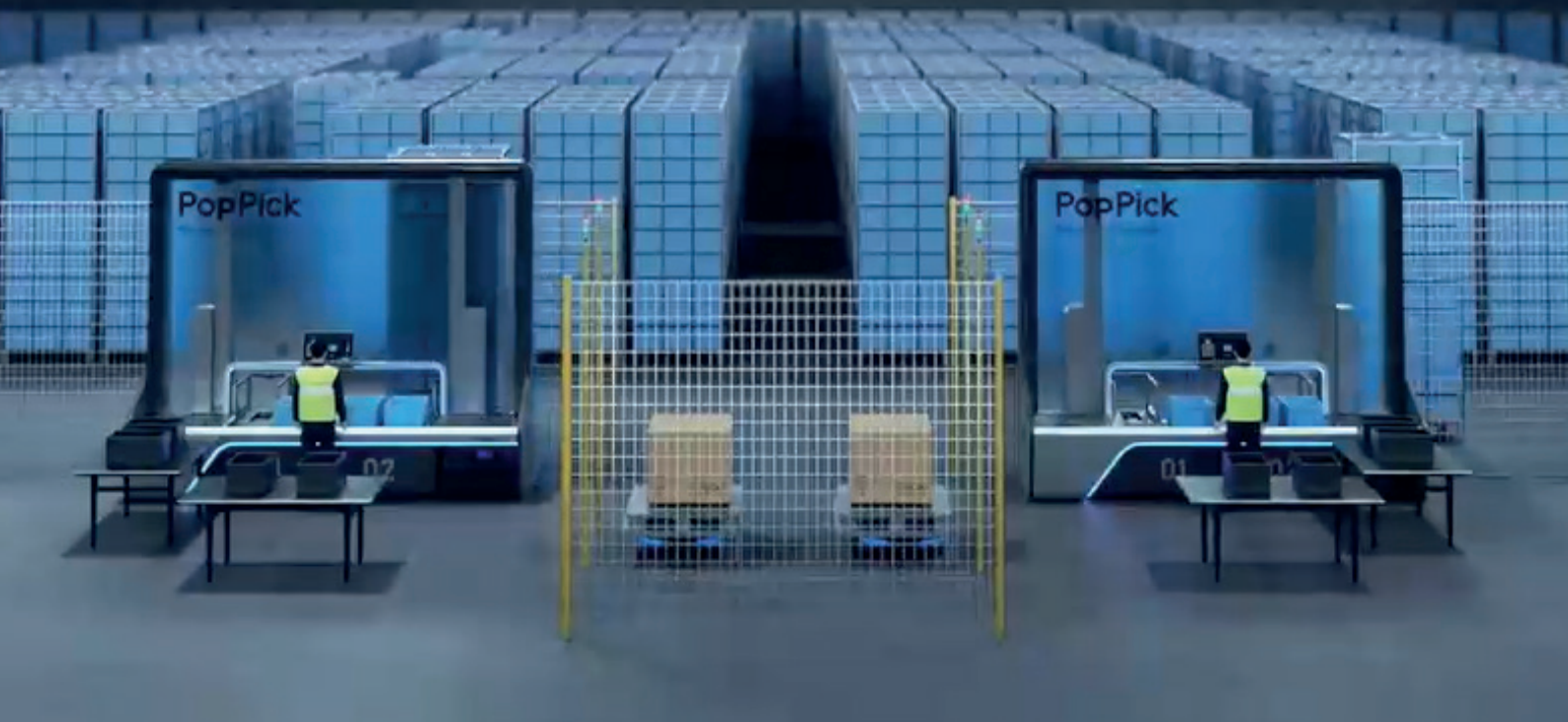


THE FUTURE OF WAREHOUSE ROBOTICS



Geek+
Moving the world intelligently



**INTERACT
ANALYSIS**

Part 1: The world of warehousing has changed

Until today, autonomous mobile robots (AMRs) have been deployed in isolated workflows in warehouses with no real integration across multiple processes in the same building. This is changing.

The pandemic meant warehouses had to cope with social distancing and staff absences. It also caused a massive e-commerce boost and has led to a protracted labor shortage. All this has forced warehouse managers to take a deeper look at the possibilities offered by warehouse automation and to accelerate any existing plans they had to automate. The goal is not only to improve the efficiency of their businesses in a newly competitive landscape, but also to boost staff retention by improving working lives. At the same time, the pandemic has highlighted that nothing is certain and that industries can be turned upside down overnight. Flexibility for operations and not being tied to major infrastructure for too long is of much greater importance.

On top of COVID-related challenges, other major changes in the market are afoot too. These include so-called 'mass-customization' which, for warehouses, means that the product lines they have to store and deliver are liable to change size and shape at short notice. As well as demands for ever more rapid delivery.

An AMR solution usually presents several major benefits compared to fixed automation: it is more cost-effective, it is faster to deploy, it is more flexible, and it is easier to scale. New mobile robot solutions are enabling robots to select individual totes and bring them to pickers, instead of bringing whole racks, resulting in major efficiency improvements. Meanwhile, combining sophisticated software management systems with the wide variety of AMR platforms now available gives the option of knitting different robot types together into a single solution. Ultimately, this presents the possibility of a wholesale replacement of fixed automation solutions with mobile ones.

To put it bluntly: if a team of well managed mobile robots can pick and carry any item to any location in a warehouse, why would anybody ever install a fixed conveyor belt ever again?



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Globally, the opportunity for warehouse automation is immense. Not least because of the huge growth in the numbers of warehouses. According to data from Interact Analysis, there were 150,000 warehouses around the world by the end of 2020. This will have grown to about 180,000 by 2025 (see Fig. 1).

Global warehouse count

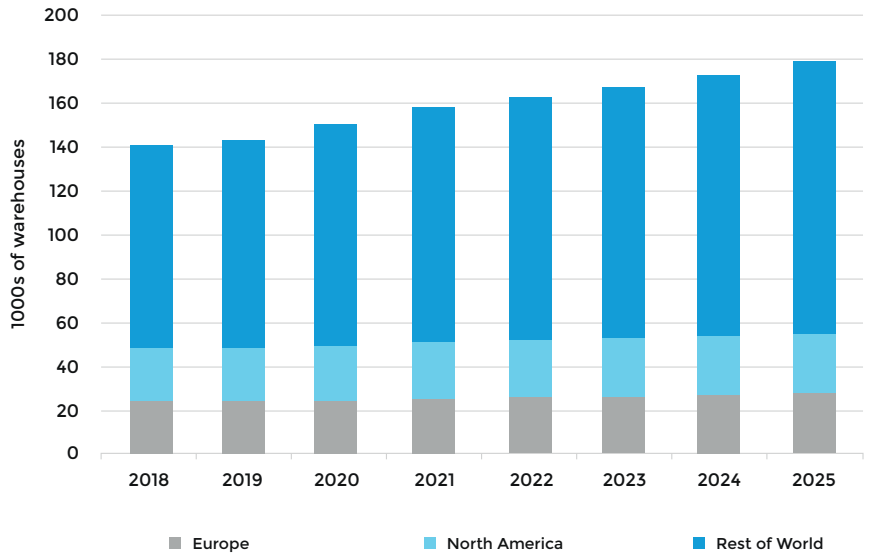


Fig. 1 – There will be about 180,000 warehouses globally by 2025, up from 150,000 at the end of 2020

Much of this growth is driven by e-commerce, with a rough rule being that, for every \$1 billion in additional online sales, an additional 1 million square feet of warehousing is needed to support it. And over half of these new warehouses (57%) will be in five countries: China, the USA, Japan, India, and Germany. Moreover, 75% of the current warehouse stock has no automation at all, so the market potential for warehouse automation is huge.



7A

7B

7C

7D

6A

6B

6C

6D

5A

5B

5C

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4A

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3C

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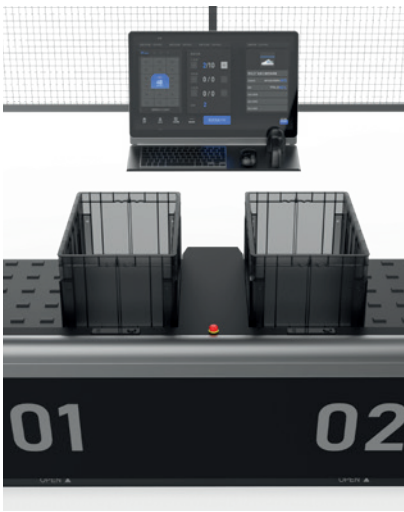
1B

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1D



WUJUN



Part 2 - Embracing tote-to-person (T2P) AMR and the mobile automation solution

What is T2P AMR?

T2P AMR technology is a new variant on traditional G2P (goods-to-person) solutions that sees robots bring individual totes to picking employees, instead of entire racks. One key advantage of T2P AMR is that keeping the main rack stationary allows for much higher racks than would be possible if the entire rack had to be moved regularly. In many warehouses today which use G2P, the higher area in the warehouse is simply wasted. An automated T2P AMR solution can therefore significantly increase warehouse storage capacity in these scenarios – with the warehouse ceiling being the only real limitation for storage.

Conversely, where warehouses are already using tall racks to fill their high space, if the picking process is automated at all, it is generally done using a bespoke solution, often involving cranes and forklifts. In these scenarios, T2P AMR offers a far cheaper and more efficient 'off the shelf' path to automation that was previously entirely lacking.

What drives T2P AMR?

Data from Interact Analysis shows that the market for T2P AMR solutions is growing fast. Revenues from T2P AMR are expected to grow from roughly \$154 million in 2021 to about 1.5 billion by 2025 (2025 will also be the first year that T2P AMR outpaces sales of standard G2P solutions which will be 1.3 billion that year).

The benefits of T2P AMR are particularly useful in some specific warehouse segments. For example, in many retail and apparel warehouses, G2P automation was never suitable in certain applications for various reasons, such as the need to pick and load very heavy goods, or the need to climb to high locations very frequently. T2P AMR represents a workable automation solution for these applications.

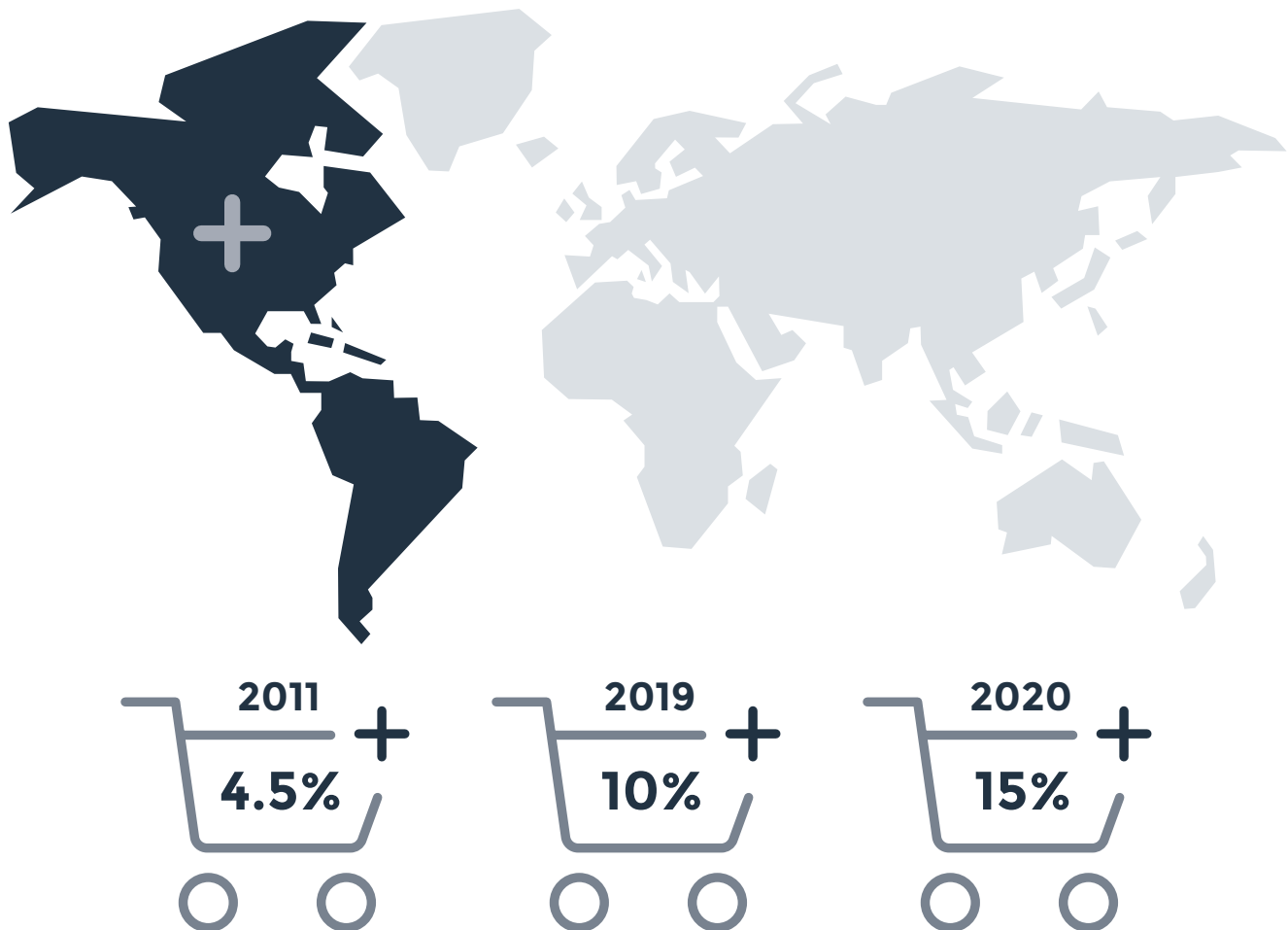
T2P AMR adoption is also being driven by wider trends. While warehouses, like all businesses, are always striving for efficiencies, the pressure to improve warehouse efficiency through automation right now is particularly strong. Part of the issue is an unprecedented global labor shortage which, though it may have come about as a result of COVID-19, shows no sign of receding along with the virus.

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**With T2P AMR,
the warehouse
ceiling is the only
real limitation for
storage.**

The other big issue is the (again, largely COVID-19 related) growth in e-commerce. US Census Bureau data reports that US e-commerce sales accounted for 4.5% of total retail sales in 2011. By 2019 this had hit 10%. Then, over the next 12 months, it increased to 15%. This means US e-commerce penetration rose as much in 2020 as it had done over the previous decade in terms of market share: a picture that was largely repeated across much of the developed world.

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The growth in e-commerce volume is radically changing the competitive landscape of retail.

U.S. e-commerce percentages of total retail sales





This growth in e-commerce volume is pressuring e-commerce companies to improve efficiency wherever possible. It is also radically changing the competitive landscape of retail. One example is the rapid rise of rapid delivery companies, which mainly use bicycle or car couriers to deliver items within very tight timeslots. While rapid delivery may not directly compete with larger e-commerce operations, it does move the entire market in the direction of ever tighter delivery timeslots. One example of a response to this from larger e-commerce companies is the rise of automated micro-fulfillment centers, which are serviced by larger centralized distribution hubs. Interact Analysis's research shows that 43 micro-fulfillment centers went live in 2021, meaning the total global stock was 86. In 2030, 1,998 micro-fulfillment centers will go live, by which time, the total global stock will be 7,338 – the vast majority of which will be in the USA and Europe.



More conservative customers are willing to test out automation solutions once they are perceived as 'tried and tested' by the market.

Warehouse automation spreads beyond e-commerce: implications of a maturing market

As the overall warehouse automation market grows (from \$29.6 billion in 2020 to \$69 billion by 2025, see Fig. 2 below), a general maturity in warehouse automation solutions has expanded the customer base. That's essentially because more conservative customers are willing to test out automation solutions once they are perceived as 'tried and tested' by the market. With such customers, it becomes primarily a question of return on investment. And since T2P AMR solutions have a rapid return, market maturity is helping to shift these systems.

Warehouse automation market revenue forecast by equipment type

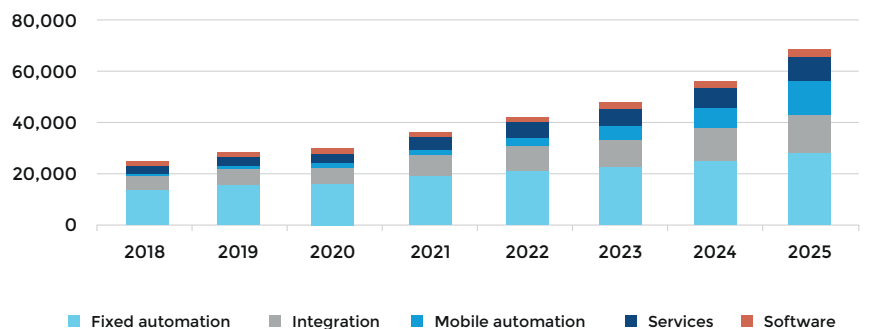


Fig. 2 – The warehouse automation market will grow from \$29.6 billion in 2020 to \$69 billion by 2025

It's important to remember that growth in the e-commerce market doesn't just impact e-commerce warehouses, it impacts warehouses further down the chain too. For example, Geek+ customer Comix has referred to a "fragmentation and randomization" of e-commerce orders as customers increasingly request smaller e-commerce shipments and also order items that (pre-pandemic) very few would have considered buying online. The challenges in predicting which products will need to be picked and in what volume drives even greater need for flexibility in warehouse operations.



E-commerce was an early adopter of more advanced warehouse automation solutions, but now market data clearly shows that many other warehouse segments are rapidly following suit. As can be seen in Fig. 3 below many individual industry segments are growing their use of warehouse automation significantly. For example, grocery accounted for 12% of warehouse automation revenues in 2020 but will account for 16% of a much larger market by 2025.

Warehouse automation market revenue forecast by vertical

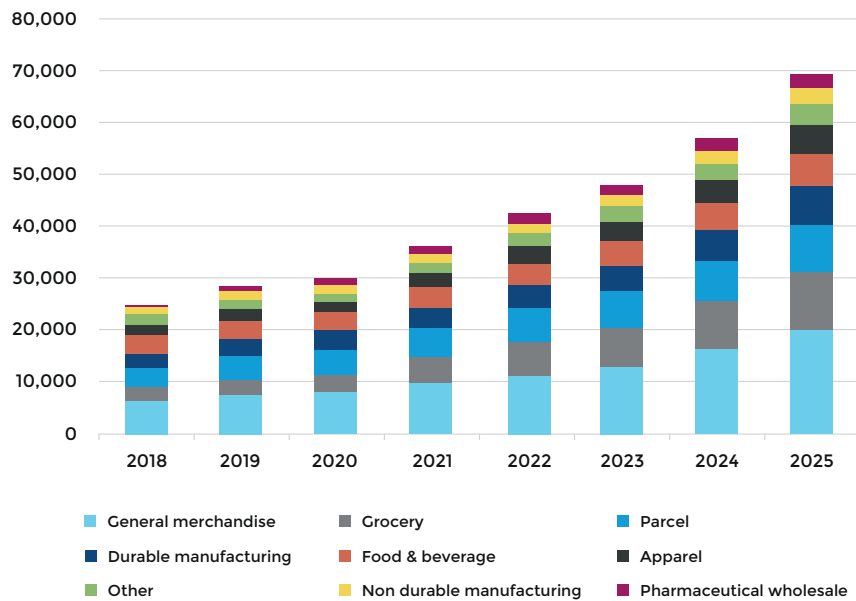
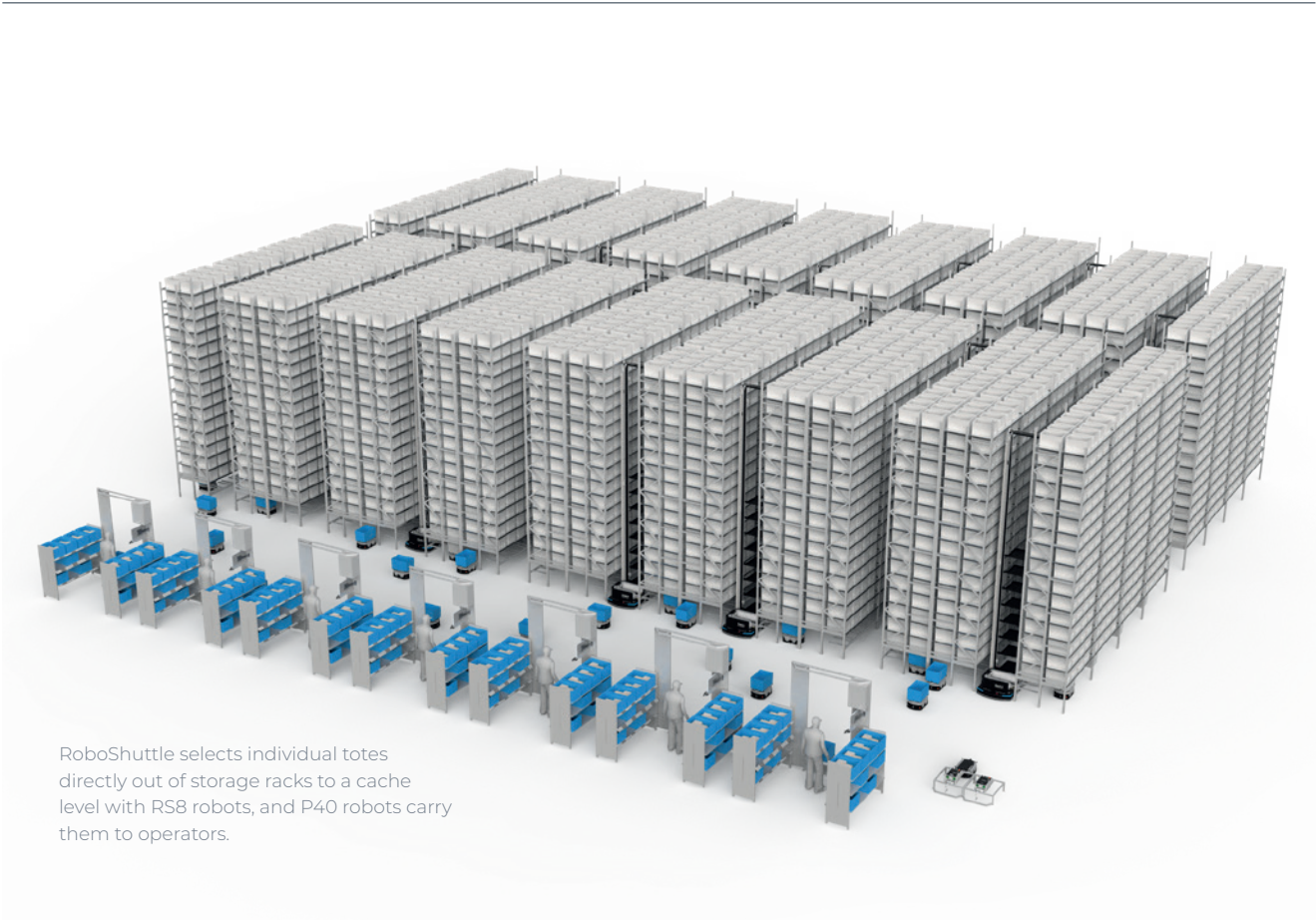


Fig. 3 – Grocery accounted for 12% of warehouse automation revenues in 2020, but will account for 16% of a much larger market by 2025



RoboShuttle selects individual totes directly out of storage racks to a cache level with RS8 robots, and P40 robots carry them to operators.





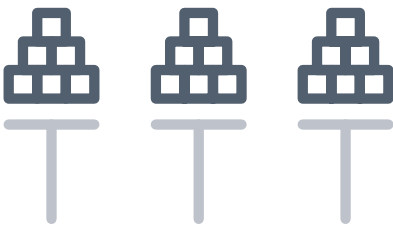
Part 3 - A real-world case study

One example of T2P AMRs is the Geek+ RoboShuttle solution, which can increase warehouse storage capacity by up to 3 times by allowing pickable shelves up to 8m in height with the RS8 tote transfer robot. The solution also offers high picking efficiency by combining the P40 picking robot which delivers the ability to pick up to 400 totes per picking station per hour. Implementation is rapid with full system deployment in under one month. And a flexible design means that existing customer shelves, racks and lofts can be reused.

Meanwhile, a modular, scalable approach means robots can be easily added or removed in line with business needs, and that the RoboShuttle solution can easily be combined with other automation solutions, such as G2P or pick and place robots. It can even be connected in a multi-process solution (see part 4 below). The result is that average return on investment is just 1-2 years.

One real-world client in France – a sustainable construction materials company – chose the Geek+ combined RoboShuttle and P40 robot solution. Their goal was to ensure next-day delivery of all products to both B2B and B2C customers. This was a tough challenge because the company ships more than a thousand products per hour at peak times. And they were also asking for an AMR solution that would help them increase this throughput, as well as deliver higher picking accuracy and lower labor costs.

Geek+ stepped in and met the challenge. Their RoboShuttle robots are now responsible for transferring totes up and down high racks. While P40 robots then retrieve the totes and take them to an operator at a picking station. This solution gives much higher storage capacity, since it uses 5.1 meter high racks – far higher than a standard G2P solution could manage. It has also improved picking efficiency because picking stations can be adjusted to the optimal height for each individual operator. Finally, the use of P40 robots instead of fixed conveyors represents a major cost saving.



INCREASED STORAGE
CAPACITY BY

UP TO 3x



400 TOTES

PER PICKING STATION PER HOUR



051



x4 INCREASE
IN AVERAGE
WAREHOUSE STORAGE

COST SAVING OF
50%

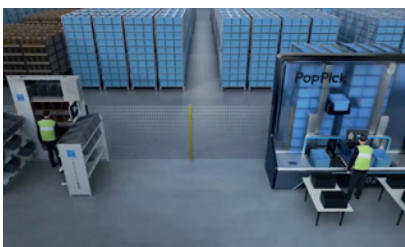
Part 4 - The evolution of G2P

It's important to understand that the coming of age of T2P AMR does not spell the end of the line for G2P technology. For many customers, current G2P solutions are more than enough. And G2P itself is evolving. In fact, G2P is continuing to drive the warehouse automation revolution, constantly improving the efficiency with which humans and robots can work together. One solution example from Geek+ that illustrates the depth and richness of G2P innovations is PopPick. Another is the robot cross-docking picking solution.

PopPick

PopPick sees G2P-style robots carry entire racks to a pick station, just like an ordinary G2P solution. But what makes it different is the PopPick employee station. That's because it is an automated AI-enabled tote picking workstation. Once the rack arrives totes are selected by robots that are built-in to the picking station. These totes are then presented to operators.

This solution enables high-density storage by stacking 12 columns of totes in a row with only a 2 cm gap between them, delivering a 4x increase in average warehouse storage density. The result is a picking efficiency of 650 totes per hour per picking station giving (on average) a 50% cost saving compared to traditional solutions.



With PopPick, entire racks are carried to picking stations, and stations select individual totes to present to operators.





Cross-docking

Robotic cross-docking is a special evolution of G2P technology, and is arguably the best practice for any cross-docking needs in the retail industry. The process takes place in a cross-docking terminal made up of a receiving dock for inbound goods, a central space for sorting goods, and an outbound dock where sorted goods are loaded into vehicles to travel to the customer. This process is a challenge because demand is unpredictable, the pace is fast and is unforgiving of human error, and the system leaves little room for storage of goods meaning any sudden stoppage of the workflow is highly problematic.

Another real-world example

One example of a customer using robotic cross-docking is a large UK supermarket chain. They adopted a robotic cross-docking solution from Geek+ in a 10,490 m² warehouse. The project used 50 Geek+ P-series robots along with 30 picking workstations to manage 600 sets of shelves. And the solution delivered a flexible and scalable picking storage area, along with intelligent order and priority scheduling. The benefits have been improved picking efficiency, a major reduction in the labor requirement and costs, and radically better picking accuracy and quality control.

Deploying multi-AMR solutions

For many mobile robot vendors, flexibility has always been a key selling point. Mobile robots are inherently flexible because they can be rapidly deployed in pretty much any warehouse, because they are very easy to adapt to match new workflows, and because they can very quickly be scaled up or down depending on the required throughput. In fact, many mobile robot vendors have a Robot-as-a-Service offering to allow customers to temporarily scale up at times of peak demand such as public holidays, and then to scale back down again after. In the current context of rapid growth due to the COVID-19 rebound, the concept of flexibility is only getting more important.

The need for flexibility, combined with a labor shortage which is providing warehouses with an impetus to automate any processes they can, is now leading to the next step in market maturity: the automation of entire (or close to entire) warehouse operations through AMRs. This can be done by deploying a combined mobile robot solution, where G2P and T2P AMR and other types of mobile robot platforms all work in unison. This is a big challenge in terms of robot management as it has to be managed centrally, and therefore requires all robots to be working in a synchronized way.



The next step in market maturity is the automation of entire (or close to entire) warehouse operations through AMRs.

While it's true that older technology, such as conveyors to move totes, is an efficient and proven set-up, many customers are moving away from them. That's because they are almost impossible to adapt as demands on the business change, and also because they are relatively expensive and time consuming to install. A well-managed team of mobile robots can pick and move anything to anywhere in a warehouse with no need for any conveyors at all. This is not just cheaper than conveyors to set up, it's also far more capable because, obviously, no fixed conveyor can have the ability to reach all areas of a warehouse.

Multi-AMR case studies: the journey to combined mobile robot solutions

Despite the relative maturity of the mobile warehouse automation market, most customers still start relatively small with an initial picking solution – usually a G2P solution – in one area of the warehouse. Only once they've made sure that warehouse automation works properly and delivers a strong return on investment within the confines of their specific industry will they look to then expand into a wider solution.

One real-world example of a more complex automation solution is at Comix – a leading B2B office supplies and SaaS cloud service company in China. The challenge was to deal with over 130,000 small-sized and highly varied SKUs. To do this, Geek+ offered an innovative T2P AMR solution that combined two types of mobile robot solution from Geek+ - the RS8 to handle the tote-to-cache storage and the P40 robot to deliver tote-to-person. Geek+ was able to tailor this solution within Comix's unique business environment, combining the advantages of both types of robots. The RS8 robot moves totes from the storage rows to a storage cache, from where the P40 robots take over and carry totes to individual operators at picking stations.¹

At Comix, this is a solution that works really effectively because it gives the ability to cache in-demand SKUs on the lowest shelf, which radically speeds up the picking process. The result has been that the overall storage capacity at Comix warehouses is up by 200%, picking efficiency is up 50%, and accuracy rates have reached 99.99%. Additionally, the solution has not only improved the efficiency of operators but has also improved their working conditions by reducing overall work intensity.¹



2



**PACKING
EFFICIENCY UP**

4-6x

**STORAGE
CAPACITY UP**

1.5-2x

**ACCURACY &
DELIVERY RATES**

99.99%

3



**WAREHOUSE
STORAGE CAPACITY**

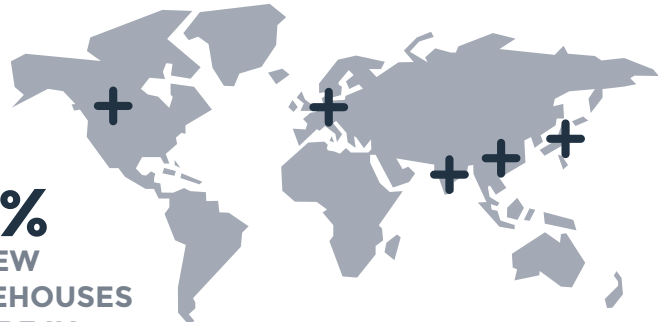
+20%

**STORAGE
UTILIZATION**

+25%

Another combined AMR case study is Shican, also in China. Shican is a leading 3PL in the apparel sector. Their challenge was the need to cope with massive SKUs (with clothes stored folded), as well as a major increase in e-commerce, and significant seasonal inventory changes. To meet these challenges, the company installed 80 RS-5 robots from Geek+. The results were that packing efficiency increased by 4-6x, storage capacity went up by 1.5-2x, and both accuracy and on-time delivery rates hit 99.99%².

A final case study is French sporting goods retailer Decathlon who adopted a Geek+ AMR solution consisting of RS8 and P800 robots at their warehouses in Kunshan, China. Decathlon was using high bay shelves and forklifts for pallet storage, severely limiting their inventory management capabilities and also requiring a lot of expensive licensed forklift drivers. The Geek+ solution increased storage capacity by 20% and also increased storage utilization by 25%³.



57%
OF NEW
WAREHOUSES
WILL BE IN
5 COUNTRIES



EVERY
\$1 BILLION
OF ONLINE SALES...



...REQUIRES ADDITIONAL
1 MILLION ft²

The modularization challenge

Not every customer will want a combined mobile robot solution, yet it is an important and growing sector. Customers tend to start by automating the low hanging fruit, only when that is implemented successfully do they look for the next automation opportunity. Yet, no matter how widespread the trend becomes, multi-robot solutions will never be available entirely 'off-the-shelf'. A degree of customization will always be required, but modularization will be possible, and this will cause costs and implementation time to fall significantly further over time.

In fact, modularization is a key driver of adoption. That's because customers tend to want a new site up and running in the shortest possible time with minimal disruption to their operations. And, once a modularized solution has been adapted to the needs of a specific customer, it can then typically be copied across all that customer's warehouse sites with ease. Generally, going with a single integrated supplier is the most efficient possible way to do this in the shortest possible time.



Customers tend to start by automating the low hanging fruit, only when that is implemented successfully do they look for the next automation opportunity.

Part 5: An AI-powered solution

These more complex mobile robot solutions are not just down to hardware. Indeed, they are not even primarily down to hardware. As with so many advanced industrial set-ups, AI software sits at their heart. Complex multi-AMR solutions simply couldn't work without AI, and neither could many of the very large scale mobile robot solutions that we are seeing more and more of.

Connecting multiple robot types together into a single solution comes with many challenges. Not least of these is the management challenge: how to ensure these robots work together and communicate efficiently. A single software interface that spreads across all robots in a warehouse is the key to this. While most customers start with a selection of what they perceive to be the best-in-class robots from multiple suppliers, they typically quickly realize that they prefer solutions from a specific manufacturer.

The best robot software systems incorporate robot management with complete warehouse execution and warehouse management systems (see Fig. 4 below). As well as offering a comprehensive data and simulation platform. Additionally, an AI algorithm with machine learning and operational optimization capabilities is key to building a sustainable competitive advantage. Such algorithms form the brain of the software

platform and can plan and manage any number of applications such as task matching, path planning, order grouping, shelf adjustment, 3D bin packing, and smart replenishment.

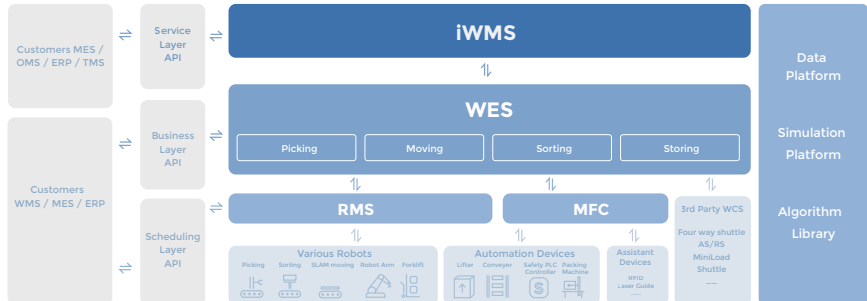


Fig. 4 – Standard Geek+ software architecture



To continue the conversation about the future of smart logistics automation, contact

Marie Peterson - VP for international business development and marketing at Geek+:

marie@geekplus.com



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