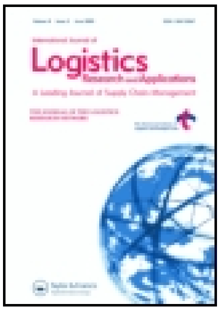

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Effective Cross Docking for Improving Distribution Efficiencies

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ABSTRACT *Cross docking is a warehousing strategy that involves movement of material directly from the receiving dock to the shipping dock with a minimum dwell time in between. Cross docking can effectively bring substantial reductions in the transportation cost without increasing the inventories while simultaneously maintaining the level of customer service. Cross docking can also lead to the reduction of order cycle time, thereby improving the flexibility and responsiveness of the distribution network. This paper provides a framework for understanding and designing cross docking systems and discusses techniques that can improve the overall efficiencies of the logistics and distribution operation.*

What is cross docking?

Having achieved significant improvements in their manufacturing operations, many companies are now focusing their efforts on improving the efficiency of their logistics and distribution operations. With increased product proliferation, the average demand for the individual product is becoming smaller and yet the variability in individual demand is increasing. Moreover, logistics costs now account for more than 30% of the sales dollar (Ballou, 1999). This has made the task of managing the supply and distribution network very challenging and critical indeed. One innovative warehousing strategy that has great potential for controlling the logistics and distribution costs while simultaneously maintaining the level of customer service is cross docking.

Cross docking involves the movement of material directly from the receiving dock to the shipping dock with a minimum dwell time in between. Although it is not a new concept, it is gaining favour as a wide range of practices, including just-in-time manufacturing, electronic data interchange

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and advanced drop ship techniques, exert influence on the logistics process (McEvoy, 1997; Ross, 1997; Schwind, 1995, 1996; White, 1998).

Cross docking (also called flow-through distribution) is the process of moving product through distribution centres without storing it. In a traditional warehouse, the product moves from receiving to storage to shipping processes. With cross docking, the product moves from receiving to shipping with little or no storage of product at the warehouse. The key to cross docking success is to have as short a dwell period as possible in the receiving/shipping facility. The shorter the period, the smaller the storage buffer needed. As volumes go up or when shipments are uncoordinated, storage buffer can increase, and it is in these cases that cross docking must be managed effectively. The material handling operations of receiving, redistributing and shipping represent the physical flow of product. Associated with this physical flow is the flow of information concerning the cross docked product. With increased volumes and product variety, the management of information flow has also become a critical factor in the success of cross docking operation.

Economies in transportation costs are mainly realised in cross docking by transporting goods through the distribution channel in full truck loads (FTLs). Traditionally, use of FTL shipments increases the level of average inventory in the distribution channel. But in cross docking, significant reductions in transportation costs are achieved without increasing the average inventory levels and at the same time providing a high level of customer service. In fact, in many cases, the level of inventory held at the warehouse is reduced under cross docking, which in turn leads to a reduced inventory holding cost. Cross docking also has other benefits, such as reduction of order cycle time, which helps improve the flexibility and responsiveness of the distribution network. These benefits of cross docking can only be achieved by: (1) effective handling of physical flow of goods; (2) effective deployment of advanced information technology to manage the flow of information; (3) effective use of FTL shipments; and (4) effective use of proper planning and management tools.

Package delivery services, such as Federal Express, the United Postal Services, and the US Postal Service provide prototypical examples of the cutting edge in cross docking. At package delivery companies, everything they receive from the shipper is sorted and shipped out to the receiver as soon as possible. Thus, hardly any inventory is held in the system, and no provision is made to store it. The incoming items are kept on the move all the time, and often the incoming items are sorted and turned around in just a few hours.

Today, cross docking is practised within both manufacturing and retailing companies. One manufacturer that practises cross docking is American Home Foods of Milton, Pennsylvania, which produces Chef Boyardee and other brands of pasta products (Schwind, 1996). Another company that has been very successful in using cross docking is Wal-Mart (Stalk *et al.*, 1992). Wal-Mart uses a Hub and Spoke network to distribute its products to its retail outlets. Items from vendors arrive at a distribution centre (DC) as FTL shipments. At the DC, the FTL shipments from various suppliers are broken up and consolidated again to create FTL shipments that go to the various retail outlets. The items stay in the DC for very little time and ideally move directly from the inbound dock to the outbound dock. Cross docking has helped Wal-Mart reduce its costs and has enabled the introduction of an every-day low price (EDLP) strategy. This has helped Wal-Mart improve its market share and profitability (Stalk *et al*., 1992). Office Depot is another major user of cross docking strategy (Ross, 1997). Over the past 6 years, Office Depot has expanded the retail portion of its cross docking programme to involve more than 400 vendors and 55% of its stock keeping units (SKUs), representing 75% of dollar volume.

In this paper, we provide a framework for understanding and designing cross docking systems and discuss techniques that can improve the overall efficiencies of the logistics and distribution operations. The framework and the techniques discussed in the paper were developed and synthesised based on a thorough review of the literature and a study and review of current warehousing practices through several field visits.

Network Structures Used for Warehousing

Traditionally, the main goals of warehousing have been: (1) to improve customer service by having available the inventory of products close to the customer; and (2) to obtain economies in transportation cost by using lower cost FTL shipments. Transportation economies have been obtained by using: a warehouse as a consolidation point; a break-bulk centre; or a mixed warehouse (Ballou, 1999).

In a *consolidation warehouse*, input materials sourced from several vendors are transported in less than full truck load (LTL) shipments to the consolidation warehouse. The consolidation warehouse is normally located close to the input sources; therefore, the cost of the LTL shipments is kept low. From the consolidation warehouse, the items are transported in bulk by FTL shipments to the ultimate destination, which is usually located far away. The consolidation warehouse thus helps in consolidating several small LTL shipments into a single or a few FTL shipments (Figure 1).

A *break-bulk warehouse* reverses the logic of a consolidation warehouse in the sense that the bulk shipment, received typically in FTL quantity from a distant vendor, is broken into smaller lots at the break-bulk warehouse. These lots are then sent as LTL shipments to smaller retail outlets or customers located nearby (Figure 2).

In a *mixed warehouse*, input shipments from several vendors arrive as FTL shipments to the warehouse. Shipments are broken up and then consolidated again to create several multi-product FTL shipments. Each of these multi-product FTL shipments goes as direct delivery to one of the several retailers/customers. A mixed warehouse thus combines the approaches of both consolidation and break-bulk warehouses (Figure 3).

In a traditional warehouse operation involving either the consolidation, break-bulk or mixed warehouse architecture, the products typically spend several days, if not several weeks, at the warehouse before being shipped out again. It is also customary for the items to enter in the warehouse inventory records, and to undergo relabelling before being shipped out again.

A cross docking warehouse is conceptually similar to the traditional

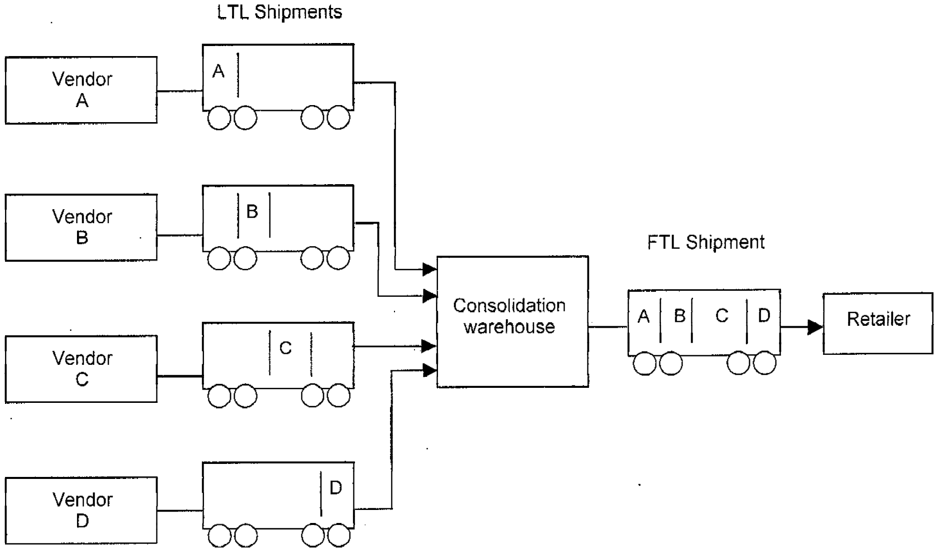

FIGURE 1. Network Structure for a Consolidation Warehouse (Adapted from Ballou, 1999).

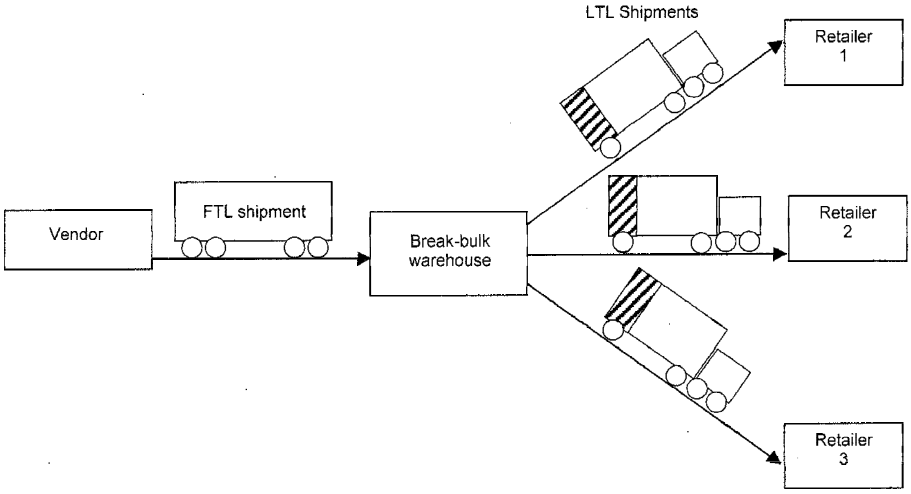

FIGURE 2. Network Structure for a Break-bulk Warehouse (Adapted from Ballou, 1999).

mixed warehouse. The primary difference is that products flow through the warehouse quickly and do not stay as inventories. A commonly held view is that there is a continuum of cross docking from "pure" to "short warehouse time". In a pure cross docking warehouse, the items do not even enter inventory records in the warehouse management system, and all the unit labelling and packing activities are already completed before the item enters the warehouse. How short the "warehouse time" should be for the process to be called cross docking is a moot point. While in practice, products never stay in a cross docking warehouse for more than 18–24 hours, this need

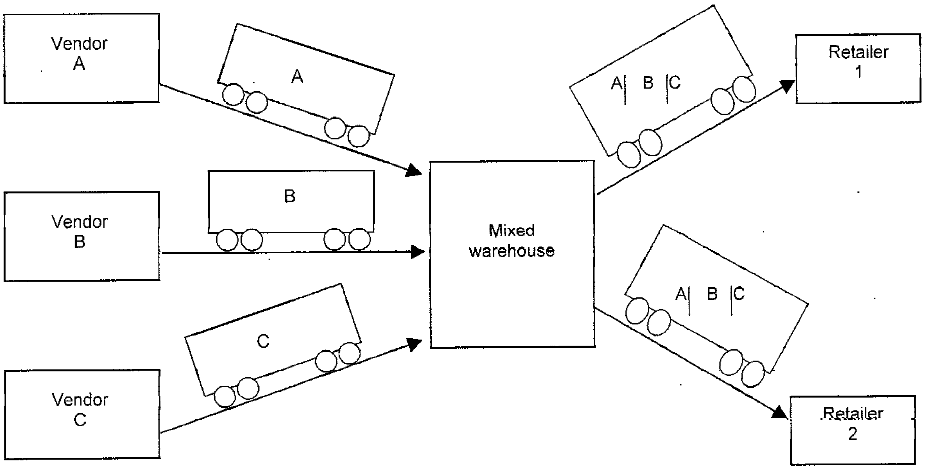

FIGURE 3. Network Structure for Mixed Warehouse (Adapted from Ballou, 1999).

not be always true. The key feature in cross docking is that the items are never put away in the storage or order picking shelves. They move directly from the inbound to outbound dock. Depending on the processes and technology in place, one could theoretically have a cross docking warehouse where the items stay in the warehouse for a longer period. Some of the differences between the traditional mixed warehouse and a cross docking warehouse are shown in Table 1.

Cross docking can also be used to provide specialisation in the warehouse handling function. Items such as clothing and other soft line items may require different handling compared to dry groceries. A warehouse that handles a specialised item such as clothing may perform certain pre-processing tasks such as packaging and labelling to make the merchandise floor-ready for the retail outlet. The shipments from such a specialised warehouse to retail outlets might not be large enough to justify FTL shipments. In such a situation, the shipments from the specialised warehouse can be sent through a cross docking warehouse to take advantage of consolidation. Thus, the specialised warehouses take advantage of the benefits of focused operations on specific types of items; at the same time, the cross docking warehouse ensures that benefits of transportation economies are realised while keeping the inventory levels low and service levels high.

Most warehouses that use cross docking do not operate as a pure cross docking warehouse. Rather, they operate as hybrid warehouses, where cross docking is used for some items and traditional warehousing and distribution strategies are used for other items for which larger inventories are kept to ensure good customer service and low lost sales. Most warehouses do not use cross docking as an exclusive strategy. Rather, cross docking strategy is used in combination with the traditional modes of warehousing and distribution. For example, at Wal-Mart cross docking is practised for big ticket shopping goods and specialty items such as apparel that are pre-processed to make them floor-ready in a warehouse specialised for that task. In addition,

TABLE 1. Key Differences Between the Traditional Mixed Warehouse and the Cross Docking Warehouse

Traditional Mixed Warehouse	Cross Docking Warehouse
Items are put away to storage or order picking areas and reside in the warehouse for at least more than a day	Items typically flow in and out the through the warehouse in a single day without being put away to storage or order picking areas
Items enter the inventory records in the warehouse system	Items need not enter the inventory records in the warehouse
Relabelling and packaging activity may be carried out in the warehouse	May function without any relabelling or repackaging

		Product demand rate	
		Stable and constant	Unstable or Fluctuating
Unit stock-out costs	High	Cross docking can be implemented with proper systems and planning	Traditional warehousing/ distribution preferred
	Low	Cross docking preferred	Cross docking can be implemented with proper systems and planning

FIGURE 4. Guidelines for the Use of Cross Docking.

a few weeks worth of inventory is maintained for fast moving staple goods, since higher level of stock availability are required for these items to minimise lost sales.

For cross docking to work properly, the items that come into the warehouse should be demanded or pulled out by the retailers or destination points quickly. The demand rates of the items are therefore very critical in daily planning of the cross docking. If there is imbalance between the incoming load and the outgoing load, cross docking will not work well. Hence, items that are more suitable for cross docking are the ones that have demand rates that are fairly stable and constant. Apart from more commonly used grocery items, regularly consumed perishable food items and chilled goods would also fall into this category. For perishable items and chilled goods, the demand rate tends to be stable since the customers cannot buy and store large quantities, and therefore have to make regular repeat purchases. The warehousing and transportation requirements of products with stable demand are much more predictable, and consequently the planning and implementation of cross docking become relatively easier for these products. Such products also require less safety stocks at both the retail and the distribution centre levels. Another factor of importance that influences the decision to use cross docking is the level of unit stock-out cost or the cost of lost sale on a single unit of product. Cross docking inherently leads to a minimal level of inventory at the warehouse, and thereby strips the system of safety stocks traditionally held at the warehouse. Consequently, cross docking raises the probability of stock-out situations. However, if the unit stock-out cost is low, cross docking can still be the preferred strategy, since the benefits of reduced transportation cost under cross docking can outweigh the increased stock-out cost. As shown in Figure 4, cross docking is therefore preferred for products with stable and constant demand rate and low unit stock-out cost. On the other hand, for products with unstable or fluctuating demand and high unit stock-out cost, the traditional warehousing and distribution strategies are still preferable. When the demand rate is constant but unit stock-out cost is high, cross docking can still be implemented, but more precise planning systems are required to ensure that instances of stock-outs/lost sales are kept to a minimum. Similarly, when product demand is fluctuating but unit stock-out cost is low, cross docking can still be implemented with proper systems and planning tools to keep instances of stock-outs and the associated stock-out cost to a reasonable level.

Other factors that can influence the suitability of cross docking include the distance of the warehouse from other points in the distribution channel, the service requirements for the product and the density of business in the region. The technology and systems used in cross docking can be quite expensive. Therefore, apart from stable demand, the total volume handled by the warehouse for the region should result in scale economies and should also be stable across time. When the warehouse is located close to several demand points or retailers, then scale economies and stability of demand are easier to achieve. The service requirement for the product essentially impacts the stock- out cost or lost sale. Generally, high service requirements imply greater fluctuations in demand, and therefore make it more difficult to operate the cross docking facility.

Design of Physical and Information Flows in Cross Docking

Efficient cross docking requires well-equipped and well-designed docks. Cross docking starts when trucks arrive with incoming goods and ends when the cross docked goods are loaded on to outbound trucks. Receiving, redistributing and shipping of product constitute the majority of the physical handling operations in docks. Success in moving the product through the system depends on both equipment and manpower. Hence, the selection and management of equipment and manpower are critical to the success of the cross docking operation.

The layout and design of receiving and shipping docks are also major factors for any cross docking system. The smoothness of the process for truck arrival, loading and unloading, and departure can greatly influence the success of cross docking. Efficient receiving and redistribution of products in creating outbound loads within the warehouse with a minimal dwell time is the other important factor behind the success of cross docking.

As discussed earlier, cross docking is essentially similar to the traditional mixed warehouse, where both consolidation and break-bulk operations are carried out together. However, it is important to manage the flow of information as adeptly as the flow of goods. Each carton or pallet from an incoming truck must be accurately identified at receipt, allocated instantaneously to a purchase order and then routed to an appropriate outbound door for delivery. The information technology tools and practices that are critically important for cross docking include electronic data interchange, shipping container marking, bar-coding and scanning of products, etc. along with sophisticated computerised analysis and planning tools.

Accurate and timely information is critical for effective management of the cross docking warehouse. Proper flow of information enables improvement of logistics planning and optimisation of transportation and inventory costs. Timely and accurate information is also essential for reducing the order cycle time and for improving the flexibility and responsiveness of the supply chain network.

The information elements concerning the cross docked products include its identity, the level and pattern of its demand, configuration and mode of its shipment, the way it is marked and identified, the location of the interim warehouse where the product is to be moved when unloaded, the manner in which it is to be handled and its final destination. The information systems and planning tools should be designed to manage and speed the flow of this product information.

Information technology is not a prerequisite for implementing cross docking. For instance, full pallets and pre-sorted pallets may be cross docked with minimal visual control and without any elaborate systems or procedures. Also, when the number of items and number of outbound destinations handled by the warehouse are low, simple manual procedures are sufficient to implement cross docking. However, for large throughput rates and for cross docking of small packages and cases, information technology along with proper systems and procedures are essential. The information technologies used in cross docking, as in supply chain management, include electronic data interchange (EDI), shipping container marking (SCM), bar-coding of products using universal product code (UPC) and scanning of bar-coded products to record sales to customers at the point of sales (POS) (Apte & Viswanathan, 1998).

EDI is the technology by which information on purchase orders, invoices, advance shipment notices and other commercial transactions such as customs clearances, etc. is transmitted electronically over a computer network. One could argue that communication over phone or fax is also a type of EDI; however, to take full advantage of EDI, computer applications that support business transactions and that are EDI capable must be present at both buyer and seller organisations. Also, the transactions must be communicated in a standard format that is recognised by the hardware and software applications at both organisations. Therefore, industry standards must be used in the EDI communications. Moreover, the downstream business applications that use the information obtained through the EDI, such as the Warehouse Management Systems and Logistics Management Systems, should be designed so that data can be ported through these applications without manual re-entry of the data. EDI facilitates reducing ordering costs by eliminating the clerical effort, and reducing the lead-time for orders by speeding up the transmission of accurate information in the order processing cycle.

Communication using EDI is proving to be highly useful in cross docking. Use of EDI between the customer, vendor, or manufacturer helps the shipment originator to plan and assemble loads of product and ship it to the customer. The warehouse in-between has access to this information and it can now plan how to handle in-transit and incoming goods. Basically, this is the information on which cross docking is based. When the doors of incoming trucks are opened, there remain no surprises. The destination of the incoming goods is already known and hence the redistribution operations and dock assignments and truck fleet operation can be suitably planned.

Bar-coding is a system in which each product is assigned a unique UPC that is marked outside on the product packaging through lines and markings. An optical scanner can read the linear bar codes and retrieve the associated information from a database to identify the item automatically. The advantage of this system is that the product identification can be done instantaneously in an accurate, timely and efficient manner. Use of bar codes or SCM for bulk packaging, which itself contains individually bar coded packages, facilitates efficient updating of inventory data, and management of warehouse and transportation activities. SCM on bulk packaging proves instrumental in automating the material handling operation in cross docking wherein a scanner can be used to sort and direct unit loads/product packages to suitable docks for outbound shipments.

Even if a truckload is expected and listed on a manifest, everything in the load must be identified for accurate and efficient receiving, redistribution and shipping operation. Bar-code scanners and packages marked with SCM provide automatic identification of all items in the load. If the incoming load is to be broken up and sorted into customer orders, labels can be produced at this time and attached to each item. The labels of any variety, style or size, including customised customer labels, can be used as necessary. Automatic identification using SCM further helps to control items in the warehouse as they pass through conveying and sorting systems.

Analysis and Management Systems for Cross Docking

Cross docking alternatives can be evaluated and the success of a system predicted through the use of *simulation* techniques. Simulation provides an understanding of the behaviour of complex systems and allows testing of new designs. Using a computer to perform “what if” analysis gives system designers and managers an opportunity to determine if the new system is going to work as envisioned, and to evaluate the impact of any system change. The basic information needed to simulate a system includes the equipment layout and specifications, product flow rates, receiving and shipping schedules, and the dimensions of the products being moved. Flow charts and alternative product routing are also needed. Finally, the capabilities of the warehouse management system and distribution requirements planning software, if being used, must also be incorporated in the simulated system.

Simulation can produce data on utilisation of labour, equipment and storage space, throughput rates, cycle time, etc. Computer animation can be used further to provide a visual model of the existing system operation that can be easily communicated and understood.

Great strides have recently been made in *warehouse management systems* (WMSs) software that can control almost every aspect of warehouse operations. Many of the programs that track inventory and direct order filling can also be used to manage people and machines. Most new software is modular or user configurable so that the software can adapt to changing situations.

Software for *transportation management systems* (TMSs) enables the effective and efficient management of the transportation fleet used in the distribution network. The TMS software is used for fleet planning, truck scheduling and planning of vehicle routes used for deliveries. The WMS and TMS software can be used to develop strategies that can minimise the costs related to warehousing and transportation.

Other Strategies for Improving Channel Efficiencies

Cross docking is only one of the several strategies that need to be implemented to enhance distribution efficiencies. Just implementing cross docking alone without paying attention to other innovative strategies will result in failure. The successful implementation of cross docking requires implementing other related innovations. For example, Wal-Mart (Stalk *et al.*, 1992) developed several other capabilities (such as good retail location, every-day low pricing, cost-effective sourcing of items and quick response systems) to enhance its competitive capabilities. Other innovations such as postponement (Feitzinger & Lee, 1997), mass customisation (Pine, 1993), distribution channel partnerships (Buzzell & Ortmeyer, 1995), efficient consumer response (Knill, 1997; Kurt Salmon Associates, 1993), vendor-managed inventory, quick response systems (Apte *et al.*, 1997; Frazier, 1986; Hammond & Kelly, 1991; Apte *et al*. 1997) and use of third- party logistics providers (Sheffi, 1990) should be implemented simultaneously to have maximum impact on channel efficiency. Apte & Viswanathan (1998) provide a survey of all the strategic and technological innovations that can be used to enhance supply chain performance.

Summary and Conclusions

Cross docking is simply the direct flow of goods from the receiving area to the shipping area in the warehouse, with a minimum dwell time and as little handling and storage in- between as possible. It is essentially similar to the concept of mixed warehouse that combines break-bulk and consolidation and has been practised in traditional distribution systems. The key difference between a mixed warehouse and a cross docking warehouse is that in the cross docking facility, materials stay in the warehouse as inventory for very little time.

Cross docking uses FTL shipments whenever possible to enable the optimisation of transportation costs while simultaneously optimising on the inventory holding costs. Cross docking also helps to reduce the order cycle time and thereby improves the responsiveness and flexibility of the distribution system.

Cross docking is as much an information handling system as it is a material handling system. Cross docking depends heavily on the use of information technology tools and sophisticated planning software to coordinate the physical product flows and information flows. Physical product flows can be improved through proper selection and management of manpower and equipment; especially the automated material handling technologies such as conveyor systems, and product identification and sorting systems that direct the product flows. Information flows are enhanced by technologies such as EDI, SCM, bar-coding with UPC and bar-code readers.

Cross docking can ideally be implemented for products that enjoy a steady and stable demand rate and a low unit stock-out cost.

As manufacturing, distribution centres and processing terminals expand, and as purchasing and delivery requirements change, cross docking is likely to become more widely adopted by manufacturers and distributors. All companies that warehouse goods will probably use some form of it. A danger that must be accounted for is the possibility that if cross docking is misapplied, the process may slow material movement, increase inventory and adversely affect the distribution efficiencies. However, if wisely applied within the overall philosophy of continuous improvement, cross docking can be a dramatic cost saver and an effective weapon in time-based competitive strategies.

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