2019 CSCMP Supply Chain Innovation Award Winner

Snap-on Uses AI and Innovative Logistics to Slash Shipping Costs

Submitted by:

Snap-on

FASTFETCH

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EXECUTIVE SUMMARY

Summary of the Initiative:

This case study describes how Snap-on, a leading supplier of hand and power tools, diagnostic software, and shop equipment, slashed shipping costs at its distribution center in Crystal Lake, IL. The initiative introduced new work processes and new technologies that resulted in significant savings on parcel carrier costs, corrugated materials and dunnage usage, and packing labor. The savings resulted from the application of artificial intelligence (AI) to minimize wasted space in shipping cartons and from a highly effective strategy and supporting technologies for managing the logistics of storing, dispensing, and replenishing shipping cartons.

Innovation Statement:

FastFetch's IntelliPack shipping cost optimization system employs three key innovations for reducing costs and enhancing worker productivity. The first is a highly effective AI strategy for minimizing wasted space in shipping cartons. The strategy computes—typically in less than a second—the dimensions of an ideal carton for shipping a collection of items of known size. The second key innovation is a search strategy that analyzes historical order records in order to identify an inventory of carton sizes for shipping orders with minimal wasted space. The third key innovation is a carton management strategy that makes right-sized cartons available to packers as soon as they are needed and guides human workers as they replenish consumed cartons using a combination of voice, barcode scanning, and light-directed technologies.

Impact Statement:

In addition to cutting shipping costs, packaging labor, and packaging material usage, Snap-on's green footprint was improved by preserving natural forest resources, reducing landfill waste, and reducing fuel consumption required for transporting packages. Snap-on's new processes also improved the efficiency of logistics regarding the movement and storage of shipping cartons within the DC. The return-on-investment payback period was less than three months.

Applicability:

The technologies and strategies employed to enhance Snap-on's order-packaging processes are generally applicable to order-fulfillment operations in any distribution center where there is a wide assortment of products to be shipped with each order typically containing collections of products of differing dimensions. The solution is a comprehensive solution encompassing the selection and identification of right-sized cartons, replenishment of consumed cartons, and management of carton reordering from a supplier. Furthermore, the system is easy to install, easy to use, compatible with any WMS, and is totally independent of the order-picking process. This innovation makes it possible for companies of almost all sizes to benefit from right-sized packaging.

INTRODUCTION

Distribution centers play a crucial role in modern supply chains by storing goods from multiple manufacturers and subsequently fulfilling orders for goods by retrieving items from inventory and packing them into cartons for shipment to customers. While automated systems are gaining in popularity within distribution centers, much of the required work remains to be performed by humans. In particular, the tasks of retrieving items from storage locations and packing them into cartons for shipping are typically performed by human workers.

When items are packaged into cartons for shipment, substantial savings can result from minimizing wasted space within cartons. Wasted space results in excessive corrugate and dunnage usage and increases charges by parcel carriers as a result of the dimensional-weight pricing structure now being used. Packaging products for shipment can be challenging, especially when there is a wide assortment of products to be shipped, and each shipment contains a different collection of products.

Modern dimensioning systems can readily determine the size of the individual items that are to be packaged. A variety of algorithms—generally known as cubing algorithms—have been created in an attempt to determine the dimensions of the optimal carton(s) to contain a collection of items to be shipped. Upon determining the optimal dimensions of a carton for shipping a collection of items with minimal wasted space, the next problem is finding an efficient strategy for making right-sized cartons available at packing stations as they are needed. One approach is to maintain a large inventory of assorted carton sizes. There are four shortcomings with this strategy. First, determining the best mix of carton sizes that should be included in inventory is challenging. Second, a large inventory of cartons can occupy excessive storage space. Third, making changes to carton sizes in a large inventory of cartons to accommodate changes in products may be costly since on-hand inventory must first be consumed. Finally, the primary drawback of a large inventory of carton sizes is the challenge of quickly delivering right-sized cartons from the large stored inventory to packing stations.

Machines for fabricating right-sized cartons on demand have been developed as a means of delivering rights-sized packaging in a timely manner. While such machines represent a welcomed advance in many distribution environments, machines for creating right-sized cartons on demand can be expensive, and the costs cannot be justified for some companies. A limiting factor, however, is the speed with which cartons can be fabricated and delivered to packing stations. Even the fastest machines for making cartons on demand are often incapable of keeping pace with the speed of some of today's large packaging production lines. Finally, if a fabricating machine can be cost justified and produces cartons sufficiently fast, the question of where the machine should be located arises. For example, if a company has 20 packing stations, it would be difficult to position the fabricating machine close to all of the stations, so the walking time for a packer to retrieve an ideal carton produced on demand might be unacceptably large.

IMPROVING SHIPPING OPERATIONS AT SNAP-ON

FastFetch worked in concert with Snap-on's management to integrate FastFetch's IntelliPack shipping cost optimization system into operations at the Crystal Lake, IL distribution center. FastFetch's solution provided a complete carton management solution encompassing determination of right-sized cartons, dispensing cartons at packing stations, and replenishment of consumed cartons.

Snap-on is a $3.7 billion S&P 500 company headquartered in Kenosha, WI and is a leading innovator and supplier of tools, equipment, and system solutions for professional users. Snap-on's products include hand and power tools, diagnostic software, and shop equipment for numerous industries including automotive, aviation, aerospace, agriculture, construction, mining, and natural resources. Snap-on's Crystal Lake distribution facility fulfills orders for Snap-on's franchisees who primarily serve vehicle service shops with sales concentrated in hand and power tools, tool storage products, shop equipment, and diagnostic products.

Overview of the IntelliPack Shipping Cost Optimization System

FastFetch's IntelliPack shipping cost optimization system is illustrated in Fig.1. At the heart of the system are carton racks located near packing stations. The carton racks maintain a reasonably large inventory of carton sizes that have been determined as optimal based upon historical order records. FastFetch analyzes historical order records, order item quantities, and dimensions, to identify an assortment of cartons—perhaps 30 - 100 different sizes—that will accommodate the entire set of past orders with minimal wasted space. A two-step process is employed to determine ideal carton sizes for the carton racks. First, an AI strategy is applied to discover the optimal carton for shipping each order in the historical record set. Upon computing the set of optimal cartons for the historical record set, a second computational strategy is employed to discover a predefined set of cartons that would have accommodated all the historical orders with minimal wasted space. Multiple flat, unerected units of each of the predefined set of carton sizes are then maintained in carton racks positioned near packing stations. This strategy typically yields a 30% decrease in the volume of shipping cartons as compared to the cartons that were reported to have been employed in the historical data set.

System Operation

As cartons are needed for packing, a clever AI technique is employed to identify right-sized cartons in the carton rack. FastFetch's algorithm for determining the optimal shipping carton employs an AI strategy—much like game-playing algorithms that can determine a good move in checkers or chess—to explore possible item placements, orientations, and item properties such as nesting (e.g., tapered trash cans stacked together) and containability (i.e., items with a hollow center that can contain other items). Upon determining the optimal carton for a given customer order, the FastFetch system identifies an ideally suited carton by illuminating a segment of LED's in the carton rack adjacent to the carton that the packer should retrieve.

The system also manages replenishment of consumed cartons so that a sufficient mix of cartons is always available at packing stations. The picking process creates and updates a list of consumed cartons so a human worker can periodically be dispatched to a carton supply area to retrieve cartons to replenish those consumed at multiple carton racks. Not only does the system identify the cartons needed for replenishment, it uses voice, barcode scanning, and numerical displays to guide workers in retrieving needed cartons.

Replenishment carts are used by human workers to retrieve needed cartons from a carton supply area and to replenish carton racks. The replenishment cart contains multiple partitions with each partition holding replenishment cartons for a particular carton rack. Upon retrieving cartons needed for replenishment, the system guides the human worker to replenish the carton racks using barcode scanning, voice, and LED strips. Finally, the system maintains records on carton usage and periodically generates order information for a carton supplier to deliver replacement cartons for those removed from the carton supply area through vendor managed inventory.

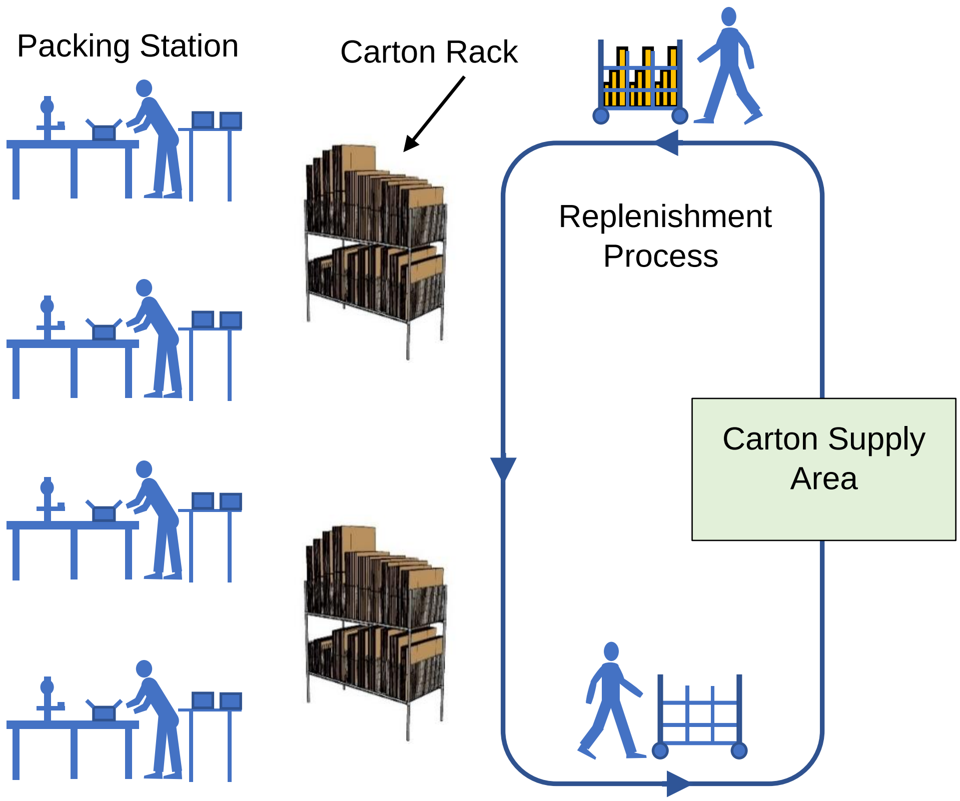

Fig. 1. Overview of the IntelliPack Shipping Cost Optimization System

A typical packing station is illustrated in Fig. 2. It consists of a carton rack containing multiple cartons of various sizes, a conveyor for transporting totes to the packing station, an automatic taping machine capable of accommodating random-sized cartons, and a conveyor for moving packed cartons to a labeling or shipping area. The sequence of activities that take place in packing stations can be understood with the aid of the numbered circles in Fig.2. The activity sequence is as follows:

1. Totes containing an order of picked items to be packed arrive at the packing station.

2. The packer scans an identifying barcode on the next tote to be packed. Upon scanning the barcode, the system uses the tote's barcode to determine the tote's order and contents and invokes the AI algorithm for determining the optimal carton size.
3. Upon computing the optimal carton size, the system indicates the right-sized carton by illuminating a segment of LED's beneath the optimally sized carton.
4. The packer removes the indicated carton from the carton rack, erects the carton, applies an order barcode (carried on or in the tote) to the carton, packs items from the tote into the carton, adds dunnage, and inducts the carton into the taping machine.
5. The taping machine seals the carton.
6. The conveyor transports the carton to the shipping area.

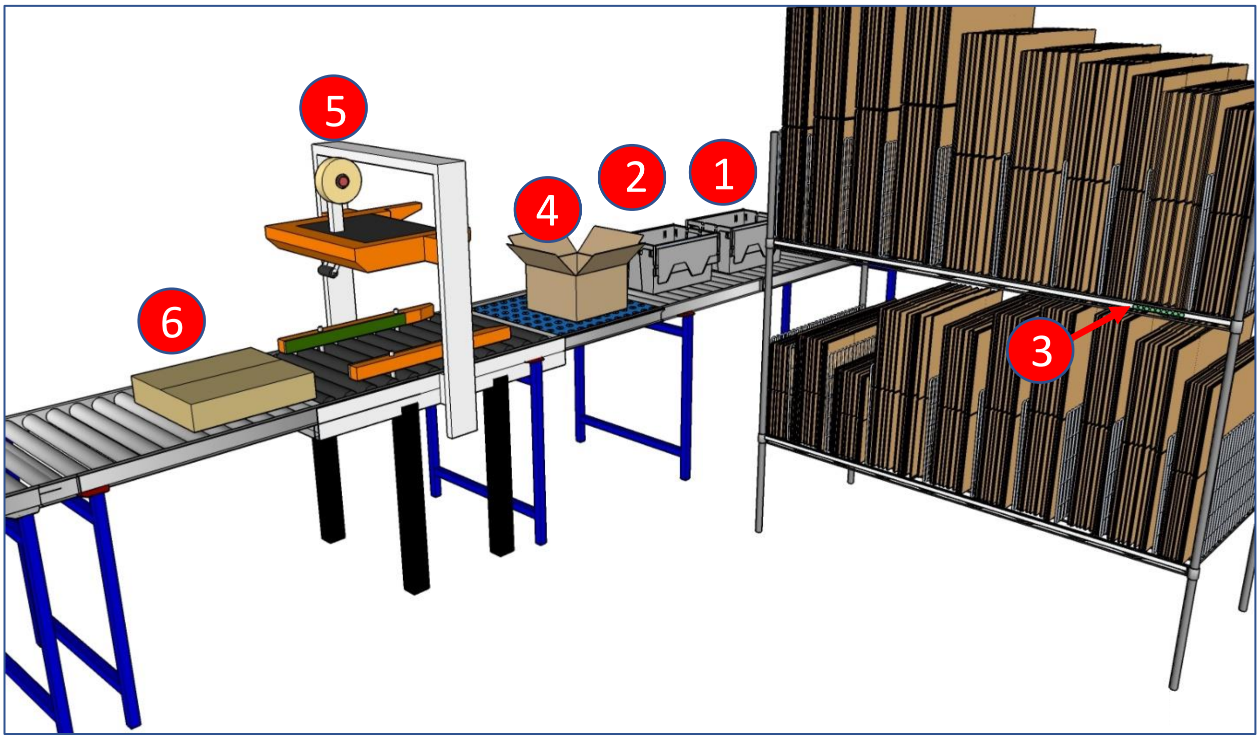

Fig. 2. Typical Packing Station

SYSTEM IMPLEMENTATION AT SNAP-ON

FastFetch installed its IntelliPack shipping cost optimization system at Snap-on in Crystal Lake, IL during 2018. Snap-on's installation consists of six packing stations, three carton racks, two replenishment carts, ancillary computers, and applications software. The system components are described in more detail below.

Packing Stations

Fig 3. shows a tote identifier being scanned as a tote containing items to be packed arrives at one of Snap-on's packing stations. Upon scanning the tote's barcode, the FastFetch AI carton selection algorithm computes the dimensions of a right-sized carton to accommodate the items in the tote. The carton selection algorithm executes in less than one second for typical orders.

While the carton selection algorithm selects the optimal carton for each individual collection of items to be shipped, the actual placement of items into to the carton is left to the discretion of the packer. Since reading and interpreting packing instructions provided by IntelliPack would a take considerable amount of time and since packers quickly become proficient at packaging a small collection of items into a carton, item placement instructions are not provided to the packer. Consequentially, the cartons selected by IntelliPack provide slightly more space than the minimum required for containing the items to be packed.

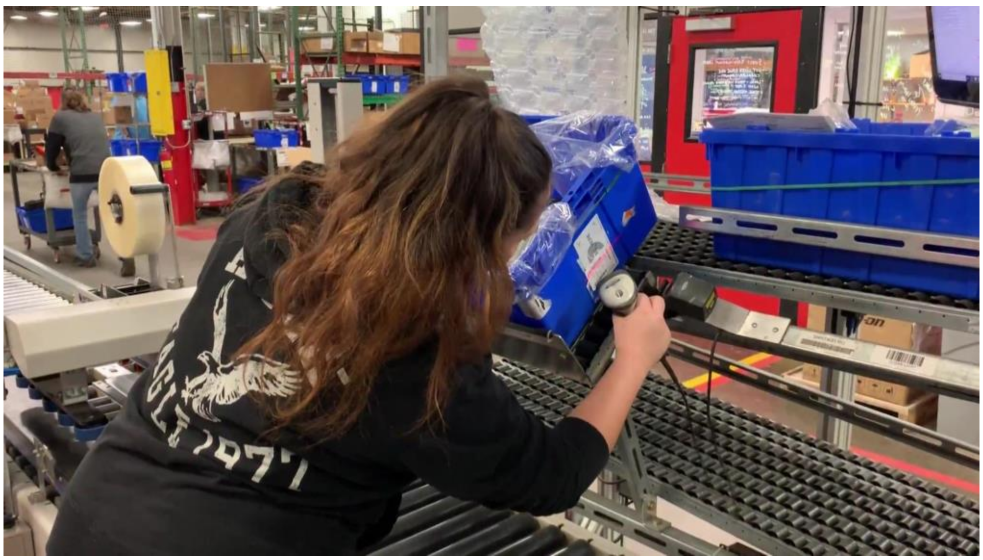

Fig. 3. Scanning Tote Identifier at a Packing Station

Carton Racks

The carton rack employed at Snap-on is shown in Fig. 4. Quite simply, the carton racks store a relatively small inventory of carton sizes near the packing stations. Carton sizes and quantities stored in the carton racks are judiciously chosen based upon the historical order profile. Carton racks are open on both sides so packers can retrieve cartons from one side and replenish cartons on the other side. On the retrieval side, LED strips highlight locations of cartons to be retrieved by packers. On the replenishment side, LED strips highlight locations where replenishment cartons are to be placed. Carton racks also employ numerical displays referred to as "message lights." Message lights display information regarding specific error conditions that might possibly occur such as failure to clock into the system before scanning a tote barcode. A single carton rack can serve multiple packing stations by employing different colored LED segments to highlight cartons for each packing station. At Snap-on, each carton rack supports two packing stations.

Determining the sizes of cartons that should be maintained in carton racks is a challenging problem. FastFetch analyzed nearly 85,000 historical order records to discover the ideal set of carton sizes to support Snap-on's packing operation. The first step of the analysis employed FastFetch's AI carton selection algorithm to determine the dimensions of the optimal-sized carton for each order in the historical data set. Upon determining the dimensions of the ideal carton for each order in the historical data set, the next step was to reduce the large set of carton sizes into a much smaller, manageable number of carton sizes. An optimization algorithm was employed to reduce the large number of carton sizes to a much smaller collection that accommodated orders in the historical data set nearly as well as the large set of carton sizes. Generally speaking, having a larger number of carton sizes in the carton racks increases the likelihood of selecting cartons that provide a better fit for the items to be packed. Maintaining a larger number of carton sizes, however, requires more storage space and perhaps includes a number of infrequently used carton sizes. At some point, increasing the number of carton sizes in the carton rack provides diminishing returns and increases costs.

Fig. 4. Carton Rack Employed at Snap-on

The analysis of Snap-on's historical order records concluded that 42 carton sizes were ideal for packaging orders in the historical record set. Because the selection of those 42 carton sizes was based upon an analysis of historical order records, the carton sizes chosen for the carton rack might possibly change as the nature of the orders changes. Therefore, it is necessary to periodically review the order profile and, if warranted, change the sizes of cartons that are chosen for the carton racks.

Carton Replenishment

Cartons are replenished periodically as they are consumed, and the replenishment process takes place concurrently with packing operations without interference. The system keeps track of consumed cartons, and carts are periodically dispatched to replenish consumed cartons. The replenishment process takes place in two phases. In the first phase, needed cartons are retrieved from the carton supply area. In the second phase, needed cartons are loaded into carton racks. Both processes are described in more detail below.

Retrieving Cartons from the Carton Supply Area

The process for retrieving cartons from the carton storage area is essentially an order-picking process where each carton rack is an order and the quantity of consumed cartons of each size are order line items. Cartons are picked from the carton supply area, placed into partitions on a cart, and transported to the carton racks. Fig. 5 shows a replenishment cart used by Snap-on. The carts employ voice, barcode scanning, and lighted numerical displays to assure fast and accurate retrieval of the cartons needed. The entire retrieval process is orchestrated by a tablet computer on each cart. The cart's electronic components are powered by Snap-on's lithium-ion tool batteries that can be periodically hot-swapped. Carts have three partitions, one for each carton rack.

To initiate the retrieval process, a worker logs into a cart's tablet and requests a set of carton rack orders. The cart then uses voice to direct the worker to the carton supply location where the first required carton is located. When the worker arrives at the location, the worker scans an identifying barcode on the location containing the carton size to be retrieved. The system then speaks the total number of those cartons required and highlights partitions on the cart where the items should be placed. The numerical display associated with each cart partition indicates the quantities required for each carton rack. When the picked items are placed into cart partitions, the worker confirms proper placement of the cartons by waving a hand or carton near a light-sensitive proximity switch to signal cart placement completion. After depositing the required quantities of cartons into the cart partitions, the tablet directs the worker to the location for the next pick. This process continues until all required cartons have been retrieved. The tablet then directs the worker to transport the cart to the carton racks.

Loading Cartons into Carton Racks

Upon transporting cartons to a carton rack, the worker retrieves a carton from the proper cart partition and scans the carton's barcode as shown in Fig. 6. In response, LED strips on the replenishment side of the carton rack are illuminated to highlight the position where scanned cartons should be placed. Barcode scanning and light-directed placement make the process for loading cartons into carton rack locations fast and accurate.

Fig. 5. Replenishment Cart at Snap-on

Fig. 6. Worker Inserts Replenishment Carton into
Location Highlighted by LED Strip Segment

RESULTS

The installation at Snap-on has yielded substantial cost savings. The cost savings result from the introduction of right-sized carton selection and increased efficiency in managing the carton supply and replenishment processes. Specifically, the IntelliPack shipping cost optimization system has decreased Snap-on's parcel carrier costs by 5%, packing labor by 30%, dunnage material usage by 27%, and corrugated material usage by 20%. The net savings when considering all these cost reductions was more than 11%. In addition to these significant cost savings, Snap-on's green footprint was improved by reducing landfill waste and reducing fuel consumption required for transporting packages.

CONCLUSIONS

The implementation at Snap-on has demonstrated the efficacy of FastFetch's IntelliPack shipping cost optimization system. In addition to slashing shipping costs and reducing packing labor, the system has proven to be easy to install and easy to use. It is compatible with any WMS and functions independently of picking processes. The return-on-investment (ROI) payback period at Snap-on was 3 months. This innovation makes it possible for companies of almost all sizes to benefit from right-sized packaging.