

RIGHTHAND ROBOTICS WHITE PAPER

# Understanding the 3Rs of Robotic Piece-Picking

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# An auspicious time

Perhaps it started when Amazon turned tens of thousands of Kiva Systems mobile robots loose in fulfillment centers around the world. Or maybe it was triggered by crazy fast Graphics Processing Units (GPUs) from Nvidia and others, powering new products and systems based on Virtual Reality and Machine Learning. Some might say it's vision systems using the latest RGB-D cameras, such as Intel® RealSense™, that have energized developers of perception-based systems. Or maybe the driver has been the dramatic decade-long cost decline for robotic arms. Lower costs, both for collaborative cobots and industrial arms, have enabled robotic arms to reach well beyond automotive production lines.

And still others might raise a hand and argue that it's all about bioinspired robotic grippers, using sensing with compliant fingers. For our part, we believe that all these trends are important indicators of what is guickly becoming the era of robotic piece-picking.

If you're not yet excited about robotic piece-picking and how it can benefit your intralogistics operations, you should be. More important than any one technological breakthrough, the excitement stems from innovations in marrying several elements to create holistic solutions that streamline and simplify how you fulfill customer orders. With e-commerce and *click and* collect retail experiencing double-digit growth and labor pools for warehouse jobs shrinking, the emergence of robotic piece-picking is happening just in time to bridge a crucial gap.

**Robotic Arms** 

**Vision Technology** 

**RightPick** 

Customers now expect on-demand access to any and every product at the individual piece level.

# **Demand is going to pieces**

If you've been involved in supply chains for retail or e-commerce and are familiar with traditional logistics and material handling systems, you've probably spent a great deal of time optimizing for the movement of pallets or cases of goods. Pallets and cases were the primary units of measure for moving products from regional distribution centers to shelves at physical stores. The internet and e-commerce have turned this model inside out. Customers now expect on-demand access to any and every product at the individual piece level.

The new logistics challenge is how to get a specific item ordered from your company's website out the door and to your customer today. The item, or piece, in question can be any one of the 100,000 or even 1 million assorted SKUs you need to offer to be competitive, stored somewhere in a facility the size of 10 to 20 football fields or more. How well does your automation support piece-flow to satisfy these new demands, 24/7, during both peak and off-peak seasons?



Every touch adds to operating expense that hits the bottom line... and every touch is an opportunity to use robotic piece-picking.

# Keeping in touch is costly

Items typically get touched multiple times as they make their way through a Distribution Center (DC) or Fulfillment Center (FC) to customers in an omni-channel or e-commerce sales channel. The touches tend to take place at boundaries between storage and processing zones, or between separate processing zones.

Inbound operations might involve picking up and placing pieces during:

- receiving,
- decant, or
- putaway.

Outbound operations including:

- picker-to-goods (such as batch-pick, zone-pick),
- goods-to-picker (such as ASRS automated storage and retrieval, or autonomous mobile robots),
- sorter induct,
- putwall, and
- packout

add several touches to each piece being delivered to a customer. Inventory control and audit teams also need to handle all types of items for cycle counting, consolidation, supplier audit, and order audit. Clearly, there's a whole lot of piece handling going on in a modern order fulfillment center.

Every touch adds to operating expense that hits the bottom line. Every touch consumes valuable human resources. And every touch is an opportunity to use robotic piece-picking.



The challenge for someone trying to pick the best option is to decipher the techno-babble and identify a solution that meets the needs of your business.

# **Pick wisely**

The encouraging news is that multiple robotic piece-picking solutions are now available, offered by industry startups and stalwarts alike. Some providers focus on the grasping hardware itself; some on the role of vision and perception. Others believe that the answer must be baked into sophisticated software running algorithms on massive datasets in the cloud. And still others might again raise a hand and argue that it's all about how you combine these capabilities to solve the piece-picking problem robustly in real operations.

The challenge for someone trying to *pick* the best option is to decipher the techno-babble and identify a solution that meets the needs of your business. In our view, those needs can be boiled down to three factors.

# Range, Rate and Reliability — the 3Rs of robotic piece-picking

First, the solution must be able to pick and place a wide range of items in one or more of the workflows in your operation. Second, this task needs to be accomplished at a rate that meets or exceeds the throughput requirements of the station as it currently exists, so it does not become a bottleneck that could starve downstream operations or back up conveyor buffers, stressing the overall system. Third, whatever solution is implemented, it needs to be reliable. The robot needs to pick and place successfully every time, without damaging products. It should be able to validate items, either by barcode scan or other means. It should be mechanically reliable, require little or no change to existing physical infrastructure, and be simple to integrate with conventional warehouse software systems.

If you evaluate solutions based on how they deliver the 3Rs, you will be more likely to identify one that will help you with the challenges of managing costs and complexity of piece-flow, while making sure the correct item is delivered to your customer on time and in the proper condition.



# Range of items your customers demand

SKU count is not a perfect measure of variety in regard to size and shape of items, since different SKUs may have the same form factor and packaging. There are many identically packaged tubes of toothpaste, bottles of shampoo, vitamin bottles, cereal boxes, bags of chips, and T-shirts, for example. Even so, it's likely that the more SKUs your company stocks, the greater the variety of these classes of items and the greater the size options offered. But the sheer variety of items is not the only challenge. With demand shifting to pieces for direct-to-consumer purchases, your customer order profile may only have between one and two units on average. Even given that there will always be some small set of fastermoving (more popular) products, order diversity is high, especially when trying to process orders quickly to meet same- or next-day deliveries. This means that a picker may not see the same item twice in a row very often through the day, depending on how orders are processed in the facility.

These requirements are different than those for pick-and-place on traditional manufacturing and assembly lines, where the environment is very structured and there may only be one product flowing through for long periods of time between line changeovers. An acceptable robotic piecepicking solution must be able to handle a significant portion of your products and frequent transitions from one type to the next.

Does the solution need to support 100% of your products? Probably not. Bicycle tires and toothpaste, for example, do not often flow through the same storage and processing steps in a warehouse. They are unlikely to be packaged together and will normally ship in separate boxes. A toaster oven may ship in its own box and always be processed as a single item. That said, the bigger the range of items that your robot workcell can pick, the better. It simplifies material flow, and gives you flexibility to consider using such a system at one or more pain points in the operation, with high utilization.

Unlike robots used in manufacturing applications, where specialized robotic end-effectors are often designed to handle only one product type, best-inclass robotic piece-picking systems for order fulfillment integrate visionbased, software-driven intelligence with multi-function mechanical grippers that combine suction, compliant fingers and integrated sensing. These systems are *model-free*, as opposed to relying on detailed 3D models of products which are time-consuming to generate, error-prone and difficult to maintain. Advanced picking systems work in unstructured environments with homogeneous or mixed-SKU totes. They improve via machine learning Advanced picking systems... improve via machine learning through experience gained over millions of picks across fleets of robots. through experience gained over millions of picks across fleets of robots. These systems adapt more quickly to an ever-changing variety of products with less effort required from your team.

When thinking about range, it's important to consider this last point regarding items the robot may have never seen before, and that aren't in the current SKU database. The system must not fail if your merchandising team decides to market some entirely new product lines next year. It can't fail if a manufacturer runs a special promotion and offers 30% more product for the same price or merely changes the packaging of a familiar SKU. It can't fail because seasonal packaging graphics change from pumpkins to reindeer to Valentine's hearts on an otherwise identical item. A solution based on model-free picking protects you from impacts on productivity caused by these everyday realities of retailing.

We think of this overall relationship between an intelligent gripper, a vision system and control software with learning as a robotic form of *hand, eye, coordination*. This phrase is a simple reminder of how the technologies can be combined and packaged as a solution to deliver picking performance over an extremely wide range of items.





# Rate that provides high throughput

Robotic piece-picking has gotten very fast. In a continuous cycle where a robot transfers items one at a time between two adjacent totes, rates of 1,000 units per hour can be continuously sustained. Commercial off-the-shelf (COTS) robot arms provide options for rapid picking, and task-specific path-planning algorithms improve efficiency. Intelligent solutions that integrate vision and smart grasping hardware with software intelligence are quick to identify items, select a motion path and execute the pick.

Given that the raw pick-and-place capability of a robotic piece-picking solution is fast enough (similar to what is required in processes designed for associates), the use cases and overall throughput for robotic piecepicking workcells depend on several workflow details. Advanced solutions can pick items from more than one source and place to multiple locations and container types, such as totes or cartons. Place locations may also include moving targets, such as trays in a sortation system, or bins, such as in a putwall process. Reach and payload capacity are also considerations for throughput. Solutions that offer robotic arm options, including collaborative and industrial arms, maximize the flexibility for reach and speed.

Our recommendation is to ask prospective robotic piece-picking partners about benchmark performance measures for items similar to what you intend to run through the workcell. These results should be supported by both lab and field data, accounting for variations in solution design. The supplier should be willing to discuss tradeoffs in order to optimize the system for your operation, whether an existing facility or a greenfield design. Robotic piece-picking can meet the throughput requirements for many typical DC and FC processes — and it is improving rapidly.

Another consideration regarding rates and throughput is how quickly can robotic piece-picking be deployed and integrated into your systems. The best systems can be deployed in roughly a day by a single technician and feature simple interfaces. As the installed experience base continues to evolve and standardize, these systems will become even more plug-andplay. There is no need to wait for the operational savings afforded by robotic piece-picking.



# **Reliability you can count on**

Robotic piece-picking is reliable if it provides order integrity — always picking the right quantity, and successfully transferring it to the place location. Robots can also provide and contribute to order integrity by validating an item, such as via barcode scan or image matching, verifying that the proper inventory was presented to the piece-picking system. Similarly, robots can capture data regarding picking tasks, including images, that can be used to confirm task completion, improving overall operational reliability.

Robotic piece-picking also must achieve a high level of robot independence, operating with minimal human intervention, in order to maximize benefits for warehouse processes. Robot independence can be achieved by having high operational reliability, incorporating error and exception handling into the software control systems, and providing a simple, robust mission control protocol for interfacing to host systems in the facility.

Robotic systems must be mechanically reliable. They should leverage highly reliable COTS technology and subsystems that are supported by data from production use at scale. For newer elements, such as gripper hardware, quick-swap designs are preferred at this stage of system maturity.

In addition, a successful robotic piece-picking solution must be reliable even in the case of exceptions or errors. It's easy to plan for happy path scenarios, where everything is perfect. But this ignores the fact that even in the best-run facility or with the best robotic piece-picking workcell design, there can be errors. How does the system respond and communicate with the host Warehouse Control System (WCS) if the source container is empty or not present when the robot is given the task of picking an item?

A well-conceived solution will have a simple message interface that can easily integrate with the WCS to coordinate and resolve these and other issues. In the first case, the robot could send an error message to the WCS ("tote empty"), and the WCS would then decide whether to route the container to Inventory Control, for example. The Warehouse Management System (WMS) or WCS might request delivery of another container with the same item to the robotic workcell or assign the task elsewhere, depending on inventory availability. When robotic piece-picking is well designed and properly integrated into an existing operation, ROI of less than two years is achievable. The issue should resolve automatically, which requires robust error handling in the integration message protocol.

Of course, all of these capabilities are great, but in terms of reliability as viewed by the DC or FC Manager, it's also important to have a service and support infrastructure for the new technology. Robotic piece-picking lends itself to pure or hybrid versions of Robot-as-a-Service (RaaS) model. This flexibility should make it easier to optimize your capital and operating expenses in predictable ways.

# Translating the 3Rs into solution requirements

When robotic piece-picking is well designed and properly integrated into an existing operation, ROI of less than two years is achievable. The difference between success and failure is determining a methodology for evaluating the various options available in the market and choosing how to implement one most effectively in your operation.

We believe that solutions that meet 3R requirements of **range**, **rate and reliability** in the new age of piece-flow will have the following characteristics:

- Multi-function smart grippers that combine the best capabilities of sensing, suction, and compliant fingers
- A model-free picking approach vs. maintaining a library of 3D models of products
- An integrated approach to robotic *hand, eye, coordination*, leveraging the capabilities of intelligent grippers, computer vision, software controls and machine learning providing required performance and accountability
- Benchmark tote-to-tote pick-and-place rates of 1,000 units per hour or more
- Ability to pick and place from/to one or more locations and container types
- Solution design resources that explain how it will operate in your workflow
- Flexibility for possible use at multiple points in the DC/FC
- Rapid implementation that works on day one and improves over time
- System architecture based on ensuring order integrity
- Options to confirm or validate items, such as via barcode scan
- High level of robot independence
- Mechanical and systemic reliability
- Simple mission control protocol interface with robust error handling
- Service, support and ownership models, including RaaS options.

# Put robotic piece-picking to work

Robotic piece-picking leverages some very new and complex technologies. When combined intelligently, the results are simple: items are picked and placed predictably, and customers receive their orders on time. The basic value framework is driven by the 3Rs of **range, rate and reliability** as they apply to your business. Best-in-class solutions have a clear set of common characteristics that offer high levels of 3R performance.

Put robotic piece-picking to work for your company and start to benefit from reduced operating costs and predictable piece-picking capacity. Now is the time to raise your hand.

## **RIGHTHAND ROBOTICS** 237 Washington Street

Somerville, MA 02143

info@righthandrobotics.com RIGHTHANDROBOTICS.COM