



WHITE PAPER

Flexible v Fixed Infrastructure

The warehouses of today and tomorrow



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Fixed v flexible

Flexible infrastructure is not only an alternative to fixed infrastructure, it could overtake it

It might seem like a flight of fancy to some, or too far in the future to think seriously about, but in fact, the roboticisation of warehouses is happening so fast that the vast majority of leading warehouses will almost certainly integrate robots within five years.

This is the only conclusion that can be drawn from the plethora of market research reports about the subject, all of which forecast growth of varying levels.

In this white paper, we look at the competition that stands in the way of robots – namely, fixed infrastructure such as conveyors and automated storage and retrieval systems.

Robots represent the flexible infrastructure model, which offers the opportunity to establish a warehouse without much if anything inside it, except for computer networking.

Which one will win out in the end? Or will they both coexist? We'll know the answers within five years. ■

Types of warehouse automation

System automation

This is typically the computing systems aspect, and includes such things as:

- networking
- warehouse management systems
- barcode-reading devices
- RF devices
- pick-to-light systems

Mechanised automation

This can include such things as:

- conveyors
 - automated storage and retrieval systems
- Shelving or racking systems are essential to this method, and most infrastructure tends to be fixed. Exceptions might be forklift trucks and automated guided vehicles. But AGVs also require magnetic strips to be fixed to the floor to enable them to navigate. As such, AGVs are mainly mechanical and considered to be fundamentally different from autonomous mobile robots, which navigate using lasers and sensors and require no fixed infrastructure.*

Robotic automation

Without getting into the semantics too much, there are different types of robots for warehouses. They include:

- autonomous mobile robots
 - driverless forklift trucks
 - robotic arms for picking
 - robots for palletising
- There are numerous other robotic systems that are either already on the market or are currently being developed. The key innovation, however, is not necessarily technical – it's in the business model. Recognising that robotics can be expensive, suppliers are increasingly offering their systems in a "robotics-as-a-service" package.*

Overview of infrastructure choices

In these computer-dominated times, the word "infrastructure" can prompt people to think both of physical infrastructure, which we are focusing on here, as well as digital infrastructure.

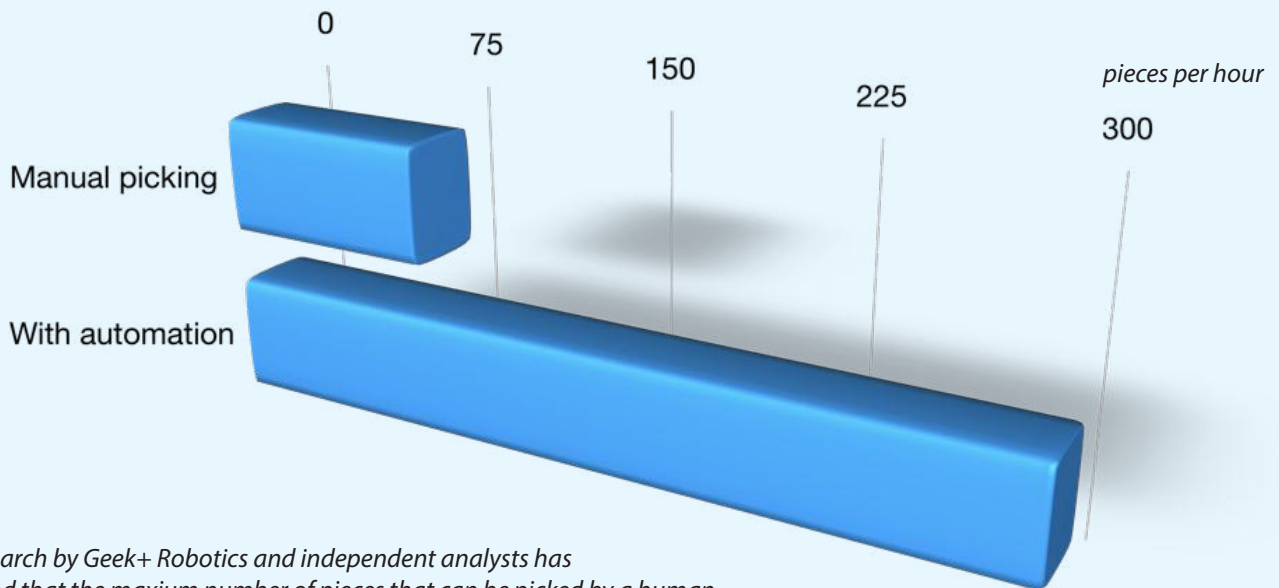
Staying in the digital dimension for a moment, if you are planning to establish a warehouse, you are likely going to need to set up your data infrastructure first.

A Local Area Network, or LAN, covers your warehouse and the immediate vicinity, while the Wide Area Network will cover facilities in various locations and connect them all up to the head office, which may be in a separate place altogether.

A warehouse LAN or WAN requires mobile devices to maximise its effectiveness. These devices – which can range from specialist handheld scanning and computing devices to smartphones and tablets – are often used in warehouses for barcode scanning, checking stock, and a variety of things.

Increasingly, warehouse managers are equipping their staff

Manual picking compared with automation



Research by Geek+ Robotics and independent analysts has found that the maximum number of pieces that can be picked by a human picker is around 60 to 80 per hour. This number is increased to around 300 an hour if robotics and automation are used along with the human picker. Walking and manually picking orders can account for more than half of the time associated with picking.

with smart glasses which integrate augmented reality, so they can simply look at boxes and items and have the relevant data displayed on the lenses.

However, all that said, what we mean by fixed infrastructure is the basics of a warehouse, the things that most people think of first when they think of a warehouse.

Namely, and ranked by historical appearance:

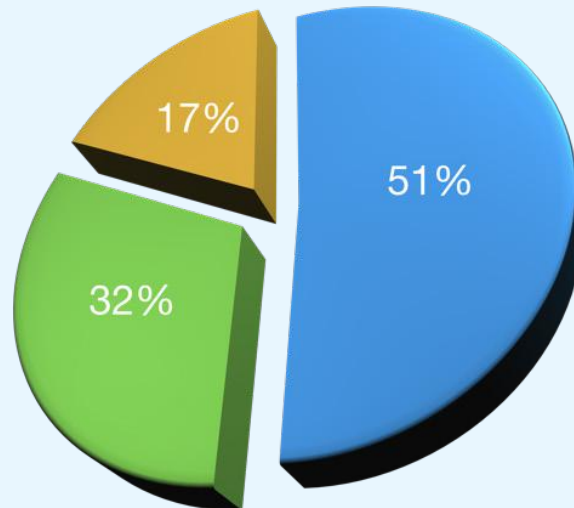
1. racks or shelves;
2. conveyors;
3. forklifts; and
4. automated guided vehicles.

And while new, flexible infrastructure components – such as moving shelves and autonomous mobile robots – are finding enthusiastic buyers and growing in adoption, they are still a relatively small proportion of the total warehouse market.

The overwhelming majority of warehouses which have

Percentage of US warehouses that are automated

Total number of warehouses ~ 20,000
(Source: Statista)



According to Statista, there are currently approximately 20,000 warehouses in operation across the US. Further research by Robotics and Automation News suggests that a slight majority (51 per cent) of these are manually operated, meaning they contain no significant mechanisation or automation. Around a third (32 per cent) feature some mechanisation, such as forklift trucks and conveyors. And a relatively small proportion – we've probably overestimated it at 17 per cent – use advanced automation systems, such as autonomous mobile robots.

● Manual ● Partial automation ● Advanced automation

any level of mechanisation or automation still use the technologies from the above numbered list and maybe one or two extras – mostly digital, or software-oriented solutions, such as Warehouse Management Systems, or WMS, which has become standard technology for most operations.

But then there are also the huge number of warehouses that do not have any automation at all. In fact, they may not have much mechanisation either, and are largely human-operated.

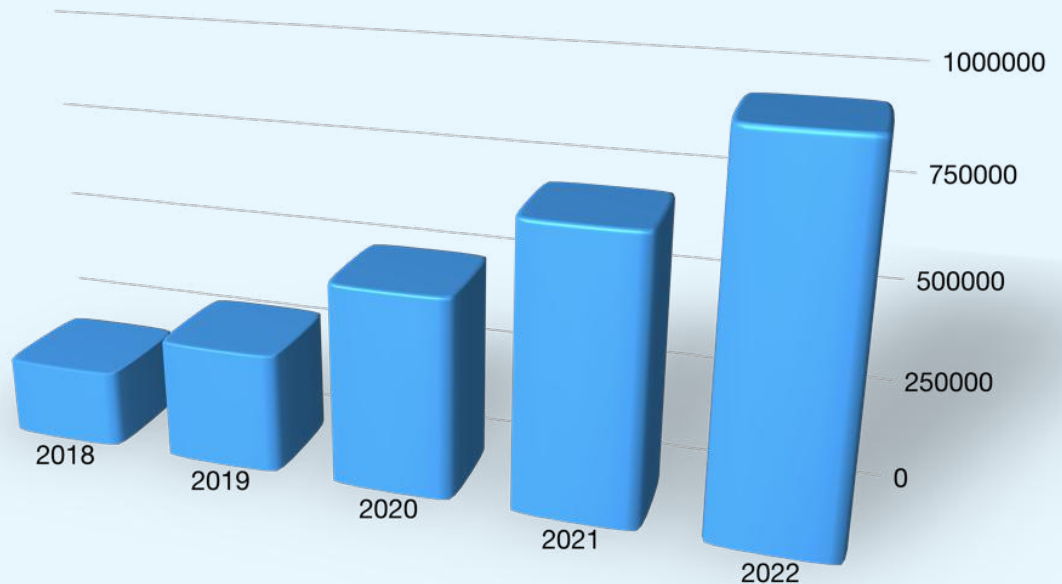
It is often thought that fixed-infrastructure facilities are suitable for high-volume, fast-moving goods. And this may be true, but how long that perception continues to persist remains to be seen.

Time and motion studies may well be done in due course comparing fixed-infrastructure warehouses to flexible warehouses, and it would be interesting to see how they compare in terms of how fast they each are.

For the time being, when a warehouse manager wants to automate their warehouse, they have a choice between fixed

Unit sales of warehousing and logistics robots

According to research company Tractica, unit sales of warehousing and logistics robots will grow rapidly over the next five years from 194,000 units in 2018 to 938,000 units annually by 2022, with the rate of growth slowing after 2021 as many major players will have adopted robotic systems by then. Worldwide revenue for this category will increase from \$8.3 billion in 2018 to \$30.8 billion in 2022, providing significant opportunities for established participants and emerging players.



or flexible, or a blend of the two, which makes establishing a warehouse that much more interesting.

Flexible infrastructure may not replace fixed infrastructure in every warehouse, but at least it offers an alternative method to the traditional system that's been around a long time.

Until recent years, the only way to set up a warehouse was to have fixed shelving for storing items and fixed conveyors for moving those items around.

In terms of mobile hardware, there was the forklift truck and the automated guided vehicle, or AGV, which also required magnetic rails to fixed to the floor to enable it to navigate.

These are the main components of a traditional warehouse, but new technology is enabling the establishment of facilities with no fixed infrastructure at all.

Not only can a warehouse now contain no fixed infrastructure, it could also be largely unmanned, with driverless forklift and autonomous mobile robots. ■

Advantages of AMRs over ASRS

- Warehouses with 1,000 to 4,000 SKUs may be more suitable for ASRS systems, but industry experts say AMRs are better suited to facilities with more than 10,000 SKUs
- AMRs require less vertical space because of lower shelf units, but need more floor space
- AMRs are fundamentally flexible and can be programmed to reorganise the warehouse
- Faster implementation – can be implemented within six months; ASRS requires double the time
- AMRs can be hired, so time to return on investment is shorter, and they are a lower investment cost than ASRS systems



Autonomous mobile robots in a warehouse

Autonomous mobile robots vs ASRS

Automated storage and retrieval systems tend to be large, cuboid structures in which a large number of items are stored. Increasingly, though not always, robotic shuttles are usually positioned at the top and they retrieve boxes as and when required. Then, a conveyor takes the boxes down to the human picker.

Before robotic shuttles were an option, a variety of cranes, pulleys and levers were used to store and retrieve items.

This type of system has become quite widely adopted over the years, and a number of long-established companies supply them. It's almost become a mainstay because it's sometimes seen an extension of a conveyor system, which has been around for more than a hundred years.

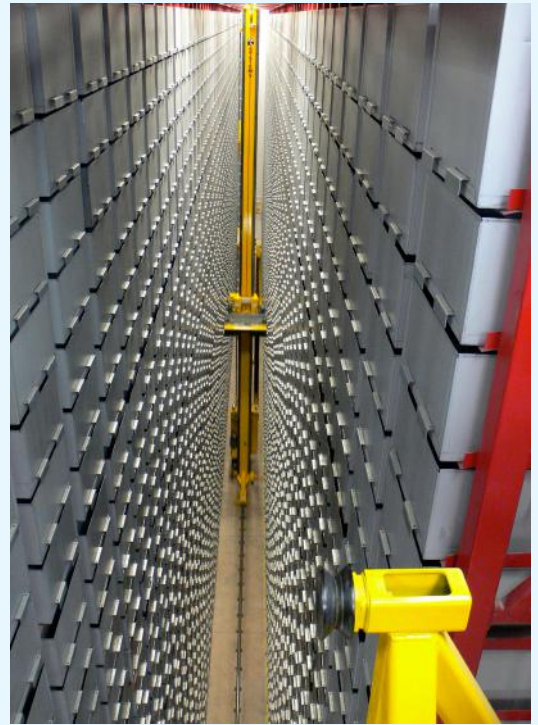
However, an ASRS requires significant investment and is essentially fixed infrastructure. It may be modular, but as it is usually combined with a conveyor system, which is also fixed, moving the whole structure or modifying it becomes a considerably time-consuming undertaking.

Disadvantages of ASRS compared to AMRs

- ASRS systems require a longer deployment time – approximately 12 months, compared to two to three months for AMRs
- ASRS systems generally require larger investments
- ASRS systems generally have lower flexibility due to having fixed volumes and throughputs, partly because ASRS crane has efficiency limitation for retrievals
- ASRS systems require larger warehouses with greater ceiling height, but can be more productive in less floor space
- ASRS systems are not thought to be suitable for operations with high-variety SKUs, but do well in

- warehouse with limited variety*
- ASRS systems are not considered to be suitable for changing business demands, such as seasonal fluctuations and changes in fashion as found in e-commerce
 - ASRS systems have less in-built capacity for growth because of their fixed nature, and they tend to initially installed to use as much of the warehouse as possible
 - ASRS systems are more expensive to buy and implement, so therefore take a longer time to provide a return on investment, depending on the business

Pictured credit: University of Utah



The new alternative to the conveyor world is robotic systems – namely, autonomous mobile robots, or AMRs – which are not fixed to anything.

Robots can be used in combination with conveyors, of course, but the reality is that robotic systems enable a warehouse to operate without any fixed infrastructure at all.

AMRs are often supplied with shelf units specially designed to be picked up, moved around, and placed in position by the robot. It's an integrated system.

This means that you could have an entirely empty warehouse one day, and then by the second day, have a fully robotised warehouse, complete with picking stations.

In other words, AMRs represent a fundamentally different way of operating a warehouse, and literally do away with the traditional, fixed infrastructure model.

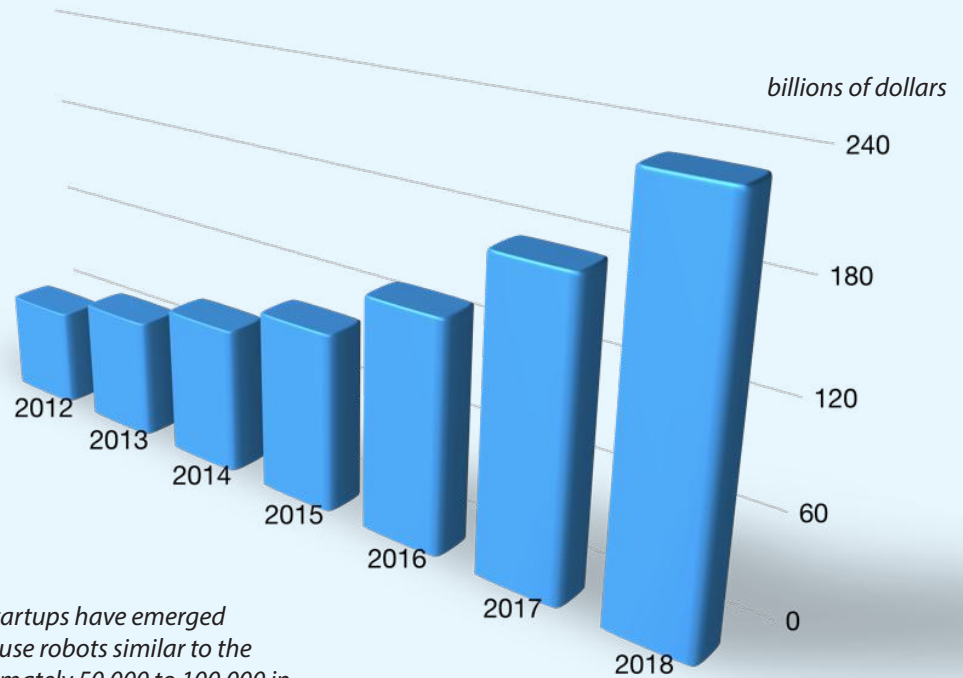
Time will tell how many warehouses are robotised. ■

Amazon's annual revenue growth

Amazon bought Kiva Systems in 2012. at the time, Kiva was the only supplier of warehouse robots. Some might argue that Amazon's subsequent, literally stratospheric, growth is partly down to its astute decision to roboticise its warehouses.

Not only did Amazon benefit from using advanced robotics in its own warehouses, speeding up its operations significantly, it concurrently prevented other warehouse operators from roboticising theirs – because it took Kiva Systems robots off the market.

Now, seven years later, a number of startups have emerged and offer to the wider market warehouse robots similar to the Kiva machine, which number approximately 50,000 to 100,000 in Amazon facilities, depending on which reports you believe.



Source: MacroTrends.com

E-commerce driving robotics

Online shopping, or e-commerce, is highly relevant to any discussion about warehouse robots because it could be argued that Amazon became the world's largest online retailer by implementing robotics at the earliest opportunity.

Amazon bought Kiva Systems, the maker of a warehouse robot, in 2012, for \$775 million. At the time, some may have been surprised at the high price, but now, with warehouses clamouring to bring in robots of their own, it seems to have been a shrewd decision.

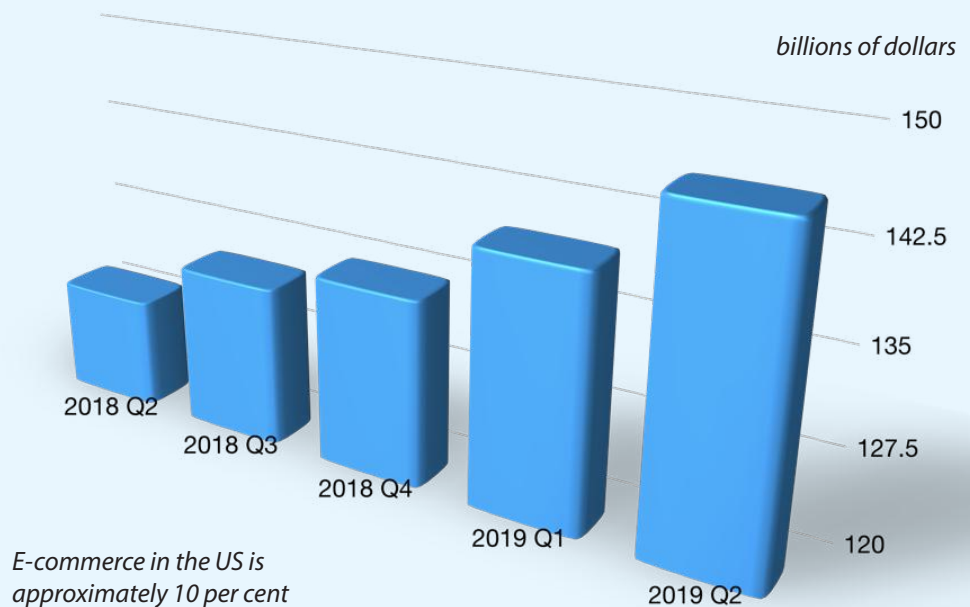
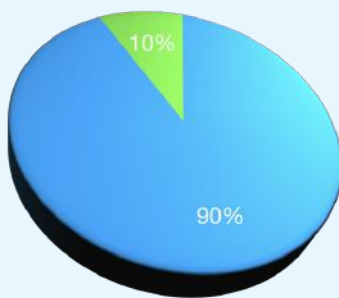
Amazon decided not to sell Kiva Systems' robots to outside companies, which created a gap in the market which took several years to start filling. Now, a number of companies have emerged that offer a variety of warehouse robots, and business appears to be good for all of them.

The reason why business is good for warehouse robot suppliers is the growth of e-commerce, both online shopping by consumers as well as business-to-business trade.

Quarterly e-commerce revenues in the US

E-commerce has experienced consistently strong growth for many years, and the most recent figures released by the US government shows growth of between 8 and 14 per cent from quarter to quarter.

Total retail sales in the second quarter of 2019 is reported as \$1.36 billion.



E-commerce in the US is approximately 10 per cent of total retail sales.

Source: US Census Bureau

In the US, and in other advanced economies, online shopping has decimated what's called the high street, by which is meant real-world, brick-and-mortar shops in the streets. Urban and rural areas in many nations have seen shops close down and leave high streets looking like ghost towns.

And this is just the beginning. E-commerce still only represents 10 per cent of total retail sales in the US, but is continuing to grow and become more sophisticated. Same-day deliveries are being offered by some online shops, and, of course, the opportunity to quickly compare many different online offers is something that high street shops cannot compete with.

The effect of all this tumultuous change in retail is that warehouses are becoming more flexible, dynamic and much more critical in the supply chains of an increasing number of businesses, whether they sell online or not.

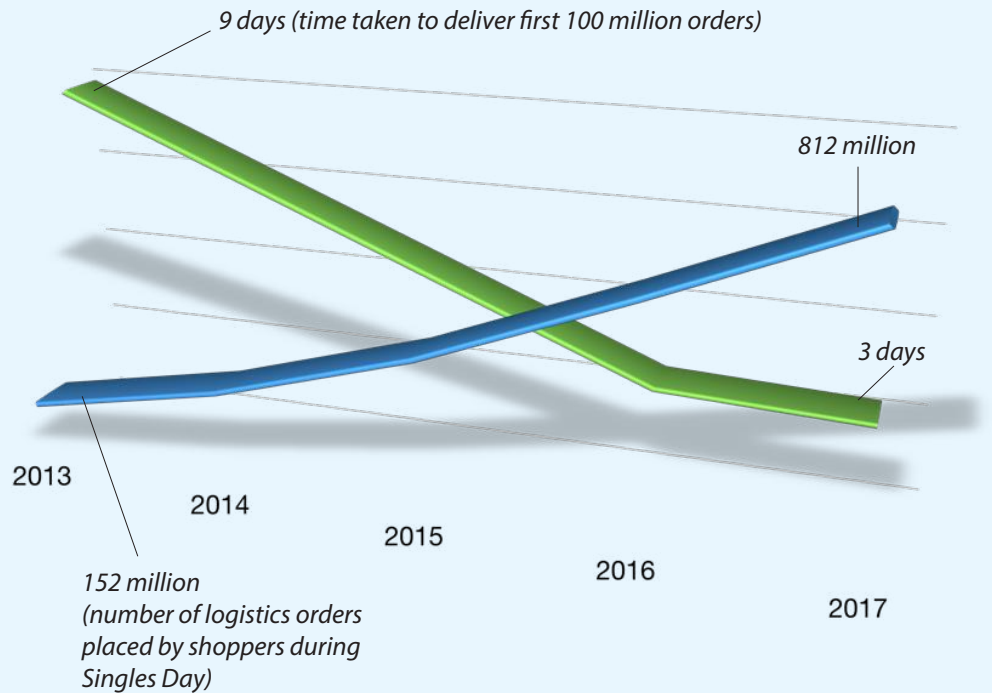
Some might say that it looks like robotics represents the future

More orders delivered in less time

Netizens in China have established a modern tradition called "Singles Day", on November 11 every year.

It's just a huge excuse to sell product online, and it works massively well. Colossal volumes of goods are sold, and although it's difficult to find accurate figures for the total amount spent, estimates suggest more than \$50 billion is spent in that 24-hour period.

Alibaba charted its logistics performance for each Singles Day since 2013, and found that it delivered about three times as many orders at about a third of the cost.



Source: Alibaba

of e-commerce – it is both a necessity, or critical component in the supply chain, and it is also a facilitator of new services that were not possible to provide before.

Same-day deliveries could be said to be an example of what robotics have enabled Amazon and other e-retailers to offer in certain areas of the US.

Across the world, another supermassive e-commerce company, Alibaba, says that it has reduced its time to fulfill 100 million orders from nine days, in 2013, to less than three, in 2017. In other words, in the space of four years, Alibaba has tripled its logistics capability.

Over the same period, the company has reduced the average cost of delivering a package by 17 per cent.

These may seem like impressive numbers, but they are really only enabling e-commerce companies to keep pace with growth rather than be ahead of it.

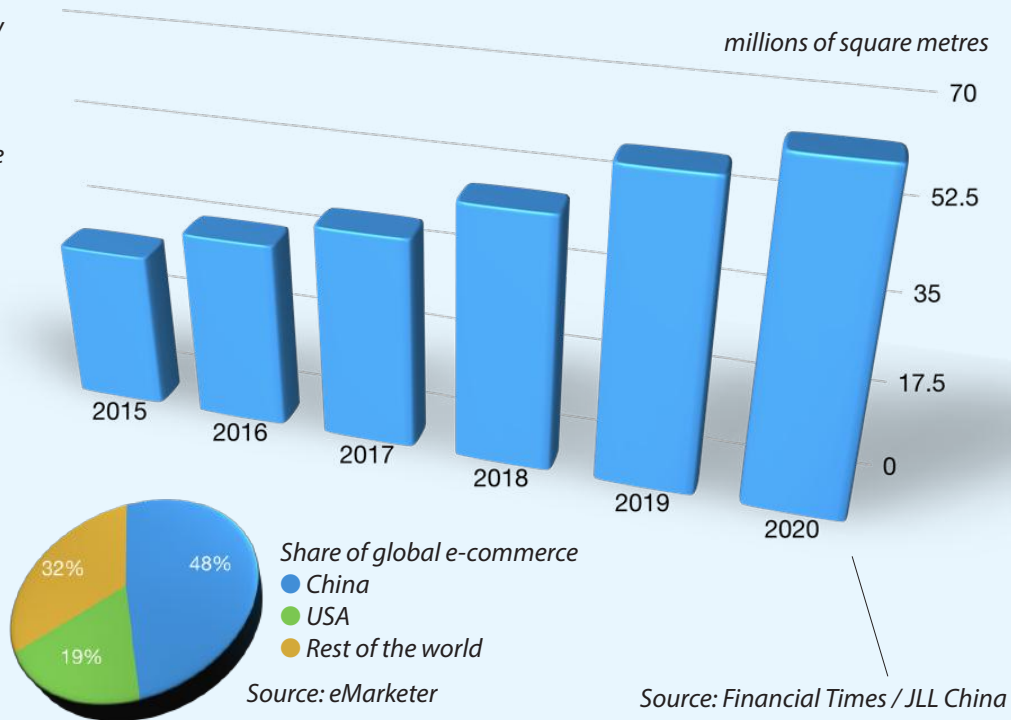
To illustrate how strong e-commerce growth is, and why e-commerce is intertwined with AMRs and other mobile robotic systems, it's worth highlighting a report in the

Warehouse growth in China in recent years

According to figures published by the Financial Times, the strong growth of e-commerce in China is causing a “warehouse boom”, with more than 65 million square metres projected to be made available next year.

The research was done by JLL, a property company, which observes that the warehousing and logistics sector is being driven by the growth in online consumption. It adds that Chinese consumers have taken online shopping to “the greatest level in the world”.

The Financial Times concludes that China is “poised to dominate global e-commerce”.



Financial Times, which, citing research by JLL, says China is experiencing a “warehouse boom”.

The figures show that warehouse space in China is currently estimated at approximately 60 million square metres. That figure is forecast to rise by another 5 million next year.

Only five years ago, warehouse space in China totalled less than 30 million sq m, so basically, there has been a doubling of capacity in half a decade – and almost all of it is driven by e-commerce, according to the FT.

The situation in the US is not much different, with new warehouse space being made available all the time. Last year, warehouse space is estimated to have increased by more than 27 per cent, to approximately 32 billion sq ft. Meanwhile, space capacity or vacancies have gone down from around 9 per cent to 7 per cent.

Moreover, according to a study by the Georgia Institute of Technology, less than 30 per cent of warehouses in the US are operating efficiently.

In other words, 70 per cent are not using robots. ■



Underlying global growth trends

There are numerous reports available about the warehouse robotics market, so it's difficult to choose one to highlight.

Having said that, one report in particular caught our attention because it appears to be the most optimistic, forecasting growth of no less than 1,200 per cent between 2018 and 2025.

Sounds outlandish at first when you think about that percentage figure, but the numbers seem realistic behind it don't seem too far fetched.

ABI Research, which produced the report, says that the growing demand for flexible and efficient e-commerce fulfillment will drive the warehouse robotics sector.

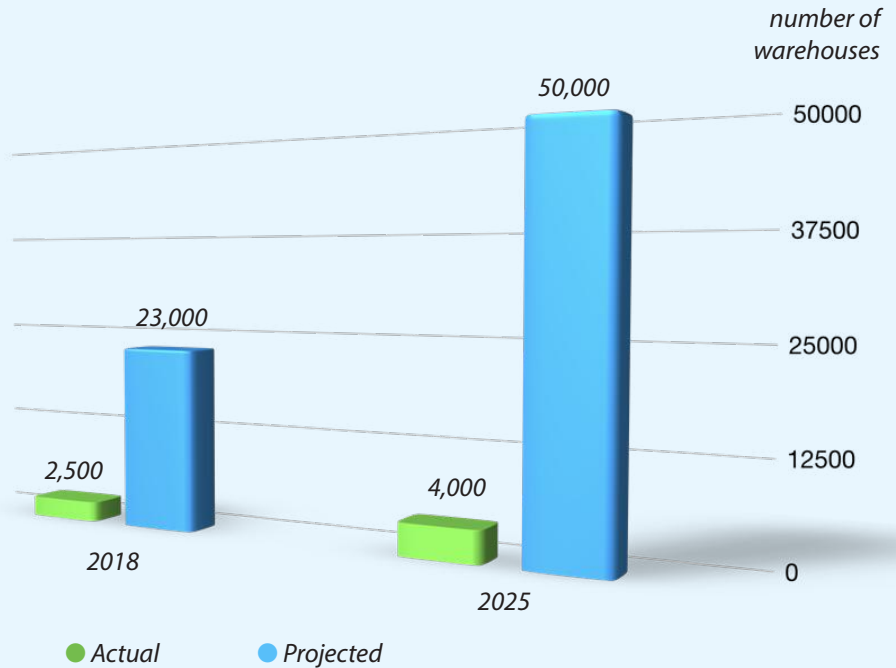
The company's analysts calculate that more than 50,000 warehouses worldwide will integrate robotics by 2025, which is a 12-fold increase from the 4,000 in operation in 2018, when the research was done.

Projected growth of robotic warehouses

The total number of warehouses in the world is, as you can imagine, difficult to calculate.

But if there are approximately 20,000 warehouses in the US, and a similar number in Europe, you could probably double that and add a few thousand and end with a figure of 100,000 warehouses in total around the world.

So, if ABI's forecasts turn out to be correct, around half of all warehouses will be roboticised by 2025, all things being equal of course – meaning, if the same number of warehouses are there in the future, which is unlikely at the current rate of growth.



Source: ABI Research

ABI forecasts that in the US, the number of robotic warehouses will rise from the current 2,500 to 23,000 within five years.

So, although 1,200 per cent seems like a massive increase – and it certainly is – ABI's projections doesn't seem completely unrealistic.

Other research companies may be forecasting smaller increases, but all of them seem to agree that the warehouse robotics market will continue to grow for the foreseeable future. The growth will only slow down in about five years, when all the major warehouse operators have already adopted them.

And even after all the big, forward-thinking warehouses have adopted them, what's to say smaller operators will not take advantage of the robotics-as-a-service model whereby they can simply hire the systems without committing to huge upfront costs? We'll just have to wait and see. ■



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