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POV

Forward-Looking **Technologies Driving Advancement** in Warehousing Operations

01 Complexities and challenges in warehousing operations

Warehousing forms an essential component in supply chain operations. The core value-add of warehousing is to decouple the push and pull forces in supply chains. This means that warehouses store goods at strategic locations and provide access to inventory depending on the demand. This inventory acts as a buffer to the downstream demand and ensures high service levels in the face of uncertainty. To fulfill this value proposition, warehousing operations perform inbound (receiving of goods), storage (put-away and inventorizing of goods), and outbound (dispatch of goods) processes.

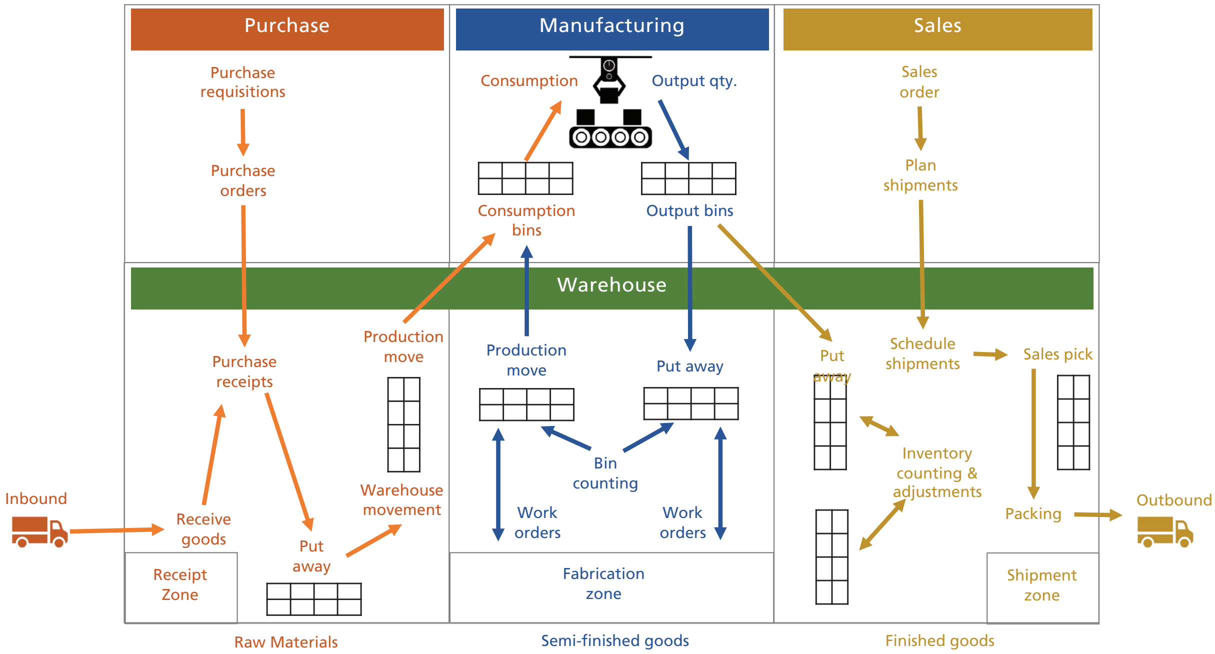

Figure 1: Warehouse processes (level-1)

Warehousing is prevalent in all industries, but its implementations vary widely depending on the industry dynamics, product characteristics, and company strategy. Consequently, practices and technologies used to manage warehousing operations also vary:

Industry	Industry characteristics	Implications to warehousing operations	Warehousing practices
Retail and e-commerce	• Dynamic demand • High volume and variety of products • Small order size • Low order fulfillment time	• High frequency of restocking and movement • Space and flow optimization	• High speed & accuracy in picking, packing, and dispatch
Automotive and after-market	• Large number of components and suppliers • Long supplier lead times	• Complex receiving and dispatch requirement • Engineering quality controls	• Lean and JIT operations
Pharmaceutical	• Highly regulated and quality-controlled • Complex business and operating models	• Ensure product integrity, safety, and tracking • Fulfil regulatory compliance	• Complete visibility at the most granular level • Controlled operating conditions
Agriculture	• High seasonality of produce • Year-round consumption	• Large-scale seasonal storage • Minimum spoilage of bulk commodities	• Specialized equipment and processes for bulk handling and storage

Challenges faced by warehousing operations can be categorized into the following themes:

- **Productivity**

It is the quantity of work done in unit time. The focus is on outcomes, such as the number of orders fulfilled. The management uses KPIs like Units per Man-hour (UPH) to quantify productivity. Lower productivity can lead to problems in workforce planning, storage constraints, delayed fulfillment, or loss of sales.

- **Efficiency**

It means how well the resources are being utilized. Warehouse resources consist of labor, space, equipment, and inventory. The focus is on the process. Management uses KPIs like utilization, unplanned downtime, and turnover to calculate efficiency. Lower efficiency can lead to higher working capital requirements, obsolescence, and write-offs.

- **Visibility**

It is the ability to monitor resources and operations, which is enabled by digital tools and processes. Lack of visibility leads to non-standardized processes and gaps between planning and execution. An integrated technological landscape enables different teams to collaborate on processes and projects.

- **Capital intensive**

The nature of warehousing operations makes it difficult to implement changes. It is impossible to stop these operations and make changes or adopt a trial-and-error approach before making them. Due diligence and adequate analysis must be performed, and all impacts of such changes must be assessed.

02 Forward-looking technologies used in warehousing operations

The challenges presented in the previous section can be addressed through forward-looking technologies and complementary processes. These technologies can be classified into three broad categories based on their intended purpose:

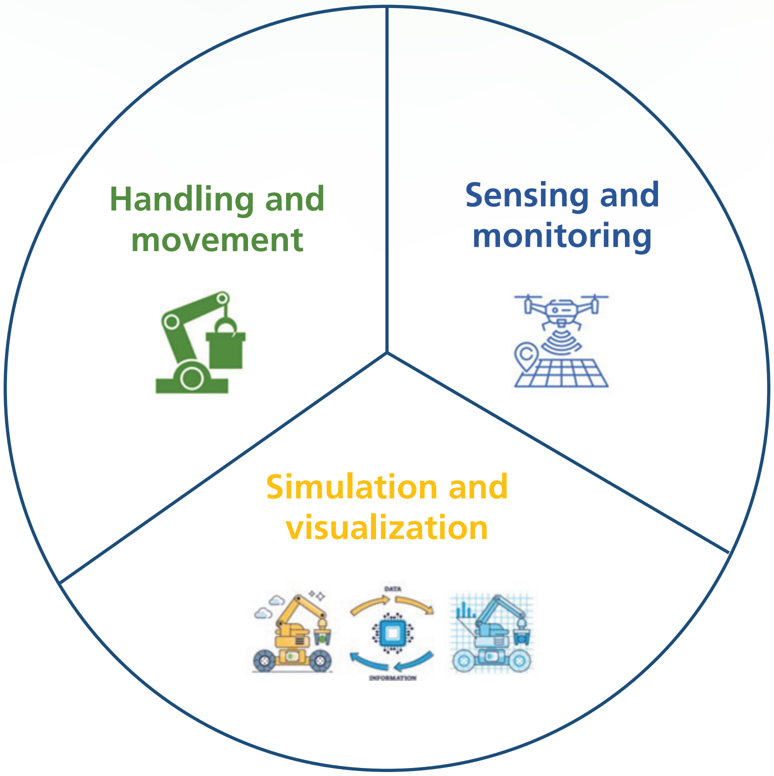

Figure 2: Classification of forward-looking technologies used in warehousing operations

2.1 Handling and movement

Technologies under this category help address the challenges of productivity and efficiency in warehousing operations through handling and movement automation. This automation either increases the speed of execution (e.g., no. of orders picked in unit time), thereby improving productivity or improves resource utilization (e.g., picking accuracy, warehouse walking) and process efficiency. Additionally, these technologies help create a safe working environment by eliminating risky and injury-prone tasks.

There is a plethora of technologies that provide handling and movement automation. Their relative benefits may vary based on the specifics of warehousing implementation, like zoning, layout, flow of goods, and degree of automation. Therefore, the specifics of each use case for automation must be analyzed in detail before any implementation. There are two extremes between which the use cases may be ranked.

Fixed automation

- High speed and accuracy
- Very limited human involvement
- Limited structural and functional change possible post implementation

Agile automation

- Enhances human productivity
- Semi-automated and requires human involvement to complete the process
- Flexible to change structurally and functionally post implementation

Figure 3: Use-case ranking matrix – Warehouse handling and movement automation.

In the use case ranking matrix, the use case of high speed and accuracy is on the extreme left, which focuses solely on productivity and efficiency measures. Such use cases are fit for technologies that provide a higher degree of automation with limited human involvement. Examples of such technologies are automated storage and retrieval systems (ASRS). On the downside, these technologies are capital-intensive and have limited scope for structural and functional changes post-implementation.

On the extreme right is the use case of enhancing human productivity. Automation is performed on a subset of all the activities required to complete a process (e.g., order picking). Therefore, human intervention is needed. Post implementation, these technologies are highly configurable and can be changed structurally and functionally based on the changing nature of requirements. Moreover, these are not as capital-intensive, and their impact can be tested through physical proof-of-concepts. Pick-by-voice is one such example. On the downside, these technologies provide limited automation and, therefore, lesser gains in speed and accuracy.

Structurally, the technologies falling under handling and movement automation can be further categorized as follows:

- **Goods-to-person** – In this form of automation, humans are stationed in one place, and the goods are moved to the humans using automation technology. This increases the speed and accuracy of the process. Examples of such technologies are carousels, conveyor systems, vertical lift systems, automated guided vehicles (AGVs), autonomous mobile robots (AMRs), and autonomous storage and retrieval systems (ASRS). Some of these technologies, like AGVs and AMRs, are more configurable than others, like ASRS.
- **Person-to-goods** – In this case, humans traverse the aisles and bring goods to the system, where the next steps are performed. Humans are assisted by automation technology during this process to perform better. Such technologies include pick-by-voice, pick-by-vision, pick-by-light, and smart carts. While some of these, like pick-by-voice, guide humans in the picking process, others, like smart carts, simultaneously traverse the warehouses, reducing human movement. These technologies are highly configurable to specific use cases. When used together, they can lead to even higher speed and accuracy than a standalone implementation.

2.2 Sensing and monitoring

Technologies under this category address visibility challenges in warehouse operations and resource utilization. These perform sensing and monitoring of materials, assets, and general working conditions within the warehouses. When this capability is paired with advanced analytics, it can also enhance warehouse productivity and efficiency. The use cases vary based on the nature of data being consumed by the analytics engine:

- **Equipment and other assets:** This data can be recorded by IoT sensors installed within the equipment and other warehouse assets. This data can be used to predict the mean time between failures and other failure metrics to inform decision-making toward the maintenance of assets. This can reduce planned downtime and improve asset availability.
- **Inventory monitoring:** This data can be collected from devices that can sense and record physical inventory. For example, RFID-powered drones scan the aisles for a physical inventory count, which could be matched with system inventory. It addresses any discrepancies related to availability and positioning.
- **Smart wearables:** This data is recorded from the smart wearable devices in possession of warehouse workforces. It can analyze labor productivity and availability and how it varies across shifts, work zones, nature of operations, etc. It can also help promote safe working conditions.

- **Video data from warehousing operations:** This data can be accessed from warehouse surveillance technologies. Using advanced analytics, this data can generate heat maps and help understand inefficiencies in the flow of goods.

2.3 Simulation and visualization

Technologies under this category improve visibility into warehouse operations. Additionally, they enable improvements in productivity and efficiency by performing advanced simulations and visual analytics before the capital-intensive changes are implemented in warehouses. Owing to the progressive nature of visualization, these technologies can also be used for workforce training. Two widely used technologies under this category are digital twins and virtual reality. Below is a comparison of these technologies:

	Digital twin	Virtual reality
Data source	Sensor data	Digital objects created by VR software
Latency	Real-time or near real-time	Not real-time, may not be an exact match of the physical space
Visualization	Models a perfect replica of the physical space	Digital objects created by VR software
Nature of usage	Strategic	The model aims for an immersive 3D experience for its users
Use cases	• Plan for demand & supply volatility • Simulate improvements in • Asset productivity • Space utilization • Flow of goods • Impact assessment of new technology or change of layout	Tactical and operational Workforce training • Loading techniques • Packing • Forklifting • Order filling • General safe behavior

03 Conclusion – RoI calculations for forward-looking technologies

These forward-looking technologies require upfront investment and recurring operations and maintenance costs. Any such implementation needs a careful analysis of return on investment and payback periods. This can be calculated by estimating gains in revenue and decline in costs due to such implementations. The levers of such changes will differ by implementation, and the calculations will vary based on assumptions. Therefore, it is important to perform due diligence and careful analysis of future states so that assumptions are as close to actuals as possible.

	Time periods	T=0	T=1	T=2	T=3	T=4	T=5
	Investment	Upfront costs	Recurring costs				
	Returns	-	SUM of Increase in revenue & Decrease in costs				
Lever (L1)							
Increase in revenue	Decrease in stock-outs	-		Est. $$ value			
	Decrease in fulfilment lead time etc…	-		Est. $$ value			
Decrease in costs	Space requirement	-		Est. $$ value			
	Working capital requirement	-		Est. $$ value			
	FTE requirement	-		Est. $$ value			
	Tech requirement	-		Est. $$ value			
	etc…						

Figure 4: Sample return on investment calculations for warehousing technology implementations

About Author

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Prateek Tewari has helped Fortune 500 clients in driving transformation across end-to-end operations value chain. He has experience in CPG, retail, automotive, manufacturing, life sciences, pharmaceuticals, and BFSI industries. Prateek has played various cross-cutting roles like process and analytics SME, product owner/manager and digital consultant.

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