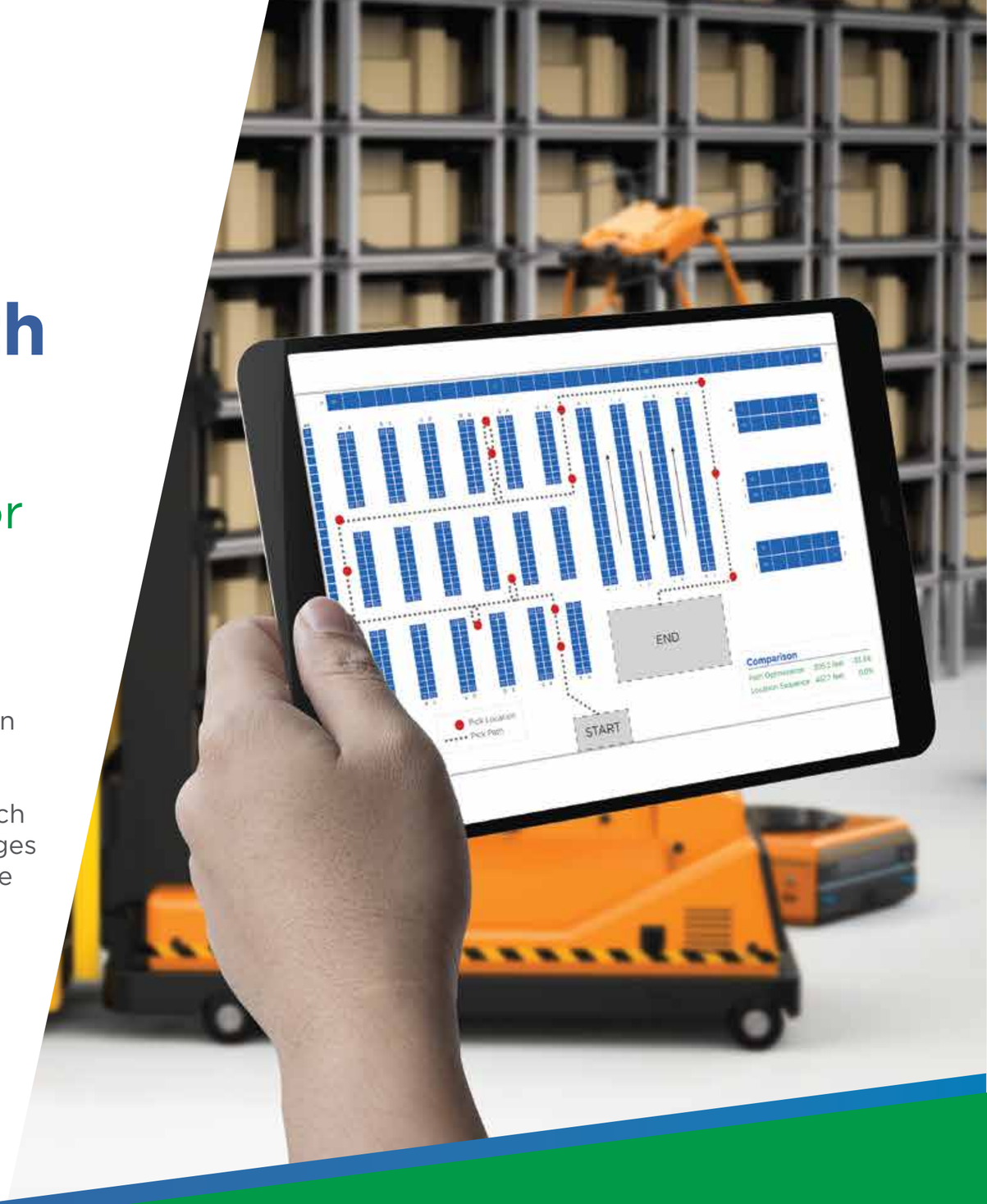
# Eliminating DC Travel With Artificial Intelligence:

## A Software Approach to Optimize Labor

Many DCs are experimenting with robotic solutions to reduce warehouse labor by eliminating travel. But what if there was a technology that could achieve the same results without adding new automation or robotics?

Lucas has introduced an AI-based tool that reduces travel 30-70 percent in picking operations. More than two dozen DCs are using this technology today. Many have doubled productivity in piece picking, while others have seen double-digit productivity gains in case picking. This software approach to travel reduction does not require any new automation systems or changes to warehouse layouts or storage systems. And the same technology can be used to automate robots and people, working together.

This paper reviews popular approaches to reducing travel in distribution center operations, and describes how AI-based travel optimization can be used, either alone or alongside other travel reduction strategies and technologies.



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# Labor Shortages And The Productivity Challenge

Labor productivity and efficiency is critical to DCs that are struggling to hire and retain workers amid tight labor markets and rising wages. Adding to the challenge, demand for warehouse workers continues to grow as companies build new fulfillment centers and expand existing facilities to satisfy the growing volume of direct-to-consumer shipments.

According to U.S. government labor statistics, the growth in ecommerce sales is driving a 10 percent annual increase in demand for warehouse labor. Due to the recent acceleration of ecommerce growth, ecommerce is expected to account for 14.5 percent of retail sales in 2020, a jump from 11 percent in 2019.

Improving productivity is imperative for meeting the ecommerce labor challenge. And reducing travel is the lynchpin to improving productivity.

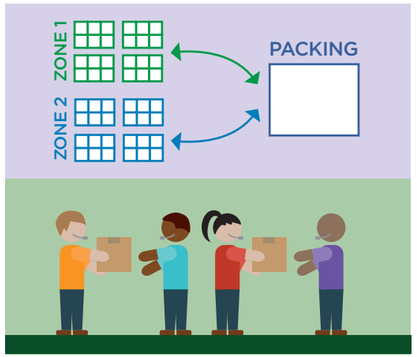
## Travel Is The Lynchpin

In a conventional, non-automated picking process, travel represents the majority of the time in a DC associate's day. Warehouse workers following an RF-picking process will typically spend more time walking or driving between pick locations than they do pulling products from bins, slots or racking locations. As illustrated by the diagram below, hands-free voice technology can significantly reduce time at the pick face, but it does not address the travel time between picks.

For years, DCs have devoted significant efforts to reducing travel through software solutions like slotting, conventional automation, and lean process initiatives. Those efforts are taking on new urgency as ecommerce growth boosts labor demand.

### Hands-Free Picking Saves Time At The Pick Face

# Tried and True Travel Reduction Strategies



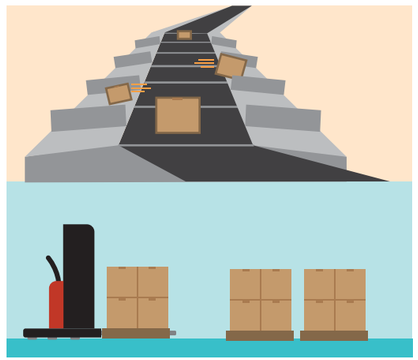

## Process Engineering

The most common process-related solution to the travel challenge is to split order lines by zone (based on product velocity, type/size, etc.), and to optimize picking processes in the various pick zones.

Many DCs place their fastest moving piece pick items in pick modules with flow rack and conveyors. It's not unusual for workers in a pick module using voice in a bucket brigade process to pick hundreds of lines per hour. Some Lucas customers hit 1000 picks per hour in high-density pick operations.

Slower-moving items may be batch or cluster picked so users can pick multiple orders to a cart or pallet on a single trip through a warehouse zone. Moving from single order picking to batching can dramatically reduce travel by increasing pick density (i.e., the number of picks per unit of travel).

Conventional material handling solutions often complement these process approaches to travel reduction.

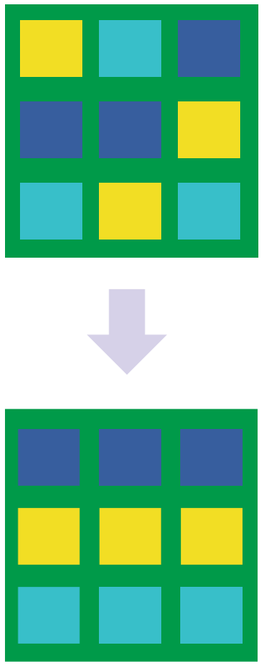


## Traditional Material Handling

Conveyors eliminate the long trips from picking areas to packing or shipping docks, and automated sortation systems improve the efficiency and accuracy of assembling orders picked in multiple zones.

Automated guided vehicles (AGVs) provide an alternative to conveyors for transporting products over long distances. First introduced in the 1980s and 1990s, AGVs have evolved from track-guided systems to wire- and light-guided systems that follow set travel paths, eliminating travel from picking to staging areas.

As noted below, autonomous mobile robots take this travel reduction strategy to a new level with robots that can operate anywhere in a DC.



## Slotting

Slotting software also goes hand-in-hand with process optimization efforts by determining which products should be placed in which warehouse locations in order to improve overall warehouse efficiency. The key objective of slotting programs is to optimize product positioning, but not solely to reduce travel in picking.

Slotting solutions are based on highly engineered models of a facility that take account of product flow and picking processes, product attributes (including physical characteristics and sales volumes/velocity), and storage types, among other factors. Periodic or selective re-slotting (or slot maintenance), focuses on regularly moving products to maintain efficiency and reduce travel, among other goals.

Machine learning technology offers an approach to Dynamic Slotting that is an alternative to manual warehouse modeling and top-to-bottom re-slotting. In this approach, machine learning algorithms analyze the wealth of data generated in DC operations to recommend slotting changes on an on-going basis. This is similar to slot maintenance but without the consulting and engineering costs of traditional slotting solutions. (For an introduction to Machine Learning technology, see the recent Lucas white paper: Making Sense of AI and Machine Learning for the DC)

# Goods-To-Person Picking

Goods-to-person picking solutions are an increasingly popular approach to reducing travel over the past 20 years. Instead of sending workers out into the DC to fetch products, goods-to-person systems eliminate travel from a picking process by bringing the products to people at fixed picking stations. These solutions have evolved from carousels and AS/RS systems to highly automated "robotic" warehouses that are being built throughout the world, largely to support ecommerce fulfillment.

## Carousels

Carousels have been used since the 1990s to store smaller products densely in bins on shelves that rotate to present hundreds of SKUs to a picker at a single pick or pack location. Workers may need to walk between carousel locations, but travel distances are relatively small considering the number of pick locations they can access at one position. The focus is on maximizing pick density.

## AS/RS Systems

AS/RS systems (automated storage and retrieval systems) follow a similar approach to carousels, but they often rely on rack storage and conveyor systems to transport products to workers at order assembly stations. Goods-to-person AS/RS systems eliminate travel in picking and putting products away, but high capital costs have made them unsuitable for most warehouses.

## "Robotic" Picking Systems

Over the past 10-15 years, AS/RS systems based on shuttle technologies and dense product storage have evolved into tightly integrated "robotic" picking systems.

UK online grocer Ocado is one of the pioneers in this area. They have built a number of large automated fulfillment centers to serve larger metropolitan areas. Kroger is partnering with Ocado to build up to 20 automated fulfillment centers in the U.S. Traditional AS/RS and material handling automation providers are getting into the act by developing their own turn-key fulfillment solutions for high throughput, high SKU ecommerce operations.

In contrast to Ocado, which is focusing on large facilities, some other grocery retailers are using similar types of automation technologies to build micro-fulfillment centers in urban or suburban locations. A number of North American Grocers are installing micro-fulfillment centers within or adjacent to existing stores. Loblaw, for example, is building an automated micro-fulfillment center within a large store in Toronto in partnership with Takeoff Technologies.

Outside of grocery retail, few other industries can justify the multi-million-dollar investment costs for these advanced, automated goods-to-person solutions – whether in all-new dedicated ecommerce fulfillment centers, or in existing DCs.

# Autonomous Mobile Robots

Autonomous mobile robots, or AMRs, are the latest trend in warehouse automation. AMRs use many of the same technologies as self-driving cars and trucks. Scores of start-up robotics companies are applying these technologies in a variety of AMR solutions specifically targeting the warehouse and distribution market. (Still other companies are developing robots that can both pick and transport products, but these systems are early in their commercialization so are not considered here.)

## Kiva's Lead

The earliest and best-known of the robotics start-ups was Kiva Systems, which was purchased by Amazon in 2012, and rebranded Amazon Robotics.

Kiva pioneered the market by offering a new approach to goods-to-person picking. Rather than packing products in a dense honeycomb for retrieval by shuttles running on tracks, the Kiva approach put products on mobile shelves that are lifted and driven to picking stations by small orange robots. Thousands of these robots have been deployed in Amazon FCs. The fleet of robots can present a new product at a pick station every 6 seconds, resulting in maximum potential picking rates of 600 picks per hour per pick person/pick station.

Kiva demonstrated the advantages of AMRs over conventional fixed automation systems, especially for ecommerce operations and DCs with very large SKU counts processing smaller orders (by lines and cube). Not all products or operations are a fit for this style of automation, however. Amazon itself continues to build a mix of fulfillment centers, many using the orange Amazon Robotics bots, and others using more conventional picking processes, including pick-to-cart from static shelving.

Continued advances in robotic technology over the past five years have led to a proliferation of new AMRs designed for warehouse operations. These solutions fit into several different categories.

## Goods-to-Person AMRs

Building on Kiva's legacy, today's goods-to-person AMRs take two forms: some that take cartons from shelves to picking stations and others that carry shelves to pickers, similar to Kiva. These solutions are typically paired with dedicated pick-pack stations. They are most applicable to each picking operations with relatively small order sizes.

## Autonomous Picking Carts

Other AMR systems are intended to function as self-driving picking carts that pickers follow to complete their jobs. The carts may be outfitted with a tablet, scanner and lights to give users their picking instructions and confirm activities. These solutions save users travel time moving carts to and from picking zones, but they do not measurably impact travel within the picking area itself.

## Conveyance Robots

Several start-up companies are offering robots that are intended to convey products over long travel distances between DC areas. These conveyance robots offer DCs a more flexible and cost-effective alternative to conveyors or traditional AGVs.

## Autonomous Lift Trucks

There are also a number of companies with a new take on AMRs for full pallet operations. Several start-ups and traditional fork truck manufacturers are adding vision guidance to warehouse vehicles so they can operate autonomously (or, in some cases, semi-autonomously). These self-guided lift trucks show great promise for reducing labor in the most travel-intensive activities in the DC, like pallet put away and replenishment. These tasks, however, don't typically require as much labor as each or case picking operations.

## Robot-to-Goods Picking

The latest twist on AMRs for each picking is robot-to-goods AMRs, or swarming robots. In this approach, numerous AMRs travel among workers in pick zones. The robots carry totes to pick locations and meet workers who pick and place the items in the totes based on instructions on a tablet mounted to the deck of the robot. Some ecommerce DCs report doubling or tripling the productivity of their pickers, with a ratio of three or four robots per picker (this is a similar ratio to goods-to-person AMR systems).

The robot-to-goods approach is being used today primarily for each picking in ecommerce fulfillment centers. Unlike goods-to-person AMRs, the robot-to-goods model does not completely eliminate human travel. One drawback is that the pick sequencing is intended to optimize robot activity, not necessarily the travel or activity of the workers. And top potential pick rates for robot-to-goods systems are less than half of the maximum rates for Kiva-style goods-to-person systems.

## AMR Advantages

Compared to traditional fixed automation systems, AMRs offer a number of advantages, including flexibility, scalability, and lower cost.

**Flexibility:** Since AMR's have free reign to travel throughout a facility, they can often be deployed in existing facilities. In addition, DC layouts can be changed after deploying robots without reconfiguring any hard infrastructure. Likewise, you can define new drop off or induction points on the fly through software.

**Scalability:** While traditional automation systems are sized to handle maximum throughput (which may only be reached for a few weeks or months per year), robotic solutions can be scaled up or down by adding or subtracting robots and/or pick-pack stations.

**Cost:** AMRs cost significantly less than conventional automation systems, but they are by no means a low-cost solution. For DCs that couldn't justify an investment in conventional automation systems, conveyance AMRs have significant cost and ROI advantages. But goods-to-man or robot-to-goods AMRs offer a less compelling investment case. As outlined on the following page, these AMR picking systems require three or more robots per picker, which represents an initial investment of greater than $1,000,000 for a relatively small operation.

## ROI Considerations

The table at right summarizes AMR costs for a goods-to-person or robot-to-goods picking solution with 10 workers and a ratio of 3 or 4 robots per human picker – this is the ratio suggested by robotics companies to achieve maximum productivity and throughput. Based on published reports, the cost per AMR is approximately $30,000, plus 20 percent annual maintenance. (Note that these cost and ROI figures do not include implementation costs for WMS integration, development, on-site testing and deployment, and training.)

For purposes of this return on investment chart, we assumed an annual average cost per full time worker of $35,000 (roughly $17.50/hour including benefits). We used these costs to estimate the time to achieve a 100% return on investment (ROI Horizon, in the chart) in operations achieving 2X and 3X productivity gains with robots. Our ROI calculations for 2X productivity (a 100% increase in pick rates/hour) assume pre-AMR staffing 20 full time pickers and 10 workers with robots. The 3X productivity figures of (a 200% increase) are based on 30 full time pickers prior to installing AMRs (and 10 workers after).

The calculations  show that it would take more than five years for a DC to earn a 100 percent return on the investment in AMRs if they were to double productivity. DCs that tripled productivity would see a total return on their investment in 1.5-3 years, depending on the number of robots per picker. These figures assume there are no other costs associated with deploying AMRs, including new staff to maintain the new equipment.

### AMR Costs And ROI Horizon

| **AMR: Picker Ratio** | 3:1 | 4:1 |
|---|---|---|
| **Number of AMRs for 10 Workers** | 30 | 40 |
| **AMR Capital Cost ($30K per robot)** | $900,000 | $1,200,000 |
| **Annual AMR Maintenance** | $180,000 | $240,000 |
| **Five-Year Cost** | $1,800,000 | $2,400,000 |
| **Annual Labor Savings at 2x productivity**<br>*(ROI Horizon)* | $350,000<br>*(5+ years)* | $350,000<br>*(8+ years)* |
| **Annual Labor Savings at 3x productivity**<br>*(ROI Horizon)* | $700,000<br>*(1.5+ years)* | $700,000<br>*(2.5+ years)* |

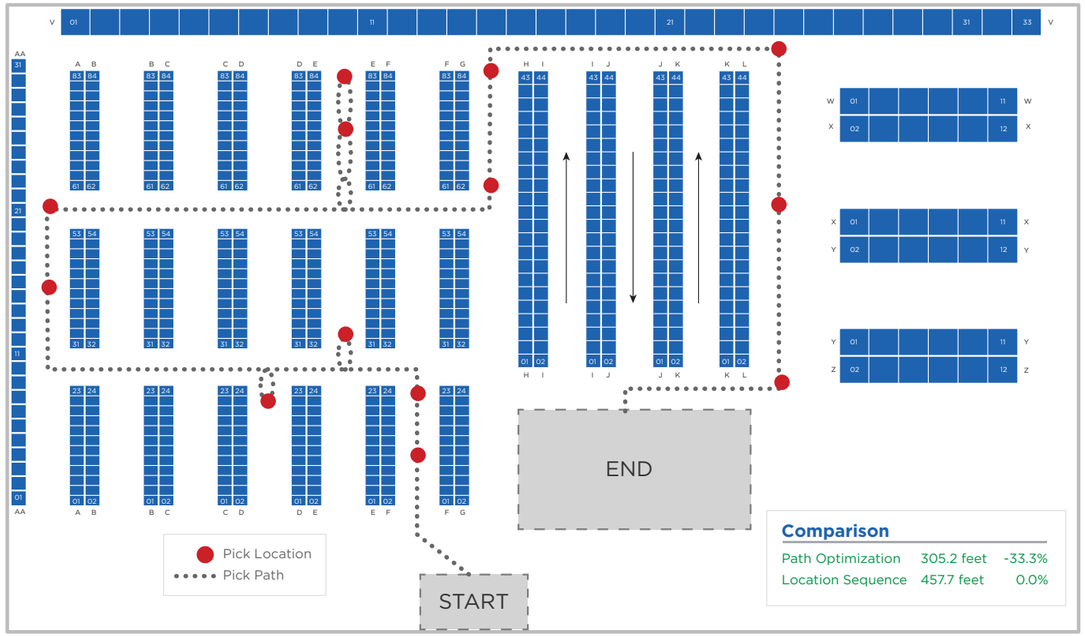
# A Software Approach To Reducing Travel: AI-Based Optimization

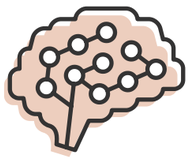
Lucas Systems has taken a different approach to reducing travel that builds on lean process engineering and applies AI-based optimization technologies that we refer to as Jennifer™ intelligence.

Jennifer™ increases pick density and reduces travel in picking and other travel-intensive DC activities. Additionally, AI-based optimization with Jennifer™ does not require any changes to warehouse layouts or storage systems, and the upfront investment cost is a fraction of robotic picking solutions. In addition, Jennifer™ simultaneously optimizes the travel of robots side by side with people.

Using AI to optimize DC processes has proven to be powerful in ecommerce pick-to-cart operations, where initial customers report doubling productivity without any fundamental changes to their picking processes. Although the biggest productivity gains are seen in each picking, the tool is equally applicable to case picking, replenishment, and other activities where workers are visiting many locations per work assignment. In testing with grocery and food DCs, AI-based optimization has demonstrated travel savings of 15-30% in case pick to pallet applications.

Jennifer™ reduces travel through two main components - Intelligent Batching and Path Optimization.

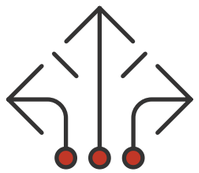




## Intelligent Batching

Jennifer™ uses order, inventory, and location information from WMS and other systems and applies real-time optimization algorithms to create batch assignments. Unlike simple rule-based batching used in a WMS (such as FIFO or product and location overlap), Jennifer™ considers order priority, pick location, travel cost, product attributes, and other factors to create optimal batches of work.

Jennifer™ evaluates millions of potential combinations to determine the “best batch” or grouping of work from among the available orders. The math behind this is daunting. If 1000 orders are available for batching, and you are trying to create batches of four orders, there are more than 41 million possible combinations. Jennifer™ runs through the combinations in less than a second as users on the floor request work.



## Path Optimization

Traditional picking systems use simple pick sequences that direct workers up one aisle and down the next in a snaking pattern. Jennifer™ path optimization algorithms use a virtual map of a facility to compute an ideal travel path that does not follow a strict location sequence. The algorithms take account of a user’s starting and end points, aisle travel restrictions (one-way aisles, for example) and other factors. Path optimization is applicable to picking, replenishment and other activities where individual work assignments span widely dispersed locations.

## Jennifer™ Orchestrates Robots Alongside Humans

Jennifer™ also coordinates and optimizes the movements of people working with AMRs, driving further improvements in labor productivity and overall efficiency. For example, while Jennifer™ orchestrates and optimizes within picking zones, a DC can add robots for conveyance between pick zones or other staging locations. This can further reduce worker travel to and from fixed drop off or induction points. Likewise, Jennifer™ can be used to optimize the travel of robots for full pallet moves, both in inbound and outbound operations.

## Results

Based on dozens of trials, intelligent batching and path optimization have reduced travel 30-70 percent compared to current batching and pick paths. A number of customer DCs have more than doubled pick rates in cart pick operations and grocery and food DCs have seen 15-30 percent savings in travel time in case pick applications, which translates to 8-15 percent productivity gains.

In addition to the productivity benefits, Jennifer™ also supports waveless order picking (sometimes called “order streaming”) through Dynamic Prioritization. In effect, rather than processing orders by wave Jennifer™ continuously reprioritizes, batches, and releases work as new orders are received.

# Eliminating Travel Without Automation

Many top-performing DCs have maxed out their productivity gains and travel savings through process design and optimization. And given today's changing market factors, most facilities are looking for other ways to eliminate travel that don't require fixed, inflexible automation systems. Many are investigating robotic systems that offer a more cost-effective, flexible, and scalable alternative to traditional material handling systems.

AMRs for picking, however, are by no means a low-cost solution, with initial investment costs of greater than $1 million. And current AMR solutions are not a fit for all product types and operations. Furthermore, while robotic picking solutions reduce the need for scarce hourly workers, they increase demand for even more scarce and more expensive technical staff to maintain the robots.

Lucas attacks the travel challenge in a novel way, in many cases doubling productivity without requiring any changes to warehouse layouts or storage systems. It represents a low-risk, high-return solution for reducing travel that can be implemented quickly and at a far lower cost than automation. In addition, the technology can be used to optimize the work of people alongside robots, allowing DCs to add AMRs where they make the most sense today.

## Learn More

For additional information, or to learn how Lucas AI-based optimization could work in your operation, access the following resources:

- View a pre-recorded webinar, Double DC Productivity Without Robots or Automation (https://lightfoot.wistia.com/medias/wleanizzpy)
- Learn more and request a personalized demonstration (https://www.lucasware.com/a-productivity-breakthrough-for-distributors/)

# About Lucas Systems

Lucas Systems helps companies transform their distribution center operations and continuously adapt to changing market dynamics. We dramatically increase worker productivity, operational agility, and customer satisfaction.

Our solutions are built on 22-plus years of deep process expertise and smart software using AI and voice technologies. Our solutions feature Jennifer™, the brain, voice, and orchestration engine that drives performance improvement gains. Make the smartest moves at the lowest cost with Jennifer™.


Lucas WORK SMARTER

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