PLUS ONE ROBOTICS

MASTERING PARCEL VARIABILITY:

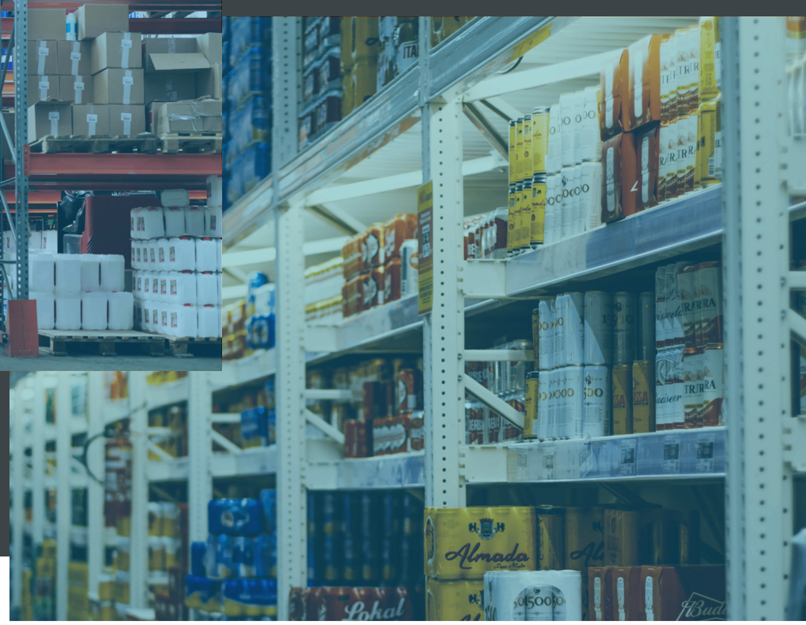
Leveraging Human-AI Symbiosis for Optimized Logistics

INTRODUCTION

Intelligent automation has become indispensable in the warehouse.

Increased consumer demand and shortened e-commerce timelines require higher throughput, which is only possible with advanced technologies, including robotics, artificial intelligence, and machine learning. However, to operate optimally, AI technologies also necessitate an ongoing partnership with humans. Human oversight and expertise enable robotic systems to overcome their inherent limitations, including their inflexibility toward variability and inability to “reason” like a human.

Thus, warehouse leaders must leverage human-AI symbiosis to be successful in 2025 and beyond. In the process, they should reevaluate their thinking about the warehouse itself; robots will never replace humans, nor can humans replicate a robot’s relentless utility. The most viable path forward requires collaboration.



The State of Intelligent Automation in Warehousing Today

After a slowdown in 2023, the warehouse automation market is rebounding impressively. Experts now predict it will reach $44 billion by 2028. We'll see this uptick in spending reflected in the budgets of almost every sector. However, the automotive and logistics industries, particularly, are preparing to ramp up their automation spending substantially. More than six in ten automotive manufacturers intend to invest over $25 million in automation before 2027, compared to 52% of logistics and fulfillment companies.

Even retail and consumer goods companies — the sector anticipating the lowest automation growth — plan to invest heavily, with 46% expecting investments of $25 million or more in the next five years.

Warehouse automation investments are rising for several reasons, arguably the most prominent being increased consumer demand. E-commerce enables customers to browse and purchase goods faster than ever before, increasing the need for warehouse efficiency to keep pace.

Automation Market

Grow to $44 Billion by 2028

Companies that intend to invest over $25M in automation before 2027:

52%
Logistics and Fulfillment

60%
Automotive Manufacturers

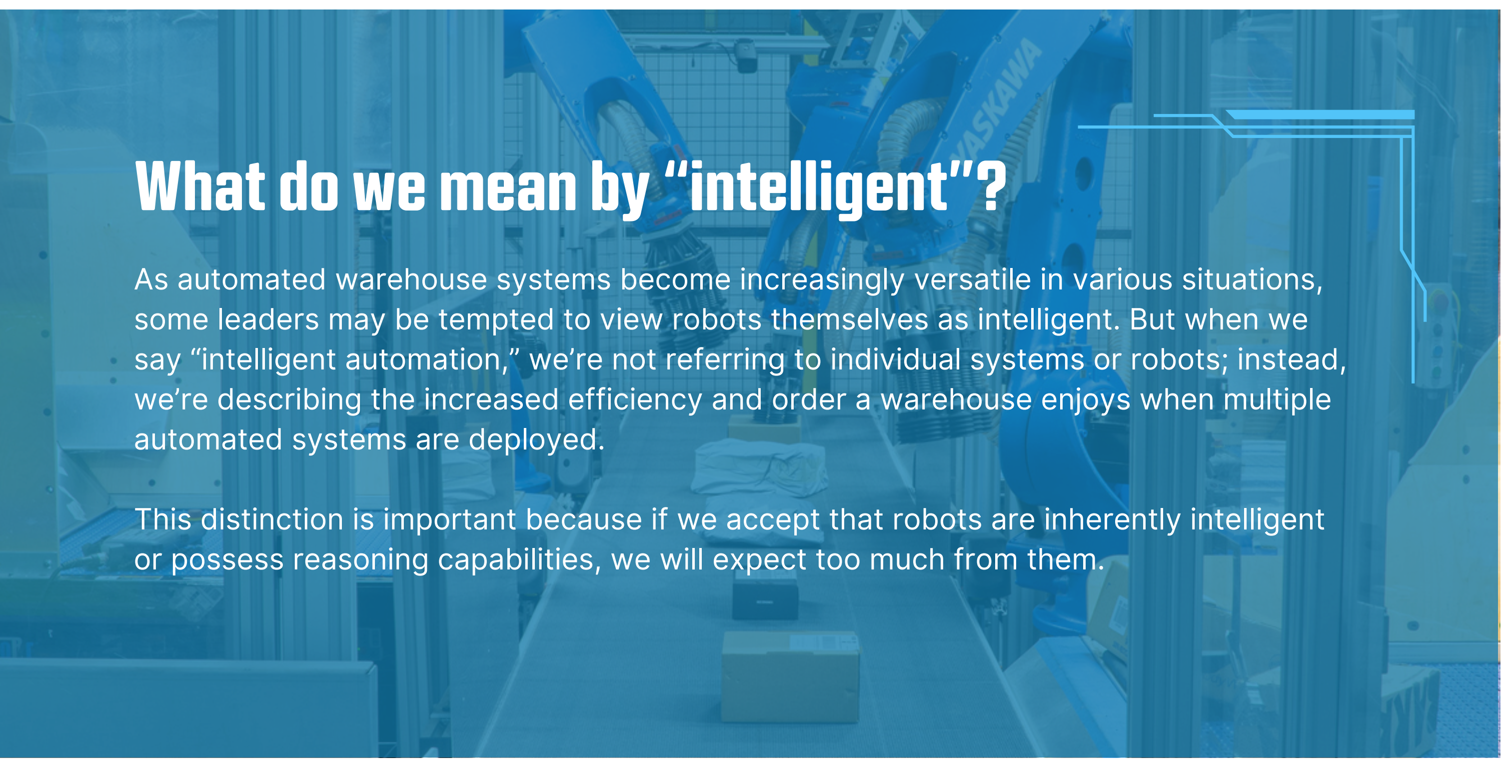
46%
Retail and Consumer Goods

Another interesting side effect of digital shopping is a shift in consumer expectations. Online shoppers anticipate rapid order fulfillment (usually two days or less), and many consumers now expect free and equally speedy returns. Suffice it to say that accommodating these expectations requires an incredibly well-oiled warehouse.

Concerns about persistent labor shortages also remain top-of-mind for many leaders. Although this issue is slightly less pressing than during the pandemic, with just 13% of warehouse leaders indicating that staffing is a more significant challenge in 2024 vs. 2023, it's nonetheless important to consider. After all, labor is usually considered the highest cost driver in warehouse operations.

Intelligent warehouse automation provides a compelling solution to rising demand and labor concerns. The term refers to warehouses that leverage advanced technologies, including AI vision, machine learning (ML), robotic process automation (RPA) and robots, to boost efficiency. Usually, automated warehouses rely on a myriad of these solutions to orchestrate better results (e.g., by using continuous ML in conjunction with AI vision-enabled robotics, automated systems can learn over time, creating better results down the line; or, by relying on RPA to generate labels and robots to scan those labels and move parcels appropriately; and so on).

Robotic parcel handling is a key element of an intelligently automated warehouse. These systems are well-established but have recently experienced a resurgence in interest as top providers further innovate their solutions — for example, with AI vision systems that enable parcel-handling systems to respond more accurately and efficiently to a changing environment.



What do we mean by "intelligent"?

As automated warehouse systems become increasingly versatile in various situations, some leaders may be tempted to view robots themselves as intelligent. But when we say "intelligent automation," we're not referring to individual systems or robots; instead, we're describing the increased efficiency and order a warehouse enjoys when multiple automated systems are deployed.

This distinction is important because if we accept that robots are inherently intelligent or possess reasoning capabilities, we will expect too much from them.

The Three Laws of AI

iRobot's Rodney Brooks has identified three laws of AI that don't govern AI itself but rather how humans co-exist with it. They are (paraphrased) as follows and accompanied by observations pertinent to warehouse robotics.

1. Humans observe AI systems performing a task they're familiar with and often believe the system is competent in other, related ways. That perception is usually incorrect.

Workers on the warehouse floor are unlike any AI solution on the market because they can handle a wide array of tasks. For example, a single employee can scan a barcode, position a parcel on a conveyor belt and proceed to another area to count inventory within a span of seconds. This capacity for cross-task performance is, as yet, unachievable in automated systems.

However, humans have a tendency to overgeneralize. So, when we see a robot that can pick and place a parcel from one area to another — say, from a pallet to a conveyor belt — we might erroneously believe that this same robot can perform other, related motor tasks. However, just because an automated system, even an AI-enabled robot, can perform a specific task, does not mean it can display equal competence on any other task, no matter how closely related it may appear to humans. For instance, just because a robot can run, doesn't mean it can walk or crawl.

2. Unbeknownst to many observers, most successful AI deployments have a human somewhere in the loop.

Even household applications of AI require human input to operate optimally. To illustrate this point, Brooks mentions household cleaning robots, which regularly become stuck in odd corners of the house and, therefore, require human intervention to function. On a much larger scale, this is also true; warehouse robots require a guiding human hand to complete tasks quickly and efficiently. This law reflects a core tenant of our philosophy here at Plus One Robotics. We'll discuss it more in the next section.

3. Real-world applications of AI require a long tail of special cases to discover and fix, which takes decades.

Again, Brooks visits a textbook application of AI to underscore this law — this time, chess. You probably know that AI systems can reliably defeat humans at chess (even Grandmasters). But chess is a rigorous and structured game. It operates in an enclosed world wherein all rules are logical, and all outcomes can be predicted with complete confidence. AI systems, which can calculate all possible permutations of a pre-defined situation, are therefore more adept at chess than humans. In the real world, the opposite is true.

Variability is the only constant in our universe. This is true whether walking to the grocery store or palletizing in the warehouse. Any number of unexpected circumstances could occur in either of these situations because the number of unknown variables is limitless. Advanced AI systems tap into deep learning and complex pattern recognition to adapt to most situations, but they cannot comprehend or react appropriately to all of them; it's simply impossible in a non-structured world. Thus, an AI system operating without a human-in-the-loop will experience inaccuracies, delays and other undesirable results.

1

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2

Unbeknownst to many observers, most successful AI deployments have a human somewhere in the loop.

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Real-world applications of AI require a long tail of special cases to discover and fix, which takes decades.

The Three Laws of AI

by Rodney Brooks

Only Humans Can Overcome the Inherent Variability of Logistics

Brooks' three laws of AI perception highlight one crucial fact: In an uncertain world, the only certainty is change.

And, humans are best equipped to navigate rampant inconsistency. So, despite impressive advancements in warehouse automation, human involvement remains indispensable, especially in high-traffic and unpredictable environments like a warehouse.

By maintaining humans in the loop, warehouse leaders can leverage the best of both worlds: the precision and tireless efficiency of AI systems, combined with the adaptability, contextual understanding and complex problem-solving skills of human workers. This symbiosis is key to achieving and maintaining peak performance.

Humans specifically complement automated warehouse systems by:

- Remaining agile in all circumstances — foreseen and unforeseen. AI systems excel at performing specific tasks, but in a warehouse environment, unforeseen events are commonplace, from irregularly shaped packages to sudden changes in inventory flow. Humans can quickly assess novel situations and devise creative solutions on the spot, a skill that current AI systems simply cannot match.

- Providing necessary context to ambiguous stimuli. Humans have a deep, intuitive understanding of context that goes beyond mere pattern recognition. For instance, a human worker can instantly recognize when a fragile item requires special handling, even if it's not explicitly labeled as such. This level of contextual awareness is crucial in maintaining efficiency and preventing errors in complex logistics operations.

- Facilitating the deep learning process. ML enables AI systems to improve over time, but how can leaders ensure that robots learn "the right lessons"? Humans in the loop can correct robots if they make misguided assumptions, ensuring that when a similar situation arises down the line, the system is more likely to react appropriately. This course-correcting feature ensures that AI systems don't, for example, onboard inflammatory or offensive behavior that might alienate potential consumers, as was the case in Twitter's infamous rollout of chatbot Tay in 2016.

As we continue to advance warehouse automation technologies, it's crucial to design systems that **complement human capabilities rather than attempt to replace them entirely**. The future of intelligent warehouse automation lies not in fully autonomous systems but in **human-AI collaboration** that maximizes the strengths of both parties.

SPOTLIGHT

Plus One Robotics' Yonder®

Leaders should think of human-robot collaboration as an opportunity to maximize their investments rather than as a cost center. Think of it like this: An AI vision robot might supply about 99.5% of your operation's efficiency gains while your human-in-the-loop fills in the last 0.5% of edge cases. Now, 0.5% may not sound significant, but if we multiply that percentage across every parcel your system processes over five years, it makes a substantial difference. We can further conceptualize these benefits by reviewing the efficiency and cost gains provided by our Yonder® system.

Yonder® is our human-in-the-loop automation system, which is comprised of remote human crew chiefs. Crew chiefs can "step in" 24/7 to support robots in a fully remote, non-localized capacity. Yonder's remote capabilities are crucial because local interventions are time-consuming and costly, whereas remote intervention is far more seamless. For reference, the cost of 300,000 local interventions in a single warehouse is about $15,000,000, compared to $750,000 with Yonder — that's 5% of the cost.

The average response time for our Yonder® system is 2.5 seconds for induction and 4.75 seconds for depalletization. Yonder agents can correct issues remotely 98.5% of the time, so local interventions are rarely necessary. In the last year, for 60 robots from five of our customers, Yonder® aided with 3.8 million picks out of 250 million total items picked, saving nearly $5 million in wages.

From these results, we learn a couple of things. One, a human-in-the-loop approach is critical to addressing variability on the warehouse floor. Trusting AI systems to "reason" through a novel situation is not only futile but possibly dangerous, especially when these systems require input about 2% of the time. Equally important, we learn that human-robot collaboration can drastically improve margins — when deployed correctly.

Yonder® reduces the cost of exception handling by 95%

The cost of 300,000 local interventions in a single warehouse is about $15M, but with Yonder® handling 98.5% of those remotely in under 5 seconds - it drops to ~$750K

SPOTLIGHT

On the Horizon: AI-First Warehouses?

There may come a time when AI systems no longer require human oversight to operate sufficiently. The immediacy (or, even, the veracity) of this possibility will differ based on who you ask.

In particular, robotics foundation models (RFMs) are receiving significant attention (and investment). Some commentators have called RFMs "ChatGPT for robots" because, like Open AI's generative AI engine, these models rely on large-language models (LLMs) to provide outputs. However, unlike ChatGPT, RFMs focus on mobility and manipulation rather than text and images.

RFMs are ML models self-trained on an extensive range of field data. Instead of becoming well-versed in one aspect of automation — say, picking and placing — robots trained on an RFM would theoretically be capable of more applications, both inside and outside the warehouse. The goal of an RFM's massive dataset is twofold: to (1) collect sufficient data from edge cases so robots respond appropriately in all situations and (2) broaden the scope of a single system's abilities, enabling it to be useful in more contexts.

As firm believers that robots work and humans rule, we at Plus One Robotics are cautiously optimistic about RFMs — but we're not holding our breath. Realistically, the technologies and data required to enable autonomous systems are young. Rounding the corner on a truly "universal model" could take five years, but it could also take upwards of 40+.

Furthermore, RFMs require an astonishing amount of computational power to operate. Because RFMs are likely too large to sit on the edge, warehouse leaders would have to rely on a cloud-based consumption model to deploy such models in their operations. That would be incredibly expensive, even for a single model. Realistically, most warehouses would probably be unable to afford more than 1-3 RFM-powered robots at once, which hampers the operational effectiveness of such a deployment in the first place.

Hesitations like these are important to consider, though ultimately, they may be surmountable. RFMs may one day dominate warehouse operations. Maybe. For now, we're sure that intelligent automation with humans-in-the-loop is the most effective and long-lasting strategy for warehouse efficiency. And that's a certainty we'll stake our name on.

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About Plus One Robotics

The team at Plus One Robotics is comprised of industry veterans willing to discuss the realities of each scenario to provide customers with clear and authentic insights into what they can expect from our equipment. Only by looking beyond headline numbers can we help you understand how a system performs in real-world conditions, enabling you to make the most informed decision for your automation investment.

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