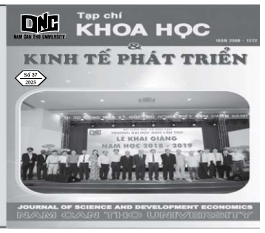
Journal of Science and Development Economics
Nam Can Tho University

Website: jsde.nctu.edu.vn



Analysis of the development of Warehouse Execution Systems (WES) in warehouse management

Ho Ngoc Kim Uyen[1], Ngo Anh Tuan[1*], Nguyen Van Tac[2], Tran Thanh Huy[2], Tran Duy[2], Vo Hoang Khang[2]

[1]*Faculty of Industrial Management, Can Tho University of Technology*

[2]*Nam Can Tho University*

[*]*Corresponding author: Ngo Anh Tuan (email: nanhtuan@ctuet.edu.vn)*

DOI: 10.64632/jsde.37.2025.611

Received: 10/6/2025
Revised: 8/7/2025
Accepted: 12/8/2025

Keywords: *automated distribution center, automatic and flexibility, avoiding congestion, optimizing resources, WES*

ABSTRACT

Warehouse Execution System – WES is a software developed and built on the foundation of existing software (warehouse control system – WCS and warehouse management system – WMS) and the need to supply goods of warehouses according to customer requirements with a large number of orders but still ensuring tight delivery time. WES was born with a number of development factors such as automation and flexibility, optimizing resources, avoiding congestion. In the future, WES will be developed and supplemented with a number of features to solve more practical requirements of automated distribution centers.

1. INTRODUCTION

Currently, there are many providers and developers of WES software. No documents accurately record the exact time this software was created or the first provider on the market. The WES software was formed and developed based on the demand for providing goods according to orders to meet customer distribution requirements with a high and stable level of distribution in automated goods distribution centers.

The software is built on multiple approaches. Some providers of WCS (Warehouse Control System) software have developed WES by adding certain warehouse operational functions, such as automatic order release, to create the functions of a WES (Reinhart, 2015). From another perspective, major warehouse automation system providers have introduced WES capabilities through supply chain execution software and WMS (Warehouse Management System) software, adding some automated display tools and order release functions (Michel, 2014, 2016).

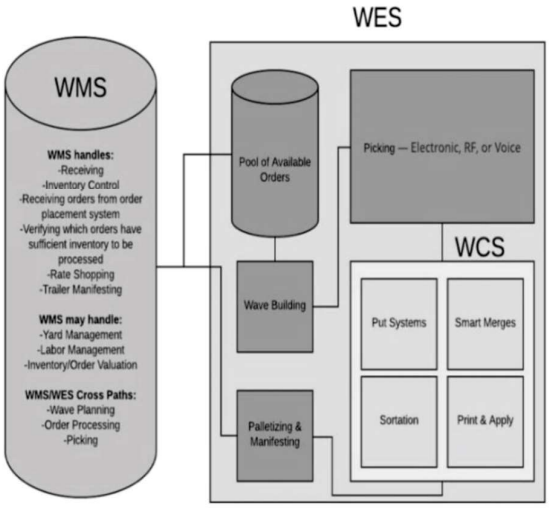


Figure 1. Relationship between WES with WMS and WCS

Source: https://www.conveyco.com/qualities-of-modern-wes/

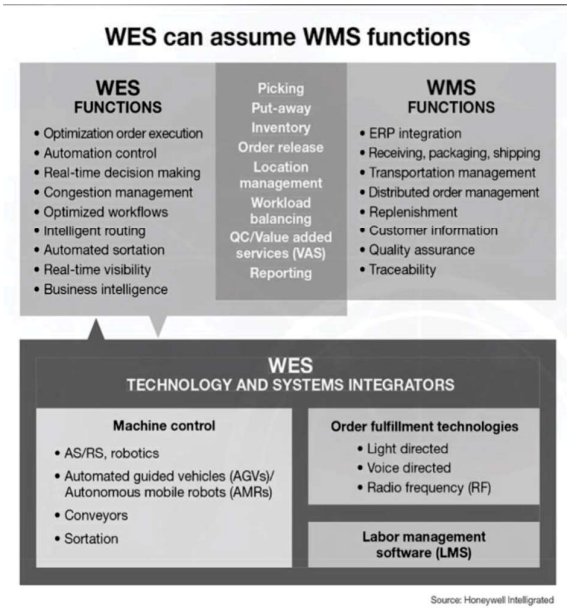


Figure 2. Functions of WES

Source: https://www.mmh.com/article/warehouse_execution_software_2.0

Despite being developed from various perspectives, WES software has fundamental functions to support warehouse management operations. These functions include managing machinery, people, and inventory resources, especially when there are a large number of orders and a requirement for on-time delivery. WES effectively allocates and manages tasks in the warehouse environment by considering various resources and constraints, including labor, inventory, and automation.

According to an article by ogistics management, WES receives product information, tracks products as they move in, out, and are stored in the warehouse, and optimally combines inventory with customer orders through its order fulfillment processing capabilities (Michel, 2019a). This system can integrate warehouse management, order management, payment, warehouse workflows, and material handling equipment, as well as automatic storage and retrieval systems.

A WES can control all the processes that occur within a distribution center. WES organizes, arranges, and synchronizes all warehouse resources. It acts as a solution to move orders in a continuous flow. If a condition changes during the process, the system will rearrange the work to continue the execution.

2. RESEARCH METHODS

This study was conducted using a qualitative approach through the synthesis of relevant documents.

3. RESULTS AND DISCUSSION

3.1 Analysis of the current development of WES

According to an article in Modern Materials Handling by Roberto Michel (2019b), WES is considered a high-tech solution. This software coordinates the general workflow across all resources and is increasingly using artificial intelligence (AI) and machines.

According to the WES Software buyer's guide from Westfalia Technologies, one of the key development factors of WES is its automaticity and flexibility. WES has the function to dominate automated machinery, sorting machines, or automated storage and retrieval systems (AS/RS). The main focus of WES is to process order releases based on customer requirements or in case of a sudden change in conditions during the order processing. WES can also collect information by displaying the status of ongoing work on conveyors at a specific time. Rather than assigning a series of tasks, WES assigns one task at a time and does not assign the next task to a worker until the previous one is completed. Additionally, WES allows employees to use voice control. WES is also equipped with software algorithms that automatically make many decisions about balancing workflow and releasing orders, instead of requiring managers to review them. This helps shorten the review time for managers, optimize delivery times, and ensure that warehouse execution proceeds according to the programmed schedule.

The second development factor for WES is resource optimization. WES can optimize any resource found in an automated distribution center (DC). It uses data science to drive work automation within the DC to meet customer service requirements while maintaining the quality of the provider's service (Warehouse Management). WES algorithms are applied to machinery, robots, and inventory positioning. This software applies lean principles and optimization algorithms to all interconnected operations in the same job. In other words, it optimizes the allocation of human resources and the methods and locations for placing goods in the warehouse system. WES is not only flexible in supplying goods for orders but also balances inventory levels and optimizes inventory volume within a certain time. WES includes determining where to pick goods, which areas need to be replenished, and how work will be arranged to access packaging stations for timely delivery to carriers. WES can also allocate and adjust the necessary labor to better support the automated workflow.

The third development factor is avoiding congestion during operation. WES coordinates multiple areas, technologies, and labor teams to create an overall warehouse flow. In distribution and goods movement, autonomous mobile robots (AMRs) are increasingly used. Each AMR has its own control software. However, WES can coordinate and synchronize multiple AMRs into the warehouse execution process. WES can also adjust the fixed automation of a cluster of AMRs working in one area and process to another. Because WES constantly updates the work progress in different areas and has information on the distribution center, robot operations, and forklift activities on the floor, it can propose optimal routes and tasks to avoid congestion through its established optimization algorithm. WES continuously and optimally releases work to different areas with consecutive tasks in a predefined process.

3.2 Direction and role of WES in the future

While WES has made developmental steps, this is only the beginning, the first version of WES 1.0. Consumers and providers have high expectations for the future WES. They want WES 2.0 to consider factors such as labor productivity and time reduction during task assignment. In other words, they want the system to be able to

estimate how long it will take to complete orders based on the number of items to be picked, their locations, and the productivity of each worker. WES can decide whether to optimize the productivity of a single cart or distribute the order to two carts to ensure they are completed within the allowed time (Trebilcock, 2020).

It has also been proposed that WES expand its value by optimizing the flow across all assets and resources, including robots and manual labor-based processes, rather than just one automated system.

Providers are also looking at how WES can optimize order picking operations into carts or something called a smart cart concept. Smart carts use lights and assisted devices to make workers more efficient at the cart. These carts can operate autonomously. When a warehouse receives an order with many different items , WES will identify groups of items located close to each other and assign tasks for each cart to pick those items and move to the staging area. These carts then continuously automate this process when receiving different orders. This means WES not only gives commands to the carts but also considers upcoming orders while the smart carts move to the staging area.

Another future development factor for WES is prediction. Cloud-based predictive analytics will become a more important aspect of the WES market. This includes not only predictions about machine downtime but also predictive models for order completion times based on variables like order profiles and available resources in key areas of the material flow. WES 2.0 will gradually allow operations to become more adaptable in real-time compared to WES 1.0.

Stemming from technological development and built on previous software, WES has, on one hand, met the practical needs of customers and warehouse managers. It can be said that WES has specific, basic features that are most suitable for automated warehouse distribution centers, which previous software could not address as specifically and directly. However, in terms of completeness and the level of expectation from both consumers and providers, WES is not yet fully convincing. They are raising more practical, specific, and technology-oriented issues for the next version of WES—WES 2.0.

4. CONCLUSION

WES 1.0 can be considered a solution for the fourth industrial revolution in Vietnam. At the same time, issues need to be raised and solutions provided for large enterprises, goods distribution centers, and logistics centers in the Vietnamese market, concerning infrastructure and resources to meet the application environment requirements for maximizing the efficiency and capacity of WES. Additionally, the Vietnamese market should consider the necessary factors for development to facilitate the practical application of WES 1.0, while also upgrading and creating stable infrastructure for the future development of WES 2.0.

REFERENCES

Michel, R. (2014). *What can Warehouse Execution Systems do for your distribution center operations. Supply Chain 247.* https://www.supplychain247.com/article/what_can_warehouse_execution_systems_do_for_your_distribution_center. Retrieved on May 10, 2025.

Michel, R. (2016). *WES Solutions: More than a bridge. Modern Materials Handling.*

https://www.logisticsmgmt.com/article/wes_solutions_more_than_a_bridge. Retrieved on May 10, 2025.

Michel, R. (2019). *Warehouse Execution Systems (WES) evolves beyond "inside the four walls". Modern Materials Handling.* https://www.mmh.com/article/warehouse_execution_systems_wes_evolves_beyond_inside_the_four_walls . Retrieved on May 10, 2025.

Michel, R. (2019). *Warehouse execution systems (WES) evolve. Modern Materials Handling.* https://www.mmh.com/article/warehouse_execution_systems_wes_evolves_beyond_four_walls. Retrieved on May 10, 2025.

Reinhart, B. (2015). *Warehouse Execution Systems: A new label for an established solution. The Material Handling Blog.* https://www.bastiansolutions.com/blog/ . Retrieved on May 10, 2025.

Trebilcock, B. (2020). *Warehouse execution systems 2.0. Modern Marerials Handling*. https://www.mmh.com/article/warehouse_execution_software_2.0 . Retrieved on May 10, 2025.

Westfalia. (n.d.). *Optimize Warehouse Operations with Savanna.NET* https://www.westfaliausa.com/automated-warehouse-solutions/warehouse-execution-software/ . Retrieved on May 10, 2025.