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Original Article

The Rise of Intelligent Warehouses: A New Era of Efficiency and Sustainability

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Abstract *- Warehousing is of paramount importance within the realm of supply chain management. It acts as a pivotal link connecting the production and distribution stages, enabling seamless and proficient transportation and safekeeping of goods. Given the significance of warehousing to business operations, it is essential to implement the solution strategy to maximize its performance. This article recognizes the industry's ongoing digital transformation and technological advancements, emphasizing the integration of SAP EWM (Extended Warehouse Management) to leverage these developments. Addressing industrial manufacturers' challenges, the article provides practical solutions to optimize warehouse operations. Implementing these solutions brings tangible benefits, including heightened operational efficiency, increased productivity, significant cost reductions through streamlined inventory utilization and labor allocation, improved customer satisfaction, and data-driven decision-making using real-time data insights. Furthermore, the article underscores the significance of tailoring these solutions to the unique requirements of the industrial manufacturing sector. By customizing and implementing these strategies, industrial manufacturers can fully harness the potential of SAP EWM, effectively addressing industry-specific obstacles.*

Keywords *- Industrial manufacturing, Supply chain management, SAP EWM, Warehousing solutions strategies, Digital transformation, SAP S/4 HANA.*

1. Introduction

Effective warehouse management is crucial for seamless supply chain operations, and businesses need to optimize warehouse activities.

Warehousing issues include space constraints, inventory management challenges, inefficient warehouse layout and design, ineffective picking and packing processes, lack of automation and technology, poor communication and coordination, seasonal fluctuations and demand variability, and safety and compliance concerns. Addressing these issues requires optimizing space utilization, implementing inventory management systems, leveraging automation and technology, improving communication, and ensuring compliance with safety regulations. Continuous monitoring and improvement are essential for efficient warehouse operations.

The advent of technology has brought about a paradigm shift in warehouse management practices, with SAP EWM (Extended Warehouse Management) emerging as a favored choice for enhancing operational efficiency.

SAP EWM is a software solution designed to enhance warehouse management efficiency. It empowers companies to handle warehouse processes, such as receiving, putaway, picking, packing, and shipping. By leveraging SAP EWM, businesses gain real-time visibility into their warehouse operations, enabling them to make informed decisions and elevate overall supply chain performance.

To fully leverage the benefits of SAP EWM, businesses should adopt solution strategies that deliver optimal results. Solution strategies serve as guidelines or recommendations for achieving success. This article delves into the solution strategies for SAP EWM warehousing, equipping businesses with insights to optimize warehouse operations and enhance their supply chain performance.

Within this article, you will explore four critical warehouse processes, uncover their associated solution strategies, and gain key takeaways for implementation to overcome warehousing issues.

2. Literature Review

Warehouse operations are vital to efficient supply chain management, influencing customer satisfaction, order fulfillment rates, and overall business performance. Extensive research highlights various proven approaches to

optimize warehouse operations, enhance efficiency, and boost productivity.

- Layout Design: The warehouse layout is a critical factor in warehouse efficiency and productivity. Ghiani & Musmanno [2] states that a well-designed layout can improve order-picking accuracy, reduce lead times, and increase customer satisfaction. In addition, the literature recommends designing the layout to minimize the travel time between pick locations and improve the visibility of inventory levels.
- Inventory Management: Effective inventory management is critical to warehouse operations. D. Sobya, and Parthasarathi Chakraborty [3] suggest that the best practice in inventory management is to adopt a systematic approach that involves tracking inventory levels, monitoring demand, and forecasting future demand. Effective inventory management can improve order fulfillment rates, reduce inventory holding costs, and minimize stockouts.
- Labor Management: Efficient labor management is essential to optimize warehouse performance. According to Sabari R. Prasanna & Ira Haavisto [4], the best practice in labor management is to adopt a data-driven approach that involves tracking employee performance, identifying skill gaps, and providing targeted training. Effective labor management can improve order fulfillment rates, reduce labor costs, and minimize errors.
- Warehouse Automation: The literature suggests that automation can improve warehouse efficiency and reduce labor costs. Mangan [5] highlights using automated technologies such as conveyor systems, automated storage and retrieval systems (AS/RS), and robotics to improve order picking accuracy, reduce lead times, and increase inventory accuracy.
- Supply Chain Visibility: Visibility is critical in warehousing operations. Waller [6] suggests that the best practice in supply chain visibility is to adopt a real-time data collection system that captures data at every point in the supply chain. An adequate supply chain visibility system can improve inventory accuracy, reduce stockouts, and enable proactive problem-solving.

Overall, existing scholarly literature indicates that the adopting effective layout design, inventory management, labor management, warehouse automation, and supply chain visibility can significantly optimize warehouse operations, enhancing efficiency and increasing productivity.

While previous studies have identified best practices, this article goes beyond by providing actionable insights and customized strategies tailored specifically to the unique challenges faced by industrial manufacturers. By addressing this gap, the article aims to empower businesses in the industrial manufacturing sector to optimize their warehouse operations effectively and achieve tangible improvements in efficiency, productivity, and overall supply chain performance.

3. Four Essential Processes

3.1. Inbound Processes

Inbound processes include:

- Goods Receipt & Putaway: Inbound processes are essential to ensure goods are received and put away efficiently. At the heart of these processes are goods receipt and putaway to destination bins. In addition, goods receipts can be posted upon the arrival of inbound deliveries.
- Transportation Unit Processing: Inbound processes, transportation unit processing is also critical. First, a precheck is performed at the checkpoint when a transportation unit, such as a truck, arrives at the gate. Then, each pallet is rechecked before further processing. Once the transportation unit has arrived in the yard, you can post the receipt of the goods for the complete transportation unit content, which is the associated inbound deliveries.
- Quality Inspection: Quality inspection is another crucial component of inbound processes, especially for imported products which can be managed using quality inspection. Quality inspection documents are, and the inspection results can be posted against them.
- Internal routing: Internal routing determines how products or handling units (HUs) are moved within the warehouse based on configuration settings and master data. This process is critical in optimizing warehouse operations and minimizing handling time.

➢ *Critical Strategies for Streamlining Inbound Processes [7-8]*

- SAP EWM is specifically designed to work with inbound deliveries. Therefore, it is essential to have the vendor send an advance shipping notification or create an inbound delivery before the receipt of the goods and putaway.
- When determining putaway strategies, utilizing packaging data is essential. This information helps identify the appropriate storage locations for different types of items. For example, full pallets can be allocated to high rack narrow aisles, while cartons or individual product pieces can be directed to the mezzanine area. Large parts, on the other hand, can be designated for bulk storage. During the putaway process, it is advisable to establish a designated handover point, especially when dealing with the physical limitations of narrow aisles that can only be accessed by specialized vehicles. This ensures smooth and efficient handling of goods, considering the specific constraints of the storage facility.

- When implementing specific putaway strategies, such as fixed bins or additions to stock, performing a capacity check is necessary to search for a suitable storage bin.
- It's essential to use RF/mobile device support throughout the receiving and putaway process. Operators should use a roll of pre-printed and barcoded handling unit (HU) labels to label the product, while pallets should be labeled with pre-printed HUs. If packaging material is meant to generate SSCC numbering, a barcode zebra printer should be readily available to pick up the labels.
- For narrow aisles, it is recommended to use a handover point where the system creates two warehouse tasks because there is an intermediate step via the handover point. If the task to move the HUs from the inbound staging area to the handover point is not yet confirmed, the final putaway task with the destination storage type is in status B – waiting.
- Ideally, operators in the two aisles should work in the RF environment and be system guided. This way, the system can ensure that after a putaway task, the operator performs a replenishment/picking task instead of returning (without an HU) to the handover point for the next putaway.
- If material is batch managed, assigning the batch during inbound delivery creation is crucial. The inbound receipt may include customer return and stock transfer receipts.

3.2. Outbound Processes

Outbound processes include:

- The Route, Wave, and Bin Planning: The outbound process starts with planning, where the system determines the route and bin based on customization settings. To ensure optimal efficiency, items from warehouse requests for outbound deliveries can be combined or split during waves, which can be picked or processed at the same or different times. SAP EWM allows for the creation of waves manually or automatically.
- Picking Optimization, Packing, Staging, Load Management, and Goods Issue: In the goods issue process, there are several essential stages involved in optimizing the picking, packing, staging, and loading of products from the warehouse. Picking efficiently moves a product from its source location to a designated destination. Packing usually involves transferring items from a storage bin to a pick-handling unit (HU). Depending on the packing specifications, the pick HU may be transported to a packing work center where the products are further packed into other HUs for shipment.

➢ *Critical Strategies for Streamlining Outbound Processes [9-13]*

- SAP EWM is designed to work with outbound deliveries. Therefore, creating an outbound delivery before the pick, pack, load, and post goods issue processes is essential.
- If the product quantity cannot be transported on a pallet, it must be moved to the work center for repacking, and a new handling unit (HU) should be assigned.
- The Pick-HU can be used as the Shipping HU for pallet quantities of products. Hence, no repacking is necessary for the Packing Work Center.
- If the product quantity is only partially palletized, it should be moved to the work center for repacking, and a new HU should be assigned.
- The shipping clerk can get an overview of all HUs ready for loading. Once enough HUs are prepared, the shipping clerk can decide which truck dock to use for loading.
- The door bin should have scanning functionality to scan and confirm the loading task.
- After the truck departs from the docking station, it is necessary to perform the goods issue process.
- The warehouse monitor can be a helpful tool for monitoring deliveries.

3.3. Storage and Operations

Storage and operations processes include:

- Physical inventory: You can carry out an inventory of products and bins for stock control and balance sheet purposes. A storage bin-specific physical inventory counts all the products and handling units in a bin. A material-specific physical inventory counts specific material in one or more bins and handling units.
- Replenishment/Rearrangement: You use replenishment control to restock a picking area depending on the demand for products in that picking area. Replenishment strategies are based on slotting or open warehouse requests. Rearrangement processes are employed to optimize product arrangement in the warehouse.
- Kit-to-stock management is a valuable feature that facilitates shipping kit stocks to customers, particularly in organizations with light manufacturing processes. There are two ways to initiate kit creation: manually within the SAP ERP system, based on a production order, or within the SAP EWM system, using a value-added service order. This functionality streamlines the process for timely customer deliveries.

➢ *Critical Strategies for Streamlining Physical Inventory [14]*

- Use RF devices: Use mobile data entry with RF devices to ensure accurate data collection and minimize errors.

- Count products in small batches: Break down the inventory into small batches to minimize the risk of errors and reduce the impact on daily operations.
- Use cycle counting: Instead of conducting a physical inventory once a year, consider implementing a cycle counting process. This involves regularly counting a subset of products throughout the year, which can help identify issues early on and improve accuracy.
- Verify data accuracy: Verify the accuracy of all data, including product codes, bin locations, and quantities. Ensure all information in the system is up-to-date and matches the physical inventory.

➢ *Critical Strategies for Streamlining Replenishment/ Rearrangement [15]*

- Use slotting to optimize product placement: Slotting is a technique that involves assigning products to specific storage bins based on their demand, size, weight, and other factors. By using slotting in your warehouse, you can reduce the time and distance required for picking, restocking, and replenishment, resulting in improved productivity and efficiency.
- Balance replenishment and storage capacity: To ensure that your picking area always has enough stock, you must balance your replenishment and storage capacity. If you over-replenish, you may end up with excess inventory that takes up valuable storage space, while under-replenishment may lead to stockouts and lost sales. By monitoring your inventory levels and demand patterns, you can fine-tune your replenishment strategy to match your storage capacity and minimize waste.
- Prioritize fast-moving items: Fast-moving items should be given priority when it comes to replenishment and rearrangement. These products should be placed in the most accessible and visible storage locations to minimize the time and effort required for picking and restocking.
- Use automated tools for replenishment: SAP EWM provides a range of tools for replenishment, such as mobile data entry, RFID tags, and automated storage and retrieval systems (AS/RS). By using these tools, you can improve the speed and accuracy of your replenishment process, reduce the risk of errors, and optimize your labor resources.
- Monitor and analyze performance: To improve your replenishment and rearrangement processes continuously, you need to monitor and analyze your performance metrics, such as inventory turnover, picking accuracy, and replenishment lead time. By identifying areas of improvement and implementing corrective actions, you can achieve higher productivity, lower costs, and better customer satisfaction.

3.4. General Processes

General Processes Include

- Resource and labor management: The resource management feature ensures that the right resources, including people and material handling equipment, are assigned to a warehouse order in the RF environment [16]. Meanwhile, labor management offers various functions to plan, simulate, visualize, and measure warehouse activities and compare and evaluate warehouse employees' performance. This function can also trigger incentives for bonus payments in a connected HR system.
- Measurement services: You can define performance parameters and key performance indicators (KPIs) to measure planned versus actual and individual employee performance with measurement services.
- Cross-docking: Cross-docking is a logistical approach that allows for the direct transportation of products or handling units (HUs) from the receiving to goods issue, bypassing the need for storage. There are two types of cross-docking processes: unplanned processes and planned processes. Unplanned processes, such as push Deployment and pick-from goods receipt, begin with a standard goods receipt process. These processes involve the immediate transfer of HUs without intermediate storage. On the other hand, transportation cross-docking is a planned process involving the transportation of HUs between different distribution centers or warehouses to reach the desired destination [17, 27].
- Yard management: Yard management monitors and manages transportation units (TUs) [19] that arrive to deliver or pick up goods to or from the warehouse.
- Import/export, compliance, and hazardous materials handling: The Environmental Health and Safety (EH&S) feature supports appropriately handling and storing hazardous substances in the warehouse, ensuring compliance with governmental regulations. EH&S data is obtained by integrating the EH&S application into the SAP ERP system. For import/export control and handling, SAP EWM is used with SAP Global Trade Services (SAP GTS).
- Native technologies: Warehouse processes rely on mobile data entry using mobile radio frequency (RF) terminals and radio frequency identification (RFID) tags. RFID tags can be used with the SAP for inbound, outbound, and internal product movements.

➢ *Critical Strategies for Resource and labor management [20 - 21]*

- Plan labor times and resources in advance: Use historical data to plan labor times and resources, considering seasonal demand, peak times, and holidays.
- Optimize task allocation: Allocate tasks to employees based on their skills and availability, ensuring that each

employee is assigned the most suitable task for their skill set.

- Measure performance: Use key performance indicators (KPIs) to measure employee performance and identify areas for improvement. Monitor employee performance regularly and provide feedback to employees to help them improve their performance.
- Incentivize performance: Incentivize employees who meet or exceed performance targets. Incentives can be in the form of bonuses, promotions, or other rewards.
- Automate processes: Use tools like Pick by Voice [26], RFID [23], and Material Flow Systems to streamline operations and reduce manual labor. This will help improve productivity and reduce errors.
- Train employees: Regularly train them to ensure they are current with the latest processes and technologies. This will help them work more efficiently and effectively.
- Monitor equipment: Monitor equipment such as forklifts and other material handling equipment to ensure they are well-maintained and operating efficiently. This will help reduce downtime and increase productivity.

4. Enhancing Warehouse Management with Process Optimization

Warehouse management optimization is critical, requiring meticulous coordination of crucial processes: inbound, outbound, storage and operations, and general procedures. Organizations can unlock substantial efficiency, accuracy, and productivity improvements by strategically aligning and fine-tuning these processes. Leveraging the advanced functionalities of SAP EWM further amplifies these benefits, enabling streamlined operations, real-time visibility, and data-driven decision-making. In addition, the interconnectedness and interdependencies of these processes can be effectively conveyed through visual diagrams, providing a comprehensive and intuitive overview that aids in identifying bottlenecks, optimizing workflows, and driving continuous improvement. Embracing this holistic approach empowers organizations to establish an optimized warehouse management framework that maximizes operational effectiveness, customer satisfaction, and competitive advantage in today's dynamic business landscape.

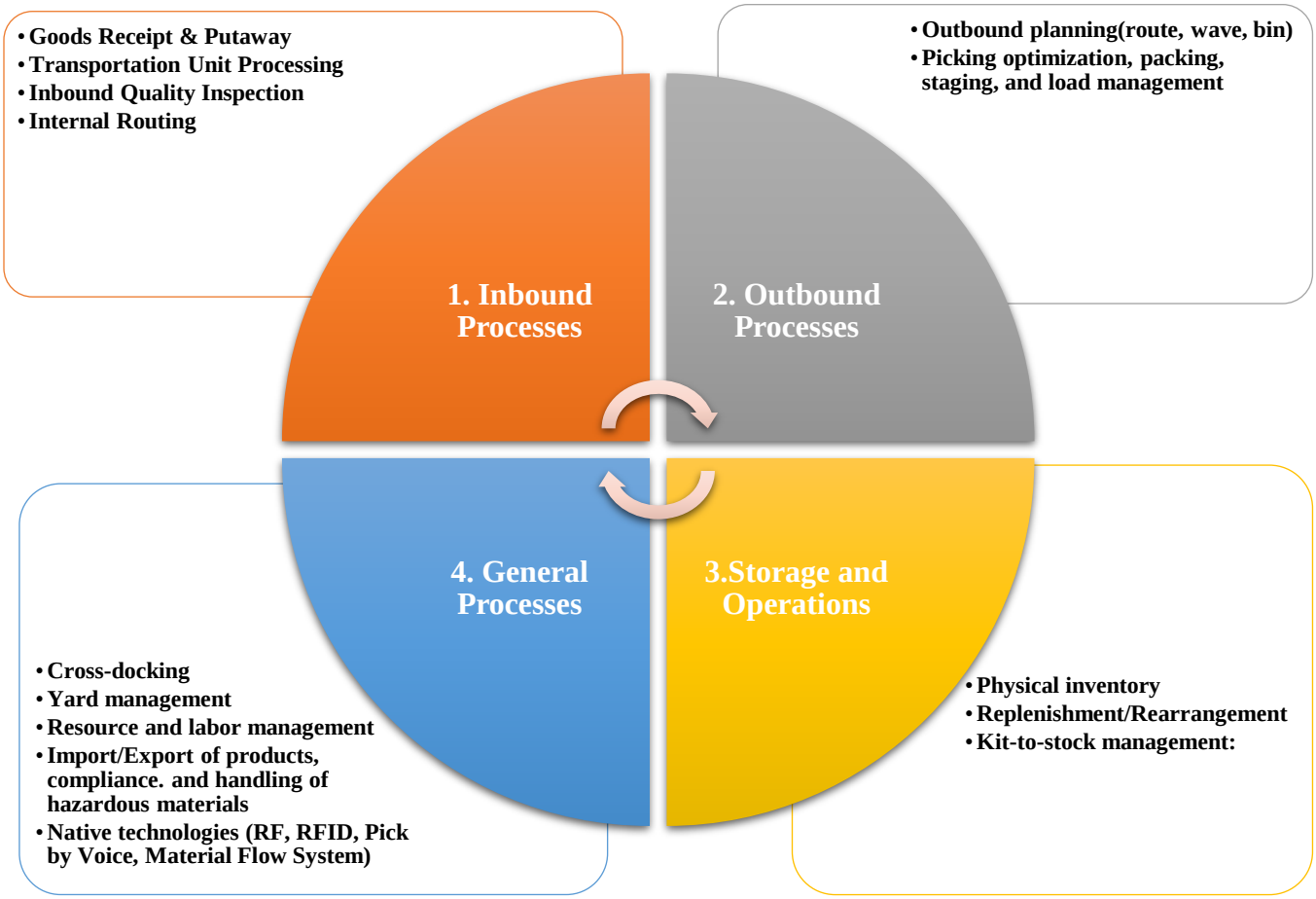

Fig. 1 The Synergy of key business processes and technology solutions

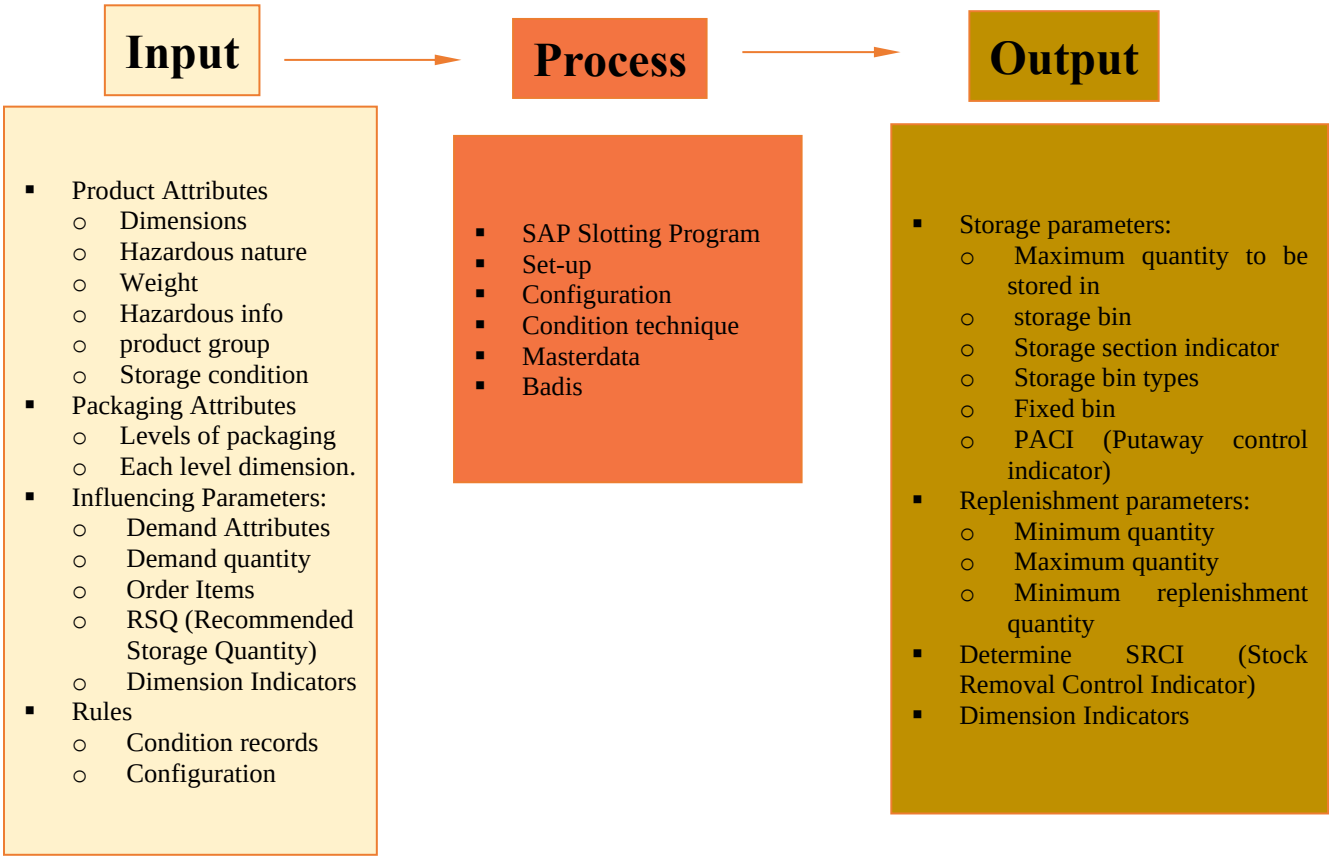

Fig. 2 Unlocking warehouse efficiency: The power of slotting process solution

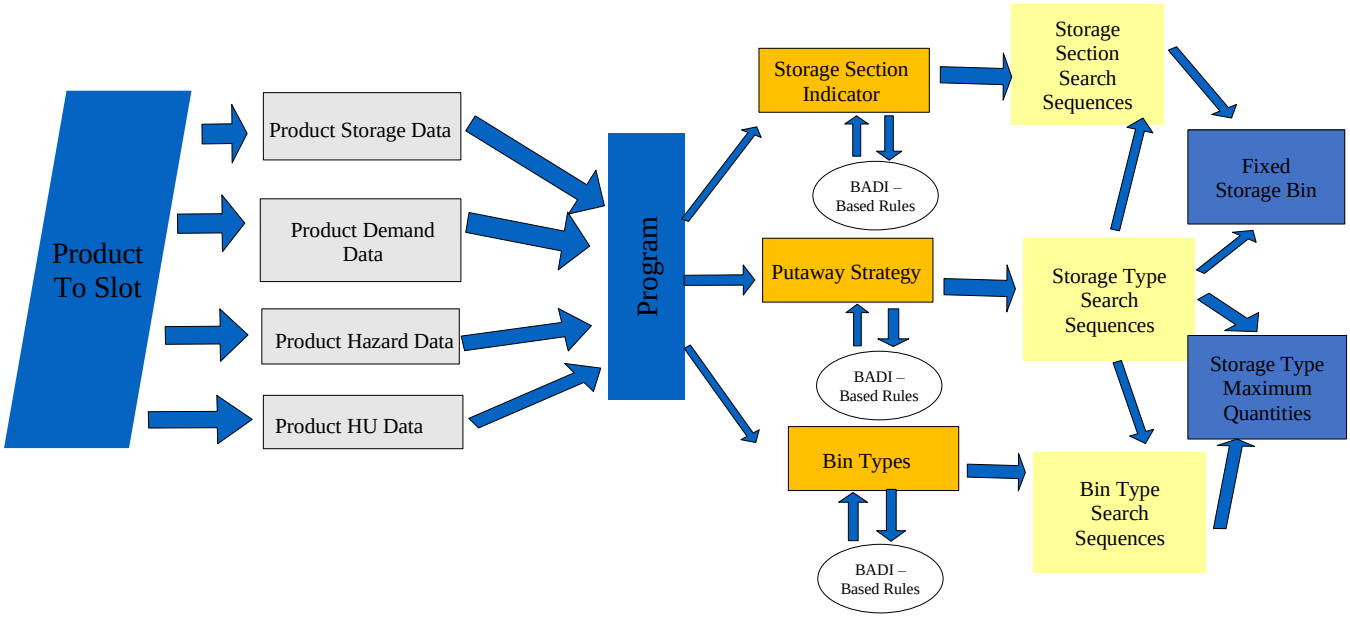

Fig. 3 Slotting process: Custom solution spotlight

5. Results

Key Strategies	Impact	Benefits
Layout design[1]	A well-designed layout [24] can improve order-picking accuracy, reduce lead times, and increase customer satisfaction. In addition, by reducing travel time between pick locations and enhancing the visibility of inventory levels, the warehouse can become more efficient, resulting in cost savings.	Improving warehouse layout can result in a 25 to 30% increase in productivity, translating to thousands or even millions of dollars in cost savings.
Inventory management[2]	An effective inventory management [28] system can improve order fulfillment rates, reduce inventory holding costs, and minimize stockouts. As a result, a warehouse can improve cash flow and reduce costs by reducing excess inventory and optimizing inventory levels.	Optimized inventory management can reduce inventory carrying costs by up to 22%, translating to millions of dollars in cost savings.
Labor management[3]	Effective labor management can improve order fulfillment rates, reduce labor costs, and minimize errors. A warehouse can become more efficient and reduce costs by tracking employee performance, identifying skill gaps, and providing targeted training.	Effective labor management can reduce costs[3] by up to 30%, translating to significant cost savings.
Warehouse automation[4]	By implementing automated technologies such as conveyor systems, automated storage and retrieval systems (AS/RS), and robotics, a warehouse can improve order-picking accuracy, reduce lead times, and increase inventory accuracy.	Automated warehouses can achieve up to 22% lower operating costs than manual warehouses, translating to significant cost savings.
Supply chain visibility	An adequate supply chain visibility system can improve inventory accuracy, reduce stockouts, and enable proactive problem-solving. In addition, by capturing data at every point in the supply chain, a warehouse can become more efficient and reduce costs.	Supply chain visibility can result in a 20-30% reduction in inventory and a 10-15% reduction in supply chain costs, translating to millions of dollars in cost savings.

[1]Layout Design

Calculating warehouse productivity involves measuring the output or performance of the warehouse against specific metrics. One of the metrics is Inventory Turnover. Inventory Turnover assesses how efficiently the warehouse manages its inventory. It measures the number of times stock is sold or replaced within a specific period.

Inventory Turnover = Cost of Goods Sold / Average Inventory Value.
Cost of Goods Sold: Total value of inventory sold during a specific period.
Average Inventory Value: Average value of stock held during the same period.

Yearly Revenue ($ Billion)	Cost of Goods Sold	Before Average Inventory Value	Inventory Turnover Before Implementation= Cost of Goods Sold / Average Inventory Value	After Average Inventory Value	Inventory Turnover After Implementation= Cost of Goods Sold / Average Inventory Value	% Improvement
$1.2	$960,000,000	$489,600,000	1.96	$412,800,000	2.33	18.60
$1.7	$1,360,000,000	$625,600,000	2.17	$530,400,000	2.56	17.95
$2.0	$1,600,000,000	$880,000,000	1.82	$640,000,000	2.50	37.50
						Average = 24.68

Yearly revenue, or annual sales, refers to the total amount of money earned by a company or an organization during a specific fiscal year.

For example, The organization has a yearly revenue of $1.2 Billion.

- Yearly Revenue: $1.2 billion
- Cost of Goods Sold: $960 million
- Average Inventory Value before implementation: $489.6 million
- Inventory Turnover before implementation: 1.96 (Cost of Goods Sold / Average Inventory Value)
- Average Inventory Value after implementation: $412.8 million
- Inventory Turnover after implementation: 2.33 (Cost of Goods Sold / Average Inventory Value)
- Percentage Improvement: 18.60%

Therefore, based on the data provided, the average improvement in Inventory Turnover for different organizations is 24.68%. This indicates that the warehouse has become more efficient in inventory management, leading to a higher turnover and potentially improved productivity.

[2]Inventory Management

Yearly Revenue ($ Billion)	Average Inventory Value Before Implementation	Average Inventory Value After Implementation	% Improvement
$1.2	$900,000,000	$660,000,000	26.67
$1.7	$1,275,000,000	$952,000,000	25.33
$2.0	$1,500,000,000	$1,120,000,000	25.33
			Average = 25.78

For example, The organization has a yearly revenue of $1.2 Billion.

- Yearly Revenue: $1.2 billion
- Average Inventory Value before implementation: $900 million
- Average Inventory Value after implementation: $660 million
- Percentage Improvement: 26.67%

Therefore, based on the updated data, the average improvement in Inventory Turnover over the different organizations is 25.78%. This indicates that the warehouse has become more efficient in inventory management, leading to a higher turnover and potentially improved productivity.

[3]Labor Management

Yearly Revenue ($ Billion)	Average Picking Hrs Per Week (In Hrs)	Average Picking Hrs Per Quarter (In Hrs)	Total tasks completed (Per Quarter) Before implementation	Productivity = (Total tasks completed) / (Total labor hours) Before implementation	Total tasks completed (Per Quarter) After implementation	Productivity = (Total tasks completed) / (Total labor hours) After implementation	% Productivity Improvements
$1.2	20	240	480.00	2.00	650	2.71	35.42
$1.7	23	276	736.00	2.67	980	3.55	33.15
$2.0	29	348	1005.00	2.89	1250	3.59	24.38
							Average =30.98

For example, The organization has a yearly revenue of $1.2 Billion.

- Yearly Revenue: $1.2 billion
- Average Picking Hours per Week: 20 hours
- Average Picking Hours per Quarter: 240 hours
- Total tasks completed per quarter before implementation: 480 tasks.
- Productivity before implementation: 2.00 tasks per hour (Total tasks completed / Total labor hours)
- Total tasks completed per quarter after implementation: 650 tasks.
- Productivity after implementation: 2.71 tasks per hour
- Percentage Productivity Improvement: 35.42%

Therefore, based on the data provided, the average improvement in productivity for picking tasks over the different organizations is 30.98%. This indicates that the warehouse has become more productive in picking tasks, resulting in more tasks being completed per labor hour.

[4]Warehouse Automation

Yearly Revenue ($ Billion)	Average Quarterly Task Executed by Employee before automation	Average Quarterly Task Executed by Employee before automation	% Improvement
$1.2	480	400	16.67
$1.7	736	509	30.84
$2.0	1,005	800	20.40
			Average = 22.64

- Yearly Revenue: $1.2 billion
- Average Quarterly Tasks Executed by Employees before automation: 480 tasks.
- Average Quarterly Tasks Executed by Employees after automation: 400 tasks.
- Percentage Improvement: 16.67%

Therefore, based on the data provided, the average improvement in task execution efficiency by employees before and after automation in the warehouse over the different organizations is 22.64%. This indicates that the implementation of automation has led to an increase in productivity and the ability of employees to execute tasks more efficiently.

6. Conclusion

In conclusion, Implementing warehousing solution strategies yields many valuable benefits for organizations. These encompass enhanced efficiency and productivity, exemplified by streamlined processes that expedite order processing and minimize lead times, enabling organizations to meet customer demands more effectively. Moreover, significant cost savings can be achieved by adopting solution strategies in inventory and labor management and warehouse automation. Notably, a well-designed layout can curtail travel time between pick locations, reducing labor expenses. Additionally, implementing automated technologies can bolster cost savings while improving accuracy. Another advantageous outcome is the enhancement of customer satisfaction. Warehouse solution strategies contribute to heightened order fulfillment rates, decreased lead times, and increased inventory accuracy, ultimately fostering customer contentment. Customers' satisfaction is pivotal as it elevates the likelihood of repeat business and prompts them to recommend the organization to others, thereby driving revenue growth.

Furthermore, embracing a data-driven approach to warehouse management empowers organizations to make informed decisions. Real-time data collection and supply chain visibility facilitate the identification of bottlenecks, anticipating demand, and reasonable resource allocation. In conclusion, the implementation of warehousing solution strategies culminates in augmented operational efficiency, cost savings, improved customer satisfaction, and enhanced decision-making capabilities, all of which positively impact the organizations' bottom line.

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