compare proposals. If a company's warehousing costs are higher than a third-party provider's, they should consider outsourcing their warehousing operations.

The productivity of a warehouse is measured by comparing the output to the input, usually by measuring the processing rate. The handling units can vary, and productivity can be measured in line items or cases processed per hour for small item operations or in actual pallets for pallet-oriented operations. However, productivity can be misleading, as it may lead to overly high investments in warehousing technology to achieve high measures.

The cycle time of a warehouse is a key indicator of its service capability. Shorter order cycle times can lead to a reduction in supply chain response time. There are two types of cycle time that can be tracked: the Dock-to-Stock Time (DTS), which measures the time from receipt to readiness for picking or shipping, and the Warehouse Order Cycle Time (WOCT), which measures the time from order release to picking, packing, and readiness for shipping.

Finally, different performance measures may be needed for the effective operation and monitoring of supplementary warehousing services. In general these kinds of performance indicators depend on the type of activities that are included in the warehousing process.

### **2.3. Benchmarking**

Benchmarking is defined as “The continuous process of measuring our products, services and business practices against the toughest competitors and those companies recognized as industry leaders.”<sup>1</sup>

Benchmarking is the process of gathering and sharing assessments of performance of some aspect of an organization, and may include developing an improvement plan of action based on the assessment. The process of benchmarking was popularized by the Xerox Corporation in the 1980s (Camp (1989)), and has become a key component of total quality management. In fact, there now exists an International Benchmarking Clearinghouse supported by over 100 major corporations.

Within warehousing and distribution, benchmarking has traditionally been focused on comparing quantitative performance measures, such as:<sup>2</sup>

- Operating cost: typically measured as warehousing and/or distribution cost as percent of sales.
- Operating productivity: typically measured in “units” (lines, orders, cases, pieces, pallets, pounds, etc.) Handled per person-hour.
- Response time and shipping accuracy.

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<sup>1</sup>RUSHTON (A), CROUCHER (P) and BAKER (P): **op.cit**, p.529.

<sup>2</sup>HACKMAN (S) et al: **Benchmarking Warehousing and Distribution Operations: An Input-Output Approach**, Journal of Productivity Analysis, 16, 79–100, 2001, p.80.

Benchmarking enables us to:<sup>1</sup>

- Understand our own performance.
- Identify any shortcomings.
- Discover what others are doing better.
- Identify performance targets that can be demonstrated to be achievable.
- Accelerate and manage change.
- Improve processes.
- Understand what is best practice.

A word of caution. Benchmarking may point to best current practice but not to best possible practice. 'As good as' is not 'better than'. It is not a substitute for creativity and innovation.

The Xerox approach to benchmarking is as follows:<sup>2</sup>

**Planning:**

1. Identify what is to be benchmarked.
2. Identify comparative companies.
3. Determine the data collection method and collect data.

**Analysis:**

4. Determine current performance 'gap'.
5. Project future performance levels.

**Integration:**

6. Communicate benchmark findings and gain acceptance.
7. Establish functional goals.

**Action:**

8. Develop action plans.
9. Implement specific actions and monitor progress.
10. Recalculate benchmarks.

**Maturity:**

11. Leadership position attained.
12. Practices fully integrated into processes.

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<sup>1</sup>GWYNNE (R): **op.cit**, p.309.

<sup>2</sup>RUSHTON (A), CROUCHER (P) and BAKER (P): **op.cit**, pp.530.531.

Benchmarking is a valuable tool for improving warehouse operations and ensuring the success of logistics and supply chain businesses. By measuring key performance indicators and comparing them with industry standards or best-performing peers, warehouse managers can identify areas for improvement and develop strategies to enhance their operations. As a result, benchmarking in warehousing leads to increased efficiency, better customer service, and ultimately, a more competitive and successful business.

### **Conclusion of the Chapter**

From this chapter, we can understand how performance management and measurement are considered to be a vital tool for companies, as well as establishing a systemic approach for measuring performance can eventually ensure growth of the entity as a whole.

This chapter has a particular emphasize on the importance of measuring and managing both logistics and warehouse performance in modern business management, using interdependent indicators and systems that reflect the impact of various actions carried out throughout the activity at different strategic, tactical, and operational levels. Logistics and warehouse performance directly impact a company's revenues, customer satisfaction, and overall competitiveness. As a result, organizations must prioritize the development and implementation of those systems to remain competitive in today's business environment.

## **Chapter 03:**

# **The Impact of Warehouse Automation on Logistics Efficiency of NAFTAAL**

## **Chapter introduction**

The energy sector of Algeria is occupied by NAFTAL, the state-owned company has the capacity to cover the national demand in terms of petroleum products, yet the growing nature of the Algerian economy requires from NAFTAL to stay competent and consistently develop its resources and strategies.

This chapter is divided into three sections. The first one is a general representation of NAFTAL including its branches, missions and objectives and resources. The second section is a presentation of the research methodology and the tools used to collect and analyze data. The third section consists of the results analysis as well as suggestion and recommendations.

### **First section: General presentation of NAFTAL**

In this section we will present NAFTAL's general organization, the commercialization branch and the distribution center of Blida

#### **1. History of NAFTAL**

NAFTAL is a joint stock company (SPA) with a capital of 160 000 000 000 .00 DA. Founded in 1982 and 100% subsidiary of the SONATRACH Group, it is attached to the marketing activity. Its main mission is the distribution and marketing of petroleum products and its derivatives on the national market.

Resulting from SONATRACH, the ERDP company (Company of Refining and Distribution of Petroleum Products) was created by the decree N° 80/101 of April 06, 1981.

It started its activity on January 1st, 1982. The ERDP company is responsible for the refining industry and the distribution of petroleum products including: fuel, lubricants, tires, liquefied petroleum gas (LPG) and bitumen.

In August 1987, the refining activity was separated from the distribution activity and the ERDP was divided to:

- **NAFTEC:** is a company in charge of oil refining, its mission is to organize, manage, promote and develop the refining industry.
- **NAFTAL:** is responsible for the marketing and distribution of petroleum products, its mission is to organize and manage the distribution network.

The name NAFTAL comes from:


- **NAFT:** Oil in Arabic.
- **AL:** Beginning of the name Algeria.

NAFTAL is now solely responsible for the marketing and distribution of petroleum products and derivatives. In 1998, it changed its status and became a joint stock company 100% subsidiary of the SVH holding company with a share capital of 6 650 000 000 DA.

On December 21, 1999, the creation of STPE, a company in charge of transporting energy products by rail, in partnership with SNTF.

In 2002, the increase of the social capital from 6.65 billion DA to 15.65 billion DA in accordance with the resolution of the AGEX.

**Table n°3.1: NAFTAL information table**

<b>Logo</b>	
<b>Legal and economic form</b>	<b>Distribution and marketing company</b> <b>A joint stock company</b>
<b>CEO</b>	<b>Mr. Abdelkader CHAFI</b>
<b>Capital</b>	<b>160 000 000 000 .00 DA.</b>
<b>Headquarter</b>	<b>BP 73, Route des Dunes, Cheraga, Alger</b>
<b>Phone</b>	<b>+213 21 38 33 70</b>
<b>Fax</b>	<b>+213 21 38 19 19</b>
<b>Website</b>	<b><a href="https://www.NAFTAL.dz/fr/">https://www.NAFTAL.dz/fr/</a></b>

**Source:** <https://www.NAFTAL.dz/fr/> (consulted on 5/16/2023 at 20h11)

In 2020, NAFTAL marketed a total volume of 14.3 million tons of petroleum products, broken down as follows:

**Table n°3.2: Sales of NAFTAL in 2020**

<b>Product</b>	<b>Realization 2020</b>
<b>Land fuels (millions metric ton)</b>	11.3
<b>Aviation fuels (millions metric ton)</b>	0.29
<b>Marine fuels (millions metric ton)</b>	0.27
<b>Liquefied Petroleum Gas LGP (millions metric ton)</b>	2
<b>Bitumen (millions metric ton)</b>	0.39
<b>Lubricants (thousands metric ton)</b>	65.58
<b>Specialty products (thousands metric ton)</b>	15.43
<b>Tires (thousands unites)</b>	50.81

**Source:** <https://www.NAFTAL.dz/fr/> (consulted on 5/16/2023 at 21h35)

For the revenues, in the year 2020, the company's activities generated sales of 317.66 billion dinars, down 16% on those achieved in 2019 (376.1 billion dinars).

## **2. NAFTAL's organization**

The organizational scheme of NAFTAL is based on the three following structures:

- The General Management
- The Functional Structures
- The Operational Structures

### **2.1. The General Management**

The General Management of the company is directed by the Chairman of the Board of Directors. The Chairman is assisted by advisors and project managers and two permanent committees (Executive committee and Steering committee).

**The Executive committee** is a body chaired by the Chairman, it is composed of the directors of the branches and major strategic development of the company, particularly in terms of management, partnership, investment, financial engineering and security.

**The Steering committee** is a body chaired by the Chairman, it is composed of divisional directors, executive directors, central directors, the director of general administration and a representative of the social partner. This committee assists the Chairman in the management and control of the company's activities.

The General Management is responsible for policy and general guidelines, coordination and overall consistency, steering and management.

### **2.2. The Functional Structures**

The Functional Structures are responsible for ensuring a directive, technical or administrative through coordination ensuring each of them a task of organizational operation of the branch, the company's functional structures are composed of four Executive Departments, nine Central Departments and two Support Departments.

#### **2.2.1. The Executive Departments**

- a) **Strategy/Planning & Economics Executive Department:** It is in charge of setting up and keeping up to date a database of statistical, technical and economic data relating to all the company's activities.
- b) **Executive Department of Finances:** It is in charge of defining, applying and controlling the financial and legal policies of the company.
- c) **Human Resources Executive Department:** It is responsible for developing and monitoring the company's human resources policy.

- d) Executive Department of Engineering & development:** It is responsible for managing engineering projects, promoting innovation and offering technical support.

The Executive Departments have multiple responsibilities, including ensuring strategic management, designing and implementing steering and control tools, assisting operational structures, and ensuring coordination and coherence throughout the organization.

### **2.2.2. The Central Departments**

- a) Central Direction of Information Systems:** It is in charge of constituting a data bank and collecting information related to all the markets by using statistics and computer science.
- b) Health, Safety and Environment Central Department:** It establishes the rules and instructions for industrial safety, particularly in terms of storage and distribution of petroleum products, this structure is also responsible for adapting and defining standards and procedures relating to environmental protection.
- c) Quality management Central Department:** it ensures the implementation of quality standards, compliance, process improvement, and customer satisfaction within the organization.
- d) Central Department of Audit and Management Control:** It is responsible for conducting audits, evaluating internal controls, and monitoring financial and operational performance.
- e) Central Department of Maintenance:** it manages and ensures the effective maintenance of equipment, infrastructure, and facilities.
- f) Central Department of Social and Cultural Affaires:** it organizes and promotes employee well-being, engagement, and a positive work culture through social and cultural activities and initiatives.
- g) Central Department of Communication and Public Relations:** This department is responsible for all the company's external relations.
- h) Central Legal Department:** This department provides legal support, guidance, manage legal risks, and handle legal matters for the organization.
- i) Central Department of Internal Security:** it ensures the protection of assets, personnel, and information through the implementation and maintenance of security measures and protocols.

### **2.2.3. The Support Departments**

- a) **General Administration Department:** It is responsible for providing the services necessary for the proper functioning of the company's headquarters and for managing the human and material resources of the headquarters unit.
- b) **Markets Department:** it strategizes and executes marketing initiatives to attract customers, drive sales, and achieve business objectives based on market analysis and customer insights.

### **2.3. The Operational Structures**

The company's operational structures are divided into three branches, each of which operates its activities in alignment with the company's general policy, within the limits of its corporate objective.

#### **2.3.1. Fuel branch**

The Fuel Branch takes charge of defining the strategic direction for the organization, conducting studies and developing programs to enhance the storage and pipeline transport infrastructures, the Fuel Branch ensures the efficient and reliable distribution of fuel and meeting the growing demands of the market.

#### **2.3.2. Liquefied Petroleum Gas (LPG) Branch:**

The Liquefied Petroleum Gas Branch is in charge of the elaboration and follow-up of the national programs of storage, conditioning, maintenance and bottling, the sale and distribution of butane, propane, LPG/fuel products...

#### **2.3.3. Commercialization Branch**

The commercialization branch is responsible for defining, monitoring and controlling the supply and marketing policy for petroleum products (Lubricants, Tires, Bitumen and other special products) throughout the national territory.

### **3. Objectives and missions of NAFTAL**

#### **3.1. Objectives**

- Strengthen the core activities which are: distribution and marketing of fuel and LPG.
- Reposition activities to adapt to the market and face competition.
- Enhance coordination of upstream and downstream activities of the chain, leading to costs optimization and thus the costs of distribution.
- Improve market understanding and responsiveness to market evolution.

### **3.2. Missions**

- Bottling of LPG, storage, distribution, transportation, and commercialization of petroleum products.
- Organize and develop the consumption and distribution of petroleum products.
- Store, transport, and/or arrange transportation for all marketed petroleum products within the national territory.
- Ensure compliance with industrial safety measures and environmental protection, collaborating with relevant organizations (e.g., used oils).
- Conduct market studies on the usage and consumption of petroleum products.
- Define and implement a policy for auditing, design integrated information systems.
- Develop and implement actions for optimal and rational utilization of infrastructure.
- Ensure compliance with internal security measures according to regulations.

## **4. Resources of NAFTAL**

NAFTAL carries out its missions through the mobilization and implementation of important means of storage, transportation, maintenance and distribution network spread throughout the national territory.

### **4.1. Human Resources:**

It consists of 30 231 employees, divided to: 24 002 permanent staff and 6 229 temporary employees. Permanent staff distributed as follows:

- 24% are executives.
- 34% are supervisors.
- 40% are operational staff.

### **4.2. Material Resources:**

- 1 072 road tractors.
- 1 078 tanker semi-trailers.
- 56 bitumen semi-trailers.
- 20 refueling trailers.
- 196 flatbed semi-trailers.
- 9 flatbed trailers.
- 455 tanker trucks.
- 4 refueling trucks.

### **4.3. Operational infrastructure**

- 41 land-based fuel depots.
- 41 LPG centers and mini-centers.

- 10 LPG bulk centers.
- 48 relay depots.
- 30 aviation depots.
- 06 marine centers.
- 15 bitumen centers.
- 48 lubricants & tires centers.
- A pipeline network of 700 km.
- A fleet of 3 300 units.
- A network of 1013 service stations including 380 directly managed service stations.

### **5. Commercialization Branch**

Resulting from the reorganization of the CLPB Branch (Fuels, Lubricants, Tires & Bitumen), the Commercialization Branch was created by decision No°S.767 DG on 22/12/2003.

The Commercialization Branch was reorganized into two structures:

- The Commercialization Branch, established by decision N°S.767 DG on 04/12/2004, is primarily responsible for the marketing of petroleum and other related products. It provides services across the entire directly managed network.
- The Lubricant, Tire & Bitumen Branch, established by decision N°S.767 DG on 04/12/2004, is primarily involved in the procurement, distribution, and commercialization of lubricant products and specialized products on an international scale.

The commercialization branch is divided into 12 districts on the national territory to ensure efficient and organized distribution for the products, the districts are divided as follows:

- 4 districts in the east of the country: Annaba, Setif, Tebessa and Biskra.
- 4 districts in the center of the country: Medea, Algiers, Tizi-Ouzo and Ghardaia.
- 4 districts in the west of the country: Sidi Bel Abbes, Tlemcen, Saida and Chelf.

The districts are represented by the distribution centers planted in the Wilayas across the country. Together, they build the distribution network which operates to move the products all along the chain.

#### **5.1. Commercialization Branch's organization**

The branch's structure consists of two deputy directors and several departments which ensure fulfilling the mission and operations of the branch, the structure is as follows:

- Deputy lubricants, tires and bitumen activities director.
- Deputy technical/development director.

There are 10 departments that form the branch:

1. Human resources.
2. Finances and accounting.
3. Administration and resources department.
4. Legal department.
5. Research and planning department.
6. Quality, Health, Safety & Environment department.
7. Transportation department.
8. Commercial department.
9. Marketing department.

**10. Distribution department:**

The distribution department is directly linked to the deputy director of activities, because it performs the main activity of the branch which makes a very important department of this entity. The main functions performed by this department are:

- Developing a strategic plan for distributing products to all centers.
- Transporting products, coordinating the logistics activities and tracking shipments.
- Managing inventory on a national level.
- Demand planning and forecasting.
- Managing distribution centers, including: layouts, equipment and innovation.

By performing these functions, the department plays a crucial role in ensuring a smooth flow of products from suppliers to the end customers while optimizing costs and meeting customer demands.

**5.2. Commercialization Branch missions**

This operates to fulfill the following missions:

- Ensure the marketing of bitumen, lubricants, special products, and tires throughout the national territory.
- Ensure the operation, modernization, and development of distribution infrastructure and resources.
- Initiate, study, and implement actions aimed at strengthening its commercial position in the market.
- Undertake studies to optimize distribution flow and minimize distribution costs.
- Establish a centralized management procedure system to control physical and financial flows at all stages of distribution.

- Implement a centralized management information system to monitor and ensure the execution of activities in accordance with established rules and procedures.
- Ensure compliance with applicable regulations in all areas of activity (technical, financial, labor relations, etc.).

## **6. Distribution center of Blida**

The distribution center of Blida was established in 1982 by a decision of the general management of NAFTAL, it is located on the Oran Road, Chiffa, Wilaya of Blida. The center operates to following operations: supply, storing and transporting products, it distributes mainly two products lubricants and tires in their different types and forms. The center supplies the Blida and Tipaza region in the first place, other regions can be covered following the customer demand.

The center aims to distribute the products in sufficient quantities and of high quality, meeting the customers' requirements, it is achieved through the development of a dedicated supply network and enhancing the infrastructure for storage, transportation, and distribution. In addition, the center takes several measures to accomplish its diverse strategic goals, including the renewal and rehabilitation of its storage infrastructure, improving service levels and meeting customer needs, implementing cost control measures, conducting training programs for human resources, renewing transportation and handling equipment, and expanding distribution networks.

### **6.1. The distribution center's organization**

The structure of the center consists of the general administration and three key departments that work together to ensure the smooth functioning of the center.

#### **6.1.1. The general administration**

The entity is managed by the center manager, who oversees the overall operations and strategic direction of the center. The manager is directly assisted by a senior assistant, chief inspector of security, IT responsible and general secretary.

#### **6.1.2. Sales department**

The sales department plays a crucial role in driving revenue and building customer relationships, it is responsible of prospecting for new clients and marketing for the products and creating bills for selling operations.

#### **6.1.3. Operations department**

The operations department handles the day-to-day activities, managing inventory, managing products movement (unloading, loading, storing, transporting), also, the data input of all stock operations happening in the warehouse in order to keep track of the inventory.

**6.1.4. Financial department**

The financial department consists of an accountant and a cashier. The accountant handles financial tasks, prepares statements, and ensures compliance with regulations. The cashier manages daily transactions, handles cash receipts, and maintains accurate records. Together, they ensure efficient financial operations.

**6.2. Resources of the center**

The facility has a total area of 66 322 m<sup>2</sup>, with a significant portion dedicated to covered storage spanning 63 350 m<sup>2</sup>. Additionally, there is an open storage area of 2 750 m<sup>2</sup>. The remaining area of 222 m<sup>2</sup> is allocated for various purposes such as administration, a guard post...

The open area is used to store oil barrels and used oil barrels where they are stacked in a pyramid shape. The covered storage area is made of 3 three warehouses, they are divided as follow:

**Table n°3.3: The covered storing capacities**

<b>Warehouse n°</b>	<b>Surface (m<sup>2</sup>)</b>	<b>Stored product</b>
01	12670	Lubricants
02	12670	Tires
03	12670	Tires

**Source:** internal documents of the company

In order to carry out its various activities, the center has a set of transport and handling equipment, summarized in the following table:

**Table n°3.4: Transportation and handling equipment of the center**

<b>Type</b>	<b>Number</b>	<b>Mission</b>
20 tons semi-trailer trucks	3	Supply from the refinery and ports
8 tons trucks	3	Delivery and collecting used oils
6 tons trucks	3	Delivery and collecting used oils
3 tons trucks	4	Delivery
Forklifts trucks	4	Handling products

**Source:** internal documents of the company.

### **6.3. Some products of the distribution center**

The center mainly handles two products which are: tires and lubricants. NAFTAL sells tires from major brands in a wide range of vehicle categories:

- Tourism cars tires
- Truck tires
- Heavy weight vehicles tires
- Industrial machinery tires
- Agriculture wagons tires
- Civil engineering vehicles tires
- Motorcycle tires
- Handling vehicles

NAFTAL sells a complete range of lubricants covering all applications in the automotive and industrial sectors. Meeting international quality standards, the lubricants commercialized by NAFTAL are packaged in a variety of containers, from ½ L cans to 180 Kgs barrels:

- Oils for gasoline engines
- Diesel engine oils
- Automotive transmission oils
- Automotive specialty oils

## **Second section: Research Methodology Presentation**

In this section we will present the objective of this research and the working methodology applied to achieves this objective and answer the general problematic.

### **1. The research objective**

The objective of this research is to understand the impact of implementing warehouse automation technologies on the logistics efficiency of NAFTAL.

In order to realize this research, we need to:

- Collect the needed information to complete the study
- Confirm or reject the proposed hypotheses

### **2. Qualitative study**

In order to reach the research objective and get more comprehensive answers, it is necessary to approach managers, therefore, qualitative study is the most suitable for this research.<sup>1</sup>

Qualitative research is expressed in words. It is used to understand concepts, thoughts or experiences. It involves collecting and analyzing non-numerical data (e.g., text, video, or audio) to understand concepts, opinions, or experiences.

Common qualitative methods include interviews in its different forms, observations described in words, focus groups and others.

### **3. Data collection methods**

Based on the objective set-in and the positions held by the interviewees, the chosen data collection method is semi-structured interviews, with the calculation of some KPIs in order to clearly understand the research.

#### **3.1. Interviews**

Interviews can be defined as a qualitative research technique which involves “conducting intensive individual interviews with a small number of respondents to explore their perspectives on a particular idea, program or situation.

Interviews is a widely used technique, there are three types of interviews, which are:<sup>2</sup>

- **Structured interviews:** the questions are predetermined in a set order, they are often closed-ended, (yes/no) or multiple-choice questions. The types of questions asked make structured interviews a predominantly quantitative tool.

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<sup>1</sup> <https://www.scribbr.com/methodology/qualitative-research/> (consulted on 26/05/2023 at 22h07)

<sup>2</sup> <https://www.scribbr.com/methodology/interviews-research/> (consulted on 26/05/2023 at 22h20)

- **Unstructured interviews:** Unstructured interviews are by definition open-ended, the questions and the order in which they are asked are not set. Instead, the interview can proceed more spontaneously. This flexibility can help collect detailed information, while still allowing to observe patterns between participants.
- **Semi-structured interviews:** Semi-structured interviews are often open-ended, allowing for flexibility, but follow a predetermined thematic framework, giving a sense of order. the interviewer has a general plan for what they want to ask, but he may also ask follow-up questions to clarify the participant's answers.

**3.2. Key Performance Indicators**

Calculating key performance indicators allows for a more comprehensive and balanced analysis of the research topic and complementing the qualitative data obtained from interviews.

Calculating KPIs adds a level of objectivity to the qualitative study. While interviews provide rich qualitative data, KPIs offer a more objective and standardized way to measure and evaluate performance. Therefore, integrating KPIs provides valuable insight, helps define areas for improvement, and provides an overall assessment of the situation.

**3.3. Interviewed population**

Before constructing the interview guide, the population to be interviewed was selected, regarding their position in the company and relevance to this research. To conduct the interviews, we have chosen a population of 3 persons.

The following table shows the managers who were chosen and their position within the company, their names are kept confidential.

**Table n°3.5: Interviewed managers and their positions**

<b>Manager</b>	<b>Position</b>
<b>1</b>	Head of tires distribution department
<b>2</b>	Head of lubricants distribution department
<b>3</b>	Distribution center manager

**Source:** elaborated by us

**3.4. Running the interviews**

In order to run the interviews, the first thing done was constructing the interview guide. The interview guide is divided into 3 parts, it is attached to the appendices section of this research, the questions were made to answer every aspect and to provide the needed information.

The interview guide questions were regrouped under 3 axes, each axis was assigned to a manager, the following table indicates the axes, the managers assigned to, place and time the interviews were run:

**Table n°3.6: Interview guide axes**

<b>Axis</b>	<b>Title</b>	<b>Manager</b>	<b>Place &amp; Time</b>
<b>1</b>	Distribution department functions and performance	Head of tires distribution department	On 15/05/2023 from 10h15am to 10h55am, in his office.
<b>2</b>	The impact of warehouse automation	Head of lubricants distribution department	On 21/05/2023 from 10h00am to 10h35am in his office.
<b>3</b>	The distribution center of Blida, functions and performance.	Distribution center manager	On 21/05/2023 from 2h30pm to 3h00pm, in his office.

**Source:** elaborated by us

**4. Content analysis**

After running the interviews with the managers, we have written down everything that was said, word by word, by the respondents during the interviews. The answers were classified and structured each one under their following axis.

Next step is proceeding to the analysis, using content analysis method, trying to extract answers for the research question.

**Third section: Results analysis of the qualitative research**

In this section, we will present the conducted qualitative research which is the interviews, as well as the findings and results collected. The interviews were conducted with the use of an interview guide (appendix n°1).

**1. Results analysis**

First of all, the answers to the first question of the 3 axes were summarized to a single answer. The answers of questions 02 and 03 of axis 1 and 2 were also consolidated to a single answer.

- **Question 01: Can you introduce NAFTAAL and its specific position in the energy sector?**

NAFTAL, the National Company for Petroleum Products Distribution, it is considered a 100% subsidiary of SONATRACH, it specializes in the distribution and marketing of petroleum products and its derivatives. NAFTAAL imports and distributes gasoline, diesel, LPG, lubricants and tires. It plays a crucial role in ensuring the availability and accessibility of energy resources in all over the country.

- **Question 02: Can you describe the structure of your department?**

The lubricants/tires distribution department is part of the commercialization branch of NAFTAAL, the department is divided into two activities following the products (lubricants and tires), alongside with other departments such as: finance and accounting, legal department and marketing department, lubricants/tires department is responsible on fulfilling the missions of the branch.

- **Question 03: What functions does your department perform?**

The main functions the department performs are: establishing distribution plan, transporting products, managing inventory, supplying centers, demand planning and forecasting working with sales and marketing department. In addition to centers management, which includes: layout, equipment and innovation.

Now we shall present the questions and answers of each axis.

**Axis 1: Distribution department functions and performance**

**4. Question 04: What is your distribution strategy?**

**Answer 04:** *“Our strategy is to distribute the products through our 48 distribution centers throughout the country. First, we receive the imported goods in the 3 poles (ports): Oran, Bejaia and Annaba, the merchandise is transported to primary centers to be redistributed to the 48 distribution centers according to an annual distribution plan (corrected monthly), for products manufactured in Algeria, they are transported directly to the centers according to the distribution plan and their needs. Then, in the centers, the products are available for sale to our customers or to intermediaries.”*

**Analysis 04:** the company’s distribution strategy involves only using its own private distribution centers which are distributed across the country this mean a decentralized approach to reach their customers. The products are distributed according to an annual distribution plan which indicates an efficient process, finally, the company serves both end consumers and business-to-business clients, offering flexibility in their distribution strategy.

**5. Question 05: What are the biggest challenges faced in products distribution?**

**Answer 05:** *“One of the challenges we face in the distribution sector is the lack of transportation means, as the fleet is being used for both lubricants and tires. To cover the shortfall, trucks are rented from service providers, so transport costs will rise. At center level, storage capacity is limited, and some centers don’t have a racking system, so products are stored on the floor, which can damage the goods.”*

**Analysis 05:** The two major challenges faced in distribution are logistics related which are: transportation and storage capacity. The lack of transportation resources requires an optimal fleet management or expanding the fleet in order to avoid renting from third-party providers. The limited storage capacity indicates that the available infrastructure requires an upgrade to handle products flow through the chain.

**6. Question 06: How do you currently address those challenges?**

**Answer 06:** *“To optimize transport costs, suppliers have been asked to send 60% of tire shipments to the port of Annaba and lubricant shipments to the port of Oran. Trucks departing from Annaba to bring the oils from Oran (from the port and the Arzew refinery), on their way from east to west, the trucks deliver the tires imported at the port of Annaba to all*

*the centers in their path, on their way back from Oran the trucks are loaded with lubricants to supply the centers in the east of the country, as we try to maximize the fill rate.*

*For the centers, we've carried out analyses to assess needs and establish development projects, purchase equipment and build warehouses."*

**Analysis 06:** The department has strategically addressed the transportation challenge by directing the majority of tire shipments to Annaba and lubricants shipments to Oran (in addition to Arzew refinery), trucks traveling from Annaba to Oran optimize their journey by delivering tires to centers along their path and returning with lubricants to supply centers in the east of the country, the optimization of the truck's fill rate reduces transportation expenses. On the other hand, limited infrastructure is taken into consideration by investing in development projects.

**7. Question 07: How do you currently evaluate the performance of your department?**

**Answer 07:** *"The fact that the merchandise is sold in large quantities means that this quantity was distributed to the various centers. As long as the merchandise is marketed, I think that distribution must have done what was necessary to move the products."*

**Analysis 07:** The evaluation of department performance primarily relies on sales metrics, this indicates a limited approach to assess the performance. Relying only on sales volume as an indicator of performance may not provide a comprehensive assessment, it should involve a broader set of metrics, including factors such as distribution efficiency and customer satisfaction.

**8. Question 08: What are the key metrics you use to measure the efficiency of the distribution process, and how do you currently track these metrics?**

**Answer 08:** *"The main indicator is the sales revenues, the quantities distributed and even the availability of products in the distribution centers, transportation costs are also taken into consideration. the sales revenues are tracked according to sales reports."*

**Analysis 08:** These answers states that the main indicator is the sales revenues which reflect the financial performance of the distribution process based on sales data (sales reports). Quantities distributed and product availability in centers are important measures of operational efficiency to ensure meeting customer demand. Transportation costs are used to decide whether relying on their own resources only or renting transport services.

**9. Question 09: How do you currently manage shipments?**

**Answer 09:** *“With regard to the inventory that we hold at the primary centers, after the reception we proceed to allocate specific quantities to each center, in collaboration with the Technico-commercial department, and then we establish a replenishment plan for each center.*

*The centers are then responsible for replenishing their supplies from the primary centers. Oils produced at the Arzew refinery are temporarily stored in the distribution center of Oran in order to be distributed throughout the country.”*

**Analysis 09:** The allocation process ensures that each center receives the needed amount of inventory. The responsibility for replenishing supplies allows centers to directly control their inventory and ensure timely replenishment based on their specific needs.

**10. Question 10: How do you ensure that customer orders are fulfilled accurately and in a timely manner?**

**Answer 10:** *“We aim to ensure that customer orders are met by supplying products in the right quantities and at the right time in all our centers. We achieve this by establishing forecasts based on previous sales, which enable us to order the quantities needed according to sales in each center, so that customers are always served.”*

**Analysis 10:** Customer order fulfillment is achieved through the establishment of forecasts based on previous sales data, which enable the department to order the required quantities for each center. The focus here is on aligning inventory levels with customer demand to avoid stockouts thus always serving customers.

**11. Question 11: Can you describe the challenges that arise when managing inventory levels of the products?**

**Answer 11:** *“Even though we make our distribution plans based on forecasts prepared by the sales team and the distribution center managers, it happens that demand can be higher than what we have available in the centers, which causes us to run out of products, so we have to be flexible and quick to react to fill this shortage of products.”*

**Analysis 11:** We can understand that unexpected exceeding in customer demand is always a possibility and it is a common challenge in managing inventory levels, therefore, being flexible and having a quick reaction is crucial to address this challenge and limit its impact.

**Axis 2: The impact of warehouse automation**

**4. Question 04: Can you describe the technology and software systems that your department uses?**

**Answer 04:** *“NAFTAL developed a software called SD-COM, which is implemented across all NAFTAL distribution centers for all products. It manages product stock, stock movements (inputs and outputs), billing, loading/unloading bills, pick-up bills... In collaboration with the technical department, we have developed a web application, which extracts data from the SD-COM and enables us to check the stock level of each center with a 1-hour delay in upload time for all products.*

*We use another software application that enables us to track the fleet by GPS (geolocation), to monitor the evolution of fleet use on a daily basis, this system offering a journal that contains: driving time on the road, parking time, routes, stops. The system uses a USB attached to the vehicle keys, which must be inserted to start the vehicle, and each driver has a USB containing his unique identifier. So, these two systems enable us to manage stocks and the fleet.”*

**Analysis 04:** The department uses a combination of software systems to effectively manage inventory levels and track the fleet, The implementation of SD-COM and the web application provides efficient inventory management, quick access to national level inventory and stock visibility, although the delays should be minimized to ensure real-time visibility. The geolocation system offers a real-time monitoring and more control over the fleet, it should be used to optimize traveling routes. These systems can be used to make data-driven decisions to improve department efficiency.

**5. Question 05: How do you plan to integrate automated systems with your existing infrastructure and software used in the distribution center?**

**Answer 05:** *“Automation should start at center level, because we have a problem with inventory management, since inputs and outputs are entered manually in the SD-COM, which wastes time and might be inaccurate, we therefore aim to integrate barcode scanning system to manage inventory in real time, so that we can set up a proper inventory management system in real time (for example automatically triggering an alert for replenishment in case of low inventory levels, and to apply the FIFO method more precisely).”*

**Analysis 05:** The department aims to integrate an automatic item identification system which is barcode scanning to enable real-time inventory management. Integrating barcode

scanning would be a significant improvement as it increases accuracy and efficiency within the center and it will enable the implementation of an inventory management system for increased control over storage, also avoiding inventory shortages. Barcode scanning can be linked to the SD-COM.

To check if the manual data entry is effective, we will calculate the following KPI:

**Inventory accuracy rate:** measures the reliability and precision of inventory records in comparison to the actual physical inventory present. The higher this KPI gets mean the inventory records are accurate.

**Calculation:**

**Formula:** (Inventory as tracked by system / Physically recorded inventory) x 100

**Table n°3.7: Lubricants and tires inventory records in SD-COM and physical records (31/03/ 2023)**

	<b>SD-COM</b>	<b>Physical records</b>
<b>Lubricants (metric ton)</b>	11 166.4	11 161
<b>Tires (units)</b>	12 703	12 775

**Source:** Internal documents of the company

According to table n°3.7:

**Lubricants:**  $(11\ 166.4/11\ 161) \times 100 = 100.04\%$

**Tires:**  $(12703/12775) \times 100 = 99.43\%$

**Interpretation:** The calculation shows a high accuracy rate, which means the method used is effective, although, it is not 100% accurate as the rates are slightly higher or lower than 100%, which requires to reconsider the manual data entry method.

**6. Question 06: Which areas do you think are the most critical to automate within the distribution center?**

**Answer 06:** *“The most critical areas to automate are the loading/unloading area and within the storage depots in order to handle products using automated equipment, more specifically the tasks related to the operations department within the centers.”*

**Analysis 06:** We can understand that automation is critical in different areas, using automated handling equipment (physical automation) is critical regarding the work intensity in order to enhance productivity, yet the type of equipment must be aligned with goods nature and designed accordingly to handle them.

**7. Question 07: Are there any specific tasks or operations that you think should be given priority for automation?**

**Answer 07:** *“For us, the task of the court manager (in the centers), who is in charge of receiving and checking the merchandise and then manually entering it into the software (SD-COM), should be automated in the first place.”*

**Analysis 07:** It is crucial to automate the manual data entry process performed by the court manager. Automating this task can eliminate potential errors and reduce the time and effort required for data entry.

**8. Question 08: In your opinion, what are the key benefits of implementing warehouse automation in terms of logistics efficiency for the distribution of goods?**

**Answer 08:** *“We can improve center efficiency by knowing inventory levels in real time, improving distribution plans and avoiding stock shortages. In general, it means optimizing center productivity and better managing products.”*

**Analysis 08:** The key benefits of implementing warehouse automation in terms of logistics efficiency, including real-time inventory visibility, improved distribution planning, and avoiding stock shortages. Automation is expected to optimize overall center performance.

**9. Question 09: What do you think are the potential drawbacks or limitations of implementing warehouse automation in your facility?**

**Answer 09:** *“I don't see any drawbacks or limitations. We've already carried out a study about this, and the acquisition costs are insignificant compared to the benefits that we can generate. But sometimes when it comes to implementing these technologies, there are some technical difficulties, such as the connection with the centers might be cut off, which prevents the information from being transferred, for example, the application we use to check the inventory levels might get a 1-day upload delay.”*

**Analysis 09:** The manager believes there are no significant drawbacks or limitations to implementing warehouse automation. However, they acknowledge that technical difficulties, such as connection issues and delayed information transfer, can be potential challenges.

**10. Question 10: How do you think automation can impact the current workforce and their roles within the distribution center?**

**Answer 10:** *“Together with HR, we'll provide training for staff in collaboration with the supplier of the purchased equipment, on how to use it, its functionalities and the importance of integrating these systems. These systems will enable staff to be more efficient, improve performance and minimize errors.”*

**Analysis 10:** Automation will have a positive impact on the current workforce and their roles within the distribution center, the training provided will play a crucial role in ensuring successful integration of the automated systems.

**11. Question 11: How do you plan to measure the success of warehouse automation in improving logistics efficiency for the distribution center?**

**Answer 11:** *“To decide whether the project is a success, we must see that inventory levels are always balanced in all centers, and that our warehouses never run out of products, and even that delays in receiving and shipping products and errors are reduced.”*

**Analysis 11:** The manager highlights several key factors to measure the success of warehouse automation such as balanced inventory levels, eliminating product shortages, reducing delays in receiving and shipping, and minimizing errors. Achieving balance ensure efficient use of resources while avoiding product shortages. By reducing delays this will enable faster order processing, as the error associated with manual data entry can be reduced is also an important factor. The previously mentions factors all serve to increase customer satisfaction and business growth.

**12. Question 12: How do you think automation can impact the customer satisfaction?**

**Answer 12:** *“The customer will always be satisfied as long as the goods are available in the warehouse the time he orders them, so we'll always be able to meet his needs on time.”*

**Analysis 12:** By implementing automation in the distribution center, customer satisfaction can be positively impacted through improved inventory management, which will ensure product availability at the right time, therefore, order fulfillment will be enhanced through warehouse automation technologies.

**Axis 3: The distribution center of Blida, functions and performance**

**2. Question 02: Can you describe your role as the distribution center manager?**

**Answer 02:** *“My role is to monitor inventory in order to avoid shortages, ensure that each product is stored to its specific standards, respect supply schedules, and last but not least, ensure that products arrive at their final destination (delivery).”*

**3. Question 03: What are the primary products that your distribution center handles?**

**Answer 03:** *“The center handles petroleum products such as lubricants, tires, detergents and batteries.”*

**4. Question 04: What are the primary functions of your distribution center?**

**Answer 04:** *“The center's main functions are replenishing, receiving, storing and dispatching goods. Additionally, the center performs commercial tasks such as: customer prospecting, negotiation, customer relation management, etc.”*

**Analysis 04:** The center performs multiple activities, the center's operational activities are crucial for product flow, from source of supply, to storing within the facility and lastly to delivering to customers. The commercial tasks show that the center is not only engaged in operational tasks but also in customer related activities.

**5. Question 05: Can you describe the current layout of your facility and how you utilize space for storage and handling of goods?**

**Answer 05:** *“The center is made up of 3 warehouses: 2 are dedicated to tires, with special racking for tires, the 3<sup>rd</sup> warehouse is used for lubricants in divisional packaging (cans and cartons) and special products, in addition, an open-air storage area (not covered) is used to store oil barrels in a pyramidal arrangement. Products are stored using the FIFO method, according to the date of manufacture and receipt.”*

**Analysis 05:** This description provides details about the physical layout and storage practices used in the distribution center. Tires occupies 2 warehouses because their fragile nature requires a specific racking system where they are stored in single units (1 tire) therefore it is space consuming. Lubricants in divisional package are easy to damage by environmental factors so storing them in a warehouse is essential to be protected. The oil barrels are arranged in a pyramidal arrangement, presumably to maximize space utilization

and ease of access. By using the FIFO method, older products are used or dispatched first which minimizes the risk of product expiration and effective inventory rotation.

**6. Question 06: How do you currently manage orders and shipping to customers?**

**Answer 06:** *“Orders are managed by region, so customers in the same region will be delivered all at once, the aim is not to send the truck empty. The orders are processed through a special document containing all details about the order (client, product, quantity...). If the customer places the order today, it will be delivered tomorrow, delivery time is generally one day if the product is available.”*

**Analysis 06:** The strategy of consolidating orders helps optimizing logistics costs and transportation resources by reducing the number of empty truck trips. The delivery time is generally one day, indicating a focus on quick order fulfillment and customer satisfaction.

**7. Question 07: How do you manage the transportation of goods from suppliers and to customers?**

**Answer 07:** *“To bring the goods back from the supply points, semi-trailer trucks are sent out according to the replenishment plan established by management to pick up the goods. When the goods arrive at the center, the operations manager supervises the unloading and checks the documents attached with the goods, verifies the quantities received, the condition, to unload and store the goods.*

*For shipments to customers, we offer the delivery, before each operation, the products must be quantified and checked before being sent to the customer.”*

**Analysis 07:** The center fully relies on its resources to transport goods from supply points (the 3 ports and Arzew refinery) as well as for customer delivery it is available. The checking conducted the operations manager is crucial for maintaining accurate inventory records and ensuring that the received goods meet the required standards, also the order control helps prevent any potential errors. Although, the shipping decision making and delivery scheduling is made manually which risks inefficient use of resources.

**8. Question 08: What processes do you use to ensure accurate and efficient order fulfillment?**

**Answer 08:** *“To ensure precise execution, the order is recorded in a special document (purchase order) by the commercial team, which is transferred to the warehouse clerk to prepare the order. If the products are available, the order is loaded and ready for shipment, after which the order is entered into the SD-COM software and validated by the operations*

*manager for delivery, the bill is made in order to dispatch the order, according to the delivery schedule.”*

**Analysis 08:** The order fulfillment process is performed through manual activities (document recording) while it can directly be processed through the SD-COM in order to better manage the orders, the billing process is essential for accurate financial management.

To verify if this order fulfillment process is accurate, we will calculate the following KPI:

**Order fulfillment accuracy rate:** This KPI calculates the number of orders that have been successfully fulfilled from start to finish, out of the total number of customer orders received. This includes orders that have been correctly delivered, on time and consisting of the right products.

**Calculation:**

**Formula:** (Orders completed without issues / Total orders received) x 100.

**Table n°3.8: Orders of lubricants and tires in Blida's distribution center (31/05/2023)**

	<b>Total orders</b>	<b>Orders completed without issues</b>
<b>Number of orders</b>	514	454

**Source:** Internal document of the company

**Order fulfillment accuracy rate=**  $(454/514) \times 100 = 88.32\%$

**Interpretation:** The calculation indicates that 88.32% of orders were fulfilled accurately, which can be considered as a low rate, therefore, the reasons causing this low rate should be looked in to in order to take corrective actions.

**9. Question 09: What are the primary challenges you face in managing your distribution center?**

**Answer 09:** *“The challenge we face is to ensure product availability, always managing stock levels. Another challenge is to complete the replenishment plan within the allotted time. We also have to satisfy our customer orders in the required quantities and on time.”*

**Analysis 09:** The center faces supply and demand challenges, the replenishment process can be a challenge when it comes to ensure timely pickups and determining optimal order quantities to supply their inventory, which will eventually cover the customer requirements.

**10. Question 10: What performance measures do you use to evaluate your distribution center's performance?**

**Answer 10:** *“Replenishment rate and sales forecasts. For us, performance is measured on the basis of predetermined objectives:*

- *Replenishment rate: we measure the number of rotations completed out of the total number of rotations required to reach the monthly replenishment objective.*
- *Sales forecasts: sales realized out of sales provisioned.”*

**Analysis 10:** The manager mentions two primary performance measures. The replenishment forecasts allow the center to assess its performance in maintaining optimal stock levels and replenishing inventory in a timely manner. Sales forecasts evaluate how well the distribution center is able to generate revenues and meet customer demands. These measures provide a quantitative assessment of the center’s performance.

We will calculate these two metrics to evaluate the performance of the center:

**Calculation:**

**Replenishment rate:** (the number of completed rotations / the number of planned rotations) x 100

**Table n°3.9: Replenishment forecasts and realizations (31/05/2023)**

	Previsions	Realizations
<b>Replenishment rate</b>	17	17

**Source:** Internal document of the company

**Replenishment rate** = (17/17) x 100 = 100%

**Interpretation:** The center has been able to complete all the replenishment plan in order to supply the inventory, which indicates that the transportation resources are sufficient for the center.

**Sales forecasts accuracy rate:** (sales realized / sales provisioned) x 100

**Table n°3.10: Sales forecasts and realizations of Blida's distribution center (31/05/2023)**

Sales	Previsions	Realizations
<b>Lubricants sales (metric ton)</b>	363	380.639
<b>Tires sales (units)</b>	994	1198

**Source:** Internal document of the company

Lubricants sales forecasts =  $(380.639/363) \times 100 = 104.85\%$

Tires sales forecasts =  $(1198/994) \times 100 = 120.52\%$

**Interpretation:** The center has realized more sales than the forecasts, which means the center is performant when it comes to sales number.

**11. Question 11: What are the main factors that affect the performance of products distribution?**

**Answer 11:** *“The factors that affect performance are skilled staff, available equipment (transportation equipment, handling, etc.) and storage capacity.”*

**Analysis 11:** The mentioned factors (skilled staff, available equipment, and storage capacity) interact and influence each other to determine the overall performance of product distribution. Skilled staff members effectively utilize available equipment and take advantage of storage capacity to optimize the movement and handling of products, leading to improved productivity and efficiency.

**12. Question 12: What type of upgrade or equipment you think should be provided to improve the performance?**

**Answer 12:** *“To improve performance, we need to provide new equipment, especially handling equipment, to help us manage the intensity of operations and handle products efficiently.”*

**Analysis 12:** The performance improvement is largely related to acquiring modern handling equipment, this will enable processing a higher number of products in less time and less manual labor. On the other hand, the software systems available within the center has successfully accomplished their missions, thus the focus now is on integrating physical automated equipment.

**2. Synthesis of the results**

By analyzing the answers collected from the three managers whom we have interviewed, we concluded that:

1. The major challenges faced in the distribution sector are related to transportation and warehousing, therefore, companies are required to implement strategic plans to address these challenges.

2. Distribution performance evaluation relies heavily on sales revenues and distributed quantities along the chain.
3. Managing inventory and providing optimal quantities is necessary to achieve customer satisfaction, as well as relying on private resources will decrease costs.
4. Integrating software systems within distribution centers offers huge benefits managing transportation and inventory, these systems provide efficient inventory management and better control over the fleet.
5. Automatic data entry is a primary step towards warehouse automation, also physical goods handling is necessary to upgrade the performance of activities.
6. Implementing warehouse automation offers key benefits such as improved distribution planning, avoiding stock shortages which will lead to optimized center performance and eventually increased customer satisfaction, other than acquisition costs there is no significant limitations or drawbacks.
7. Warehouse automation will positively impact the workforce by enabling them to be more productive, reduce manual labor and minimize errors.
8. Implementing a well-studied and thought warehouse layout will optimize space utilization despite having a limited storage capacity.
9. The distribution center is primarily evaluated by products availability (replenishment efficiency) and customer orders fulfillment (sales).
10. Including commercial tasks to the center will improve sales revenues and enhance customer relation management.

### **3. Suggestions and recommendations**

In order to improve the logistics efficiency of the distribution centers through the implementation of warehouse automation technologies, we will propose some suggestions which will allow the company to grow and achieve its objectives. Based on collected information our recommendations are:

1. The acquisition of a Warehouse Management System (WMS), this system will upgrade the existing software tools and gives the possibility of making data-driven decisions regarding inventory (inventory management and visibility, replenishment forecasting...) and transportation (routes planning, delivery scheduling...). A WMS is a necessity for a big company like NAFTAAL.

2. To build an improvement plan, it's important to start by analyzing all current processes. Monitoring the way things currently work can provide valuable insight into existing performance bottlenecks and potential areas for improvement.
3. NAFTAL covers the national territory which makes it difficult to track inventory, thus a barcode scanning system should be integrated to ensure traceability and secure product distribution.
4. Modernizing and developing the logistic infrastructure, increasing the transportation means and upgrading handling equipment to automated/developed means.
5. Considering collaboration with transportation service providers to move goods all along the chain, this solution can be more cost-effective than acquiring new private means on the short-term scale.
6. The distribution department should integrate an adequate performance measurement system such using KPIs, to evaluate different aspects of the distribution efficiency rather than sales revenues and quantities.
7. Training staff should be a priority, whether when implementing new technologies or to improve existing processes the staff always has the most critical role and can drive the overall productivity to enhancement.

### **Conclusion of the Chapter**

This chapter was the presentation of the qualitative study carried out in NAFTAL, with the aim to find out the level and types of automation technologies used by NAFTAL and its impact. Thus, the distribution centers of NAFTAL are still at a low level of automation, NAFTAL has developed software systems like SD-COM to manage inventory and stock movements and uses GPS tracking system to monitor the fleet. However, the distribution department aims to integrate barcode scanning to improve inventory management in real-time and automate manual data entry processes. The distribution department relies on basic indicators to evaluate its performance, this needs to be upgraded to a more comprehensive performance measurement system in order to enable data-driven decision making.

Finally, we can conclude that warehouse automation is an inevitable approach to enhance the overall performance, these technologies require a well-studied integration plan to ensure a positive impact because they represent a huge investment, so automation should be implemented based on priority and necessity.

# **General conclusion**

The main objective of this research is to study the impact of warehouse automation on logistics efficiency, also this research aimed to define the key concepts about warehouse automation, types and forms, challenges and factors to consider when implementing automation and related to distribution logistics in general.

The main findings of this research consist of:

- The major challenges faced in the distribution sector are related to transportation and inventory management, thus, implementing warehouse automation techniques will positively impact these two areas.
- Implementing warehouse automation offers key benefits such as improved distribution planning, avoiding stock shortages which will lead to optimized center performance and eventually increased customer satisfaction.
- In order to remain competitive and improve overall performance, modern technologies are required to be integrated.
- Setting performance objectives is a tool to evaluate the current performance and will eventually lead to optimize it.

The data collected from our research allowed us to test the hypotheses:

**H01:** Automating item identification and order processing can lead to improve accuracy and enhance order fulfillment.

This hypothesis is **confirmed** through the analysis of question 10 from axis 1 and question 5 from axis 2, automating item identification will lead to improve inventory management, hence improving order fulfillment by satisfying customer demand, automating products handling is also considered important when it comes to enhance accuracy.

**H02:** Evaluating order fulfillment and inventory management can improve the logistics efficiency.

This hypothesis is **confirmed**. The distribution center aims to always fulfill customer orders by providing the needed products in inventory. From the analysis of question 10 from axis 3, sales and replenishment forecasts are the main activities to track, this indicates that order fulfillment and inventory levels are important activities to evaluate.

**H03:** Technological complexity, existing infrastructures and software, and implementation costs are the key factors to be taken into consideration before automating a warehouse.

this hypothesis is **confirmed** through the analysis of the different answers from axis 2, it is remarkable that the main factors to be looked into when automating a warehouse goes back in first place to technical and integration complexity, although acquisition costs can be negligible for big companies in comparison to gained benefits.

The research we have realized at NAFTAL commercialization branch allowed us to see how can warehouse automation improve the logistics efficiency and what its impact is, the main results are as follows:

- warehouse automation will optimize inventory management and increase inventory visibility and tracking.
- warehouse automation will optimize transportation means usage, optimize routes planning and delivery scheduling.
- warehouse automation can improve logistics efficiency and accuracy which will eventually contribute in a better customer experience.

Thanks to the great collaboration and understanding, the data collection process related to the practical study, both for interviews and quantitative data for KPIs, was smooth and easy, no difficulties were faced at the company to gather the needed information. This collaboration has assisted the research process in order to find answers for our problematic.

When it comes to warehouse automation as a topic, it is relatively new and constant changes are occurring, therefore we would like to suggest new topics to be explored:

- The impact of barcode scanning systems on inventory management.
- Analyzing the role of Warehouse Management System in improving the logistic performance.

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# **Appendices**

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## **Appendix n°3.1: Interview guide**

Dear Mr.

In preparation for my thesis in order to obtain a Master's degree in Commercial Sciences option Distribution and Management of the Logistics Chain. Under the theme «The impact of warehouse automation on the efficiency of a distribution center», I am currently conducting a study within NAFTAL, commercialization branch, for the realization of my thesis. The purpose of this study is to study how logistics efficiency can be improved by implementing warehouse automation.

In order to clearly identify the study and make recommendations for possible improvement, this interview guide was constructed. We would like to hear your opinion on certain aspects related to distribution centers and logistics performance.

### **Axis 1: distribution logistics and performance**

1. Can you introduce NAFTAL and its specific position in the energy sector?
2. Can you describe the structure of your department?
3. What functions does your department perform?
4. What is your distribution strategy?
5. What are the biggest challenges faced in products distribution?
6. How do you currently address those challenges?
7. How do you currently evaluate the performance of your department?
8. What are the key metrics you use to measure the efficiency of the distribution process, and how do you currently track these metrics?
9. In your opinion what are the performance gaps that should be fixed?
10. How do you currently manage and track shipments?
11. How do you ensure that customer orders are fulfilled accurately and in a timely manner?

### **Axis 2: warehouse automation and performance related**

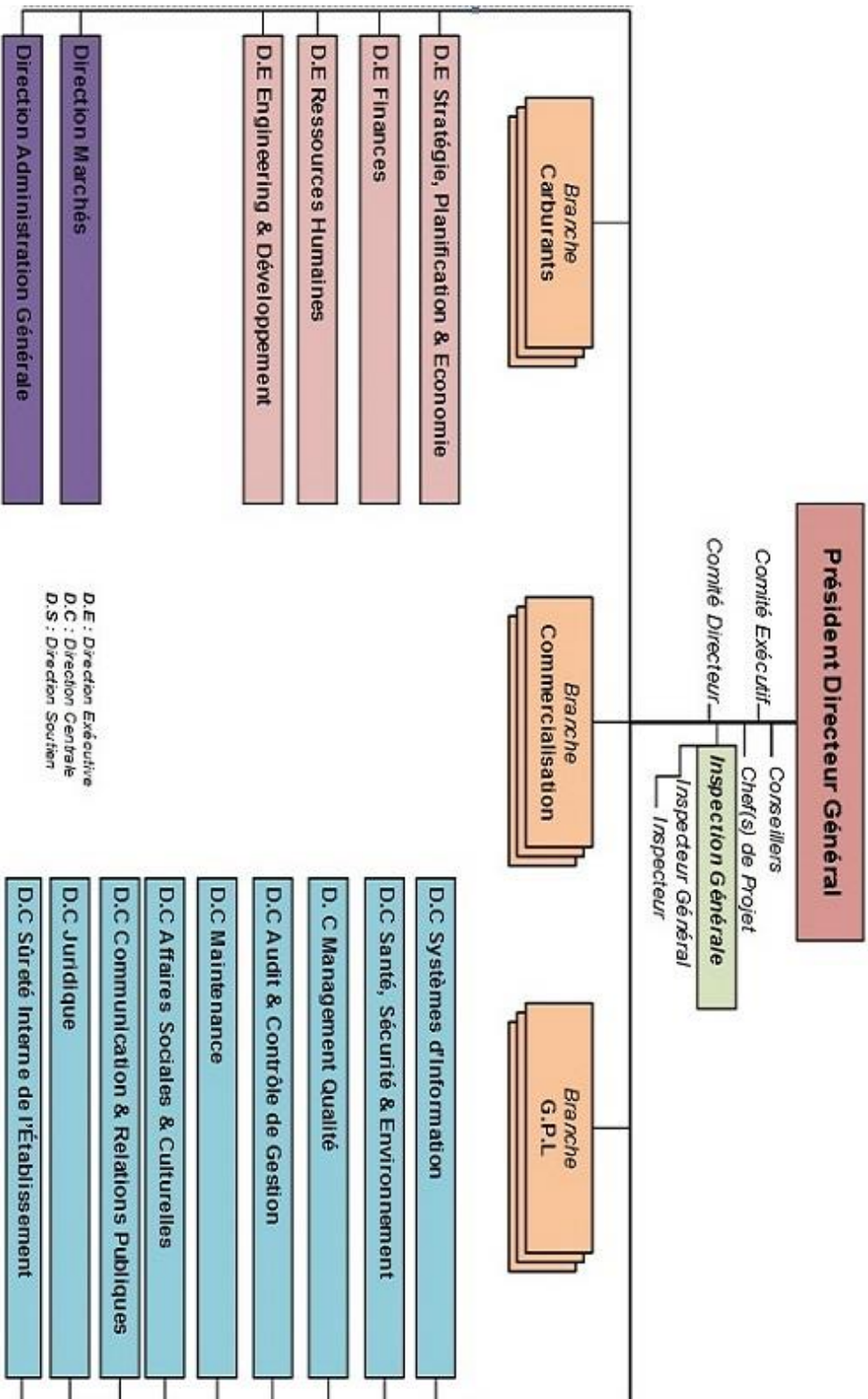
1. Can you introduce NAFTAL and its specific position in the energy sector?
2. Can you describe the structure of your department?
3. What functions does your department perform?
4. Can you describe the technology and software systems that your department uses?
5. How do you plan to integrate automated systems with your existing infrastructure and software used in the distribution center?

6. Which areas do you think are the most critical to automate within the distribution center?
7. Are there any specific tasks or operations that you think should be given priority for automation?
8. In your opinion, what are the key benefits of implementing warehouse automation in terms of logistics efficiency for the distribution of goods?
9. What do you think are the potential drawbacks or limitations of implementing warehouse automation in your facility?
10. How do you think automation can impact the current workforce and their roles within the distribution center?
11. How do you plan to measure the success of warehouse automation in improving logistics efficiency for the distribution center?
12. How do you think automation can impact the customer satisfaction?

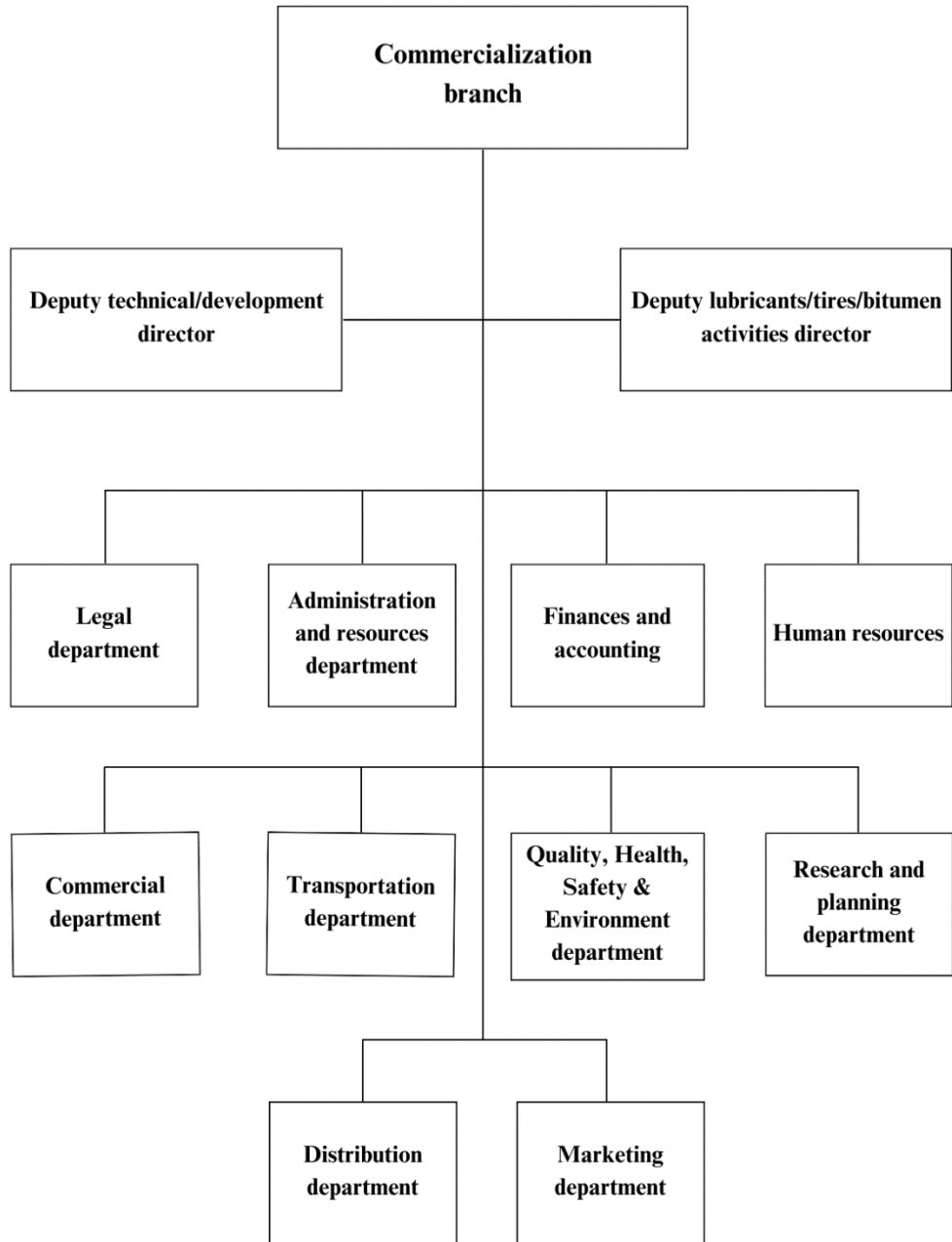
**Axis 3: Distribution center related**

1. Can you introduce NAFTAL and its specific position in the energy sector?
2. Can you describe your role as the distribution center manager?
3. What are the primary products that your distribution center handles?
4. What are the primary functions of your distribution center?
5. Can you describe the current layout of your facility and how you utilize space for storage and handling of goods?
6. How do you currently manage orders and shipping to customers?
7. How do you manage the transportation of goods from suppliers and to customers?
8. What processes do you use to ensure accurate and efficient order fulfillment?
9. What are the primary challenges you face in managing your distribution center?
10. What performance measures do you use to evaluate your distribution center's performance?
11. What are the main factors that affects the performance of products distribution?
12. what type of upgrade or equipment you think should be provided to improve the performance?

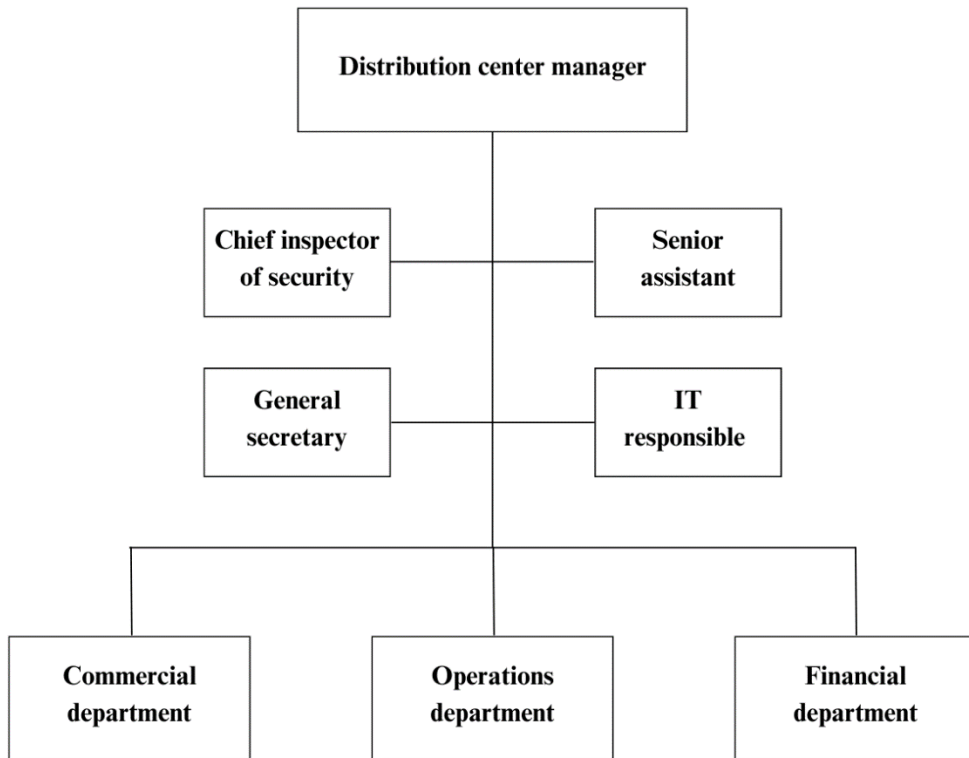
## Appendix n°3.2: NAFTAL's general organization




**Appendix n°3.3: Commercialization branch organization**



**Appendix n°3.4: Distribution center organization**



## Appendix n°3.5: Inventory reports application



### BRANCHE COMMERCIALISATION

### RAPPORTS D'ACTIVITE

**Stock Journalier des Lubrifiants Par Produit**

Grade : 30110 CHIFFA/CHELIA 40  
Emballage : 310


GAMME : HUILES MOTEUR DIESEL    PRODUIT : 30110 : CHIFFA/CHELIA 40  
 EMBALLAGE : 310 : FUT D'HUILE ET GRAISSE 180 KG    100%

[1] Produits d'entretien :  
 [2] Produits spéciaux :  
 [3] E-PAIEMENT :  
 [4] Vente / Zone :  
 Rapports/chemin Documents  
 [5] Stock Journalier :  
 [6] Lubrifiants :  
 Stock National (Format 1)  
 Stock National (Format 2)  
 Stock Par Région  
 Stock Par District  
 Stock Par Centre  
 Stock Par Produit  
 Evolution Stock/centre  
 Evolution Stock/canal  
 Stock Clients (O)  
 [7] Pneumatiques :  
 [8] Produits diversifiés :  
 [9] Bauxite :  
 [10] Ventes Journalières :

DISTRICT	CENTRE	QUANTITE (KG)	NOUVEAU	DATE LIMITE
DISTRICT COM ALGER	2106	37,990	211	25/09/23
	216C	150,300	890	15/09/23
	216D	118,440	658	15/09/23
DISTRICT COM ANNABA	20M1	80,820	449	15/09/23
	221G	9,900	55	15/09/23
	221C	95,400	530	15/09/23
	2247	35,280	196	15/09/23
	225A	40,860	227	15/09/23
	225C	17,280	96	15/09/23
	20C6	55,080	306	15/09/23
	202B	5,400	30	15/09/23
	229B	21,960	122	15/09/23
	214C	158,720	604	15/09/23
DISTRICT COM ORLF	2387	68,400	380	15/09/23
	2487	124,200	691	15/09/23
	202C	140,200	781	15/09/23
	203C	41,200	248	15/09/23
DISTRICT COM GHAZOUA	208G	15,480	86	15/09/23
	2004	3,660	21	15/09/23
	220B	14,220	79	15/09/23
	220A	48,420	269	15/09/23
	220C	2,600	20	15/09/23
		107,900	575	15/09/23

## Appendix n°3.6: Order receipt form

Société Nationale de Commercialisation et de Distribution de Produits Pétroliers



Société Nationale de Commercialisation et de Distribution de Produits Pétroliers  
NAFTAL SPA AU CAPITAL DE 160.000.000.000 DA R.C. 99 B 9691  
Route des Dunes Chéraga B.P 73 (Wilaya d'Alger)

F

№ 126218

### FORMULAIRE DE RECEPTION DE COMMANDE

CODE CLIENT		Heure :	Date :	Date de Rappel :
Nom Adresse de Livraison		Méthode de Réception	Interlocuteur ou n° de référence	Livraison Originale N° du 002
		Telephone		
Adresse de Facturation		Courrier		N° du 804
		En Person		
Instruction Particulières		A Livrer	Prise en Charge	Livraison Reliquat N° du 002
		Nom du Réceptionnaire		N° du 004

N°	Reliquat	P R O D U I T S			Code Produit	U M	E M B A L L A G E S			Quantités Unites	Prix Unitaire	Montant	
		Désignation	Grade	Type			Nombre	Code					
1													1
2													2
3													3
4													4
5													5
6													6
7													7
8													8
9													9
10													10
11													11
12													12
13													13
14													14
15												<b>TOTAL</b>	15

**LIVRAISON DE LA COMMANDE ORIGINALE**

Contrôle Crédit : **STOP**  Comptant  En Compte  Date d'échéance \_\_\_\_\_ initiales \_\_\_\_\_

Observations \_\_\_\_\_

1 Contrôle Stock : **ok**  Livraison Partielle  Reliquat annulé  Date prévue livraison reliquat \_\_\_\_\_ initiales \_\_\_\_\_

Observations \_\_\_\_\_

Dispatching : **ok**  Livraison Partielle  Reliquat annulé  Date prévue livraison reliquat \_\_\_\_\_ initiales \_\_\_\_\_

date de Chargement **méthode de livraison : NAFTAL**  SNTR  SNCFA  CLIENT  AUTRE  N° du Véhicule \_\_\_\_\_

2

Detail du Chargement	B A L E	1	2	3	4	5	6	7	8	9	10	11	12

**LIVRAISON DU RELIQUAT**

1 Contrôle Stock : **ok**  Livraison partielle  Reliquat annulé  Date prévue livraison reliquat \_\_\_\_\_ initiales \_\_\_\_\_

Observations \_\_\_\_\_

Dispatching : **ok**  Livraison partielle  Reliquat annulé  Date prévue livraison reliquat \_\_\_\_\_ initiales \_\_\_\_\_

date de Chargement **méthode de livraison : NAFTAL**  SNTR  SNCFA  CLIENT  AUTRE  N° du Véhicule \_\_\_\_\_

2

Detail du Chargement	B A L E	1	2	3	4	5	6	7	8	9	10	11	12

Ref 001 Imp NAFTAL

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