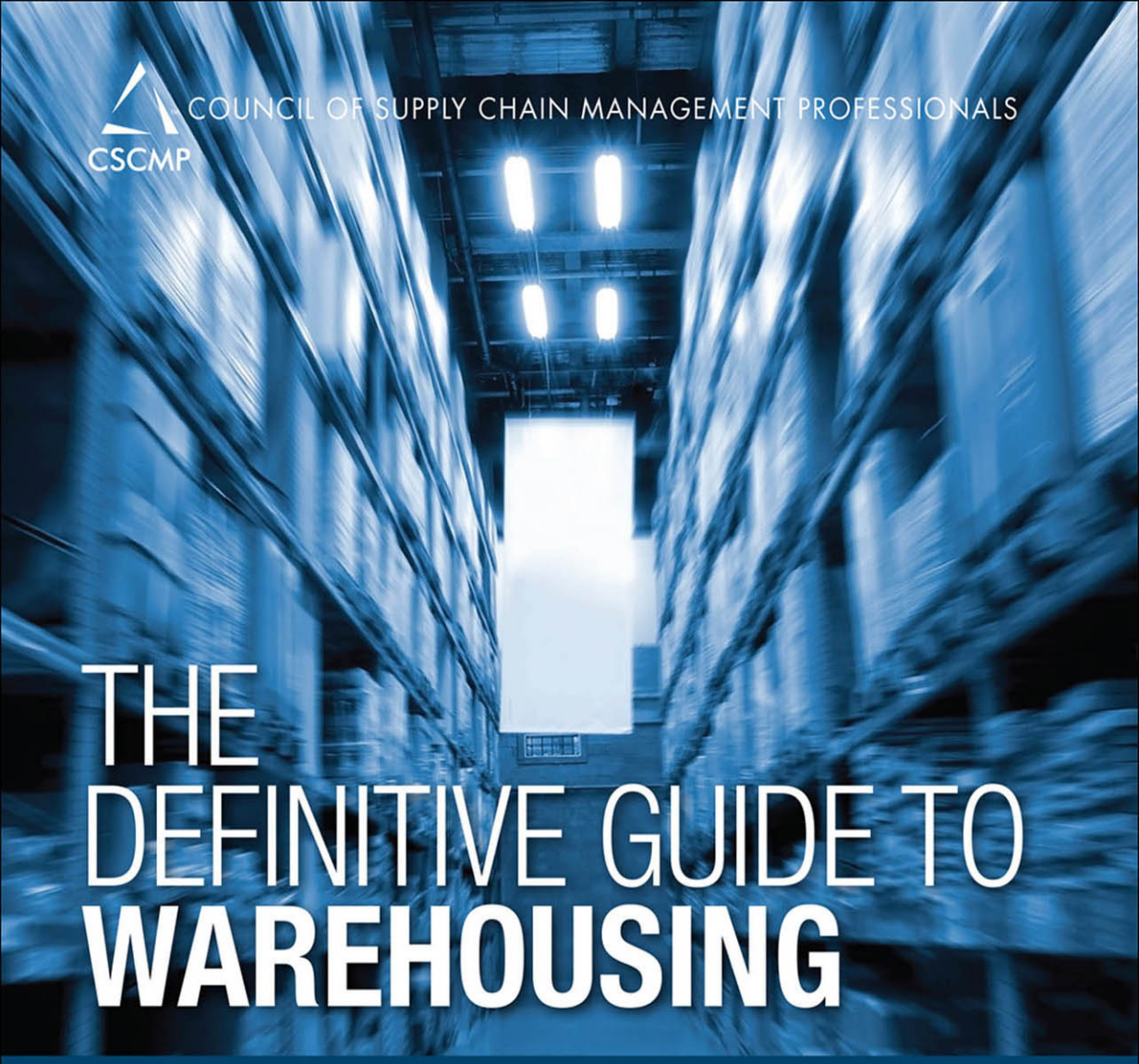


# THE DEFINITIVE GUIDE TO WAREHOUSING

## Managing the Storage and Handling of Materials and Products in the Supply Chain

**Council of Supply Chain Management Professionals** and

**Scott B. Keller** & **Brian C. Keller**

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*Dedicated to Karen C. Keller—Mother, friend, and family logistician.*

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# CONTENTS

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**Brian Keller** became an independent consultant in 2006. In this capacity, he has supported commercial industry companies as well as Government entities including the Office of the Deputy Under Secretary of Defense for Innovation & Technology Transition, the Defense Advanced Research Projects Agency (DARPA), and the Defense Science Board. Previously, Keller was chairman and president of GMA Cover Corporation, a multinational company that designed, manufactured, and supported signature management products including the Ultra Lightweight Camouflage Net System (ULCANS). During Keller's tenure, GMA won the Department of the Army competitive procurement for a $1.7B ULCANS production contract. Prior to GMA, Keller was a vice president for Stewart & Stevenson (now part of BAE) where he was responsible for the Family of Medium Tactical Vehicle (FMTV) A1R program including the successful award of the $4B rebuy production contract. Keller completed a 21-year military career as a logistician, Lieutenant Colonel, and the Army Product Manager for Field Support Systems. He is an alumni of the Harvard Business School, received a Bachelor of Science degree from the United States Military Academy at West Point, an MBA degree from the Florida Institute of Technology, and an MS degree in industrial engineering from the University of Alabama.

# 1

# WAREHOUSING'S ROLE IN THE SUPPLY CHAIN

## Introduction

This chapter explores warehousing's expanded role in customer operations and supply chain management. You learn about historical and current examples of warehouse support to manufacturing, purchasing, and various economies of operations. This chapter discusses competitive supply chain strategies, providing examples of value-added services that warehouses can now provide. With the expansion from a one-dimensional storage repository to a main element of customer supply chains, the warehouse is now expected to contribute to the overall client business objectives and contribute to cost reductions.

## Warehousing's Role in the Supply Chain

Warehousing played a role in the storage and exchange of goods for centuries. Long-term storage to provide product for future consumption has been a utility of warehousing both past and present. Transit sheds, warehouses connected to a wharf, have facilitated the movement and storage of goods embarking or disembarking merchant and military vessels supplying domestic and world trade. Rail transportation set in motion the industrial era with the transport of agriculture commodities and livestock; warehousing was leveraged to store such cargo prior to processing and then distribute finished products traveling to other parts of North America.

Long-term storage and places to interchange products may have been enough utility prior to and during the initial stage of industrial development; however, U.S. involvement in World War II required the manufacturing of products to support military efforts. Increased manufacturing demanded more storage and organization of raw materials and parts, as well as more room for the stockpiling and strategic positioning of completed military products from ammunition and vehicles, to food stores. Figure 1-1 depicts a

high-cube military storage warehouse. Warehousing became more of a strategic function in the chain of supplying the U.S. military and its allies.

**Figure 1-1 High-cube military storage warehouse**

**Army Warehouses in World War II**

During World War II the U.S. Army established supply warehouses in the state of Washington. These depots played critical roles in supplying the war effort in the Pacific. The depots warehoused large quantities of material. The warehouses in Washington delivered goods through the ports to support the war in the Aleutian Islands. They also supported the war in the Pacific by shipping critical equipment and supplies to Hawaii and beyond.

Engineering breakthroughs partially resulting from war efforts were adopted by industry post WW II. Although railroads provided dominance in freight transport prior to the World War II, motor carriers and eventually air carriers would surface as viable competition for freight transportation. Competitive changes, such as these, changed the face of warehousing. Now, a warehouse could receive a single truckload of product rather than a railcar load of product. Dynamics of unloading a tractor-trailer load compared

to unloading a railcar are dramatically different and require differential planning for unloading and storage.

At the same time, developments were achieved in forklift handling equipment. Simple pallet jack capabilities were exceeded by higher reach forklifts enabling operators to build and manage freight in higher vertical storage buildings and reduce the fixed cost of engineering and fabricating the facility.

With the proliferation of computers, information exchange in the late 20th century became a game-changer in the way warehouses collected, transmitted, and utilized data and information within facilities and with warehouse customers. Perhaps computers came about in such good time to enable warehouse operators better control over the increasing variety of products demanded by consumers. Ever since the end of WW II, the United States realized a growing middle class society demanding a greater selection of products that required greater warehouse control. Product variations require greater skill in inventory control over that of managing a single commodity or a few finished goods items. Each unique product type requires a location in the warehouse that it cannot share with a different product type. Moreover, as market expansion spread, so too did the number of warehouses called upon to service the distant markets. Products to satisfy customer regions were dedicated to a specific market warehouse. Consequently, the aggregate inventory total for all market warehouses increased the investment in stock required to compete for market share.

## Traditional Roles of Warehousing

Although supply chains demand greater service value from warehouse operations, the basic economies of manufacturing, purchasing, and transportation must continue to be supported. Cost trade-offs, along with service expectations, must be evaluated to determine the role of the warehouse in supporting the traditional economies of scale.

### *Supporting Functional Economies of Scale*

Wide scope business strategies catering to broad-based clientele require large scale purchasing, production, and distribution. Achieving competitive scale demands operating efficiencies and economies supported by large scale warehousing of supplies and product. Economies of scale in purchasing, production, and transportation have long required warehouse support, and today, need continues for such warehouse support.

#### Role in Supporting Economies of Manufacturing

Long manufacturing runs of single products create efficiencies in production processes, allocation of personnel, and capacity utilization of machinery and equipment. A manufacturer and marketer of a major brand of candy found that it would be financially feasible to

operate a single production line for three flavors of a specific candy. To change from one product to another, the changeover process required that the machinery be completely disassembled, sterilized, and reassembled prior to running the next item on the master production schedule. Three days were required to complete the changeover, and the sterilization was critical because one of the three products included a nut ingredient. Sterilization reduced the threat of cross-contamination of products that could have devastating consequences if consumed by people with severe allergies toward nut products.

Plant supporting warehouses must add value in the supply chain by supporting long manufacturing runs to gain economies of production and reduce changeover needs. Single-item finished products produced in mass quantities must be stored and maintained for future demand.

## Role in Supporting Economies of Purchasing

Materials planners utilize the master production schedule and materials requirements plans to determine ordering needs for each material or component required to meet production plans. Planners and procurement personnel work together to evaluate material needs, lead times for receiving materials, and price-break concessions afforded to buyers for ordering in bulk quantities. All the components influence the need to receive and store materials and components for future production. Specifically, bulk purchase pricing may provide cost-savings per item that when purchased in great enough quantity it more than offsets the cost of storing and maintaining the materials.

Warehouse operators add value for manufactures, assembly operations, and consolidation points by receiving, storing, maintaining, picking, and shipping materials and components to support large volume purchase discounts. The need is further realized as variations in quality and lead times necessitate purchasing added safety stock to protect against such fluctuations.

## Role in Supporting Economies of Transportation

Similar to both manufacturing and purchasing economies, the better a carrier utilizes the full capacity and capability of its transportation equipment, the more efficient and cost-effective products are transported. Transportation cost per unit is reduced as a greater number of units are transported. Fixed costs are spread over the greater product amount being transported, and the variable costs do not necessarily increase one-for-one as another case of product is loaded onto a trailer and transported. Truckload (TL) business models are based on this premise, and truckload (LTL) and package carriers create bulk shipments by consolidating or bundling independent orders destined for a common ZIP code zone.

Costs associated with managing and holding greater levels of inventory in warehouse stock must be compared with the cost of transporting in large quantities to gain economies of transportation associated with reduced unit pricing. In many supply chains the

transportation savings per case or item more than offsets the cost to warehouse additional product. Carriers can more efficiently utilize transportation equipment and offer discounts to shippers for helping carriers fill trailers. Warehouses add value by supporting large volume transportation needs.

## Demand for Contemporary Warehousing

Warehousing has been called upon by corporate to add value to supply chains while continuing to support traditional economies of scale and customer demand. As discussed, large storage warehouses are utilized to stockpile inventory that is produced, purchased, and transported in quantities large enough to gain competitive and cost-effective economies of manufacturing, procurement, and transportation. Such economies cannot be ignored by contemporary warehouse operators; however, additional factors must be considered when designing the strategy of the warehouse plan.

### *Anticipatory Inventory*

Many times products are produced in anticipation of demand and especially items that have a low cost associated with each unit. Brands associated with long historical demand data and with relatively predictable patterns (little unexpected variations in customer ordering quantities) may be prime candidates for producing in anticipation of the forecasted demand. Items with well-established demand patterns, low cost of goods sold, and minimal handling requirements would be kept in stock at levels to meet ordering and service requirements of customers. Although all inventory represents value in terms of dollars, items such as canned vegetables that have relatively steady base demand patterns, strong historical demand data for adjusting forecasts based on other relevant factors, ordered in case and/or pallet quantities, and require little value-added within the warehouse are potential items for anticipatory inventory.

### *Seasonal Stocking*

Red and white, and sometimes varied in colored, candy canes sold and consumed during the December holiday season represent an extreme case of seasonal stock. Manufacturers of the candy begin production and stock piling inventory well before orders are shipped to wholesalers and retailers. Historically, a southern U.S. candy maker would level production of the item by producing candy canes months in advance of demand so that labor and production machinery could more efficiently be utilized. Production strategies like this helped to reduce costs associated with overtime and running equipment near maximum capacity, thereby, risking an equipment breakdown. Producing well in advance of the season also allowed the candy maker to adjust production plans as the season approached. Compared to many other consumer products, candy canes are relatively low in cost per unit, require little handling without the cost of palletizing materials, may be

stacked in high-bay storage, and are less susceptible to theft. As such, warehouse costs are more than offset by the reduction in production and labor costs.

## *Balances Supply with Demand*

It is infeasible to expect all customers to possess the capacity to order and receive full truckloads or even full pallet quantities of single items. Moreover, not all have the capability to store or the equipment to receive in large quantities, be it single items or mixed pallets. Warehouses offer storage to support production economies while also allowing customers the ability to order in lesser quantities and more often. Product assortment is available to customers so that they are not forced to receive and hold large quantities of single items in stock. In addition, warehouses receive products from various producers and offer a single point of interchange with the customer for distributing multiple items from multiple manufacturers. This minimizes the exchange points necessary between producers and their many customers.

## *Protection Against Uncertainty in Demand and Lead Time*

As previously discussed, seasonality may be a factor in the increase of demand for products sold and consumed during holidays or other seasons. Short-term marketing and sales promotions designed to stimulate customer purchases also must be considered in determining future demand while changes in business cycles and product life cycle trends may influence longer-term demand patterns for some products. Various influences on demand must be identified and taken into consideration when planning production; otherwise, left unknown, the factors may create an uncertainty in the quantity and assortment ordered by customers. Manufacturers will have to rush special production and carriers will have to expedite shipments; all adding cost to the supply chain while risking the loss of sales due to a product shortage when customers demand.

Warehouse inventory is compiled in anticipation of forecasted future demand. In addition, safety stock includes inventory on-hand to protect against any unknown influences that stimulate demand beyond the level forecasted. Under such conditions, warehouses are utilized to position and maintain stock in strategic locations where uncertainty exists and forecast accuracy is low.

In a similar manner, carrier on-time transit and delivery may fluctuate due to unforeseen circumstances or in extreme cases on-going poor quality of on-time delivery service. Marketers wanting high levels of in-stock availability will, in this case, hold a level of safety stock above the forecast to meet demand even if carrier deliveries are delayed.

## *Competitive Supply Chain Strategies*

Beyond supporting traditional economies of production, purchasing, and transportation, modern-day warehousing must assist in achieving corporate strategies designed

to compete based on low cost and differentiation through various time-based strategies. Michael Porter, Harvard Business School professor and leading expert on competitive business strategy, and others have long established these as two overarching corporate-level strategies.

## Low-Cost Strategy

Low-cost corporate strategies may require long-term storage of large quantities of product. This was shown to support economies in production, purchasing, and transportation. Warehouses offer intermediate stocking points so that manufacturers do not have to service each individual final customer location. This allows manufacturers to ship in larger quantities to regional facilities servicing multiple end customers. The longest distance from the manufacturer to the regional warehouse utilizes truckload carrier service, thus leaving the shortest final distance for the more costly, yet flexible, LTL services. Overall, the total cost of transportation would be reduced with the help of the location of the regional warehouse (decentralized warehousing).

## Time-Based Strategies

While walking through a warehouse, a customer service manager looked up and said, "Look at all that candy." The accounting manager replied, "Look at all that money!" Twenty-first century supply chains must reduce costs and increase service to maintain competitiveness. Warehouses must do the same, and in ways unlike in the past break the service versus cost trade-off. By designing and adopting time-based strategies, supply chains may reduce inventory in the system and improve service responsiveness for themselves and their clients.

Firms are constantly seeking ways to reduce the lead-time from customer order placement to customer receipt of product and all while reducing levels of inventory in the system. Warehouses must contribute by instituting processes that are flexible and responsive to individual client needs. This may entail a cross-dock strategy, whereby, multiple shipments or items are received into the facility in bulk form and sorted according to final destination consignees. Orders for an individual consignee are then rebulked, loaded on an outbound trailer, and shipped to the destination without ever having been entered into storage.

Cross-docking and other time-based distribution strategies can assist in reducing supply chain system inventory, improving inventory turnover in stocking warehouses, responding better to customer lead-time requirements, adjusting to demand fluctuations, and reducing distribution facility costs. Postponement is another product customization and distribution strategy used to support firm-level, time-based market strategies. Intermediate or final stages of product customization are postponed until actual demand is realized; at which point the product is finalized according to customer specifications. Items are

held in a higher level general state within materials or finished goods warehouse inventory until orders are received from customers.

## *Interface Between Supply Chain Partners*

Warehouses occupy strategic positions between suppliers and customers. Oftentimes, warehouse operators are the last personnel to see and touch products before final delivery. As such, they are the final entity to inspect product quality, condition, and count, and verify documentation accuracy. During any time of receipt, putaway, storage, picking, or loading products are vulnerable to cost increases. It is the efficiency, accuracy, and overall customer orientation of the warehouse operator that ultimately influences final customer perception and reality of quality and cost.

Managers of warehouses and their employees, alike, must interface with clients and customers of clients. Therefore, warehouses must be seen and managed as supply chain partners. Their impact can mean the success or failure of supply chain relationships between marketers and the ultimate customers.

## *Critical Customer Service Role of Warehousing*

For an order fulfillment center, customer service's role in order processing encompasses receiving the completed order form via an electronic or a paper device. On-hand inventory is checked to verify that the amount of stock requested on the order is in the warehouse and available to fill that specific customer's order. Stock availability, thereby, becomes a critical component of customer service that is influenced by the warehouse/order fulfillment center. Figure 1-2 illustrates warehouse racks consisting of multiple stock-keeping units with a majority of the slot locations having less-than-pallet quantities of product. Varied products and reduced inventory levels create challenges for warehouse operators to hold the correct amount of each product to satisfy customer demand.

When a stockout occurs and the item is not available in inventory when ordered, a customer must wait for the product to be replenished or authorize a substitute product to replace the original item ordered. Substituting a case of cherry breakfast pastries for a case of blueberry that was originally ordered may be of little consequence to the customer. (This is an assumption to make the point.) However, some products may not have suitable substitutes and a stockout could influence the customer to source from a competing supplier one time or for all future orders. Warehouses are often measured on stockout frequency or the related fill rate percentage of cases ordered (case fill rate = cases shipped / total cases ordered). This too impacts the ratio of orders shipped complete compared to total number of orders also known as order fill rate.

**Figure 1-2 Storage of varied stock-keeping-units (SKUs) in varied quantities**

Frontline warehouse operations also influence the condition of the product upon shipping. Damaged product arriving at a customer's facility may be denied and the bill of lading or delivery receipt adjusted at the receiving dock and the invoice cut or a claim initiated to recover the value of cases damaged. Percentage of damaged cases can be tracked over time to indicate severity and frequency of the problem. The number and type of a claim can be recorded and evaluated to identify potential issues and trends pertaining to specific items, customers, or warehouse order picking personnel.

Overages, shortages, and damages (OS&D) cause issues that oftentimes adversely impact multiple partners within the supply chain. Take for instance an issue discovered by the customer service director for a warehouse that managed the southeastern U.S. product distribution for multiple manufacturers of major national household brands of consumable products. In an effort to improve the standing of the warehouse in the eyes of customers, the customer service director began conducting field visits to the receiving docks of customers. When walking into a small wholesaler, the director was greeted by an angry and frustrated owner. The owner showed the director a closet filled with empty boxes that he claimed arrived empty and concealed within the interior cases on pallets. The director and owner set out to discover the root cause of the concealed, empty cases. Assuming the pallets were full pallets of single items, it could be that the cases were empty when they were palletized at the end of the production line. A second possibility is that the cases were emptied by warehouse or carrier personnel anywhere along the distribution channel.

At the end of the supply chain, the wholesaler's receiving personnel came in early mornings to break down pallets of product that were delivered during the night to a secured fenced area of the receiving dock. After careful investigation, it was determined that the wholesaler's personnel were breaking down the pallets, emptying and taking the product out of some of the boxes, and then reconfiguring the cases on the pallets where the empty cases would be concealed among the full cases. The owner would come in an hour later to find the issue and naturally assumed the shipping warehouse or carrier was at fault.

Two more critical service factors influenced by warehouses include the lead time required to process and ship an order from the time the order is received and the consistency of that lead time. Greater lead-time requires added inventory in the system to fulfill orders during the time orders are processed. This refers to cycle stock. Moreover, as lead-times fluctuate additional units of inventory are necessary to satisfy customer demand during times when the lead-time increases. Safety stock is necessary to protect against such fluctuations in lead-times caused by inefficiencies in warehouse processes.

Today's supply chains more often require flexible processes and partners. By working closely together to communicate alterations in demand and service needs, warehouse clients and operators can formulate the best circumstances for building flexibility in the warehousing and distribution system.

## *Light Manufacturing and Assembly*

Partners subscribing to the supply chain concept continuously search for more efficient and economical means to reduce supply chain costs. Here is where warehouses can add value beyond tradition. For example, a third-party warehouse (neither the manufacturer nor the customer) was storing wiring harnesses for a major automobile assembly plant. A plant in Mexico's Maquiladora region along the U.S. Texas border performed the laborious task of running and securing the many wires along each harness. To increase the value that the warehouse provided its customer, the warehouse operator drafted a proposal to perform the wiring of harnesses in the warehouse that is more strategically situated nearer the U.S. automotive assembly plant. The warehouse reduced the cost of the light manufacturing of the harnesses while also reducing the cost associated with the transportation and transit time required from the Mexican plant. Figure 1-3 illustrates a warehouse operation adding value by assembling tires to wheels that are then shipped just-in-time to the production line for final assembly on automobiles.

Oftentimes, certain light manufacturing or assembly activities can be more efficiently and effectively conducted within a warehouse instead of within a complex manufacturing plant. Under such circumstances, forward-thinking warehouse operators can add value in the supply chain by removing some of the manufacturing burden from the plant. This is especially beneficial given the warehouse has the capability to perform such processes to a level of expected quality and lead time all while reducing the cost to do so.

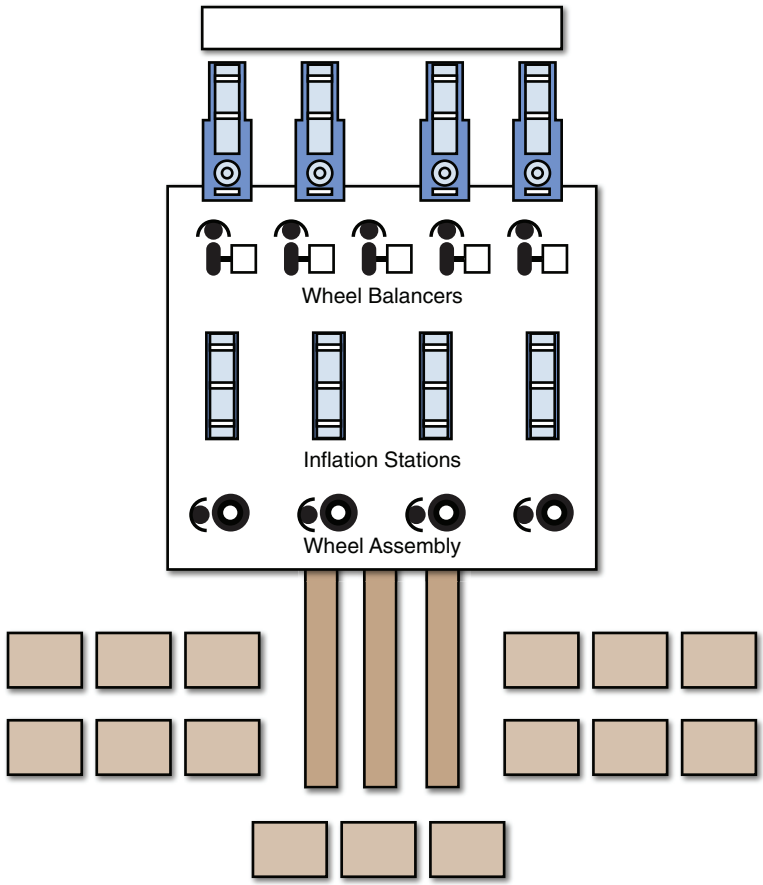


**Figure 1-3 Warehouse value-added tire and wheel assembly**

## Summary of Key Points

Warehousing's role in the supply chain has become more critical and at an escalating rate during the past two decades. Responsibilities of warehouse operators have evolved from maintaining long-term storage of materials and products to supporting economies of purchasing, production, and transportation to including light manufacturing and facilitating time-based supply chain strategies.

Warehouse operations contribute to the overall total cost of managing a supply chain, and as such, the trade-offs between warehousing costs and services to that of other critical functions of the firm must be evaluated. It is when warehousing contributes to reduced costs and improved service, flexibility, and responsiveness that warehouses become more valued to the organization and supply chain as a whole.

Value is provided through

- Storing product to fulfill customer demand and protect against uncertainties in demand and lead-time
- Providing customers with product assortment
- Postponing or delaying inventory commitment to form or location until demand is better known
- Achieving low total cost and improved lead-time through consolidating multiple orders
- Reducing lead-time through cross-docking
- Sequencing materials and components from multiple third-party logistics (3PLs) providers for time-based delivery to factory production lines
- Performing light manufacturing, assembly, and kitting

Most important, warehouses impact the receiving customer in many critical ways. Front-line warehouse personnel may be the final customer service defense in ensuring product accuracy, quantity, timing of shipment and delivery, accuracy of documentation, and overall product condition—all of which impact total cost and customer perception of the brand.

## Key Terms

- Anticipatory Inventory
- Bill of Lading
- Cost of Goods Sold
- Cross-Docking
- Cycle Stock
- Demand Patterns
- Distribution Channels
- Economies of Scale
- Fill Rate
- Fixed Cost
- Lead Time
- Less-Than-Truckload (LTL)

- Mixed Pallets
- Overages/Shortages Damages (OS/D)
- Putaway
- Supply Chain
- Supply Chain Management
- Third-Party Logistics (3PL)
- Variable Cost

## Suggested Readings

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# Index

## Symbols



## A

## B



## C

## D



## E

## F

## G



## H



## I

## J



## K



## L

## M

## N



## O

## P

## Q



## R

## S

## T

## U



## V

## W

## Z