TECHNICAL NOTES

VASAN008

Designing Distribution Centers: Low CapEx Piece-picking Options

Just a few years ago distribution centers handled most of their goods either by a pallet load or as individual closed cases. Piece picking, an operation that demands a lot of resources, was an exception to this rule or was a very small portion of the distribution center operation.

Conditions have changed greatly in recent years. Distribution centers servicing retailers are facing radical changes in ordering patterns. Most retailers have adopted just-in-time inventory practices sustained by smaller, more frequent orders with line item quantities smaller than full case quantities. As companies venture into e-commerce applications, they find that their new Internet customers order mainly single items or -- even harder to fulfill -- multi-SKU, single-item orders.

Below are several low capital expenditure options available for eight piece-picking operations. The effect of each option is quantified on a pure piece-picking or e-commerce application.

For the purpose of this analysis, the time thatpickers spend in a piece-picking process is divided into three categories: walking between transactions; executing picking transactions (including finding the location to pick from, retrieving requested quantity, placing items in shipping container, and other sub-tasks); and setting up orders (releasing complete orders and starting new orders).

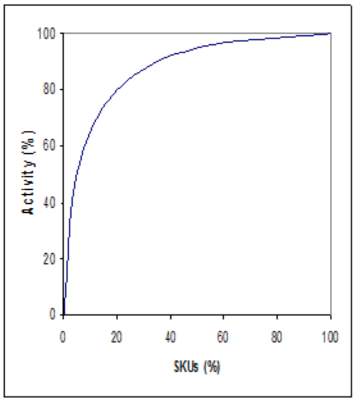
Many piece-picking techniques focus on picking orders in batches in order to reduce the walking between transactions. In highly automated processes (piece sorters, ASRSs) the size of these batches can be very large (more than 2,000 orders) and walking between transactions can almost be completely eliminated. However, these systems require very large initial investments, which are not considered in this analysis.

The costs provided are equipment only and exclude any software costs that may be required to support the option.

The sample application

The piece-picking reference requirements used to compare different technologies are:

- 150 orders per hour with an average of five lines per order and 1.5 items per line
- 12,000 active SKUs to be picked from a combination of flow rack and static rack. The total aisle length adds up to 2,000 feet. The SKUs are small enough to be handled manually by workers.
- The average number of pieces in a receiving case is 20.
- The 80-20 rule applies in this reference application; therefore, 80 percent of the line transactions include the 20 percent most active SKUs (fast movers). Also, the 5 percent most active SKUs (super fast movers) account for 50 percent of the line transactions.
- The distribution center operates two shifts five days per week.



A link to a spreadsheet for people to check the calculations behind the results presented in this document can be found in the conclusions section at the end of the article.

The time parameters used to estimate picking times in each option are walking time per foot, transaction time per line, and setup time per container.

When possible, the best way to estimate these parameters is using software logs of the actual operation and videotape of the operation corresponding to the logs. While the log records provide large data samples already in electronic format, the videotape is very helpful to explain log records that show unexpected deviations from other records of the same tasks. People may question the time parameters used, but even though it may be is easy to disagree with estimations, it is not so easy to disagree with electronic records and videotapes. While the numbers presented here are estimations, they should be representative of a true physical system.

Scenario 1: Individual order picking with paper lists

This is the least sophisticated option to analyze. It implies an operator picking one order at a time from a paper list and having to walk the entire picking loop, meaning the total length of all the picking aisles, to complete the order. This is a very inefficient operation with very low productivity, yielding a high incidence of errors. It will be used only as a base for comparisons. The calculations are performed by the spreadsheet for all the presented scenarios.

Time parameters

Walking time	Transaction time	Setup time
0.5 seconds per foot	12.0 per line	5.0 seconds per container

To determine productivity and labor:

Lines to pick per loop = 5.0 lines per container X 1 container per loop = 5 lines per loop

Setup time per loop = 5.0 seconds per container X 1 container per loop = 5 seconds per loop

Walking time per loop = 2,000 feet per loop X 0.5 seconds per foot = 1,000 seconds per loop

Transactions time per loop = 5.0 lines per loop X 12 seconds per line = 60 seconds per loop

Total time per loop = 5.0 seconds per loop + 1,000 seconds per loop + 60 seconds per loop = 1,065 seconds per loop

Results

Productivity = 3,600 X 5 / 1,065 seconds per loop = 16.9 lines per hour per picker.

Labor = 150 X 5 X 2 / 16.9 = 88.8 pickers.

Scenario 2: Batch picking with paper lists

This option introduces a picking cart that allows the picking of six orders in the same loop using a paper-picking list. In this scenario the walking time per foot increases because the picker is pushing a cart with six containers on it. The transaction time per line increases because the picker needs to find the container for the picked items among the six on the cart. This option represents a substantial labor reduction with a very low investment in equipment ($300 to $500 per cart); however, it does not address the problem with errors.

Time parameters

Walking time	Transaction time	Setup time
0.6 seconds per foot	13.0 per line	5.0 seconds per container

Results

Productivity = 67.0 lines per hour per picker.
Labor = 22.5 pickers.

Scenario 3: Batch picking with handheld scanner terminals

This option eliminates all paper from the operation by replacing paper lists with handheld terminals. These terminals are capable of task validation through the scanning of picked items and destination containers. The transaction time per line and the setup time per container increase because pickers have to scan items and containers in this scenario.

The labor reduction with this option is still very substantial and the errors are almost completely eliminated with the validation. The required investment in equipment is in the range of $1,500 to $2,000 per handheld terminal plus the communication system.

Time parameters

Walking time	Transaction time	Setup time
0.6 seconds per foot	15.0 per line	6.0 seconds per container

Results

Productivity = 64.0 lines per hour per picker.
Labor = 23.4 pickers.

The original handheld terminals tied one hand of the picker completely. Manufacturers of these devices have developed units that pickers can carry attached to their wrist or finger, partially returning the use of the two hands to the pickers.

Voice terminals that issue verbal picking commands and accept verbal responses from pickers can replace the handheld terminals. Voice technology leaves workers' hands completely free for picking and excels in transactions that require heavier than usual data exchange between the software and the worker, such as exceptions handling. On the other hand, without a scanner, validations become more cumbersome as workers need to read data on labels back to the software. Voice technology is an option that can be very attractive for some applications.

Scenario 4: Batch picking with smart carts

Handheld terminals have small displays that limit the amount of information available to the picker. A smart picking cart furnished with an onboard computer and with one or more full-size monitors can become a very powerful source of information for the picker: current location of the cart highlighted in an aisle layout, optimal or shortest route to the next picking location, next bay location to pick from highlighted in a graphical bay layout, bin location identification to pick from, full description of item to pick, quantity to pick, picture of item to pick, etc. The required time per transaction can be reduced with a carefully designed system presenting useful information to the picker.

Increasing the batch size from one to six orders results in a large productivity increase; however, further increases in the batch size could be limited by other factors such as carton size and/or the weight of the picking cart in a manually pushed cart operation. A self-propelled smart cart could be considered to eliminate some of these restrictions.

This option introduces smart carts into the operation. The batch size increases from six orders to 12 orders per loop. Walking time per foot increases because the picking cart is larger. Transaction time per line increases because the picker needs to sort the picked items to 12 containers instead of to 6.

Smart carts can bring an even larger labor reduction, the same accuracy as with handheld terminals, and a sophisticated interface traveling with the picker providing all information necessary for the picking tasks. Smart carts with the features mentioned should be in the $10,000 to $15,000 per cart range.

Time parameters

Walking time	Transaction time	Setup time
0.7 seconds per foot	16.0 per line	6.0 seconds per container

Results

Productivity = 89.0 lines per hour per picker.
Labor = 16.9 pickers.

Scenario 5: Virtual batching with smart carts

Many people dislike an inherent fact linked to batch picking: Containers that have been completed still have to be carried on the cart until the completion of the picking loop. This situation is particularly undesirable when the picking loop is very long and the number of picks per container is low. The condition is even worse when orders require more than one container per order and all the containers are carried the full length of the picking loop.

The most efficient solution for this issue is the use of virtual or dynamic batching. When an order is completed, the software can inform the picker that the container does not have any more pending picks, allowing the picker to release that container and start a new one. The released container can be dropped on the aisle or moved to a top shelf in the cart -- a shelf not ergonomically useful for picking. The top shelf can also be used to carry empty containers. Once the cart goes by a point where it can release containers, like a take-away conveyor spur, all containers on the top shelf can be released. The concept of a single build cart area in the loop disappears and is replaced by a continuous loop that has neither an end nor a beginning.

The impact to productivity comes from the reduction in the actual walk required to complete a container. Defining the virtual loop length as the expected distance walked to complete a container, its value would be the total actual length of the picking loop multiplied by two factors.

Virtual loop length = Actual loop length X (N/(N + 1)) X (1/M)

In the equation, N is the average number of lines per container and M is the average number of containers per order.

The expected effect of this option in our application is below. The setup time per container increases because containers are now released in two steps. This option yields a labor reduction of 9 percent that can be achieved without any additional investment in equipment. The only potential investment is in software to support it.

Time parameters

Walking time	Transaction time	Setup time
0.7 seconds per foot	16.0 per line	8.0 seconds per container

Results

Productivity = 97.0 lines per hour per picker.
Labor = 15.4 pickers.

Fast moving – slow moving separation

The intelligent selection of picking locations for each individual SKU (slotting) also has an impact on DC productivity. Among several slotting strategies, fast moving SKUs can be segregated from the other SKUS and picked with a different process that better fits their requirements. Fast mover SKUs and slow mover SKUs behave differently from the picking perspective. For fast movers there is shorter walking distance between transactions, the bulk of the picking time is in the actual picking task. Conversely, for slow movers there is longer walking distance between transactions. This results in the walking time being the largest component of the picking time for slow movers.

Scenario 6: Pick fast movers with pick-to-light and slow movers with smart carts

This option separates the 5 percent fastest moving SKUs that account for 50 percent of the transactions and place them in a pick-to-light aisle. Pick-to-light is an option that can reduce by more than half the transaction time per line. The length of this aisle is 120 feet. The other SKUs (slow movers) are picked with smart carts.

The pick-to-light aisle will need to be split in sections with one picker working each section in a pick and pass process. There is no batch picking in this aisle.

This particular application does not seem to benefit from pick-to-light; nevertheless, this technology is very attractive for high density picking applications. The cost of pick-to-light technology is in the range of $125 to $175 per SKU location.

Time parameters

Walking time	Transaction time	Setup time
0.5 seconds per foot	5.0 per line	5.0 seconds per container

Results

	Fast Movers	Slow Movers	Whole System
Productivity (lines per hour per picker)	133	57	80
Labor (pickers)	5.6	13.1	18.7

Scenario 7: Pick fast movers with smart carts and slow movers with carousels

An available technology that addresses the excessive walking in slow moving zones is carousels. Carousel pods substantially reduce the long walking between picks for slow movers. The picker does not need to go to the location; instead the location comes to the picker. As the picker is completing a transaction other carousels in the pod are rotating to be ready for the picker by the time he completes the current transaction, reducing picker idle time between transactions. Productivity using this type of device can easily reach 250 lines per hour per picker.

This option separates the 20 percent fastest moving SKUs, which account for 80 percent of the line transactions activity, to process them with smart carts. The length of these fast moving aisles is 400 feet. The other 9,600 SKU (slow movers) are picked from a carousel pod.

Even though the calculations show a very attractive labor reduction, the problem with this particular application is to have all the required inventory of 9,600 SKUs in one carousel pod. Carousel technology in this case addresses very well the throughput requirements but not the storage requirements. The cost of carousel technology is in the range of $350,000 to $500,000 per carousel pod. With this cost, this option could be considered a borderline low capital expenditure option.

Results

	Fast Movers	Slow Movers	Whole System
Productivity (lines per hour per picker)	154	250	167
Labor (pickers)	7.8	1.2	9.0

Scenario 8: Pick fast movers with smart carts and slow movers with a two-step picking process

Another option to deal with the excessive walking in slow moving zones is two-step picking. Smart carts picking in slow moving zones could be picking larger batches than 12 orders per loop. For instance, workers could be picking to six containers. Each of these containers, instead of representing a single order, could represent all the items required by the 12 orders in a smart cart picking in the fast moving zones. The items in each container would be mixed together in this first step. After the cart is finished, the slow moving cart would be parked in the path of the fast moving cart. The picker of the fast moving cart would stop in front of the container and do a second sort from the slow moving cart single container to his six individual order containers. Walking between picks is reduced at the price of touching twice the slow moving items.

This option keeps the 20 percent fastest moving SKUs to process them with fast moving smart carts. These carts also do the second sort of the items coming from the slow moving zones. The length of these aisles is 432 feet. These 2,400 SKUs account for 80 percent of the transactions.

Smart carts carrying six containers pick the other slow moving SKUs. Each of these six containers collects the items for 12 orders picked as a batch in the fast moving zone. The slow moving aisles add up to 1,600 feet.

The calculation shows that even with the additional step for picking slow movers, this option offers an increase in total productivity of the system. The only additional investment would be more floor space in the fast moving area to park the smart carts coming from the slow moving zone. Of course, the software would need to support this operation, which requires the pre-picking of the items in the slow moving zones and directing the fast moving carts to the locations where the pre-picked items are. This option also can be implemented pre-picking items from the slow moving zones to smaller containers representing either pure SKUs or even individual orders. Flexibility in the software is indispensable to take advantage of all these options.

Results

	Fast Movers	Slow Movers	Whole System
Productivity (lines per hour per picker)	162	112	126
Labor (pickers)	9.3	2.7	11.9

Conclusion

When a distribution center requires piece picking, there are several options and basic calculations that estimate the effect of each option on the distribution center operation to consider. These are not the only available options, and even within these options, conditions can be changed to better match the requirements of a particular operation. A real life problem would require the analysis of more options and different conditions for each option in order to find an optimal solution. The effect of these options on actual applications is available by inserting your own operation data on the spreadsheet at http://VARGOcompanies.com/LowCapEx_PiecePickingOptions.htm#Spreadsheet.

Productivity improvements can come from additional equipment (handheld terminals, smart carts, pick-to-light, carousels) or from additional software features (virtual batching, two-step picking). Make sure the software that supports the operation will be flexible enough to allow the operations people to operate the distribution center under the best conditions that the requirements dictate.

Software development is expensive, however it is a cost that is incurred once, while the savings or over-costs resulting from the used software will repeat every hour of every day that the distribution center operates.

The flexibility of the software should not be limited to support the original design, but it should allow the design to be tuned up after the operation starts and allow modifications to the operation when the market conditions that dictate the operation of the distribution center change with the times.

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