THE EVOLUTION OF ASRS:

How Technology has Developed to Solve Fulfillment Problems

EXOTEC | INTERACT ANALYSIS

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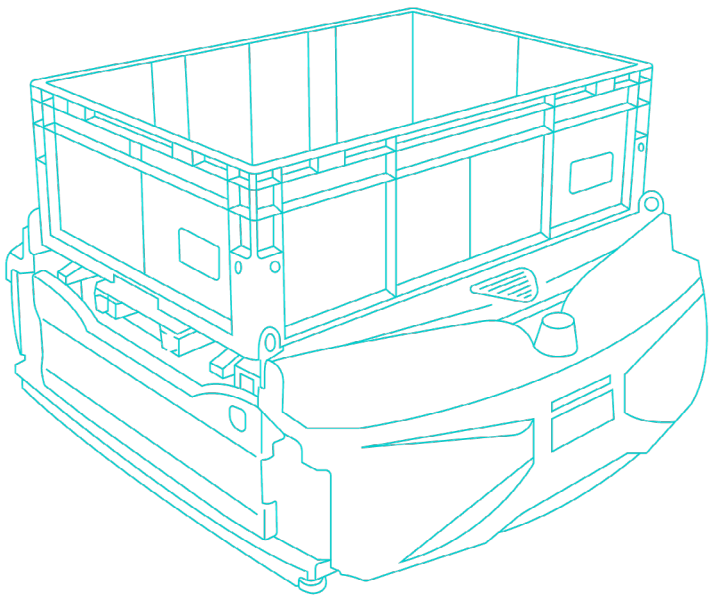

Executive Summary

This whitepaper explores how warehouse automation and Automated Storage and Retrieval Systems (ASRS) have evolved from shuttle and cube-based systems into the next generation – mobile ASRS (mASRS). The latest evolution of warehouse automation provides companies with robotic systems that blend the critical needs of throughput, density, and flexibility in a single solution. We examine the ways in which mASRS technologies assist businesses in overcoming obstacles and taking advantage of opportunities within their warehousing and fulfillment operations. Combining the extensive industry knowledge of market intelligence specialist Interact Analysis and global mASRS warehouse robotics provider Exotec, the report also looks at what the future holds for the warehouse industry and how mASRS technology will rise to meet the challenge.

The Evolution of Warehouse Automation

Fulfillment and distribution warehouses have evolved from inventory picked and packed manually, through various stages of fixed Automated Storage and Retrieval Systems (ASRS), to today's advanced mobile ASRS (mASRS) solutions. Huge changes in channel mix (sales via channels such as brick-and-mortar stores, pickup-in-store, ecommerce), the expanding number of SKUs (stock-keeping units), and evolving retail habits (ballooning returns rates, demand for faster delivery times) have required **significant innovation.**

From mechanization to full automation

Mechanization of warehouses started with the use of pallets, forklifts, and conveyor belts to reduce physical workload and improve efficiency within warehouses. The very earliest ASRS systems went into operation in the 1960s and were designed to manage heavy pallet loads. As the technology evolved, systems were created that could handle smaller, lighter loads in totes, cartons, bins, and trays.

Automated shuttle systems, which have been around since the 1980s, have often been the "go to" solution for warehouse automation. They are fixed to racking, with shuttle devices moving horizontally on fixed rails and vertically via a lift system. Although capable of high throughput and storage density, traditional shuttle systems have been hampered by a single point of failure (if a lift fails then this compromises the entire system by causing a bottleneck). Also, if a system maxes out, it is nearly impossible for customers to gain extra throughput.

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The robots revolution

A major step forward in automating warehouses has been the introduction of robots. These have enabled the development of traditional shuttle systems into new forms of automated storage and retrieval, including high-density cube systems, shelf-to-person solutions, and mASRS. Using individual robots operating independently, rather than fixed tracks and lifts, eliminates the single point of failure problem. Systems are also easy to install and scale up or down to meet fluctuating demand. On the use of mASRS technology, Qerys Group Logistics Director Frédéric Bailleul, comments, ***With mASRS "there is no bottleneck, no lifts"*** adding, "we have 60 robots, which translates to 60 ways of accessing our goods."

The Covid-19 pandemic was a 'black swan event', fuelling the uptake of advanced warehouse automation technologies. The need for flexible solutions became more apparent with the rapid change and unpredictability in shopping habits. As ecommerce boomed, warehouses were forced to pivot from store fulfillment to ecommerce. Covid-19 also accelerated existing trends, such as consumers wanting shorter delivery times. The shift away from brick-and-mortar stores led to a growing number of omnichannel warehouses.

Evolution of ASRS: Technologies timeline

1950s
Introduction of first conveyors and sortation systems

1960s
Inception of ASRS technology, initially designed for heavy pallet loads

1970s
Warehouse Management Systems developed

1980s
Widespread adoption of barcoding and scanning technology

1996
Cube storage system developed

2000s
Increasing use of robotics and autonomous vehicles

2003
Kiva Systems offers revolutionary goods-to-person picking

2012
Kiva is acquired by Amazon leaving a technology vacuum

2015
Exotec is founded in Lille, France. The first system is operational in 2017 at Cdiscount facility

2020s
mASRS technology increases its share of the global warehouse automation market

Customer expectations for faster delivery

Availability of labor to fulfill orders

CASE STUDY:

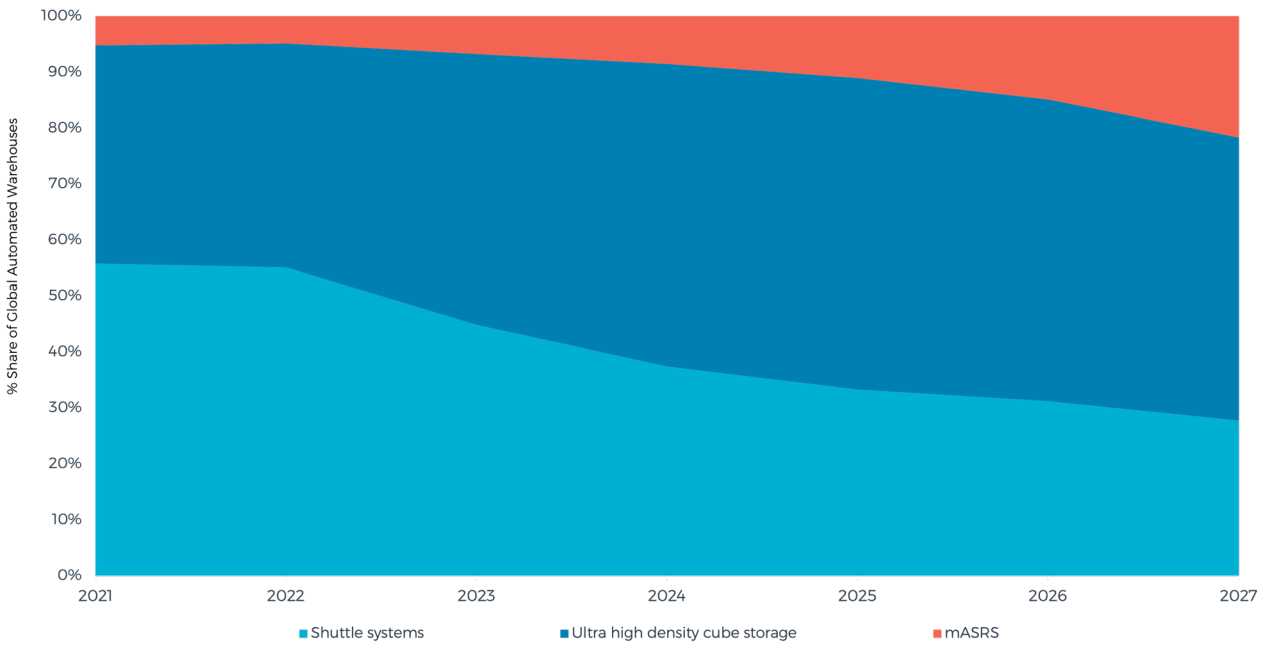
Praise for Skypod's ease of implementation and market-leading interoperability

Exotec's Skypod mASRS solution enabled Texas-based performance footwear and clothing brand **Ariat** to handle challenges at its warehouse, including rapid sales growth, labor shortages, increasing customer expectations, and an expanding product range. The company - which distributes products online and to more than 6,500 retail locations worldwide - had already introduced some warehouse automation at its purpose-built 1m sq ft central distribution center. Ariat needed a system that operates seamlessly alongside Geek+ technology.

The company's Director of Building Operations, Josiah Girton, praises the smooth implementation process, as "once we went live, we just flipped the switch and started running." Ariat increased from 57 to 86 robots in a matter of minutes during 2022 to boost capacity, and has been able to expand its B2B offerings to include next-day shipping and later order cut-off times.

mASRS: The flexibility and scalability needed for the future

2023 saw a marked increase in mASRS uptake, and it was one of the fastest-growing warehouse automation technologies. Successful pilots of mASRS systems in prior years led to much greater adoption rates. Interact Analysis forecasts 6.7% of new automated warehouses in 2023 used mASRS systems and this will increase to 21.6% by 2027.



mASRS share of global market continues to grow

Source: Interact Analysis 2024

21.6%
GROWTH

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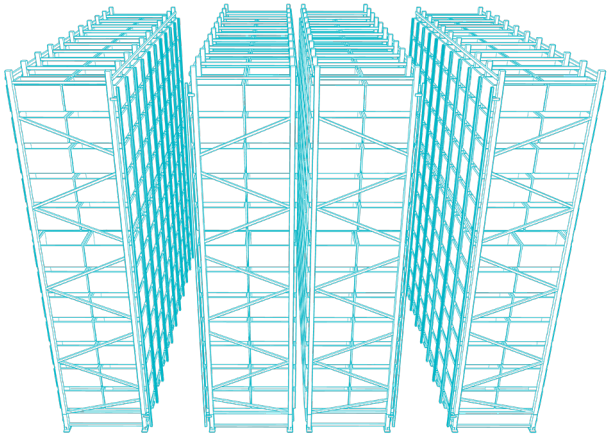
For today's omnichannel operations, achieving the correct balance of throughput, density and flexibility is key. Although ASRS have been around since the 1960s, today's mASRS are dramatically different. mASRS technology provides the advantages of real-time adaptability, higher productivity, and better utilization of warehouse space to streamline processes. This enables businesses to respond rapidly to changing trends and global events.



Increasingly Complex and Dynamic Landscape for Global Warehousing

Growing competition from a globalized market means companies need to remain lean and agile. This is particularly pertinent to warehousing, which has been impacted by a series of macro trends, including evolving customer expectations, a move towards smaller warehouses in urban locations, and severe labor shortages.

Changing customer expectations

Consumers increasingly want products fast and retailers are offering shorter and shorter delivery times. This poses additional challenges for logistics and distribution. At Interact Analysis, our data shows the average delivery time for an online grocery order has decreased from 2 days to 8 hours between 2020 and 2022, and is expected to halve to 4 hours by 2030. The ability to offer rapid (and cheap) delivery has become a competitive advantage for retailers and is also increasing the trend for urban fulfillment.

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CASE STUDY:

Greater storage density, rapid implementation and faster delivery times for Carrefour

Multinational retail and wholesaling giant **Carrefour** approached Exotec to help improve picking accuracy and meet demand at its central distribution hub for curbside and home delivery grocery orders in France. Exotec worked with the company to meet high demand for same-day delivery and growing orders by creating a system that utilized the entire height of the warehouse space, increasing storage density by 4x. This resulted in two-hour delivery, order preparation accuracy of over 99%, and the capacity to fulfill up to 4,000 orders/20,000 items each day.

At a further Carrefour facility housing ambient groceries for ecommerce curbside pick up, Exotec supplied 26 robots and 8,100 bins in just six weeks, with minimal disruption to on-going operations. Carrefour Ecommerce and Operations Director France Mourad Bensadik praised the “record implementation time”, as well as “the structural flexibility and agility” of the Skypod solution.

Growing shift towards smaller fulfillment centers in urban locations

To facilitate shorter delivery times, there is a growing trend for storing inventory closer to consumers. Warehouses are sought in urban locations to reduce transportation costs (which account for up to 80% of total fulfillment costs) and speed up delivery times. These are often not purpose-built spaces and have space constraints due to the higher cost of real estate in urban locations. Warehouse automation solutions, therefore, need to be adaptable and high density.

Skills and labor shortages continue to hamper warehouse operations

One of the most acute challenges hampering warehouse operations is the global labor and skills shortage in the sector, which is contributing to rising labor costs. Our research indicates scarcity of labor remains the biggest factor driving demand for mobile robots, and the impact of shortages is becoming more acute.

Executive Vice President of North American Sales at Exotec Andy Williams states, "The single biggest challenge, and this really spreads through most geographies, certainly in North America, is this shortage of labor." He added, "If you can find people, you can't retain them. They may go from one warehouse to the next. So, that is certainly a big overarching factor that's driving automation." There is little sign of the labor and skills gaps narrowing, with data from the U.S. Chamber of Commerce showing labor force participation dropped from 63.3% in February 2020 to 62.8% in 2023.

> "The single biggest challenge in most regions is the shortage of labor.

With the right solutions, warehouse industry challenges become opportunities.

Many challenges also offer opportunities for companies that are strategic, agile and forward-looking enough to adapt. Companies are responding to the shortage of workers by investing in technology, while also speeding up their fulfillment processes. In addition to increasing employee productivity, warehouse automation can create a more rewarding working environment for employees, helping businesses attract workers. With the right solutions in place, businesses can optimize their existing warehouse space and respond quickly to change.

[1] Ferguson, Stephanie (2023) Understanding America's Labor Shortage, US Chamber of Commerce

mASRS Offers a Solution to Warehouse Challenges

As shopping habits change and consumers demand even more from brands, pressures on distribution and fulfillment networks increase.

Businesses want to be able to:

- **Increase throughput**
- **Carry and access extensive inventory quickly**
- **Handle case picking for store replenishment and each picking for consumers**
- **Facilitate reverse picking**
- **Cope with seasonal changes and fluctuations in demand**
- **Maximize use of warehouse space**

mASRS systems are designed to optimize storage and retrieval processes. Each autonomous mobile robot (AMR) is capable of moving in three dimensions within the racking to enable dynamic access of inventory stored in bins and trays, speeding up the order-picking process. Sensors and advanced control systems mean the solution is safe and accurate to operate alongside human workers. The modular racking and individual, interchangeable AMRs make it uniquely scalable in response to changing inventory demands. Decoupling throughput from storage provides the flexibility to adapt systems in response to changing needs. Installation of a complete system within a warehouse is achievable in as little as 6 weeks.

CASE STUDY:

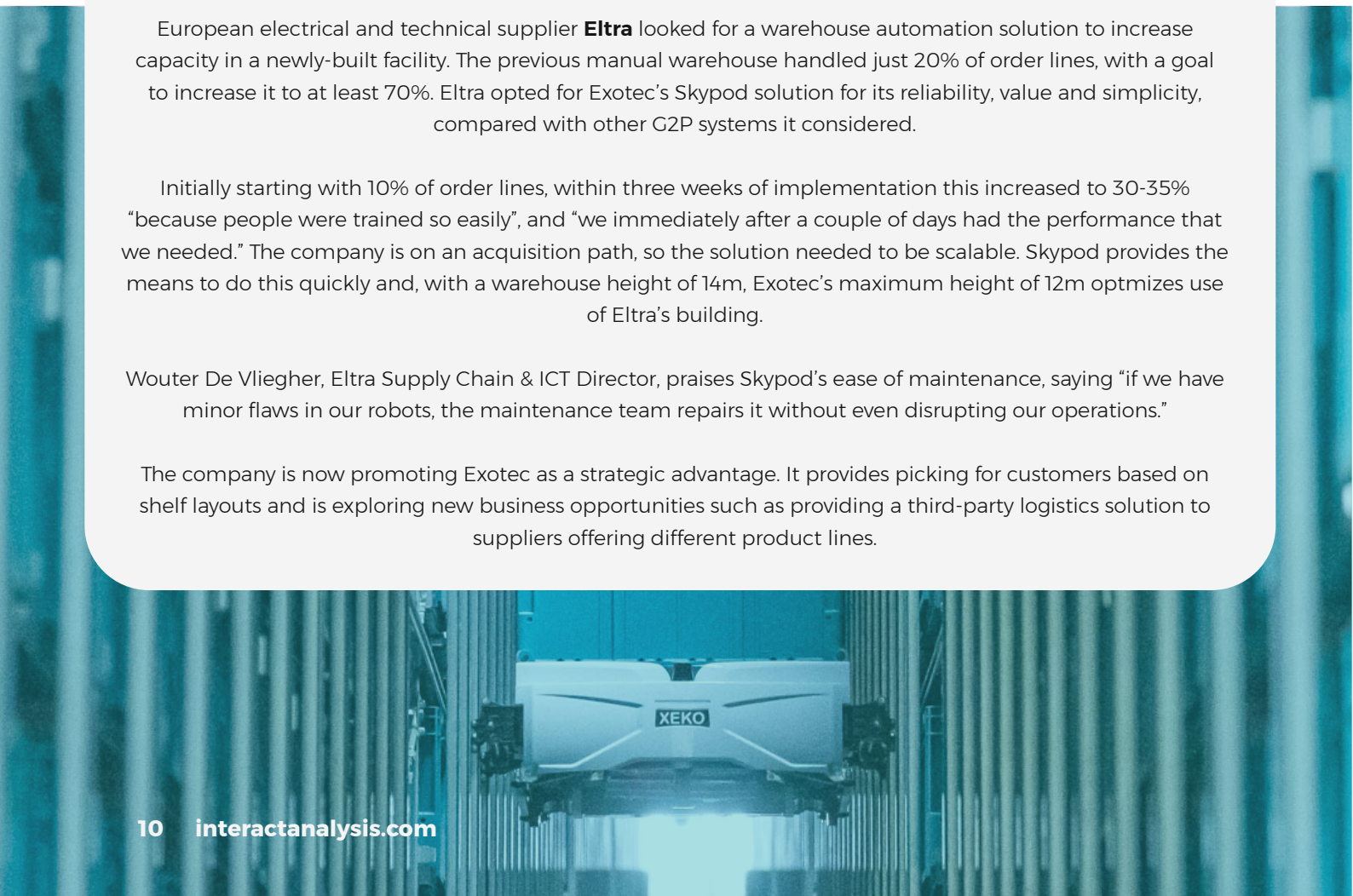
European electrical supplier reaps the benefits of Skypod

European electrical and technical supplier **Eltra** looked for a warehouse automation solution to increase capacity in a newly-built facility. The previous manual warehouse handled just 20% of order lines, with a goal to increase it to at least 70%. Eltra opted for Exotec's Skypod solution for its reliability, value and simplicity, compared with other G2P systems it considered.

Initially starting with 10% of order lines, within three weeks of implementation this increased to 30-35% "because people were trained so easily", and "we immediately after a couple of days had the performance that we needed." The company is on an acquisition path, so the solution needed to be scalable. Skypod provides the means to do this quickly and, with a warehouse height of 14m, Exotec's maximum height of 12m optmizes use of Eltra's building.

Wouter De Vliegher, Eltra Supply Chain & ICT Director, praises Skypod's ease of maintenance, saying "if we have minor flaws in our robots, the maintenance team repairs it without even disrupting our operations."

The company is now promoting Exotec as a strategic advantage. It provides picking for customers based on shelf layouts and is exploring new business opportunities such as providing a third-party logistics solution to suppliers offering different product lines.



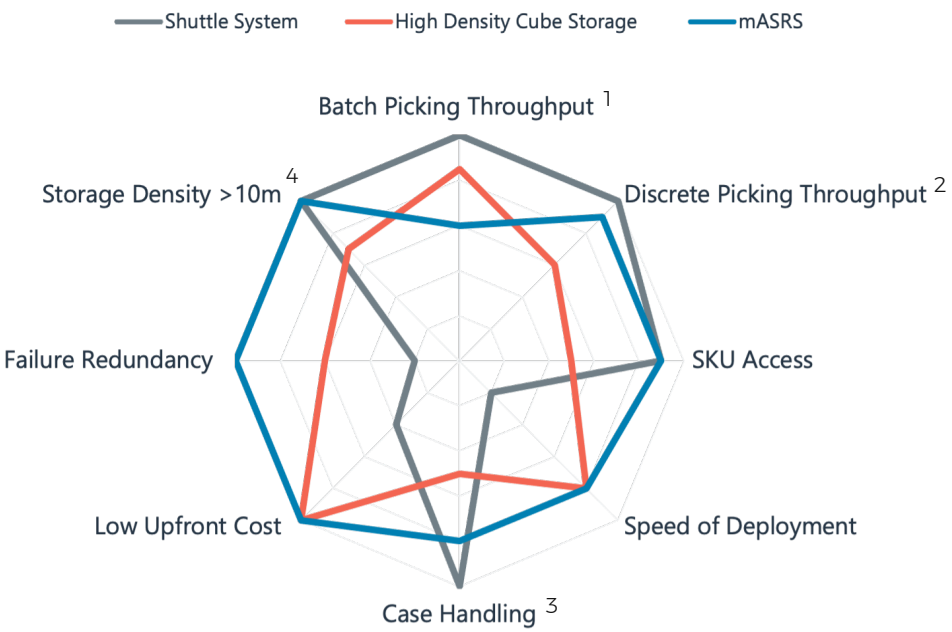
mASRS harnesses the best aspects of warehouse automation

In addition to mASRS systems, there are other solutions available for warehouse automation, each of which offers its own particular challenges and benefits. For example, **cube systems** provide high storage density (below 8m) and higher throughput than manual operations, but are often complicated and expensive to implement, and more difficult to scale up and down. Bottlenecks may occur as robots navigate the grid and retrieval of less popular products takes longer because of a process known as 'slotting', where they are stored further down the cube.

Shuttle systems can offer high levels of throughput but are hampered by a single point of failure, in addition to longer installation times, higher costs, and less scalability. With mASRS, if a problem with a robot occurs then the system still functions with the remaining fleet. Oftentimes, these systems even come with spare robots stored outside of the system for additional redundancy.

There has been a natural progression for G2P technology, from shuttle systems to high-density cube storage to mASRS. **mASRS** technology can be seen as the next evolutionary stage of warehouse automation. With a maximum height of 12m, mASRS occupy a "sweet spot" in the market by balancing the competing capabilities demanded of warehouse automation solutions (as the chart below demonstrates).

Comparison Between ASRS Technologies



Notes:
[1] Typical retail batch pick throughout
[2] Example shows an approx. ratio of 50% of lines containing 50% of total SKUs across 3 shifts
[3] Considers system effectiveness at handling eaches and cases
[4] Considers bin storage density and also downstream packing and sortation space

Source: Interact Analysis 2024

Companies Around the World are Reaping the Benefits of mASRS Solutions

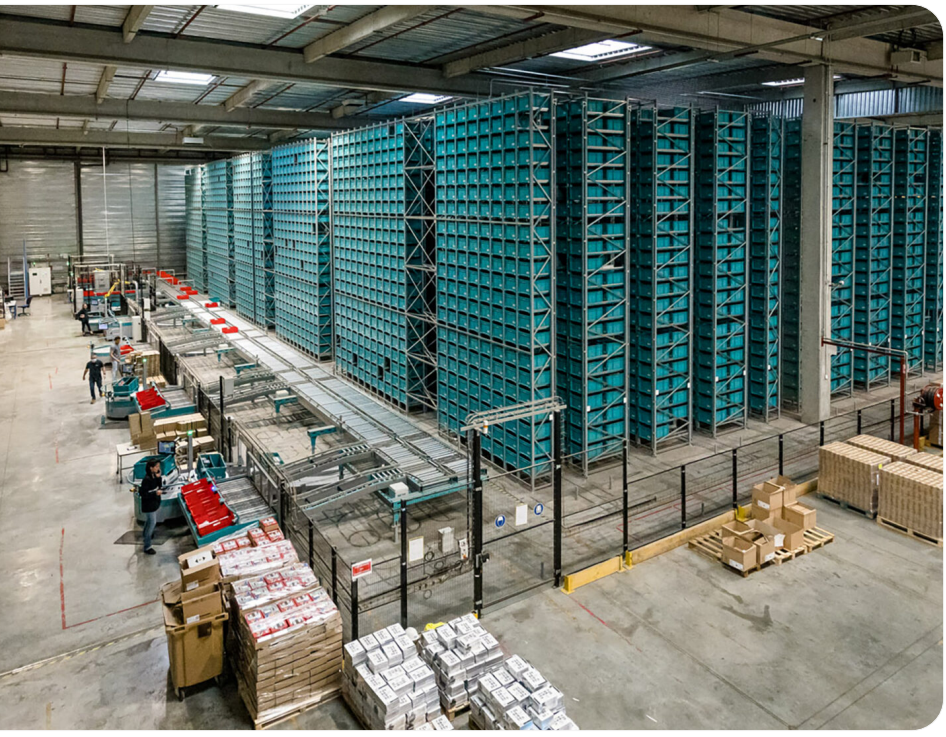
mASRS provide a wide range of benefits throughout the supply chain, just some of which are explored here.

mASRS solutions are future-proof

Fluctuating demand, rapidly-changing channel mix, and global uncertainty are leading businesses to prize solutions that are easily adaptable and future-proof. The ability to install mASRS technology fast, and to scale it up and down quickly (new bots can be added in a matter of minutes and racking within weeks), is a key driver of its rapid adoption. Quality & Operations VP of Lacroix Electronics Benjamin Gauchenot says, "Exotec's solution perfectly blends into our Industry 4.0 approach. It's simple to implement and can evolve to meet our future needs."

Maximizing warehouse space

The high-density storage of mASRS allows companies to make the most of their warehouse space and expand their operations. With a maximum height of 12m for Exotec's Skypod, Leclerc Agile Transformation Manager Solange Marie explains, "Today, we use the entire height of the building. And our solution, which was initially manual and spread over 5,000 m^2, i.e. over the entire warehouse, is now concentrated on 3,000 m^2 of storage."



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Speed and accuracy for rapid fulfillment

Within a single climb, mASRS technology provides market-leading reactivity - any goods are retrievable within two minutes or less - enabling orders to be processed fast and accurately end-to end. Having every tote accessible is particularly useful to companies with tight turnaround times between order cut-off and shipping times. Zac Boehm, Vice President of Robotic Solutions at Hy-Tek Intralogistics, notes that when "I have to be able to drive that volume out in that short amount of time, those other technologies [shuttle and cube-based systems] can't keep up... so that really defines reactivity for being able to drive orders out the door, before a specific cutoff time or a commitment to an SLA."

The efficiency of mASRS technology has seen productivity enhancements of up to 7 times in some warehouses. Highlighting the speed and accuracy offered by mASRS systems and its impact on customer service, Carrefour Director of Logistics Mohamed Ben Aissa, says, "This allows us to respond and satisfy very tight requests from our customers with a satisfaction rate and full order rate of close to 100%."

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mASRS capabilities deliver savings throughout supply chains

mASRS solutions add significant value to business operations in diverse ways and at various stages of the supply chain. Andy Williams, Exotec EVP of Sales for North America, explains Exotec's Skypod solution can ensure that the correct box to fit an order arrives at the picking station at the same time as goods, so they are packed at the same station. This generates considerable savings in picking/packing, and shipping costs. "I think that's something unique we're bringing", Andy says, "if you look at the labor split up in a facility... maybe 60% of your labor is in picking, but you might have 25% of your labor in packing... So, you're looking at big productivity enhancements for these facilities." mASRS also benefit a discount retailer in South Carolina, which uses organized pallet arrangements with inventory sequenced from the system to reduce handling times for store employees.

Companies enhance employee satisfaction with mASRS

mASRS systems carry out physically demanding and repetitive tasks, freeing up employees for higher-value work. Beyond simply addressing ongoing labor shortages, they can improve employees' workplace experience. Vice President of Robotic Solutions at Hy-Tek Intralogistics Zac Boehm points out that 30-50% typically goes into the ROI for retention and recruitment. He states, "People like to work with technology. It makes their job easier and makes them more efficient. And honestly, it's pretty cool, right? When you go home and talk to your kids, and they say, 'what did you do today?' ... 'I had a robot presenting to me a tote and I was picking out of it, and that allowed me to pick faster than anybody else in the building'."

What Does the Future Look Like for Warehouse Automation and mASRS?

Many warehouses are still highly manual, providing significant scope for automation. Businesses which respond and adapt to changing modes of consumption, global events and consumer requirements are likely to enjoy the greatest success. mASRS provide many ways to do so within their supply chains.

While currently a relatively small proportion of the overall warehouse automation market, Interact Analysis forecasts a strong outlook for mASRS systems. Our latest research reveals the popularity of mASRS technology is increasing rapidly, with sustained growth anticipated through to 2027 and beyond.

We predict the number of mASRS customer sites globally will soar to almost 5,000 by 2027, increasing sharply from 22 in 2018. The total number of mASRS robots installed worldwide is also set to climb over the same period from fewer than 1,000 to almost 300,000.

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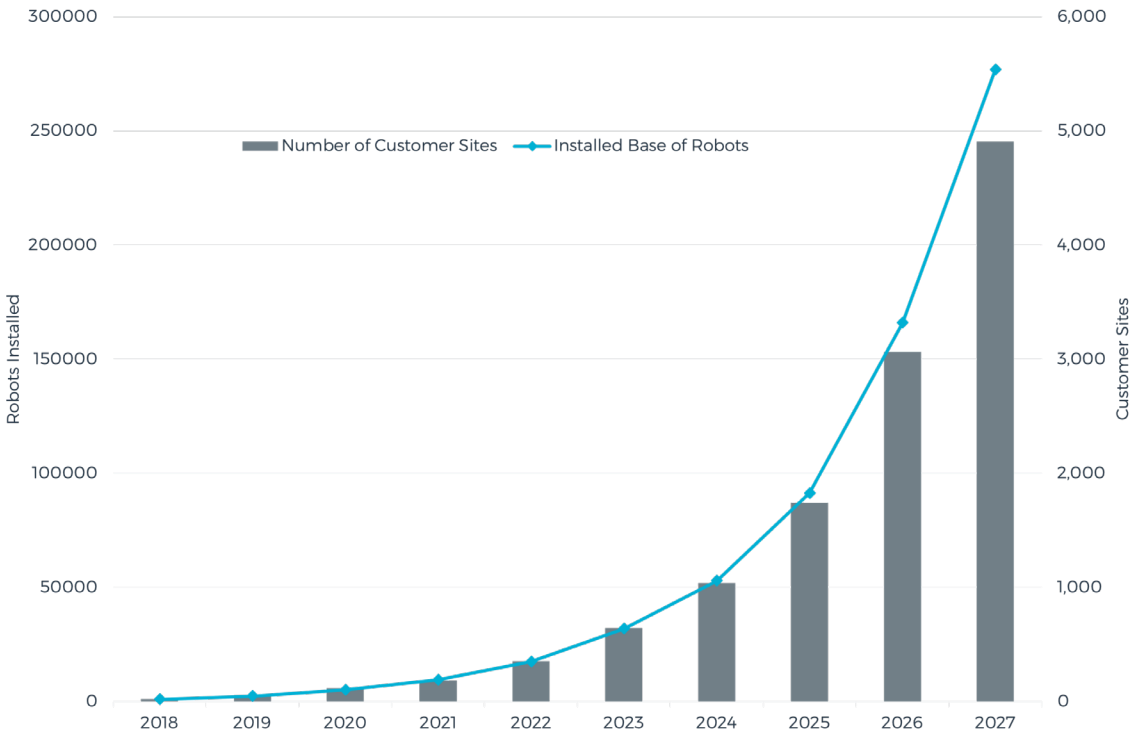
Forecast for Number of mASRS Customer Sites Globally & Installed Base of Robots

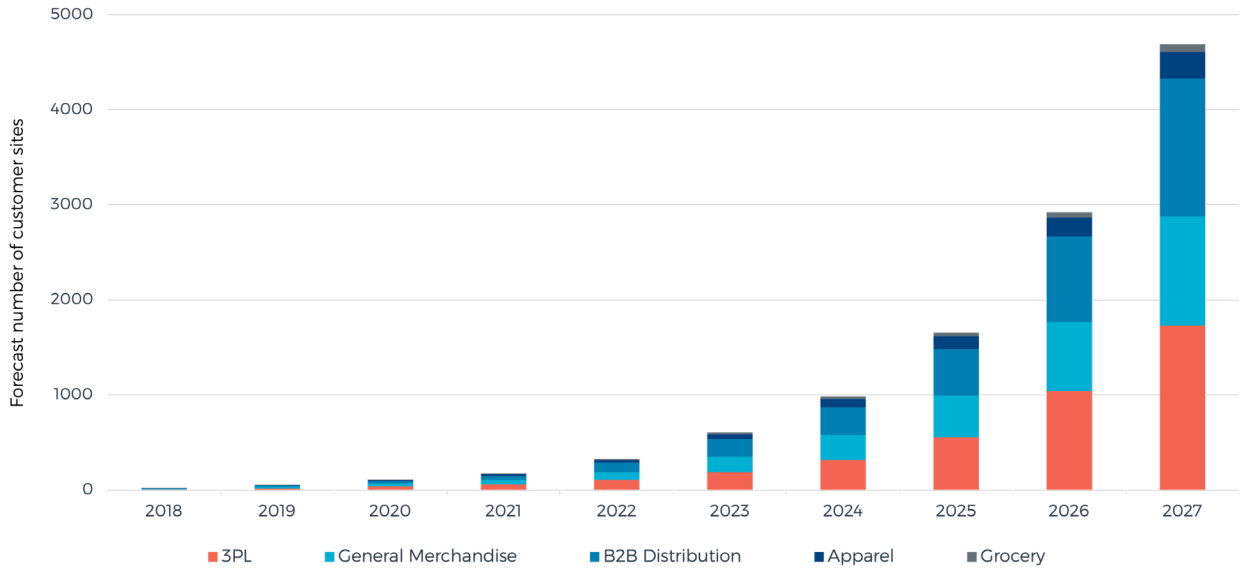


mASRS robots installed and customer sites forecast to grow rapidly

Source: Interact Analysis 2024

Our analysts anticipate the ability of mASRS to pair with other solutions (such as piece-picking robots), the absence of a single point of failure, and the scalability of systems will drive growth. Our forecasts predict a compound annual growth rate (CAGR) of 50% for mASRS technology between 2023 and 2027, with strong growth across a range of industry verticals, in particular 3PL, retail and B2B distribution.

3PL, Retail and B2B Distribution Forecast for Strong mASRS Uptake



mASRS customer sites will soar from a handful in 2018 to almost 5,000 by 2027
Source: Interact Analysis 2024

Technologies well-suited to use in brownfield sites - including high-density storage solutions and mobile robots - will prove particularly popular over the coming years. As major retailers test out mASRS technology and order more systems, numbers will continue to grow sharply over the forecast period. Sales will largely be in downstream verticals, but the manufacturing industry is also showing interest in the technology.

Zac Boehm, Vice President of Robotic Solutions at Hy-Tek Intralogistics, notes some customers are already on second or third Exotec system installations. He sees the market growing steadily until another issue like Covid-19, or perhaps acute labor shortages, "throws gasoline on the fire". With a rapidly-evolving landscape, warehouse automation's future role in the global logistics network is assured. mASRS technology offers a means for businesses around the world, of all sizes and across verticals, to meet new challenges and ensure future success.

Glossary of Terms Used in This Report

AMR: Autonomous mobile robot

ASRS: Automated Storage and Retrieval System

Eaches: Individual items taken from a larger package

G2P: Goods to Person

mASRS: Mobile Automated Storage and Retrieval System

ROI: Return on Investment

Shuttle Systems: Mobile cart that transports items in automated pallet racking

SKU: Stock-keeping Unit

High-Density Cube Storage: Stacked bins in a dense cube accessed via smart robots

About Exotec

Exotec builds elegant goods-to-person warehouse robotic solutions for the world's largest brands. The company combines the best of hardware and software to offer flexible warehouse systems that drive operational efficiency, add resiliency, and improve working conditions for warehouse operators. 30+ industry-leading brands including Carrefour, Decathlon, Gap, and Uniqlo trust Exotec to improve their operations and profitably navigate rapid shifts in business models and customer expectations Learn more at **www.exotec.com**

About Interact Analysis

With over 200 years of combined experience, Interact Analysis is the market intelligence authority for global supply chain automation. Our research covers the entire automation value chain – from the technology used to automate factory production, through inventory storage and distribution channels, to the transportation of the finished goods. The world's leading companies trust us to surface robust insights and opportunities for technology-driven growth. To learn more, visit **www.InteractAnalysis.com**

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