IMPROVING ORDER-PICKING THROUGHPUT IN A WAREHOUSING/DISTRIBUTION CENTER

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Abstract

This paper reflects the result of a research project conducted on behalf of a mail-order and internet marketing distributor of dietary supplements [1] [5]. The main objective of the project was to develop proposals to improve order-picking processes in a warehousing and distribution center. This project entailed not only researching available systems to increase order-picking throughput, but also improvement to processes such as the placement of inventory, the operator interface with the system, and the information flow. Study and analysis of alternative technologies led to the development of a proposal which included the addition of a horizontal carousel system as well as the integration of a zone bypass system into the existing pick-to-light (PTL) system. The main focus of this paper is the impact of the proposed systems on the order-picking throughput and operating expenses. Also included are summaries of the alternative systems and a brief outline of proposed changes to the PTL inventory placement and order release filtering processes to balance the order-picking workload.

Introduction

Traditional warehouse functions include receiving, storing products, replenishing, order-picking, packing, and shipping. Over the years, more complex functions such as cross-docking, cycle-counting, and kitting have been added to the list of warehouse functions [13] [15]. To stay competitive in today's market, continuous efforts to improve all of these functions are important, but order-picking deserves the most scrutiny because it accounts for a large percentage of warehousing/distribution operating expenses. A prerequisite to the design of an effective order-picking system requires a thorough understanding of its key ingredients and an understanding of systems and technologies available to help with its requirements.

Saenz [13] identifies the following as the key ingredients to designing an effective order-picking operation:

1. Activity profiling. Fast-moving vs. slow-moving products and cube velocity. Cube velocity is calculated by multiplying the quantity picked per item by the product's cubic dimensions.
2. Picking equipment/technology. Product activity, cube velocity, and product variety need to be identified to help with the selection of storage and picking equipment.
3. Slotting strategy. Assigning a product to a location.
4. Replenishing forward pick. Replenishing picking locations when the pick-location inventory reaches a predefined level.
5. Layout/pick-zone design. An effective layout that minimizes handling, maximizes space utilization, and reduces backtracking.
6. Picking methods. Defined in terms of: pickers per order - the number of pickers that work on a single order at one time; lines per pick - the number of orders a single item is picked for at one time; and periods per shift - the frequency of order scheduling during one shift.
7. Material handling. The physical characteristics of the product and cube velocity also impact the material handling equipment used.

Jaecques [8] outlines the increased need for productivity improvements in distribution centers and how some of the current technologies can help with improved order-picking. Dallari, Marchet, and Melacini [4] share their study on the development of a methodology to support warehouse designers in choosing the most suitable order-picking system. A number of other studies offered examples of specific order-picking technologies and case studies [2] [3] [9] [6] [11] [12] [16] which also proved to be helpful in conducting this project. The website of the Material Handling Industry of America (MHIA) [10] offers links to useful information for equipment and systems used for storage, warehousing, and order-picking operations.

Dietary Supplements Company Overview and Research Activities

Due to rapid expansion in the market for dietary supplements, Swanson Health Products (SHP) is continuously improving its operational efficiencies to meet the growing market demand. The current 120,000 square-foot facility in Fargo, North Dakota, allows SHP to operate its call center, customer care center, marketing, manufacturing (bottling operations), warehousing, and distribution from one central location. With the exception of cross-docking, other functions listed earlier also characterize the warehousing and distribution at SHP.

One of the competitive priorities at SHP is the quick order-processing and delivery to customers. The company promises a 48-hour turnaround for orders and has a successful record of completing and shipping 65% of the orders within 24 hours and 95% of the orders within 48 hours. The company offers more than 2,500 products (SKUs) and processes and ships 11,000 orders per day with each order including about 8.4 individual items. Based on the forecast and expected growth in the dietary supplement market, the company's goal is to increase this capacity to 18,000 orders per day.

An integral part of the order processing and shipping is the company's pick-to-light (PTL) system. The current order-processing operation has a potential throughput capacity of 18,000 orders per day. The PTL, on the other hand, is the bottleneck and has a lower throughput of about of 11,000 orders per day. Therefore, to achieve the company's goal of 18,000 orders per day, there is a great need to improve the order-picking operation throughout while maintaining or enhancing the quick product delivery to customers. The current order processing potential capacity of 18,000 units per day was determined using time study and analysis of the sub-systems' capacities. These subsystems are explained later and include box erector, label printer and insertion, PTL, inspection, packaging, sorting, and shipping.

The research activities to address the needs of SHP to increase its order-picking system are summarized in Table 1. The remainder of this paper reflects the results of the research and analysis of the current processes and outlines characteristics of systems that can increase throughput. The major focus of the paper is on capacity and the economic analysis of the proposed systems.

Table 1. Project Research Activities.

Analysis of Current Processes	Research Alternative Systems	Proposals
Process Flow and Layout Analysis Inventory Placement Information Flow	A-Frame Zone Bypass Carousel Business Research	Systems Proposal Capacity Planning including Time Study and Inventory Placement Economic Analysis

Analysis of Current Processes

Understanding the current order-fulfillment process at SHP provided the necessary information to establish a baseline and to discover some improvement opportunities.

Process Flow and Layout Analysis

A macro-level view of SHP product flow is shown in Figure 1. SHP's overall operations can be divided into four major areas: manufacturing (bottling), warehousing, order fulfillment, and call center. The bottling process entails the bottling of bulk-purchased capsules into smaller, retail-sized quantities. The products that go through the bottling process are then put in trays in batch quantities and are palletized together to be stored in the secondary storage warehouse. Warehousing has control over the bottled pallets as well as the products purchased from other vendors. Ultimately, the products are placed on the racks in the order-picking areas.

Customers place their orders either by mail, phone, or online. The order-picking process is initiated by the customer orders entered into the SHP's Enterprise Resource Planning (ERP) system. The ERP system filters the orders based on a number of parameters such as next-day orders, box sizes, back orders, and expedited orders. Typically, the box sizes drive the sequence of the orders for the order-picking since batching by box size reduces the set-up times on the box erector. Once a box, which also includes the order information barcode, leaves the erector machine, it is conveyed to the order-picking area where a PTL system is used for order-picking. The PTL system directs operators by means of signal lights on the shelves that indicate the quantity of each product to be picked and placed in the box. This PTL system can also signal if a particular pick is the last pick in a zone and/or is the last pick in an order. The filled boxes then go through inspection, packaging, mail sorting, and shipping.

The layout for the order-processing area is shown in Figure 2. The PTL area is divided into four zones; A, B, C, and D. These zones are further broken down into 63 subzones defined by the number of bays allocated for each zone; A1-A17, B1-B17, C1-C14, and D1-D15. Each bay includes a number of shelves and each shelf includes a number of bins where individual SKUs are stored for pickup. As part of the study, detailed information including the total SKUs within zones as well as pick frequencies for each zone and order-picking time standards were also collected. These data are used for determining order-picking frequencies.

In the current PTL operation, boxes for individual orders need to go through every zone until they reach the last pick zone. Thus, all of the SKUs to be placed on the shelves are based on pick frequency. Faster moving products need to be placed in the earlier zones (zones in A), and also in the most accessible middle shelves. In order to determine the best locations for SKUs, SHP performs "front-end loading" which is the optimization of inventory locations using popularity ranking matched up with the location ranking (listed in the order of accessibility and proximity to the starting location). For example, high-demand products are located along the first priority shelf from zone A1 to A7. The products are distributed amongst all zones and priority shelves in that manner. Figure 2 includes a table that shows the result of the front-end loading process. The table shows that about 46% of the orders are completed within zone A. The table also shows that about 80% of all the SKUs picked come from zone A.

Every quarter, all the locations are re-optimized to reflect the updated high-demand products at a cost of $22,000 per year because the PTL operation is completely shut down for a full day for re-optimization. In order to compensate for the short-term ups and downs in the SKU demands within a quarter, single-item location swapping occurs about 15-20 times a quarter. The ERP system keeps track of inventory levels in different zones and in real time. Thus, when the inventory on shelves reaches the minimum value specified, the request for re-stock will be automatically generated for the material handlers.

Information Flow

Figure 3 illustrates the information flow that is associated with the PTL process at SHP. The information-flow process begins with the order database, Mozart. Once orders are entered into the database, they are filtered out based on next-day order priorities and box sizes. Orders are batched according to box sizes to minimize the setup times necessary for each change in box size. Once the orders are filtered, they wait in the queue to be processed. This information is then transferred to the first steps in the order-fulfillment system. Boxes are erected and sent down the conveyer where the information from Mozart creates the customer purchase orders which are inserted automatically. Barcode labels are also generated which are attached to each box. These barcodes are the main source of information flow for the rest of the PTL order-fulfillment process. Each barcode is then scanned at each workstation. The barcode initiates the PTL system by signaling the proper buttons to light up on the corresponding shelf where an item or items need to be picked. The operator ends the signal by picking the item(s) and hitting the green button. The PTL system is also the source of information for signaling that the order has been completed.

If the order has not been completed, it is conveyed to the next zone. If the order is completed, it is sent down the middle return conveyor to be packaged and shipped. After the order is shipped, the customer is billed, and the information is sent back to the database management level. At this point, the inventory levels are updated and, if necessary, operators are signaled to restock the shelves.

The Mozart order database is also the source of information for the placement of inventory. Placement of inventory is tracked weekly in order to ensure that the highest-

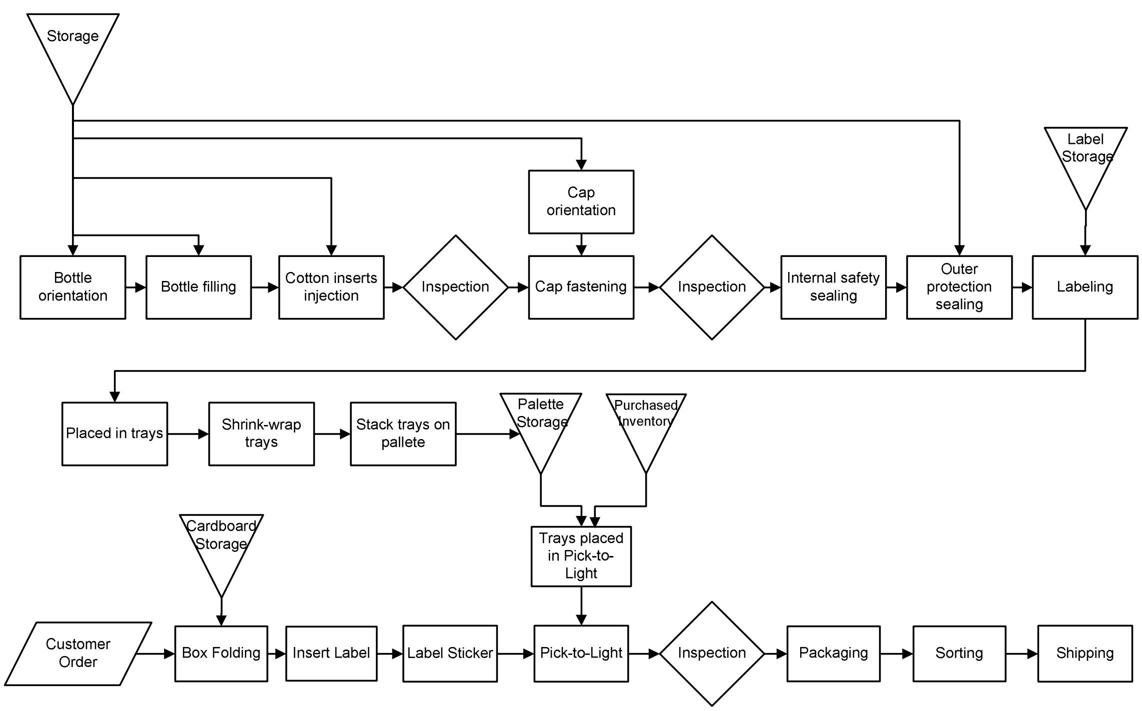

Figure 1. Macro-level Product Flow

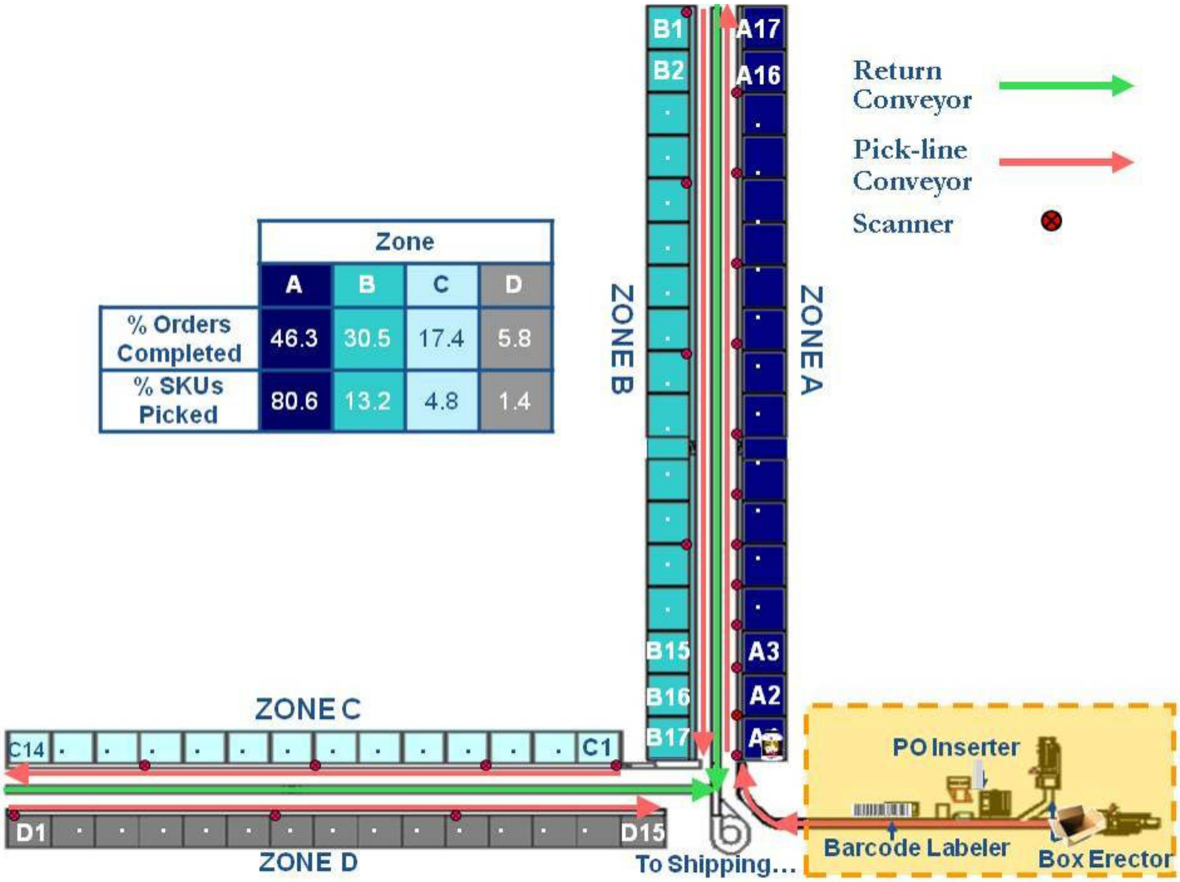

Figure 2. Order Processing Area Layout and Product Placements

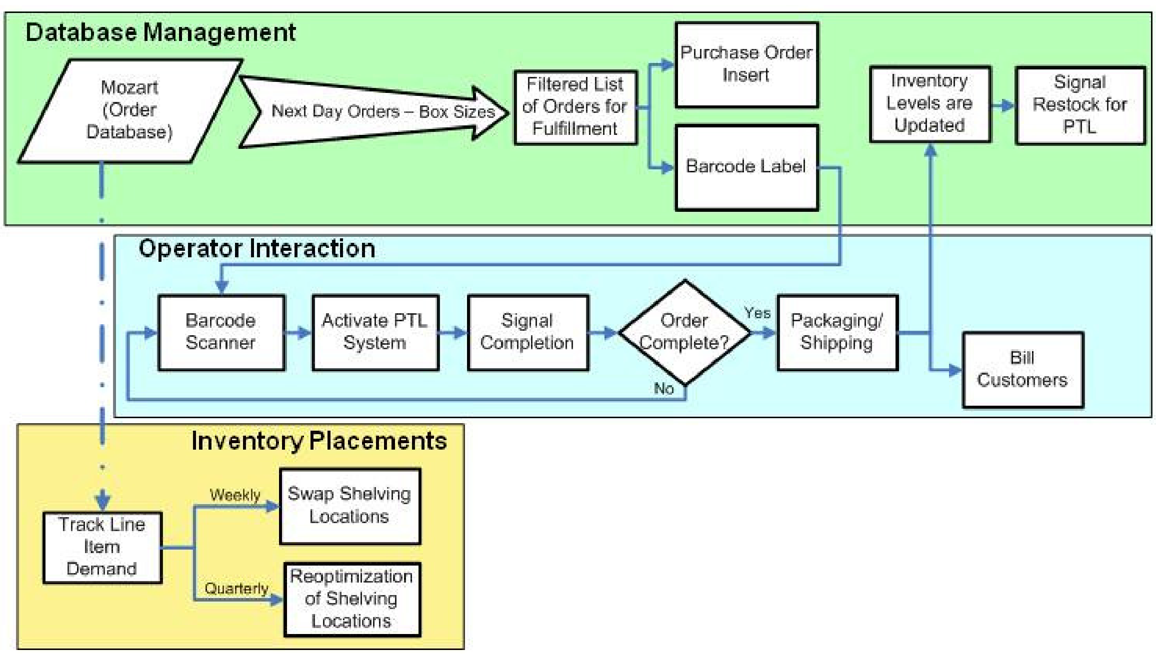

Figure 3. Information Flow

demanded SKUs are located in the proper locations of zone A. Based on the demand percentages, switches in product locations are made weekly, if necessary.

Alternative Methods and Systems for Improved Throughput

A number of systems with the potential to increase the order-picking process were identified and briefly discussed with SHP. The list of the systems to be further researched was then narrowed down to three: A-Frame, horizontal carousel, and zone bypass system. The research activities included online case studies and materials provided by system vendors, visiting and benchmarking distribution and warehousing operations, and studying relevant literature.

A-Frame System

An A-Frame system consists of a fully automated dispenser system which is primarily used for high-volume picking operations. A-Frames are known for increasing quality and throughput in the order-picking processes. The system consists of multiple dispensers that hold a vertical stack of products. Although the basic design of all A-Frame systems is the same, system manufacturers offer different options and various levels of automation. Most designs include system controls that direct dispensers to actuate based on the order totes that pass beneath them [7]. An A-Frame system would be able to handle orders at a rate of 4 items per second, which would dramatically increase throughput. The vertical stacking system design allows for the dispensers to be replenished while the machine is operating to fill orders. At SHP, an A-Frame could be used to hold some of the high-volume products currently placed in zones A and B, but the system would demand twice the amount of space currently needed to pick these products. While the A-Frame could handle product sizes ranging from 1.5" wide x 1" long x 0.25" high to 12" wide x 12" long x 3" high, the system could not handle the fragile glass products delivered by SHP.

Horizontal Carousel System

Horizontal carousels are a popular order-picking system because they are relatively easy to use, require few operators, and increase throughput capabilities in order fulfillment. The systems are designed to be flexible, expandable, and configurable to a wide variety of order fulfillment needs. These systems include individual carousels (modules) that are available in a wide variety of heights, widths, and depths. These modules hold inventory, and a system can include one or more of these modules. A typical system also includes a conveyor system that interfaces with the modules and conveys the products to the pick operator. When inventory or throughput requirements increase, the modular nature of some of the carousel systems can allow for meeting such increases by installing additional modules. Along with a variety of sizes and configurations, they can be operated with very little automation or can be nearly entirely automated according to customer needs.

In a carousel system, the orders are entered individually or as a group called a batch. The system delivers the ordered products, usually in a compartmentalized bin, to the pick operator. A light bar signals the SKU location in the bin and the pick quantity to the operator. Once the pick is completed, the operator pushes the complete button. The system then moves the next SKU bin to the operator. This process is repeated until all items for an order are picked.

Horizontal carousels offer the advantages of many of the "order-picking principles" [15] including the elimination of order-picking tasks such as traveling, extracting, reaching and bending, documenting, sorting, and searching. The system helps with the efficient and ergonomic implementation of the "products-to-picker" principle. Clear operator guidance confirms, manages, and controls each procedure, which enables the implementation of zero-defect order-picking. The carousel system offers a relatively high pick rate and a high storage-compaction rate. A 50% or more compaction rate is not unusual [14].

Zone Bypass System

The concept behind the zone bypass system is to increase the flow of material through a process by manipulating the travel path of the orders. Due to the flexibility of zone bypass systems, they can be incorporated into various processes and in multiple configurations. Typically, a zone bypass system consists of a conveyor configuration that routes orders throughout a process by means of automatic identification devices strategically placed along the conveyor line. Once the order has been successfully scanned, it is then routed to a predetermined destination based on the information read from the barcode attached to the order box. The logic feature behind the zone bypass, which controls the accumulation and the movement from zone to zone, allows orders to bypass certain work areas if no order-picking is required. This feature eliminates the need for front-end loading discussed earlier and further enhances flexibility while increasing productivity. In addition, zone bypass has the capability to be incorporated into systems that contain other automated processes such as carousel and A-Frame systems.

Table 2. Comparisons of A-Frame, Horizontal Carousel, and Zone Bypass Systems.

System	Advantages	Disadvantages
A-Frame	• Fully automated system • Very fast order fills - 4 items per second (*Varies by manufacturer*) • Reduce bottleneck in Zone A • Reduce the number of pickers needed	• Requires large amount of space • New system/technology; maintenance concerns • Can hold about 750 different products [1] [14] • Requires relatively large investment • Require more people to restock system
Horizontal Carousel	• Reduce number of pickers needed • Can be highly automated • Allows for Modular design • Reduce walking for zones C and D • Facilitates batch picking • Accommodates wide range of products • More ergonomic	• Very high initial cost • Requires more frequent restocking • New system/technology; maintenance concerns
Zone Bypass	• Less touches/manual material handling • Can be incorporated into current pick-to-light system • Shorter travel distances for some of the boxes • Elimination of front-end loading • Utilization of unused overhead space and free up valuable floor space	• Investment in equipment/conveyors • Costs associated with incorporating into PTL • Ergonomic issue. Some bypass layout can lead to increased twisting and turning • Potential for bottlenecks in zone A (without reconfiguration of product placement)

Table 2 shows comparisons of A-Frame, horizontal carousel, and zone bypass systems. The table captures some of the advantages and disadvantages of these systems relevant to SHP's need to address order-picking throughput.

Proposals Development

A careful analysis of the available space indicated that an A-Frame system would not be a feasible option. Based on customer order data, twice as much space would be needed to fit all the SKUs into PTL stations. Other factors that were taken into consideration were the number of SKUs, projected growth in orders, and the typical orders. The exceptional speed of the order-picking feature offered by typical A-Frame systems makes them very suitable for lower variety orders or high demand for limited SKUs.

Features available through a typical horizontal carousel made the system a feasible option for high-variety/low-volume orders which are mostly picked in zones C and D. Such orders constitute less than 10% of all the orders at SHP. The system features allow for reduction of most of the labor as well as increased throughput. The zone bypass system was also viewed as a feasible option to be integrated with the current PTL system at SHP. As previously mentioned, one factor that decreases throughput in the PTL system is that each box travels through every zone during the picking process. Zone bypass equipment routes each box to only the zones needed for picking. Thus, unnecessary box checking is eliminated, which increases the throughput.

Several technical issues related to horizontal carousels are very important for study and analysis of their suitability for inclusion in an order-picking and storage system. Equally important are the technical issues related to zone bypass systems, such as layout and type of pick line (single vs. double), etc. Even though the study of such technical issues was an integral part of this research project, the discussion is not within the scope of this paper. The remainder of this paper analyzes the integration of the systems and expected effects on the throughput of the system.

Time Study

In order to study the throughput potential of the PTL, an estimate of order-picking time was required. Extensive time study and simulation revealed that the average time to pick SKUs from a given zone in PTL was approximately 8.03 seconds. Data was collected on the length of time needed for the operator to pick items that were randomly selected from different shelves and zones. The main elements of this estimate included the time needed for the operator to pick the products, place the products in the shipping box, and push a button to signal confirmation. The estimate did not include the time needed for the operator to remove plastic wrapping from product trays or to complete other miscellaneous tasks done during the work day. The estimated time was relatively conservative, so the actual time was expected to be shorter.

Product Placements and Capacity Planning

Integral to the new system was a proposal for redistribution of line items (SKUs) to balance the work load between the PTL with an integrated zone-bypass system and the automated horizontal carousel. In the new system, the PTL will continue to provide the largest percentage of SKUs, but at a higher rate. The carousel system will help the order completion by automatically retrieving and delivering the slow-moving SKUs. The two proposed systems work together to help SHP achieve its goal of improved order-picking throughput. Therefore, it is essential that the current SKUs in zones A-D be redistributed between the PTL and carousel system in a way that provides the best opportunities for order-picking improvement while taking full advantage of the systems' features.

Different levels of SKU redistributions were considered, and simulation was used to estimate the impact of each on order-picking capacity. Table 3 contains summary calculations showing the impact of one of the alternative proposals on the system throughput and daily operation times. The alternative used for calculating and compiling the data shown in the table include the reallocation of the current SKUs (line items) in zone A and half of the SKUs in zone B to PTL with zone bypass and reallocation of half of the current SKUs in zone B and all of the SKUs in zones C and D to the horizontal carousel. The following assumptions and/or inputs were used in performing the calculations:

- Growth per year is 8%.
- The PTL included 16 main zones, with each zone operated by one operator. Each of the zones is divided into a number of sub-zones. One of the factors used to determine the number of zones was the impact on pick rate caused by the walking distance within each zone.
- The automated carousel system requires one operator for order-picking. Additional operators are needed for restocking of the carousel.
- Average picking time for the PTL SKUs is 8.03 seconds.
- Productivity of the proposed systems is 90% due to fatigue and other allowances.

As Table 3 indicates, the company currently processes and ships 11,000 orders per day. The average customer order includes 8.4 individual items with 5 SKUs. The table shows the impact of shifting 12% of the SKUs from the PTL to the proposed carousel system. This shift requires the PTL to pick about 52,272 SKUs per day during the first year. Each of these picks includes an average of 1.68 SKUs (8.4 items per order/5 SKUs per order). The current PTL setup is the bottleneck in the order-picking system, inhibiting the SHP from achieving its potential capacity of 18,000 orders a day. The alternative discussed here shifts some of the work from the PTL, thus increasing the order-picking throughput. The carousel system will help the order completion by automatically retrieving and delivering the slow-moving SKUs.

Table 3 shows that the PTL hours of operations per day during the first year will be 8.1 hours. It is believed that this represents the worst-case scenario, and the actual operating time would be less than 8 hours and closer to 7.5 hours. This matches the available hours for workers during an 8-hour shift. The table indicates that adjusting the hours of operation will result in the same daily and hourly PTL order-picking rates during years 1-6. The corresponding pick rates for the carousel, on the other hand, vary year by year. The carousel system still will be able to complete the orders coming off the PTL line without negatively impacting the target order-picking throughput. To maintain the balance, the current ERP filtering system will be slightly modified and used to filter out orders only requiring products from the carousel system, which accounts for 5.58% of the total orders. For example, year 1 will involve 663 orders (11,880 * 5.58%) that can be scheduled during an additional hour after the regular shift.

Economic Analysis

Table 4 shows a summary of estimated labor costs for the current order-picking as well as for the proposed system that includes the bypass zone and the horizontal carousel. The table also shows the estimated annual and cumulative savings in personnel costs.

Currently, the number of hours required to complete 11,000 daily orders is about 15 hours (see Table 3). The total number of personnel needed for order processing is 32 with an hourly cost of about $407.50. Therefore, the total personnel cost for the current PTL operating 15 hours per day is $6,113 per day ($407.50 * 15). Table 4 also shows the expected "total personnel costs" for years 1 through 6, assuming that the current system will be able to handle the expected 8% growth per year.

The proposed zone bypass requires 16 pickers operating 8 hours to pick the current orders. At a cost of $200 per hour, this translates to $1,600 order picker cost per day. The corresponding figures for the carousel system are 1 picker, 8.16 hours, and $102 per day. The proposed systems require additional personnel at a cost of $2,017 per day. The proposed systems' personnel costs for years 1 through 6 are calculated to reflect an annual 8% growth. The cost savings per day reflect the difference between personnel costs associated with continued use of the current PTL vs. using the proposed systems.

Table 3. Sample Work Summary Calculations Showing Throughput and Operation Times.

	PTL	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
a	Number of orders per day	11,000	11,880	12,830	13,857	14,965	16,163	17,456
b	Items per order (average)	8.4	8.4	8.4	8.4	8.4	8.4	8.4
c	SKUs per order (average)	5	5	5	5	5	5	5
d	Percentage of SKUs filled	93%	88%	88%	88%	88%	88%	88%
e	SKUs picks per day	51,370	52,272	56,454	60,970	65,848	71,115	76,805
f	SKUs picks per hour	3,425	6,456	6,456	6,456	6,456	6,456	6,456
g	Hours of operation per day	15.00	8.10	8.75	9.45	10.20	11.00	11.90

	Carousel System	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
h	% of SKUs allocated		12%	12%	12%	12%	12%	12%
i	SKU picks/hour (capable)		900	900	900	900	900	900
j	Hours of operation per day		8.80	9.50	10.26	11.09	11.97	12.93

(e) = (a) (c) (d)
(g) For years 1-6 = (e) (8.03 seconds per item pick /3600 seconds per hour) / (16 operators) (0.9)
(f) For years 1-6 = (e) / (g)
(j) = (a) (c) (h) / (900) (0.9)

Table 4. Estimates of Labor Costs per Day and Potential Annual Savings

Existing PTL	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Pickers	\$3,188	\$3,443	\$3,718	\$4,015	\$4,337	\$4,683	\$5,058
Other personnel (1)	\$2,925	\$3,084	\$3,256	\$3,441	\$3,641	\$3,858	\$4,091
Total personnel cost	\$6,113	\$6,527	\$6,974	\$7,457	\$7,978	\$8,541	\$9,150

Proposed systems	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Zone bypass pickers	\$1,600	\$1,620	\$1,750	\$1,890	\$2,040	\$2,200	\$2,380
Carousel pickers	\$102	\$110	\$119	\$128	\$139	\$150	\$162
Other personnel (1)	\$2,017	\$2,104	\$2,196	\$2,297	\$2,407	\$2,524	\$2,651
Total personnel cost	\$3,719	\$3,834	\$4,065	\$4,315	\$4,586	\$4,873	\$5,192

	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Cost savings per day	\$2,393	\$2,693	\$2,909	\$3,141	\$3,392	\$3,668	\$3,957
Annual savings (2)	\$598,313	\$673,250	\$727,155	\$785,327	\$848,120	\$917,031	\$989,306
Cumulative savings		\$673,250	\$1,400,405	\$2,185,732	\$3,033,852	\$3,950,883	\$4,940,189

Savings based on anticipated 8% annual growth

Annual labor costs savings if no growth in demand

1. including personnel for shipping, packaging, restocking, supervising
2. 250 working days

The cost for the new systems is estimated to be \$2,631,140. This cost includes:

- \$2,600,000 for zone bypass and automated carousel equipment including installation, training, and software installation. This estimate was provided by potential systems' vendors.
- \$27,620 for shut-down and PTL reconfiguration
- \$2,800 for relocation of equipment and products
- \$720 for changes to the ERP filtering system

Another cost saving resulting from the new systems and changes to the order-release filtering system would be an annual \$22,000 cost avoidance due to elimination of re-optimization. The purpose of the re-optimization process has been explained in previous sections. This process would be replaced by a simplified, small, weekly re-optimization with a negligible cost. The new re-optimization method does not require line shut down. A summary of cost savings as well as the estimated payback period is shown in Table 5.

Table 5. Summary of Costs Savings and Payback Period

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Annual savings in personnel cost	$673,250	$727,155	$785,327	$848,120	$917,031	$989,306
Re-optimization cost avoidance	$22,000	$22,000	$22,000	$22,000	$22,000	$22,000
Total annual savings	$695,250	$749,155	$807,327	$870,120	$939,031	$1,011,306
Cumulative savings	$695,250	$1,444,405	$2,251,732	$3,121,852	$4,060,883	$5,072,189

New System Cost = $2,631,140
Simple payback period = 3.44 Years

Based on the economic analysis, SHP can recover its initial investment of $2,631,140 in about 3.44 years and realize a cumulative cost savings of $5,072,189 by the end of the sixth year when the projected demand for its products will approach nearly 18,000 orders per day. The estimated cost savings and payback period do not take into account the time value of the money.

Summary and Conclusions

This paper reflects the result of research to identify systems that can improve order-picking throughput in warehousing and distribution operations at a dietary supplements company (SHP). Order-picking is one of the most important warehousing and distribution functions. Study and analysis of this function can lead to great opportunities for productivity improvements. A prerequisite to the design of an effective order-picking system requires a thorough understanding of customer order requirements and order-picking ingredients [13]. Once these are understood, more informed decisions can be made to identify and select systems and technologies to improve order-picking throughput.

In order to develop feasible proposals, the current order fulfillment processes at SHP were studied and documented. The major focus became the pick-to-light (PTL) system which was used for the vast majority of order-picking functions. Data relevant to the PTL layout and performance were collected. Data included were number and the distribution of SKUs in PTL zones and SKU picking frequencies and time standards. The mapping of product and information flow proved very helpful in better understanding the current system and, hence, identifying additional opportunities for improving order-picking throughput.

Study of available systems with the potential to improve order-picking throughput led to the development of a number of proposals including the addition of a horizontal carousel system and the integration of a zone bypass system in the current PTL. This proposal and its economic analysis were the main focus of this paper. Additional proposals included redistributing SKUs among the PTL zones as well as creating a standardized ERP filtering system to adjust the order saturation level for each zone to ensure a balanced workload. The capacity analysis showed that the proposed systems along with the proposals for SKU redistribution and an order-filtering system will be able to offer the throughput required to meet the anticipated growth in demand. The economic analysis indicated that the proposed systems are viable. The two main focal points in the economic analysis were the cost associated with the purchase and installation of the systems and the savings that might be realized through the implementation of these proposals compared to the current order-picking process.

Post Script

Prior to the start of this project, SHP was considering alternative systems, including a horizontal carousel, for increased throughput. The results of this research project were presented to SHP during late May of 2007. The results confirmed the suitability of a horizontal carousel system, both in terms of system throughput and payback. In addition, some of the recommendations for changes to the ERP filtering system were incorporated. A modular horizontal carousel system was installed in SHP during May 2008 and became fully operational in September of that year. The system included three high-density storage modules. In June of 2009, an additional high-density module was installed to help with the addition of new SKUs.

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Biographies

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