

# **Implementation Of The Value Stream Mapping 4.0 Method In A Warehouse**

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## **Abstract**

Warehouse digitalization promises new opportunities for businesses. By overseeing the entire line through the Lean Manufacturing tool VSM, solutions will be sought to optimize the process.

## **Keywords**

Digitization, Warehouse, VSM and Lean Manufacturing.

## **1. Introduction**

The automobile industry in general is characterized by very high competitiveness and product diversity. Morocco has become the leading construction hub on the African continent, ahead of South Africa and Egypt with distribution on an international scale. Adaptation to new technological changes can be essential for the success and growth of a company in the logistics and distribution sector. Technologies can help companies improve the efficiency and flexibility of their distribution system, expand their range of products, reduce costs, and provide increasingly high levels of quality and timeliness. Industry 4.0 is a major digital transformation in the industrial sector that involves intelligent automation and increased interconnectivity between machines, products, and people throughout the value chain. 4.0 factories are designed to be connected and intelligent, using advanced technologies.

VSM 4.0 is an evolution of traditional VSM, which has been adapted to include new technologies such as IoT, AI, and data analytics. It enables visualization of production processes and detection of waste, including information waste, that can have a negative impact on the efficiency and profitability of the business. Companies can design more

efficient value streams, by eliminating waste and improving coordination between different production processes. This can help reduce production costs, increase productivity, and improve product quality.

Therefore, our problem is to study, analyze, and optimize the efficiency and effectiveness of a supply chain of a multinational located in Casablanca, with a focus on the warehouse. This article will include a literature review on the warehouse and propose a methodology for the work. Then, a VSM mapping of the current state will be carried out, the process defined, and our case analyzed to propose improvements for establishing the future state of a VSM 4.0. Finally, the results will be compared, and a conclusion drawn.

## 2. Literature Review

A logistics warehouse is a storage facility where goods are stored for later distribution. It is generally used by companies to store products that are waiting to be shipped to customers or to store raw materials before they are transformed into finished products. They can be managed internally by the company itself or entrusted to specialized logistics service providers. They are often equipped with computerized inventory management systems to track the movement of goods and optimize supply chain management operations. Their size varies from one warehouse to another depending on the needs of the company. With the 4th industrial revolution, the warehouse has evolved from a traditional warehouse to a digitized warehouse equipped with technologies born from the rise of Industry 4.0 to increase performance, speed, and flexibility of storage and distribution operations. To support our research, a study was conducted on Scopus to discover the number of publications using the term "Warehouse 4.0".

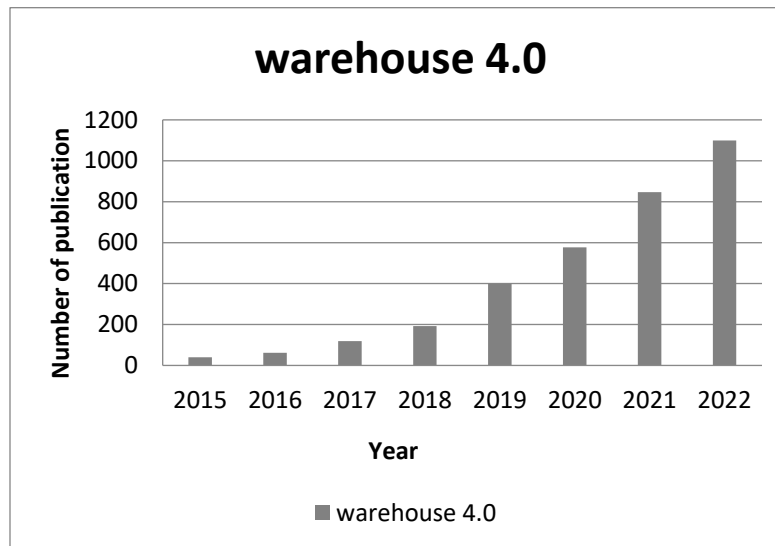


Figure 1. Number of publications related to the warehouse

The number of publications on warehouse 4.0 has started to significantly increase in recent years, especially since 2015, when the concept of Industry 4.0 began to be widely discussed. Since then, the number of publications on logistics 4.0 has steadily increased, reflecting the growing interest of researchers and logistics professionals in this field. Warehouse 4.0 is a rapidly expanding area, which has seen a significant increase in the number of publications over the years due to its importance in Industry 4.0. Companies are increasingly aware of the importance of adopting advanced technologies to improve their efficiency and competitiveness, and logistics 4.0 is a key element of this transformation. The following figure presents a research on the most used technologies in a warehouse to digitize it, which was conducted on Scopus.

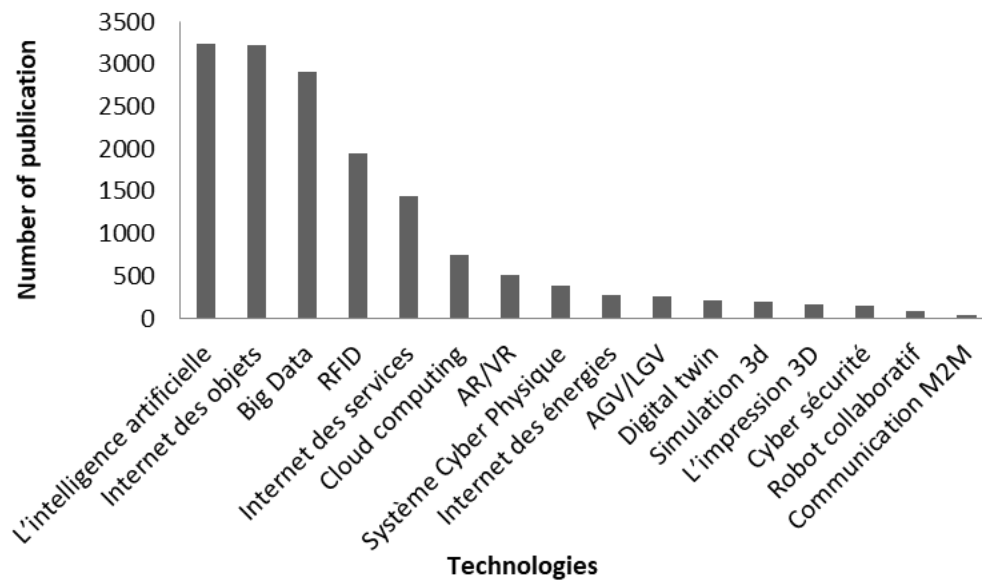


Figure 2. Number of publications per technology.

Industry 4.0 relies on several enhanced technologies, such as artificial intelligence and the Internet of Things, Big Data, RFID (Radio Frequency Identification), robotics, and augmented reality. These technologies are also widely used in modern warehouses to optimize warehouse functions. For example, Artificial Intelligence (AI) is used in warehouses to improve stock management, supply chain planning, and demand forecasting.

### 3. Methods

The integration of digitalization in a warehouse can present significant challenges for companies. Firstly, it can be difficult to determine the most appropriate technologies for each company and the necessary investments for their implementation. It is therefore essential to have a framework for the adoption of digitalization to facilitate decision-making and reduce the risks associated with the implementation of new technologies. Lack of information sharing and personnel resistance can obstruct Supply Chain managers in their deployment of digital technologies. To address this challenge, we will propose a working methodology in Figure 3.

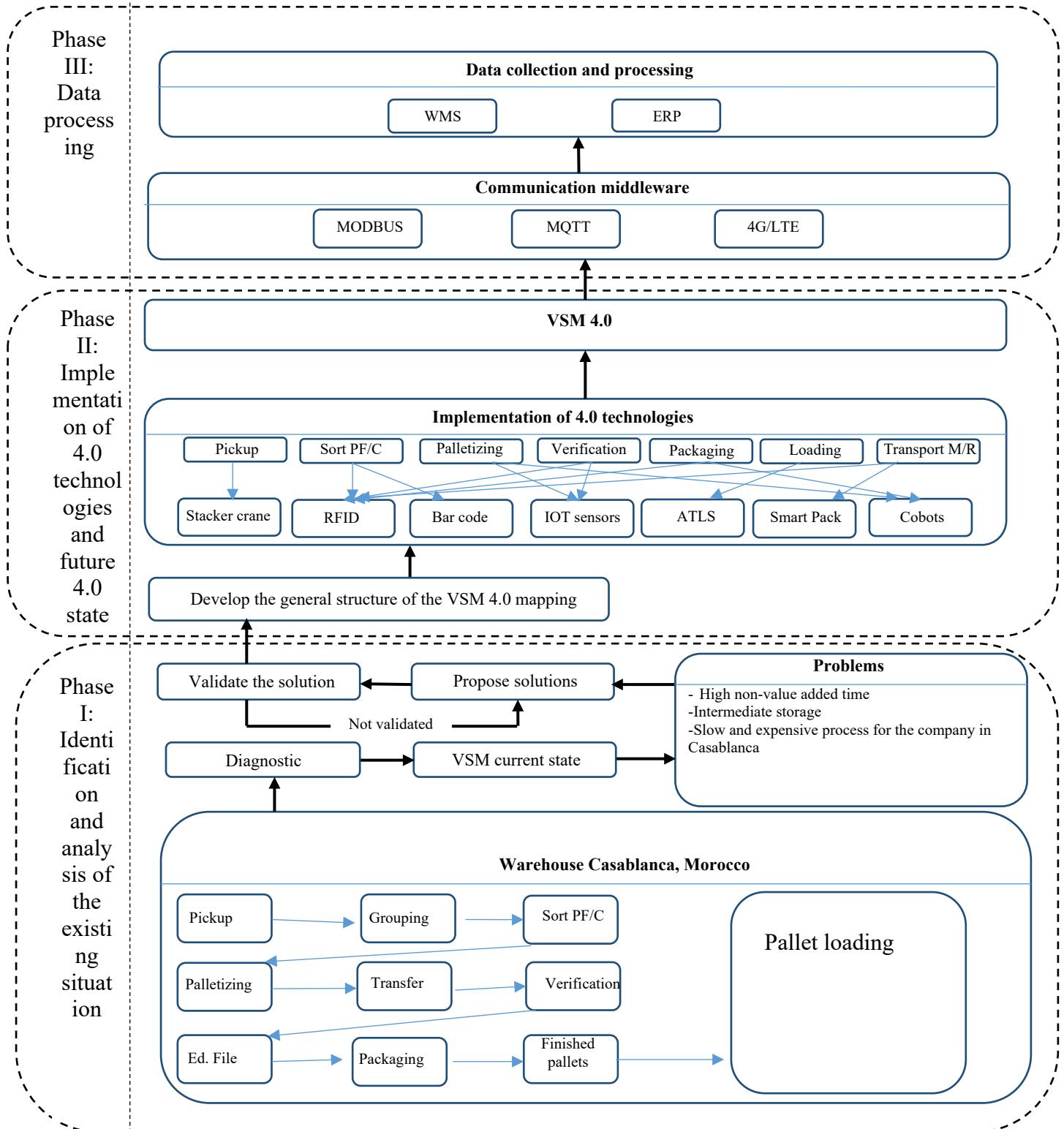


Figure 3. Implementation methodology in 4.0

New warehouse technologies

The technologies that are at the heart of Industry 4.0 are enabling digital transformation in various industries, including warehouse management. These technologies are revolutionizing the way warehouses operate, allowing them to become more efficient, productive, and flexible. By leveraging technologies such as IoT, robotics, AI, cloud computing, AR, and blockchain, warehouses are transforming their operations, improving inventory management, enhancing supply chain visibility, and reducing costs. As a result, digital transformation is becoming an essential aspect of warehouse management, here are some of the main technologies related to digital transformation in warehouse management.

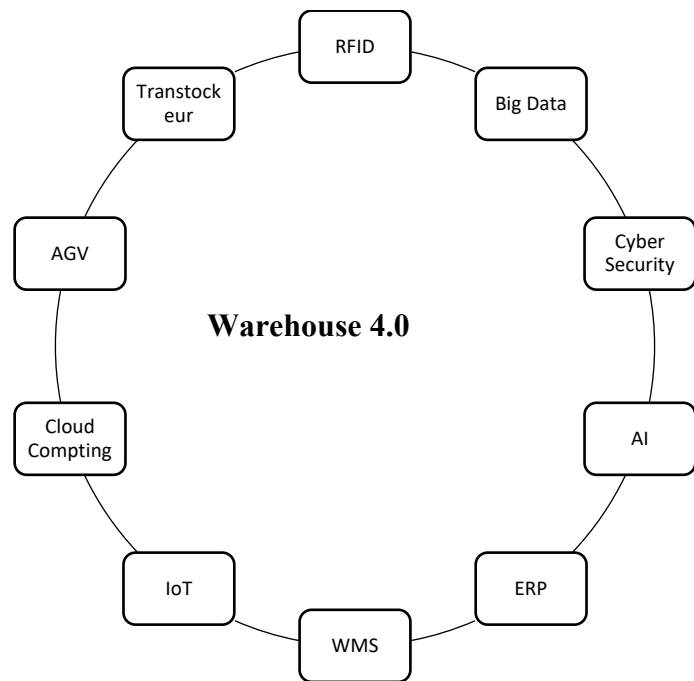


Figure 4. Warehouse 4.0 technologies

4. Case Study

Overview of the company

Our use cases is a company operating in the automotive industry based in Morocco for a delivery to a warehouse in France. His official seat are in France, and the group specializes in the design and production of electrical wiring for the automotive sector. Production is entirely dedicated to export for all electrical and electronic industries, and more particularly to major automotive suppliers.

Warehouse process

It is crucial to have a clear understanding of the nature and functioning of new technologies before implementing them in the logistics processes of a warehouse. This understanding will help warehouse managers and operators determine whether the technology is suitable for their needs, what benefits it can provide, and how it can be integrated into existing operations. Table 1 presents the different warehouse processes in Morocco.

Table 1. Warehouse Processes

Pickup	The accumulation of finished product stock requires several pick-up rounds during the rotation of all teams
Consolidation	By grouping, we mean the placement in racks in the shipping area
Sort PF /Client	The shipping area is divided into different zones in order to allow for the storage of one lot per customer
Sort PF/ Reference	In the shipping area, sorting can also be done by reference
Palletizing	The palletizing of finished products begins as soon as a reference reaches the quantity required by the customer
Transfert	The pallets meeting the required packaging and quantity standards will have to be transferred from warehouse F to warehouse E using the F warehouse's radio frequency scanner.
Editing the file	Preparation of the export file (invoices...).
Packaging	The pallets transferred to the warehouse and thoroughly checked are now ready to be wrapped in stretch film using handling equipment
Moving finished pallets	The finished pallets must be loaded in accordance with the priority given to pallets that need to be unloaded first.
Loading	The loading of the trailer starts each time there are finished pallets, while complying with the applicable loading standards

### **Current state analysis**

Creating a visual representation of the value chain in a warehouse allows for the visualization of material and information flows. The results of this analysis can help identify processes that can be improved or eliminated to reduce costs and improve operational efficiency. By using this method, companies can improve their operational efficiency and reduce costs. It sounds like you are describing a process map or flowchart that outlines the current state of the distribution process. This type of visual representation is commonly used in logistics and supply chain management to identify bottlenecks, inefficiencies, and areas for improvement. The process map typically includes different steps or tasks involved in the distribution process, such as receiving, storage, picking, packing, and shipping. Each task is represented by a box, and the boxes are connected by arrows to show the flow of materials or products through the process. In addition to the boxes representing tasks, the process map includes data boxes that provide information about each task, such as the number of shifts required to complete the task, the cycle time.

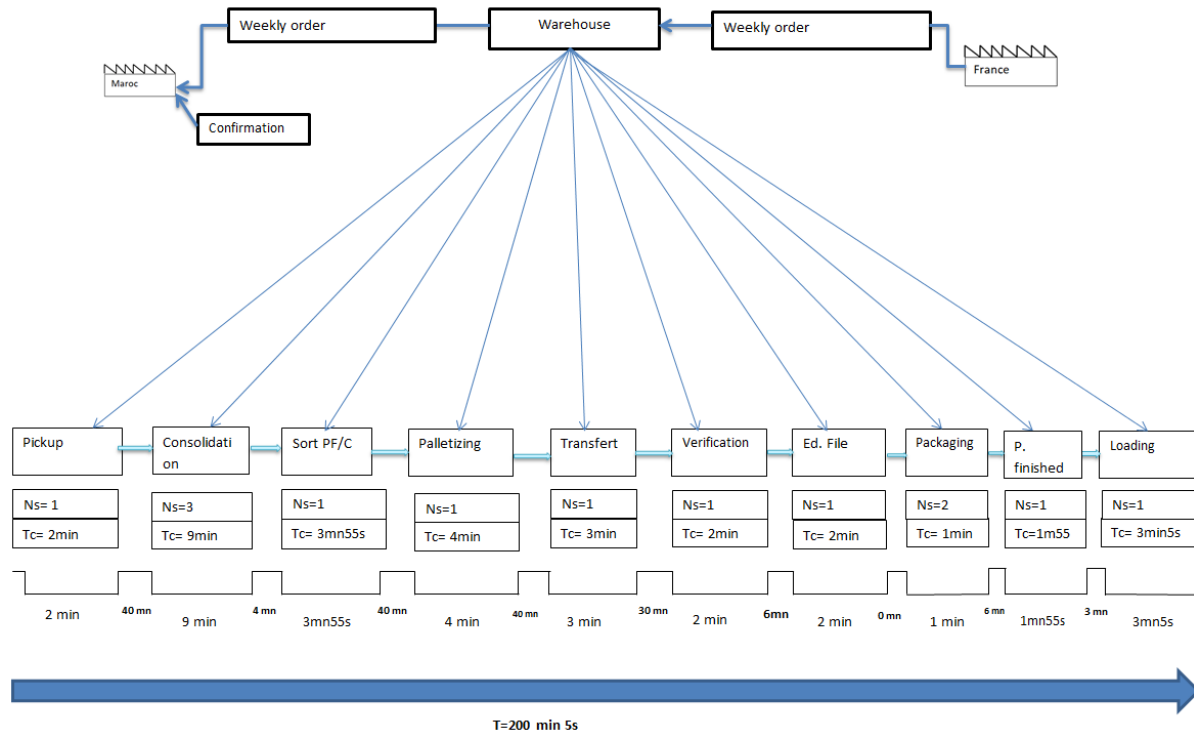


Figure 5. Current Status Mapping

Indeed, it is wise to consider the adoption of Industry 4.0 technologies to optimize the warehouse. Industry 4.0 technologies include intelligent production systems, IoT sensors, data analytics, artificial intelligence, robots, and augmented reality solutions, among others. Integrating these technologies can significantly improve warehouse efficiency by conducting a thorough analysis of workstations, followed by a judicious selection of technologies.

### Contribution of Technologies

Technologies must be adapted to the specific needs of each workstation to maximize benefits and minimize costs. A thorough analysis of work processes and material and information flows can help determine the most suitable technologies. It is also important to consider the costs of acquiring, implementing, and maintaining technologies in order to evaluate their profitability.

Table 2. Contribution of technologies to the process function

Technologies Functions	Big Data	Cloud	IOT	Cobots	AM	Drones	AI	AR	VS	RFID	Smart pack	Barecode	Power BI	WMS	Scan-3D	ERP	ATLS	AGV/LGV	Transtockeur
Pickup & consolidation				X				X		X				X		X			X
Sort				X			X	X		X		X							
Palletizing & transfer			X	X						X								X	X
Editing the file	X	X					X	X					X	X		X			
Packaging & Shipping				X			X	X								X			
Moving finished pallets																		X	X
Loading				X	X									X			X		X

The technologies have a significant impact on warehouse management and can help improve the efficiency, accuracy, and productivity of each warehouse function. Here are the benefits of technologies for each warehouse function and according to the priorities of the company.

Table 3. Detailed contribution of new technologies

Task	Contribution of new technologies
Pickup & consolidation	<b>Stacker cranes</b> -Transport of products from production according to traceability to the grouping area - Optimize the role of the operator optimize space -Merge picking and grouping <b>WMS</b> -Receipt of goods from imported files, the characteristics of the goods received and the purchase orders (order number, reference, quantities, etc.) are recorded in a file
Sorting	<b>Bar codes</b> -Automatic sorting where you already know where each product is and to which category it belongs -Reduce the verification time for the operator
Palettisation & transfert	<b>Cobots and IOT sensors</b> -Optimize the role of operators with an automatic palletizing system that contains IOT sensors and cobots to palletize packages. -Significantly reduce palletizing time at this stage
Checking and editing the file	<b>RFID&amp; Scan</b> -Instantly detect which product is which and fill in the file data automatically -The shipping warehouse manager here will have the role of confirming the exit of the product without the need for manual entry. -It will save time for the last verification of the products.
Packaging and shipping	<b>RFID &amp; WMS</b> In this step, the RFID technology allows us to track each finished product after wrapping and labeling, the WMS software allows us to control the goods before shipping and their allocation to the truck, we can add a third operator to speed up the operation.
Moving finished pallets	<b>AGV</b> -For fast and organized movement without the need for operator intervention Follow-up of the product until it is loaded in the trucks.
Loading	<b>ATLS</b> -Reduction of the loading time in the trucks -Rare intervention of the operator whose role will be to supervise -All the boxes are of standardized size which will allow to gain in storage space and to optimize the distances between boxes -Optimize the logistic resources of the company.

### Future state mapping

The figure shows a map of a future state, where an improvement in time and a reduction in the number of workstations can be observed, as well as:

- Reorganization of the warehouse process.
- Automation and merging of several processes.
- Using Industry 4.0 technologies yields data that is able to be transmitted in real time
- Value Stream Mapping (VSM) is permanently receiving new data and information from the overall supply chain, which makes it possible to both manage flows and detect bottlenecks.
- Track product throughout the process to identify its location promptly and, most of all, avoid the potential for loss. Updated at the same time facilitates data consolidation, allowing for fact-based decision making.
- Connectivity between all processes, products, and human operators.

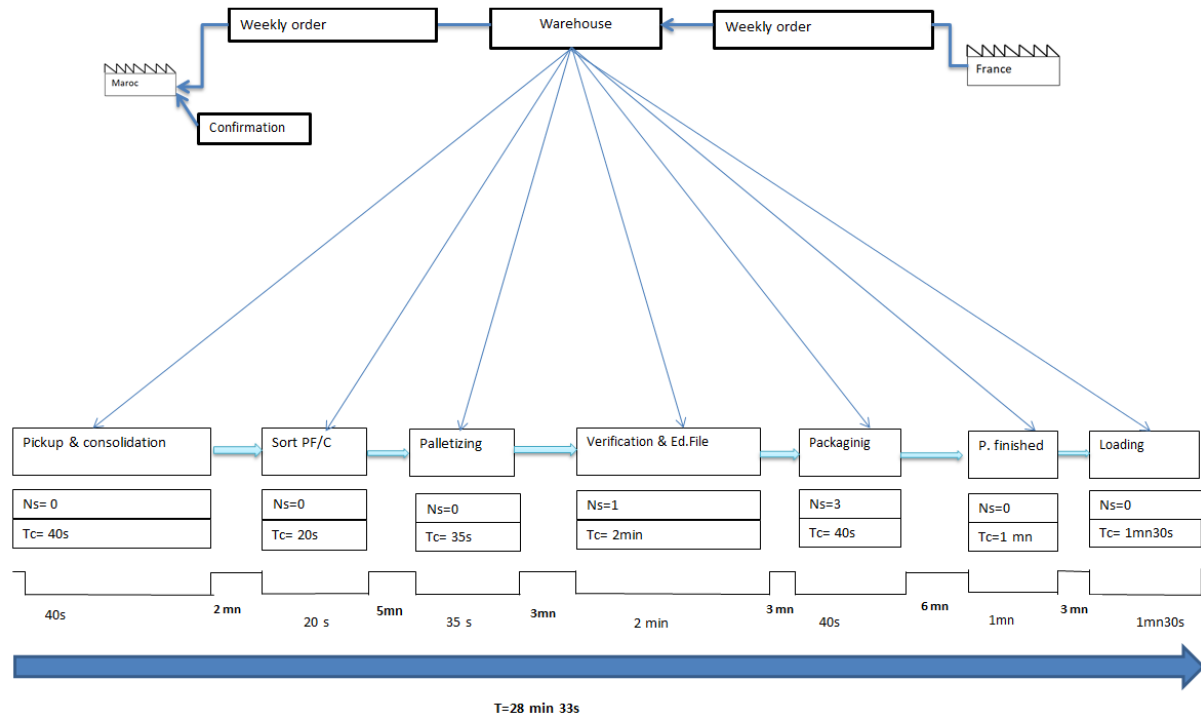


Figure 6. Future State Mapping

## Analysis of result

Warehouses play a crucial role in the logistics industry as they serve as the main storage and distribution centers for goods and products (Hong-Ying, 2009). The transition to a 4.0 warehouse has not only helped to solve management-related problems but also ensures real-time warehouse control, eliminates unnecessary and repetitive tasks, reduces the number of accidents, and meets customer requirements with the help of technologies. The table below shows a comparison between the current state and the future state:

Table 4. Comparison of Current and Future Conditions

Task	Current status (min)	Future state (min)
Pickup	2	0.40
Consolidation	9	
Sort PF/C	3.55	0.20
Palletizing	4	0.35
Transfert	3	
Verification	2	2
File Editing	2	
Packaging	1	0.40

Completed pallets	1.55	1
Loading	3.55	1.3

The merging of picking and consolidation using AS/RS (Automated Storage and Retrieval Systems) and Warehouse Management Systems (WMS) can help reduce processing times and picking errors in the supply chain. AS/RS are automated equipment that can quickly move materials and products within a warehouse, while WMS can efficiently manage inventory and warehouse operations. The use of cobots (collaborative robots) and IoT sensors for palletizing and transfer can improve the safety and accuracy of operations while reducing cycle times. The use of RFID technology for verification and file editing can help speed up verification and tracking processes. RFID tags can be used to track products throughout the supply chain, enabling quick error detection and problem correction. In summary, the use of technologies such as AS/RS, WMS, cobots, IoT sensors, and RFID technology can help improve productivity, accuracy, and speed of operations in the SC. The implementation of technologies has led to significant gains in the following areas:

Indicator	Current status	Future state
Number of positions	11	7
Number of operators	14	4
Time (min)	200mn5	28mn 33s

By introducing Industry 4.0 technologies within the warehouses in Casablanca, we have achieved a gain in Lead Time, which has been reduced from approximately 200 to 28 minutes, and we have also optimized the number of positions by 36% and the number of operators by 71%.

## Conclusion

The presented VSM 4.0 method is an extension of the well-known VSM method. VSM 4.0 focuses on redesigning a standard process from a Lean Manufacturing perspective, as well as processing all the necessary information for a value chain. One of the key benefits of using VSM 4.0 is the ability to monitor processes and quickly identify any inefficiencies or waste in real-time. This allows for quick adjustments to be made, leading to a more agile and responsive production process. In addition, the interconnectivity provided by the technologies 4.0 allows for greater collaboration and communication between machines, processes, and employees.

Another important aspect of VSM 4.0 is the integration of Lean Manufacturing principles. This involves not only streamlining processes, but also reducing waste, optimizing resources, and improving quality. By combining the VSM methodology with the principles of Lean Manufacturing, companies can achieve a more efficient and effective value chain.

The interconnection between machines, processes, and employees provided by 4.0 technologies makes the VSM tool capable of monitoring value flows in real-time to quickly address any potential waste, including machine setup delays and costs.

Ultimately, the introduction of new technologies can help a company remain competitive in the market and adapt to rapid changes in the business environment. Although this may require significant initial investment, the long-term benefits may be worth it and allow the company to realize higher profits in the future.

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## **Biography**

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