Perspectives on Material Handling Practice

Papers in the Perspectives series have appeared in conference proceedings of the Material Handling Institute between 1992 and the present. As such they provide a point of reference as to how the industry is changing as well as insight into accepted practice during this period. In many cases the authors credited have either changed jobs or are no longer in the industry. Some companies as well have been the subject of mergers or reorganization with a new corporate identity.

SPLIT-CASE ORDER FULFILLMENT

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Abstract

The methods used to improve the performance of order fulfillment systems are presented, along with a scheme for easy identification and reference. The impact of these various methods on multiple order fulfillment performance measures is assessed. Various on-line merchandise storage configurations are then identified along with material handling concepts for transportation, sortation, and support of the picking and packing functions. Finally, a case example is presented to illustrate the costs, benefits and justification factors associated with implementing new methods and mechanization.

1.0 INTRODUCTION

The picking and packing of split-case merchandise to fulfill orders in the distribution environment may be approached in several different ways. The methodologies and systems utilized should minimize fulfillment cost and cycle time while maximizing accuracy and facility throughput.

Split-case picking, also referred to as broken-case picking or piece-picking involves the selection of individual units of merchandise as “eaches” or inner-packs to satisfy order requirements. Re-packing of this merchandise into cartons or other suitable shipping containers is normally required before shipment to the customer.

A conceptual layout of a typical mechanized split-case order fulfillment system is illustrated in Figure 1.

The following sections identify the common methods employed in split-case order fulfillment as well as addressing the merchandise storage, transportation, and sortation mechanization that is often utilized.

MECHANIZED DISCRETE ORDER FULFILLMENT SYSTEM

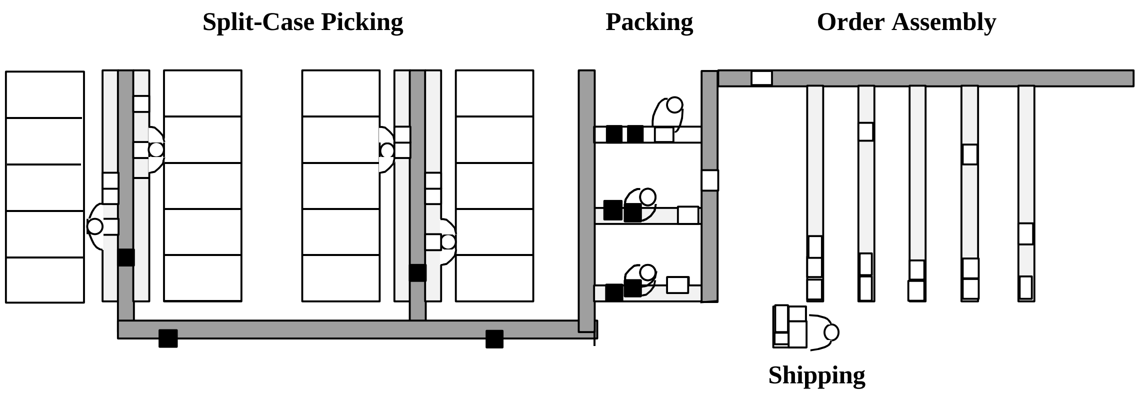


Figure 1.

2.0 GENERAL METHODOLOGY

The following paragraphs identify the general methods and strategies that are employed in split-case picking and packing.

2.1 Order Picking Methods

The orders to be picked and packed to meet customer requirements must be assigned to personnel in a logical manner in order to maximize their productivity and fulfillment accuracy.

The picking assignment methods utilized generally involve two (2) basic factors:

1. **Order Extent** - the number of orders to be selected simultaneously by a picker in an assignment, and
2. **Coverage Extent** - the physical area in the picking system to be traversed by a picker in selecting merchandise for an assignment.

Each of the above factors may be further divided into two (2) strategies. Order Extent may involve:

1. **Discrete Order Picking** - where a single order is selected at a time, or

2. **Batch Order Picking** - where the merchandise requirements of multiple orders are combined and selected in one pass through the coverage area.

Coverage Extent involves personnel selecting merchandise using either:

1. **Zone Picking** - picking order segments in a limited portion of the picking system (A zone is normally a contiguous set of picking locations with boundaries that may be fixed, or dynamically adjusted to balance workload.), or
2. **Tour Picking** - picking orders throughout the entire picking area.

In the case where Batch Order Picking is the strategy chosen for creating selection assignments, a further distinction is necessary to identify the method to be used to subsequently sort and segregate the individual orders for packing. Two common alternatives are as follows:

1. **Sort Immediate** - merchandise is sorted by order as it is picked. The aggregate quantity required of each item is picked for the batch of orders in the assignment with one visit to the item's pick location. Sortation of each item is performed manually by the picker by placement into containers or compartments dedicated to each order according to each order's demand (e.g., using RF Pick Carts, Cluster Pick/Put-to-Light, Carousel Put Bars, etc.).
2. **Merge & Sort** - all merchandise for a given batch of orders is picked and then merged and sent through a centralized sortation function to segregate and assemble the orders for packing.

In the case where Zone Picking is chosen as the coverage extent for creating picking assignments, a further distinction is necessary to identify the method to be used to move orders through the zones. Three (3) common alternatives are as follows:

1. **Routing** - orders are routed only among those zones where picks are required. Zones for which there are no picks are skipped.
2. **Chaining** - orders are routed from zone-to-zone in sequence, whether or not there are picks to be made in any particular zone.
3. **Parallel** - each order is started and picked simultaneously in multiple zones where there is item demand.

In Chaining systems, pickers pass orders having no picks in their assigned zone to the next zone in the chain (order passing). In Routing systems, orders do not enter zones where there are no picks (zone skipping). In Parallel systems, orders are picked simultaneously in all zones having picks.

Pickers are typically assigned to work in specific pick zones. Zone boundaries may dynamically expand or contract in some systems for workload balancing within a scheduling interval. Orders generally flow through the zones according to one of the above strategies.

2.2 Order Packing Methods

In addition to the two (2) factors mentioned above which are used to determine picking assignments, a third factor, the order packing method, completes the overall order fulfillment methodology.

Merchandise for split-case orders which has been picked to meet customer requirements must usually be re-packaged before shipment. There are two (2) basic strategies used for order packing:

1. **Pack Immediate** - orders are packed by the selection personnel as they are picked (pick-pack). This is used when packing tools and supplies can travel with the picker or are readily available throughout the picking area.
2. **Assemble & Pack** - orders are assembled and consolidated in a dedicated area equipped for packing (typically by dedicated packing personnel).

When the Pack Immediate strategy is used, the picking task is extended to also include many of the functions related to packing orders for shipment (e.g., carton set-up, labeling, dunnage fill, carton closing, etc.). Although this may not provide the optimal packing environment, it offers the benefits of "one-touch" order fulfillment.

With the Assemble & Pack method, the picking and packing functions are segregated and specialized, offering the greatest productivity potential for each, as well as the opportunity for 100% order verification. Of course, merchandise must be handled two or more times with this approach.
A conceptual layout of a batch picking system with parallel zones, centralized merge & sort, and centralized order assembly & packing follows in Figure 2:

BATCH ORDER FULFILLMENT SYSTEM

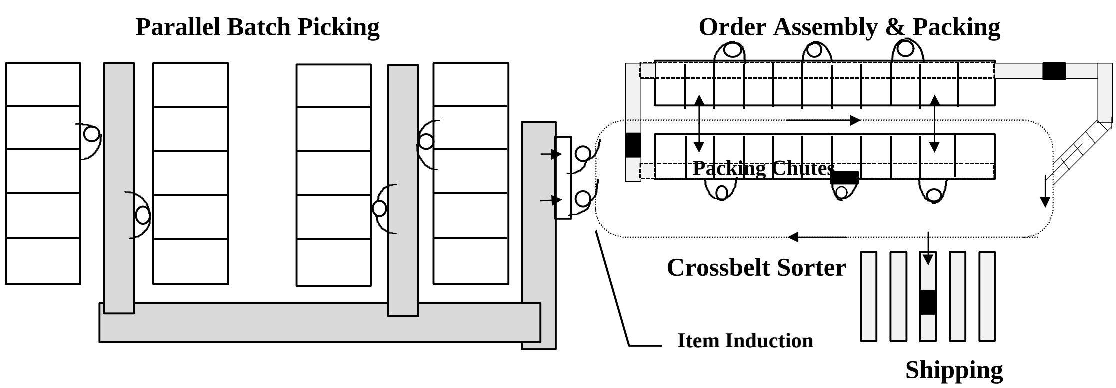


Figure 2.

3.0 CLASSIFICATION SCHEME

This section outlines a scheme to classify and identify the various split-case order picking and packing systems which are possible when utilizing the various combinations of methods and strategies described in Section 2.

In this scheme, letters and subscripts are combined to uniquely identify any one of the many possible picking and packing methodologies. The three (3) major factors characterizing a system are each represented by a letter in sequence:

1st Letter:	**D** iscrete Order Picking (or) **B** atch Order Picking
2nd Letter:	**Z** one Picking (or) **T** our Picking
3rd Letter:	**P** ack Immediate (or) **A** ssemble & Pack

For example, the acronym **DTP** indicates a discrete order picking system where the picker covers the entire picking area and packs the order as it is selected.

This classification and identification system can be extended to designate the batch sortation and zone visitation methods by the use of subscripts as follows:

1st $Letter_{subscript}$:	$\mathbf{B_S}$	Batch Order Picking - **S** ort Immediate
	$\mathbf{B_M}$	Batch Order Picking - **M** erge & Sort
2nd $Letter_{subscript}$:	$\mathbf{Z_R}$	Zone Picking with **R** outing
	$\mathbf{Z_C}$	Zone Picking with **C** haining
	$\mathbf{Z_P}$	Zone Picking in **P** arallel

For example, the acronym $\mathbf{B_M Z_P A}$ identifies a system with batch order picking in parallel in multiple zones with a centralized merge and sort function leading to a separate order assembly and packing area.

With this classification and identification scheme, it is possible to designate up to twenty-four (24) different split-case picking and packing systems (3*4*2). Of course, not all 24 approaches make sense operationally. A few of the common strategies, along with their pros and cons, are highlighted in Table 1 which follows.

Table 1. - Common Split-Case Order Fulfillment Strategies

System	Description	Advantages	Disadvantages
1. **DTP**	W***alk-pick & pack***	Single touch pick/pack, good selector accountability;	Excessive walking, access to packing supplies difficult; picker must know full layout;
2. **DZ_CA**	***Order passing w/ central packing***	Good control over pickers (dedicated to zones), less walking & searching;	Two-touch pick/pack, bottleneck zones, orders in zones with no picks, empty tote handling req'd;
3. **DZ_RA**	***Order routing w/ central packing***	Order cycle time reduced vs. order passing, No handling of orders with no picks in zone;	Difficult to know order status in picking, control complexity;
4. **DZ_PA**	***Parallel order pick w/ central packing***	Shortest order cycle time;	Large number of items/totes to transport to packing, lower picking productivity;
5. **B_STP**	***Batch walk-pick & pack***	Good productivity & accountability, good for slow moving items (large area with few picks);	Greatest potential for picker errors with large coverage area, counting, and manual sorting;
6. **B_SZ_CA**	***Cluster picking***	Good picker control & productivity;	Potential for errors, bottleneck zones, orders in zones with no picks, empty tote handling req'd;
7. **B_SZ_PA**	***Parallel batch pick- sort w/ central packing***	Good pick productivity & order cycle time;	Order assembly & consolidation more difficult;
8. **B_MZ_PA**	***Parallel batch pick w/ central packing***	Highest picking productivity with good order cycle time;	Potential third touch req'd for item induction to sortation;

4.0 GENERAL ORDER CHARACTERISTICS

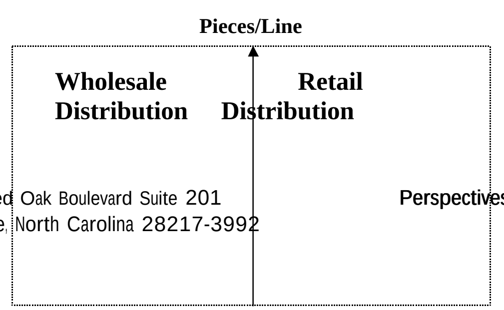
Although in most order fulfillment operations, there is no such thing as a typical order, orders can generally be characterized by two (2) parameters:

1. Number of line-items, and
2. Quantity of pieces per line-item.

An order line-item is a demand for a specified quantity of a particular item of merchandise or stock-keeping unit (SKU). The number of pieces required in a line-item for split-case operations is typically expressed in eaches or sales units. Inner-packs containing multiple eaches or other units of measure may be used as well.

Orders generally may be thought of as falling into one of four (4) categories depending upon which quadrant in the coordinate system depicted in Figure 3 best represents the order characteristics:

GENERAL ORDER CATEGORIES



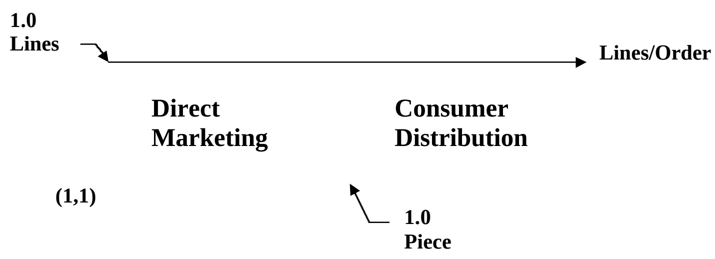


Figure 3.

The names used for the order categories in Figure 3 are generally illustrative of the environments where such orders are found:

1. **Wholesale Distribution** - orders for large piece quantities of a relatively small number of items to replenish warehouses and distribution centers;

2. **Retail Distribution** - orders for large quantities of a large number of items to replenish retail store inventories;

3. **Direct Marketing** - orders for a small quantity (often one) of a small number of items (often two or three), and

4. **Consumer Distribution** - orders for a small quantity of many different items (for evaluation, promotion, or consumption).

Note that the smallest order is defined as one (1) piece of one (1) item. Note also that the point of intersection of the two axes in Figure 3 has intentionally not been quantified.

The category labels identified above are intended for the purpose of illustration and further discussion. Orders from more than one category may be found in a given application as well.

5.0 CHOICE OF OPTIMAL FULFILLMENT STRATEGIES

The particular order fulfillment strategy to be employed in an operation should be selected in large measure based upon the predominant order characteristics.

The fulfillment strategy is generally chosen to satisfy certain performance measures:

1. Minimize pick/pack cost per order
2. Minimize shipping cost per order
3. Minimize cycle time
4. Maximize fill rate(1)
5. Maximize accuracy
6. Maximize accountability

(1) Note: Order fill rate and back-order reduction are primarily related to inventory and stock location policies. However, certain order picking and packing strategies offer a better opportunity to improve fill rate (e.g., when the merchandise is not available in the pick slot, but is located in reserve storage).

The degree of importance, weight, or priority attached to each performance measure varies from one operation to the next. Table 2, which follows, identifies for each general order category, the optimal split-case order fulfillment strategy, if each of the performance measures is considered in turn to be the highest priority (all other measures being secondary but equal).

Note that the Wholesale Distribution category has been included in Table 2, although it is unusual to pick and pack the large line-item quantities required by these orders in split-case units (full cases or pallet load quantities generally being more appropriate).

Optimal Split-Case Order Fulfillment Strategies

	Order Category			
	Wholesale	**Retail**	**Direct**	**Consumer**
Performance Measure				
1. Pick/Pack Costs	**DZ_RP**	**DZ_CP**	**B_MZ_PA**	**B_MZ_PA**
2. Shipping Costs	**DZ_RA**	**DZ_PA**	**B_MZ_PA**	**B_MZ_PA**
3. Cycle Time	**DZ_PP**	**DZ_PA**	**DZ_PA**	**DZ_PA**
4. Fill Rate	**DZ_PP**	**DTP**	**DZ_PA**	**DZ_PA**
5. Accuracy	**DZ_PA**	**DZ_PA**	**DZ_PA**	**DZ_PA**
6. Accountability	**DZ_PP**	**DTP**	**DZ_PA**	

Table 2.
The primary rationale for the selection of the strategies found in Table 2 is described in the paragraphs that follow.

5.1 Wholesale Orders

Wholesale Orders are characterized by relatively large quantities of a relatively small number of items. The appropriate strategies for fulfilling these particular orders are:

(**DZ_RP**) With a large number of pieces demanded of each item, a single-touch pick/pack approach is favored. Discrete order selection is favored over batch to avoid having to sort an excessive number of like pieces. Zoned picking is preferred to reduce the amount of walking required to select a few scattered items. Zone routing is favored over chaining to avoid passing orders through many zones having no picks which increases cycle time and decreases productivity. Routing is also preferred to parallel picking to minimize the number of shipping cartons generated.

(**DZ_RA**) If shipping costs become a major factor, centralized order assembly & packing can yield some benefits (at an increase in overall pick/pack costs).

(**DZ_PP**) Discrete order picking/packing in multiple zones in parallel provides the shortest fulfillment cycle time but with a possible penalty in increased shipping costs. This may be mitigated if the line-item quantities are substantial (i.e., partial carton count is small relative to total).

Fill rate can be increased by this strategy as well: temporary out-of-stock (emergency replenishment) only affects the picker in one zone and only one portion of a single order.

Accountability is the greatest with this strategy as each shipping carton completed for an order can be traced back to a single picker/packer

(**DZ_PA**) Z_P and Z_R are inherently less prone to picking errors than Z_C as orders only enter zones if picks are required. Centralized assembly & packing also allows the opportunity to check and re-count large line-item quantities thus improving accuracy.

5.2 Retail Orders

Retail Orders are characterized by relatively large quantities of many items. The appropriate strategies for these orders are:

(**DZ_CP**) With a large number of pieces demanded of each item, a single-touch pick/pack approach is favored. Discrete order selection is favored over batch to avoid having to sort an excessive number of like pieces. Tour picking/packing may be appropriate for these orders but picker interference in the aisles can reduce productivity. Zone routing is not appropriate if shipping cartons can generally be filled in a zone or less. Parallel picking of discrete order segments offers good productivity potential but potentially higher shipping costs. Chaining is a reasonable compromise as these orders should have picks in most zones.

(DZ_PA) Parallel zone picking of discrete order segments reduces cycle time and increases accountability. Adding centralized order assembly & packing (with checking) improves accuracy and can reduce shipping costs.

(**DTP**) Maximum potential for high fill rate as well as the highest level of accountability can be achieved by tour picking/packing individual orders.

5.3 Direct Marketing & Consumer Orders

The optimal methods for the Direct Marketing and Consumer Distribution order categories are generally the same. It seems to make little difference, considering only the pick and pack functions and the performance measures used, if the fulfillment operation must handle many orders with few lines and few pieces or many orders with many lines and few pieces.

(**B_MZ_PA**) Order batching is appropriate for these order types in order to gain picking efficiency (maximizing orders picked vs. walk time). Central Merge and Sortation is favored over Sort Immediate due to the large number of "sort-to" containers that would need to be transported with the picker. Parallel zone picking allows multiple pickers to work on a batch of orders simultaneously. Central order assembly & packing permits order consolidation to reduce shipping costs and the allows the opportunity for checking to improve accuracy.

(**DZ_PA**) Order fill rate and accountability are both improved with discrete picking of order segments in parallel zones (selectors can hold order segments awaiting emergency replenishment of pick slots without impacting other orders or other selectors).

6.0 COMMUNICATION OF PICKING DIRECTIVES

Several techniques have been utilized to communicate order picking requirements to order selection personnel. Although not specifically evaluated here, the method chosen to communicate picking directives has an impact on the performance measures as well. Some of the most common techniques are:

1. **Reports** - Computer-generated pick lists, packing slips, or even customer invoices are used to identify order line-items and stock locations. Generally, paper reports are found only in Discrete Order Picking operations. Paperwork normally "flows" with the order or is split and distributed for parallel picking.

2. **Labels** - Labels are often used to direct order picking activity. Depending upon the operation, a single label may be produced per line-item or a label may be generated for each piece to be picked. Pick labels typically indicate pick locations in addition to item and order data. Pick labels are often bar-coded for item sortation and/or order verification. Labels may be used with either Discrete Order or Batch Selection methods, although use with Batch Selection is more common.

3. **Radio Frequency (RF) Terminals** - RF terminals are used in some operations to achieve totally "paper-less" order selection. In other cases, RF terminals are used in

combination with bar-coded shipping labels to identify the orders for routing or sortation.

4. **Lights** - Computer-driven slot displays with blinking "attention" lights are sometimes used to direct order selectors to items and locations to pick order or batch requirements (i.e., Pick-to-Light systems). This form of paper-less picking can support much higher levels of selection activity than RF terminals.

   Computer-driven lights are also used to direct the placement or "putting" of items into designated locations in designated quantities. This Put-to-Light concept can be used to direct the Sort Immediate process in Batch Picking (B_S) when sorting to a group of totes assembled at a carousel pod, bins on a picking cart, etc. The Batch Picking with Merge & Sort strategy (B_M) can also use computer-directed lights to manually put (sort) the proper quantity of each item to each order being assembled for packing.

7.0 ORDER PICKING & PACKING ECONOMICS

The economic factors involved in optimizing split-case order picking & packing efficiency center around minimizing costs while maximizing service level. The primary cost factors can be divided into two (2) categories: capital and operating costs. Capital costs include facilities, material handling systems, etc.; whereas operating costs include taxes, insurance, utilities, labor, consumable supplies, etc.

A thorough economic analysis might include incidental costs associated with resolving errors, damage, inventory shrinkage, returns handling, label printing, etc.; however, only the major costs of facility space, material storage and handling systems, and direct labor are considered here.

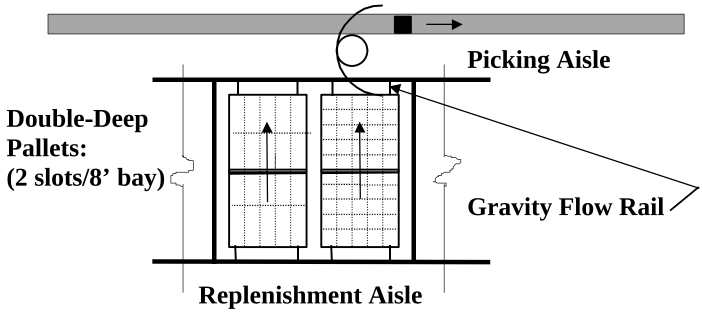
7.1 Space & Storage Equipment Costs

The space consumed by the split-case picking and packing functions can be broadly divided into the following uses: on-line storage for inventory, replenishment aisles, picking aisles (workspace), packing workspace, and material handling space.

Methods for on-line storage of split-case picking inventory are typically chosen based on item activity levels. Item activity in this instance refers to item movement or velocity expressed in: pieces picked/day, "hits" or lines picked/day, or cubic volume moved/day.

The typical on-line storage methods utilized for split-case items include:

1. **Pallet Rack/Shelving (P) -** cases of items on pallets stored on the floor, on shelving, on gravity flow rail, or on rack supports; Cases, inner-packs, or individual items are picked from pallet directly to conveyor or into totes/shipping cartons as shown in Figure 4:



Note: Pallet Rack - 3 Levels High in Pick Module (Typical)

Figure 4.

When order demand is high for a relatively small number of items, it may be possible to batch pick order requirements in case quantities from Pallet Storage and only break open the cases when necessary to induct and sort the individual pieces by order (possibly eliminating broken-case picking locations).

2. **Case Flow Rack (F)** - gravity flow lanes for storage and first-in-first-out (FIFO) usage of cases of items; Items are picked from the forward case in each lane; A common layout follows in Figure 5. Note that picking and replenishment activities can occur simultaneously in dedicated aisles.

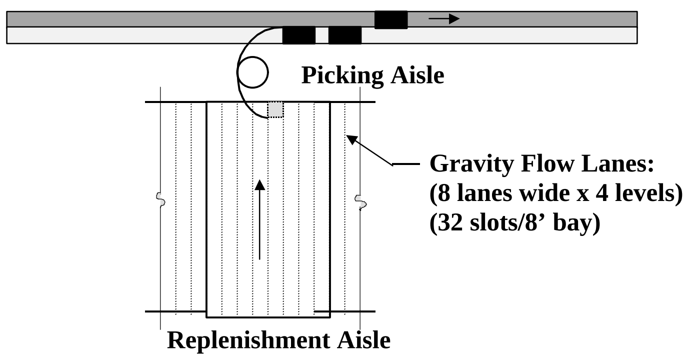


Figure 5.

3. Bin Shelving (B) - rows of shelving for storage and last-in-first-out (LIFO) or random access picking of items; Pickers walk through aisles to select order requirements. Picking aisles are shared with replenishment activity as is shown in Figure 6.

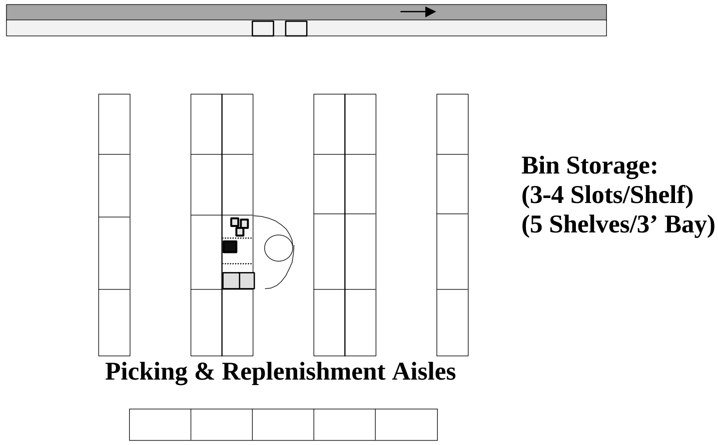


Figure 6.

4. Carousel Storage (C) - cases or individual items in horizontal carousel bins; Items are automatically brought to the picker working at the end of the Carousel Pod as shown in Figure 7. Replenishment is typically interleaved with picking or is performed on another shift.

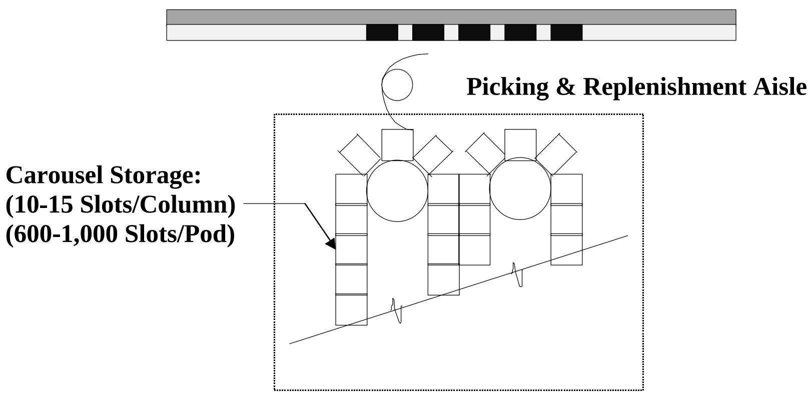
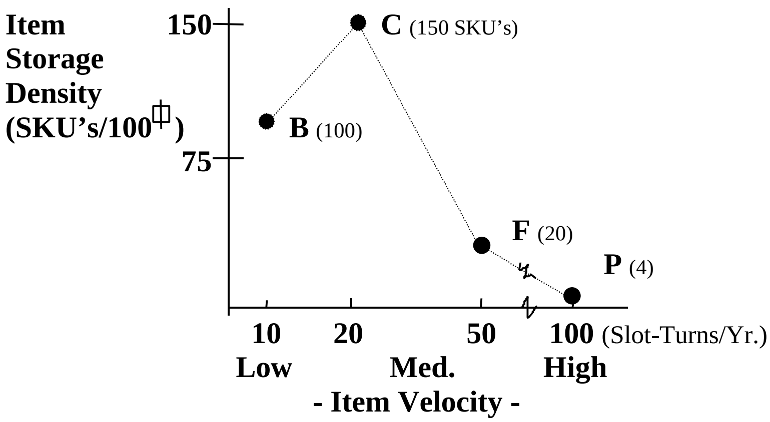


Figure 7.

The relationship of picking storage method and resulting SKU density to item velocity is depicted in the graph in Figure 8:

STORAGE DENSITY VS. VELOCITY



Note: 3 level pick module assumed for (P) Pallet Storage equipment.

Figure 8.

As the graph in Figure 8 indicates, Bin Storage is the favored storage method for the slowest moving items, although Carousel Storage provides the greatest storage density. Generally, it is not appropriate to use Carousel Storage for the slowest movers as they necessarily extend the length of the Carousel, reducing throughput and impacting response time. The economics of using mechanized vs. static Bin Storage for the slowest movers is questionable as well.

For faster moving items, Carousel Storage begins to lose favor as greater replenishment activity begins to interfere with picking efficiency. In addition, the number of personnel which may simultaneously access Carousel Storage for picking or replenishment becomes a limiting factor.

Case Flow Rack has the advantage of physically separating replenishment and picking personnel, thus allowing simultaneous access to storage by as many persons as are necessary, given the item activity levels. In addition, more merchandise can be stored in a case flow pick location than with Bin or Carousel Storage.

Pallet Rack/Shelving offers the least SKU density at four (4) SKU's per 100 square feet but provides the most merchandise in the picking slot, thus minimizing replenishment cycles for the fastest moving items.

Table 3 which follows summarizes the relationships between storage method, slot capacity, and item activity levels:

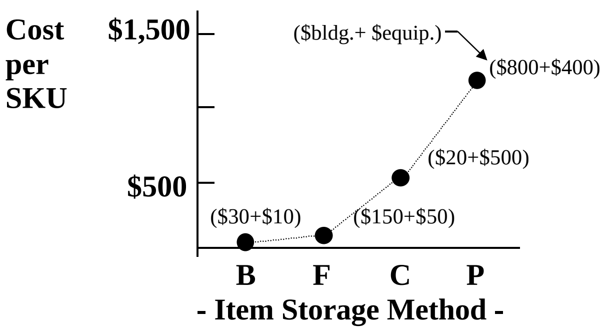
ON-LINE STORAGE UTILIZATION

Storage Method	Slot Capacity	Supply On-Hand	Slot Turns/Yr.	Cube Movement/Yr.
B	2 cu.ft.	4-6 weeks	10	20 cu.ft.
C	2	2-3 weeks	20	40
F	10	1 week	50	500
P	85	2-3 days	100	8,500

Table 3.

The major capital costs associated with on-line storage for order picking are building (space) costs and storage equipment costs. The relationship of capital cost per SKU to picking storage method is depicted in the graph in Figure 9. Building costs of $30 per square foot have been assumed.

CAPITAL COSTS FOR ON-LINE STORAGE



Note: 3 level pick module assumed for (P) Pallet Storage equipment.

Figure 9.

As can be seen in Figure 9, Bin Storage is clearly the least costly form of on-line storage while also providing good storage density (Figure 8). It is often selected as the best method for holding slow-moving split-case SKU's which must be stocked for customer service reasons.

Another picture of storage economics can be obtained when the capital cost per SKU for on-line storage is rationalized with annual item cube movement as is illustrated in the graph in Figure 10:

STORAGE COSTS PER ANNUAL CUBE MOVEMENT

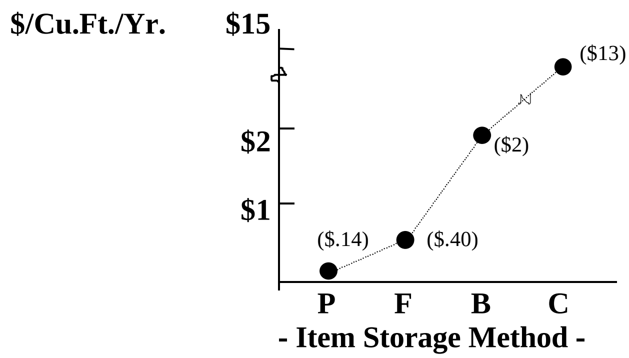


Figure 10.

As can be seen in Figure 10, the capital storage cost per annualized cubic foot of movement for Pallet Storage is the lowest, as the investment in racking, flow rail, etc. is amortized over a significant volume of merchandise moved through the storage system.

The rationalized cost of Case Flow Rack increases only slightly over Pallet Storage, although costs begin to escalate at a higher rate with Bin Storage. Bin Storage is 20% of the cost of Case Flow Rack but supports only 4% of the cube movement. Rationalized costs of Carousel Storage are again significantly higher than Bin Storage as the capital cost of Carousel Storage increases by a factor of thirteen (13) while only supporting a seven-fold increase in cube movement.

7.2 Picking & Packing Costs

Order picking and packing are very labor-intensive functions which often make up the majority of "touch" labor costs in a distribution center. Performance measures for order picking and packing productivity are typically expressed in either pieces/man-hour or order lines/man-hour. Clearly, either measure can be used to yield such statistics as orders/man-hour or man-hours per 1,000 orders, etc.; but the key issue is, what kind of orders?

The problem with these measures is that they are often applied indiscriminately without regard to order type. Referring to the order types defined in Section 4.0, it can be seen in Table 4 that each performance measure is naturally influenced by the characteristics of the orders being filled:

RELATIVE THROUGHPUT BY ORDER TYPE

	- Productivity Measure -		
Order Type	**Pieces/Hour**	**Lines/Hour**	**Orders/Hour**
Wholesale	**HIGH**	**LOW**	**HIGH**
Retail	**HIGH**	**LOW**	**LOW**
Direct	**LOW**	**HIGH**	**HIGH**
Consumer	**LOW**	**HIGH**	**LOW**

Table 4.

In light of these order characteristics, the "pieces/hour" measure will be used in the following sections for W and R order types and "lines/hour" for D and C orders. The projected picking and packing productivity rates for the four (4) basic order types when using the optimal strategies to minimize pick/pack cost (as identified in Table 2) are shown in Table 5 following:

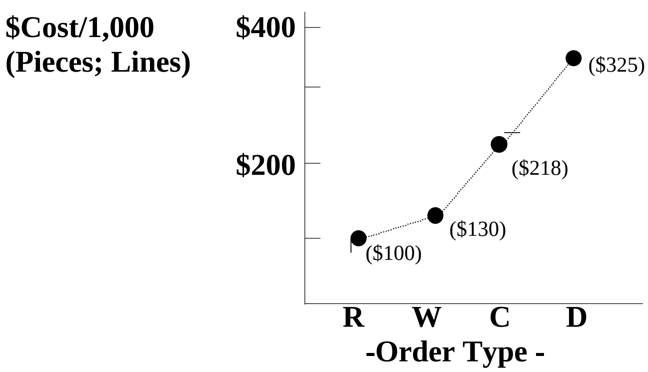
OPTIMAL PICKING & PACKING PRODUCTIVITY

Order Type	**Strategy**	**Picking**	**Packing**	**Measure**
Wholesale	**DZ_RP**	**100-200**	**-NA-**	**Pieces/Hr.**
Retail	**DZ_CP**	**150-250**	**-NA-**	**Pieces/Hr.**
Direct	**B_MZ_PA**	**300-400**	**50-100**	**Lines/Hr.**
Consumer	**B_MZ_PA**	**300-400**	**100-150**	**Lines/Hr.**

Table 5.

The man-hours required per 1,000 pieces or line-items for order picking and packing combined can be computed from the productivity projections in Table 5. Using an assumed rate for labor and fringes of $20/hour, the minimum labor costs can then be computed as follows in Figure 11:

LABOR COSTS FOR PICKING & PACKING



7.3 Justification for Material Handling Mechanization

The picking and packing costs projected in Section 7.2 are based on optimal strategies designed to minimize cost by investing in mechanization and methods improvement.

To illustrate the cost savings afforded by these strategies, and thus the investment justification rationale, consider the labor costs associated with the basic, least mechanized method for order picking and packing. Table 6 contains productivity projections for the DTP method when used for each order type:

BASE PICKING & PACKING PRODUCTIVITY

Order Type	Strategy	Pick/Pack	Measure
Wholesale	**DTP**	**100-150**	**Pieces/Hr.**
Retail	**DTP**	**80-120**	**Pieces/Hr.**
Direct	**DTP**	**20- 60**	**Lines/Hr.**
Consumer	**DTP**	**40- 80**	**Lines/Hr.**

Table 6.

Assuming the same rate of $20/hour for labor and fringes, the approximate base cost per 1,000 pieces or lines picked and packed is shown in Figure 12 which follows:

BASE PICKING & PACKNG LABOR COSTS

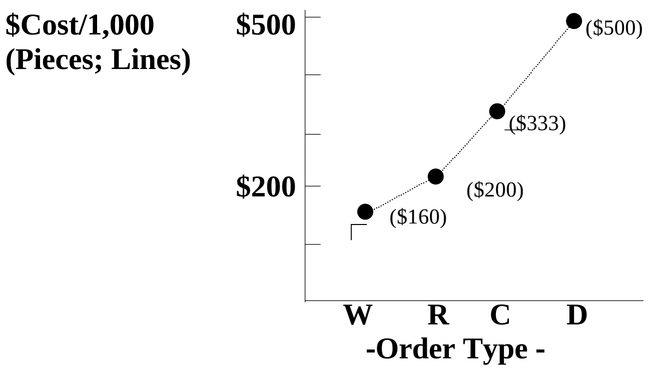


Figure 12.

Computing the differences in the cost data presented in Figures 11 & 12, the order fulfillment cost savings due to an investment in methods improvement and mechanization can then be summarized as follows in Figure 13:

COST SAVINGS DUE TO METHODS & MECHANIZATION

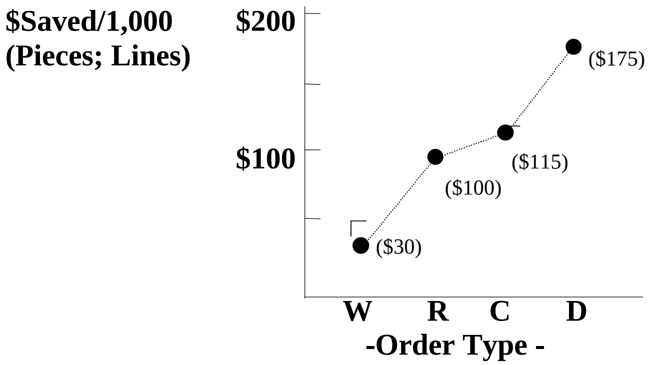


Figure 13.

Figure 13 provides projections of cost savings in labor only, assuming a rate of $20/hour. Of course, these projections can be factored up or down based upon the labor rates prevailing in the application under consideration.

The following Sections 7.4 and 7.5 identify the capital costs associated with the mechanization of the material transportation and sortation functions needed to achieve the cost savings in Figure 13.

7.4 Mechanization Costs for Zone Transportation

Many Chained Zone (Z_C) split-case order picking systems utilize gravity conveyors for the "pick-to" work positions and powered (roller) conveyor for transportation to shipping as shown in Figure 14:

ZONE TRANSPORTATION CONVEYOR

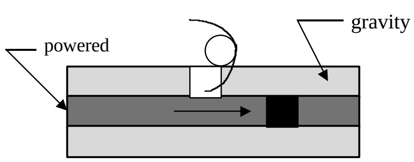


Figure 14.

Additional trash disposal or empty tote/carton supply conveyors may be included if necessary. Assuming an approximate $300 per lineal foot for the picking/transportation conveyor identified in Figure 14, the base material handling equipment cost per 100 SKU's can be projected as follows in Figure 15:

Z_C CONVEYOR COST/100 SKU's

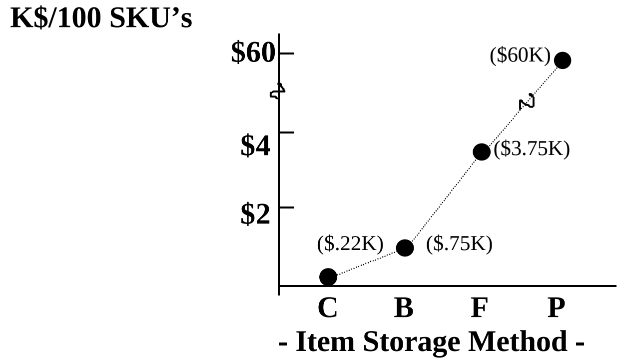


Figure 15.

The costs depicted in Figure 15 represent the capital investment necessary in picking/transport conveyor to implement the Chained Zone (Z_C) type of order routing through various types of on-line storage systems. It is assumed that both sides of the conveyor are used for picking (i.e., only half of the installed conveyor cost is allocated to span the lineal frontage required by each storage method).

In order to merge the output of multiple pick lines (each line representing multiple Chained Zones) it is necessary to add controlled merges and inter-line transport/accumulation conveyor. From 15% to 25% should be added to the transport conveyor costs from Figure 15 to cover this equipment. In many cases the inter-line conveyor may include inclines, declines, or spiral conveyors (e.g., to link multiple levels in a picking module).

To implement the Parallel Zone (Z_P) type of order routing, it is typically necessary to merge the output of multiple zones (usually smaller than pick lines) before transporting the picked items to packing or shipping. The addition of controlled merges and inter-zone transportation/accumulation conveyor typically adds from 25% to 33% to the base transport conveyor costs in Figure 15.

Mechanization of a Zone Routing (Z_R) system is conceptually different than Chained or Parallel Zones. Rather than providing conveyor transportation along (or in close proximity to) all of the pick faces, only inter-zone transportation is provided. In addition to the inter-zone transportation conveyor, a more intelligent control system is necessary to route orders to only those zones requiring picks. Some accumulation conveyor is also typically provided at each zone to act as a buffer and to provide temporary holding positions for the pick-to containers.

Like Z_C and Z_P systems, the mechanization costs of a Z_R system are a function of the number of SKU's and the storage types employed; however, Z_R system costs are also sensitive to zone sizes (SKU counts). It is highly unlikely that the Z_R strategy would be applied to zones containing exclusively Pallet Storage due to high activity levels and storage space requirements which both serve to make routing system costs prohibitive.

The conveyor mechanization costs for a Zone Routing (Z_R) system must include the zone transfers (diverts) and related routing controls in addition to the inter-zone transportation conveyors and zone accumulation or queuing conveyor. An illustration of the routing conveyor interface to a pick zone follows in Figure 16:

ZONE ROUTING CONVEYOR SYSTEM INTERFACE

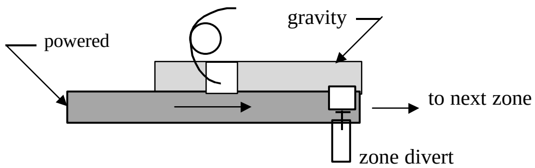


Figure 16.

With some basic assumptions regarding zone size (SKU's) and inter-zone distances, the conveyor and routing control system cost ($000's) per 100 SKU's is depicted in the following graph in Figure 17:

Z_R CONVEYOR COST/100 SKU's

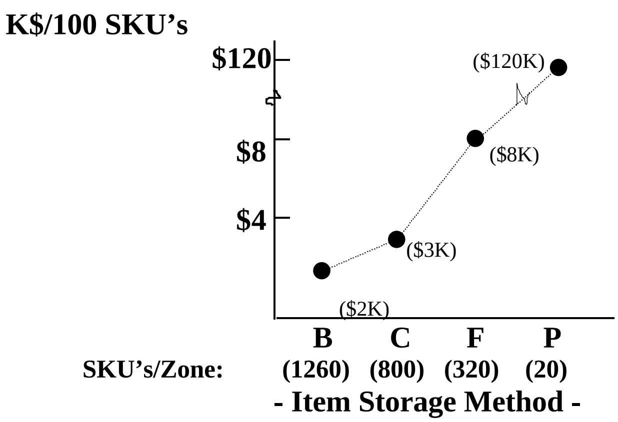


Figure 17.

Zone sizes in Z_R systems are usually configured based upon activity levels. As can be seen in Figure 17, the assumed size for Bin Storage zones (1,260 SKU's) includes more items of a slower moving variety than say, the Carousel Storage zones at 800 medium mover SKU's per zone.

7.5 Mechanization Costs for Order Assembly & Packing

Split-Case Order Assembly and Packing systems usually fall into one of two (2) categories: Tote Sortation or Item Sortation.

In Tote Sortation systems, totes containing the picked merchandise are transported from the picking zones to a sorter which then automatically directs all totes of a given order to an accumulation conveyor supplying each packing station. Orders are normally dynamically assigned to pack stations to level the packing workload among the active stations. A conceptual layout of this type of packing system is shown in Figure 1.

In Item Sortation systems, totes containing the picked merchandise are transported from the picking zones to one or more induction stations where individual items are removed from the totes and inducted onto an item sorter such as a Tilt-tray or Crossbelt. Individual items are then sorted by order to chutes where the orders are assembled for packing. Pack stations are located at the discharge ends of the chutes.

Some Item Sortation systems utilize bulk handling (belt) conveyor to transport merchandise from the pick zones directly to the induction stations when item protection and conveyability are not issues See Figure 2 for a conceptual layout of an Item Sortation and Packing System.

The capital costs of mechanization to support the sortation, order assembly, and packing functions is roughly the same for Tote and Item handling systems at approximately $15K per packer. However, this number can vary from $10K to $20K per pack station depending upon the sortation rate, sorter technology employed, number of order assembly positions and packing stations, station ergonomics, etc.

The approximate capital cost ranges for mechanization of these functions as a function of order type and throughput (lines/hour or pieces/hour) are shown in Figure 18.

ORDER ASSEMBLY & PACKING SYSTEM COSTS

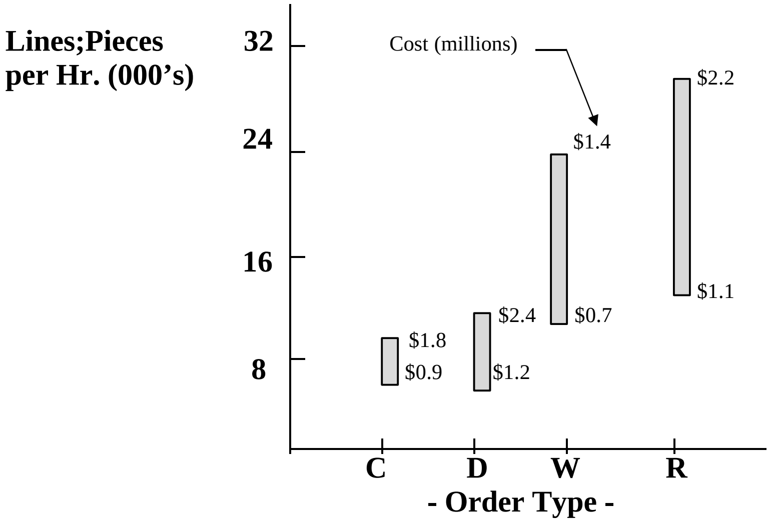


Figure 18.

As can be seen in the chart in Figure 18, Order Assembly and Packing System costs can be roughly estimated within a range of volume depending upon order types. Extrapolation of costs for lessor volumes is not reliable as system costs per packer rise in a non-linear fashion as the number of packing stations is reduced.

8.0 CASE EXAMPLE

In order to illustrate the application of the information presented in the previous sections, an example of a hypothetical order fulfillment application is provided in the following paragraphs.

Electronic Supply is a Catalog Merchandiser with the following operating characteristics:

Active Items (SKU's):	2,000
Orders/Day:	15,000
Lines/Order:	3.0
Pieces/Line:	1.0
Productive Hours/Day:	7.5

Current picking and packing is performed using the DTP method with an overall net productivity level of 40 line-items per man-hour for both functions. The current staff level is 150 personnel, picking and packing orders on one shift.

Electronic Supply intends to incorporate a B_MZ_PA strategy for order picking and packing to boost productivity and reduce order cycle time. Customer service policies require same day shipment on all orders received by 5:00PM. Average item value tends to be high and 100% checking of orders is desired to assure accuracy in fulfillment.

An ABC analysis of item movement over the prior year shows the typical 80/20 pattern, with 80% of the activity coming from 20% of the items. The 2,000 items offered by *Electronic Supply* are currently stocked in 10,000 square feet of pallet rack, case flow rack, and bin shelving.

In conjunction with their new picking strategy, *Electronic Supply* intends to change their on-line storage configuration to a combination of case flow rack, carousels, and bin shelving for the fast, medium, and slow moving items respectively.

The intended item storage configurations and associated storage equipment and material transportation conveyor costs are shown in Table 6.

STORAGE & TRANSPORT EQUIPMENT COSTS

Movement Category	No. of Items	Storage Method	Space Required(1)	Storage Eq. Cost (2)	Transport Eq. Cost(3)
A	400	Case Flow(F)	2,000	$ 20	$18.8
B	600	Carousel (C)	400	$300	$ 1.7
C	1,000	Bins (B)	1,000	$ 10	$ 9.5
Totals	2,000		3,400	$330	$30.0

Notes: (1) Storage density (Sq.Ft.) from Figure 8
(2) Storage equipment cost (000's) from Figure 9
(3) Transport conveyor cost (000's) from Figure 15, inflated by 25% for Z_P layout

Table 6.

With the B_MZ_PA methodology, *Electronic Supply* expects to achieve picking and packing productivity of 350 lines/hour and 75 lines/hour respectively (Table 5). Therefore, to support current activity levels, 17 pickers and 80 packers are projected with a net savings of 53 personnel.

The space required for on-line storage is projected at 3,400 square feet (Table 6). This is approximately one-third of the space currently consumed. Since the building already exists, no new construction costs are avoided, however additional space can be made available for value-added functions or future expansion.

From Figure 11, the projected picking and packing costs are $325 per 1,000 lines or $14,625 per day. With current cost levels of $500 per 1,000 lines picked and packed (Figure 12), the projected savings are $175 per 1,000 lines (Figure 13) or approximately $2 million per year.

The additional mechanization necessary to support the assembly and packing of orders using the $B_M Z_P A$ methods includes a Tilt-tray or Crossbelt sorter with chutes and packing stations to support the 80 packers projected above. The rough cost for this mechanization from Figure 18, is $1,200,000.

The total capital investment in storage and handling equipment can be summarized as follows:

1. Storage Equipment	$ 330,000
2. Transport Conveyor	$ 30,000
3. Sortation & Packing Equipment	$1,200,000
Total Investment	**$1,560,000**

With labor savings alone of over $2 million/year, *Electronic Supply's* capital investment in the proposed order picking and packing system is easily justified.

9.0 CONCLUSION

Several methods for improving split-case order picking and packing performance have been discussed. Many of these methods require some level of mechanization to be feasible. The cost savings afforded by labor reduction alone is often sufficient to justify the investment in conveyor transportation and sortation equipment.

It should be noted that the performance and cost statistics cited in this paper are representative of the author's experience. Data for individual applications can vary widely due to local environmental factors. *Caution should be used before making any specific projections based upon the general data presented in the previous sections.*

Many of the benefits of mechanization and methods improvement in order fulfillment operations cannot be quantified and expressed in monetary terms. Cycle time reduction, improved accountability, higher fill rates, etc. are of value in improving customer service and providing a competitive advantage. It is becoming more common to pursue such improvements for these strategic reasons rather than the traditional "hard" justification factors.