

GOODS TO PERSON (G2P) ROBOTICS *[ecommerce warehouse fulfilment]*

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Accelerated growth forecast. China to account for bulk of AMR sales, PA-AMR's to dominate the US in the short term



Disclaimer This document does not constitute investment advice. While the analysis presented is based on interviews with a large number of suppliers & experts, extensive desk research and internal industry knowledge we are unable to guarantee the accuracy of the content. Readers are encouraged to fact check details. Our data-book can be requested for a fee.

Consumers demand faster delivery; access to labour increasingly difficult; increased competition; G2P robotics is one solution

Goods to Person (G2P) robotics covered in this report include AMR's, PA-AMR's and ASRS

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Acronym	PA-AMR	AMR	ASRS
Definition	<ul style="list-style-type: none">Pick Assistant with AMR base, often including Lidar.Human collaborative robots	<ul style="list-style-type: none">Autonomous Mobile Robot, (incl. AGV's using fiducials)'Dark warehouse'	<ul style="list-style-type: none">Automated Storage and Retrieval System'Dark warehouse'
Use Case	<ul style="list-style-type: none">Deployed in existing warehouse infrastructureAugmented pickingHighest H&S specifications, such as lifting heavy goods, working among humansLow pick speed	<ul style="list-style-type: none">Mainly deployed in existing warehouse infrastructureMove pods (shelves) to a pick & pack stationFlexible & fast changing warehouse/sorting spaceSpace efficienciesLow-medium pick speed	<ul style="list-style-type: none">Mainly deployed in new warehousesIncludes high speed shuttle systemsMedium to high goods densityAutoStore-type warehouse pick speed is low-medium
Suppliers			

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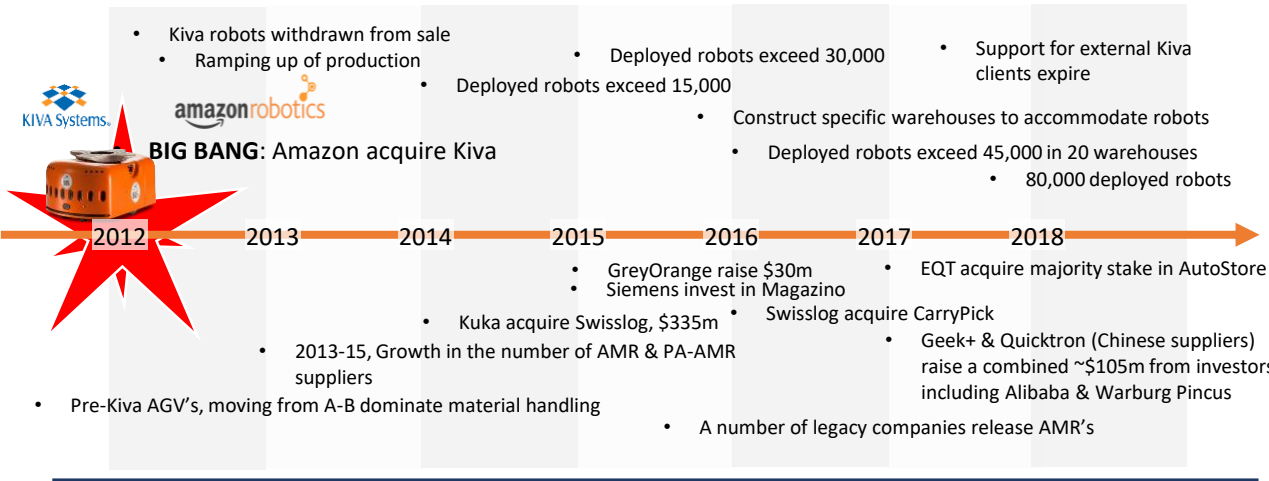
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A Brief History of Goods-to-Person Robotics ¹



KIVA REVENUE ESTIMATED AT \$100M IN 2012

Kiva Systems pioneered the G2P robotics concept and had become a successful business in its own right by the time Amazon acquired the company for \$775m in 2012.

“By the time amazon acquired kiva in may 2012, it was a 300-person company with a long customer list that included Walgreens, Staples, and Saks, and roughly 30 warehouses deployed across Europe and North America.” (Mick mountz, founder, kiva systems via ieee)

AMAZON WITHDRAW KIVA ROBOTS

Amazon strategically withdrew Kiva robots from general sales to maintain and develop its advantage (estimated at 1-2 years ahead of the competition).

Having acquired Kiva (as opposed to taking a stake in the business) and removed it from the market Amazon accelerated Kiva's R&D efforts by providing full access to its warehouse environments.

This ability to iron out any problems in a live environment has constituted a large part of the success of Amazon Robotics and is the reason the company has now deployed more than 80,000 AMR's worldwide.

This report does not include Amazon Robotics as a supplier and all figures exclude Amazon deployments unless specified.

AN ABSENCE OF COMPETITORS

It may sound as a cliché, but Kiva really did not have many (if any) competitors at the time of its acquisition. However, in the following three years, between 2013 and 2015, there were 15 start ups working on AMR's and PA-AMR's.

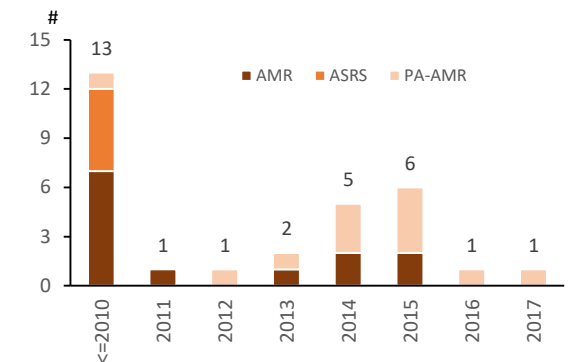
“AMR's give a really high efficiency level when combined with 'chaos warehousing'. In the case of ToysRus they had 6 pick stations with a capacity of shipping 130,000 items per day. I think they had 3-4 put stations. That facility operated 24-7. Initially ToysRus deployed 80 Kiva robots over two floors and later expanded to 4 floors.” (Wyncore)

FEAR OF LEGAL ACTION IN THE US?

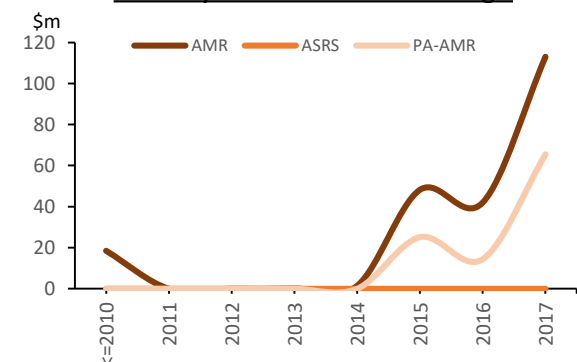
PA-AMR's has dominated US start up activity, possibly as a result of the fear of legal action by Amazon. However, European and Asian start ups have built 'Kiva similar type' of robots, carrying shelves/pods to a picking station. so has the willingness of suppliers to sell into the US market increased.

As a possible side-effect, the Asian market for AMR's has developed rapidly over the last 2-3 years and is set to dominate AMR's for some time. However, a few larger recent AMR projects in the US may challenge this domination.

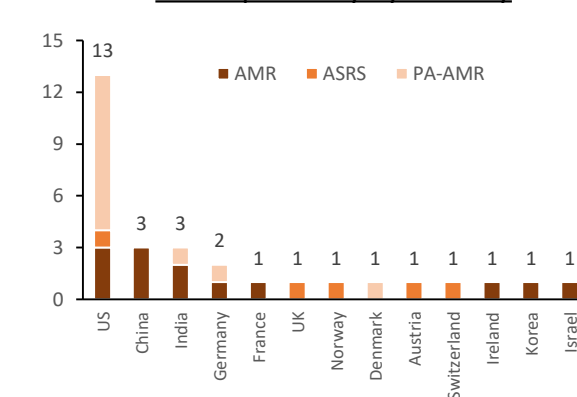
Start up Activity (newco's)



Publicly Available Fundraising ²



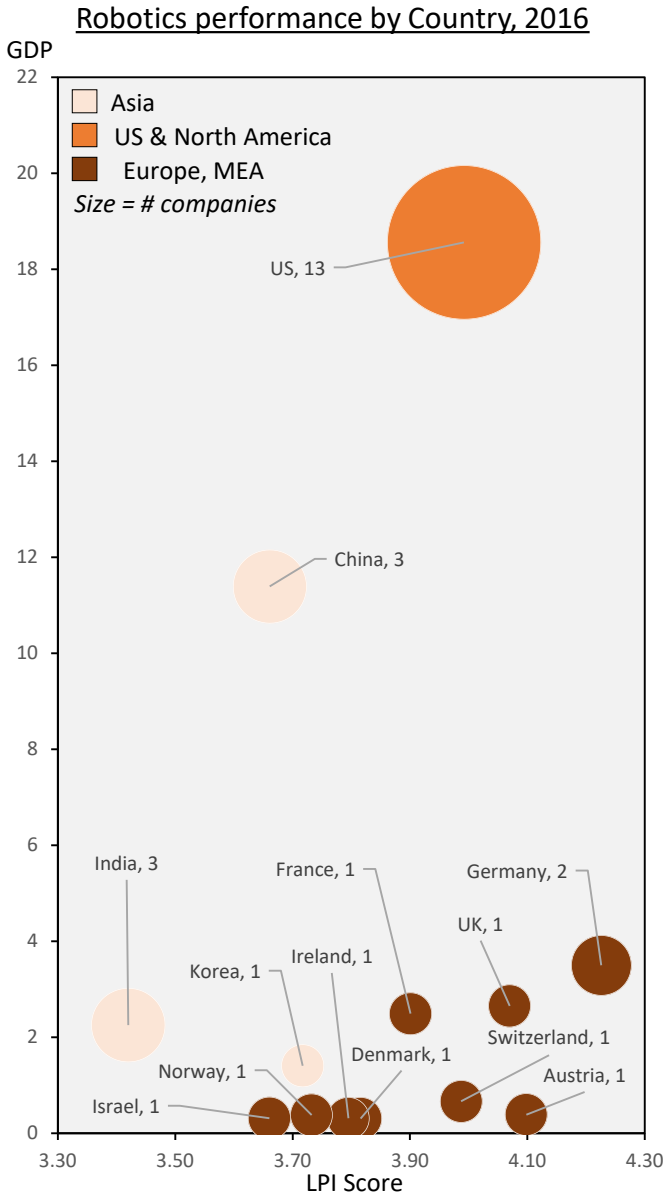
#Start up Activity by Country



¹ A number of companies were founded pre-2010 but did not release AMR's until mid-2010's or later including HIK Vision and Bleum. ² Publicly available fundraising does not include EQT's investment in AutoStore, etc.

Most G2P start ups operate in countries with a high LPI score; US and Europe usual suspects, but China increasingly active

A large and growing ecommerce sector, relatively high labour costs and a developed education system also nurture start up activity



COUNTRY & CULTURE INFLUENCERS

Close to half of the relevant companies covered are located in the US with China, India and Germany in a 'second tier' with 2-3 companies in each country. The remaining companies operate in a variety of European countries.

US companies have the widest robotic application covering all three types of robotics (AMR, PA-AMR, ASRS) with India and Germany covering two each. Interviews with market experts indicate a growing number of suppliers of AMR's in China as a result of increased funds pouring into AI, Robotics and related sectors backed by the "Made in China 2025" plan announced by the Chinese government in 2015.

Funding in China comes partially from the large ecommerce players, JD.com and Alibaba among others and is also helping technology development with access to logistics infrastructure. However, most Chinese investments are stake building. Such share holders may stifle R&D to some extent as suppliers have to deal with several different clients.

LOGISTICS PERFORMANCE SCORE

Countries hosting robot companies mentioned in this report are mostly well developed logistics countries with

China, India and Russia the only ones falling below an average score of 3.7. Russia is the laggard with an average score of 2.6.

"Salaries are a bit lower in Asian markets so ROI is slightly longer than for European and US clients, but we are still seeing a lot of interest." (MIR)

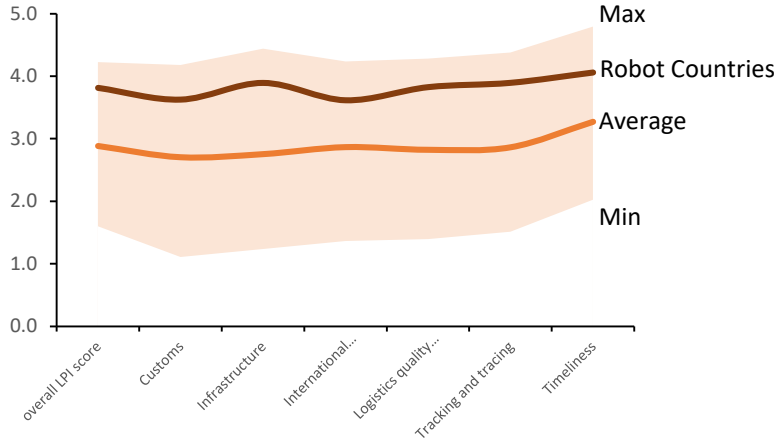
LABOUR vs TECHNOLOGY COSTS

According to Roland Berger consulting the hourly cost for operating a robot will be close to half of that of a human by 2020.

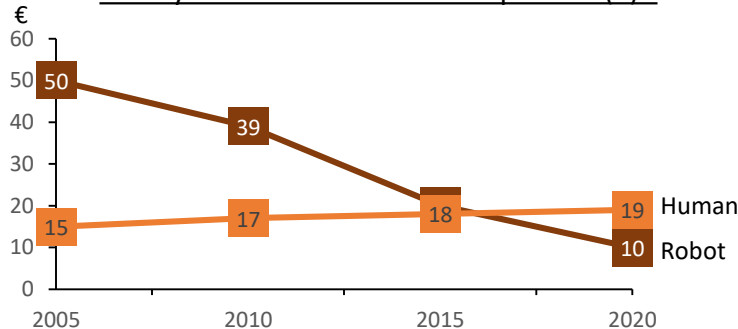
Interviews suggest the cost for an AMR is currently about equal to that of a full time staff member (Western measure). There are no immediate indications this will change dramatically in the near future. However, a leading Lidar supplier recently announced it was halving the price of one its most popular products.

However, despite the lower salaries in many Asian markets, robotics suppliers report they continue to attract significant interest and traction.

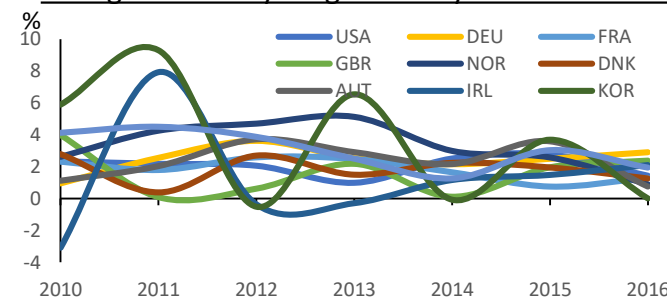
Logistics Performance Index, 2016 ¹



Hourly Cost Robot vs Human Operator (€) ²



Changes in Hourly Wages for Key Robot Countries ³



¹ World Bank. ² IFR, INSEE, Eurostat - Roland Berger of Robots and Men in Logistics towards a confident vision of logistics in 2025. ³ OECD.

Amazon's head start in G2P robotics is slowly stabilising and may even shrink as a result of wider G2P adoption

Retailers are not used to looking at efficiencies and a change 'retail process thinking' may open up new exciting avenues for improved margin growth



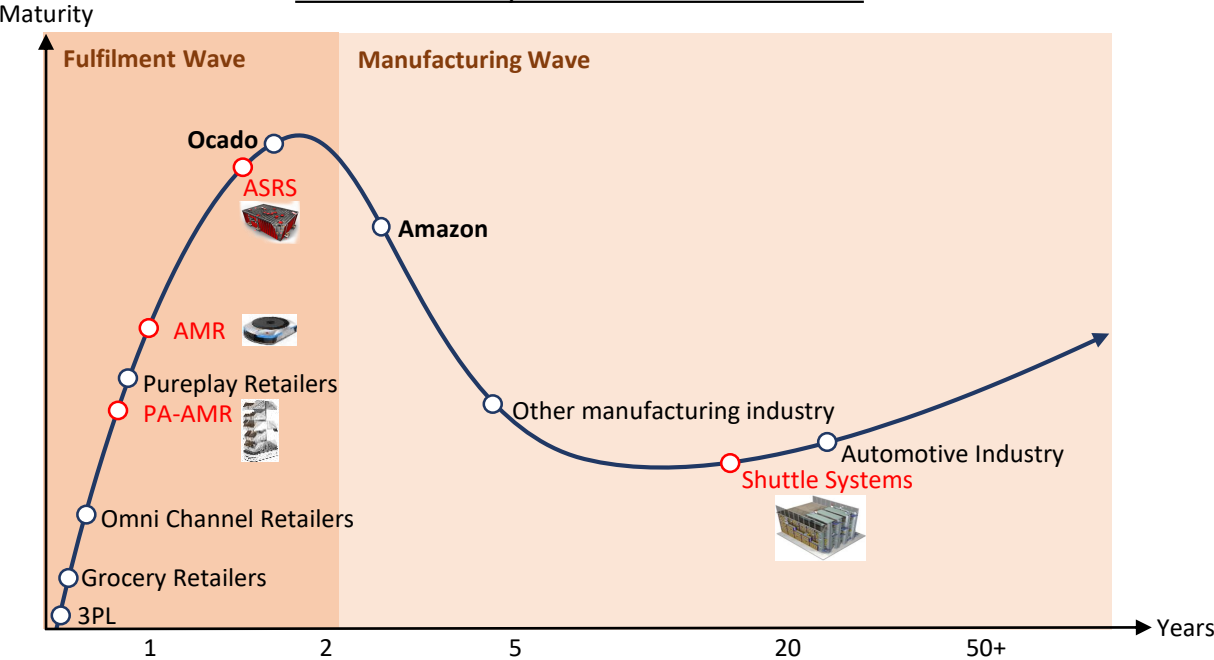
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Relative Maturity of Robotics & Automation



"In August 2017 JD.com's CEO predicted that robots and AI will handle all order fulfilment and delivery in 5-8 years." (The Paper).

THE MANUFACTURING WAVE

There is a lot of talk about Industry 4.0 at the moment, particularly in the manufacturing industries. The automotive industry is one of the most advanced users of automation and robotics combined with a philosophy of seeking savings through efficiencies. The retail sector, and in particular the apparel sector, pales in comparison when it comes to use

of automation and robotics. Part of the reason for this can be attributed to differences in philosophy and business focus. Many retailers have become vertically integrated but abstained from taking on manufacturing and prefer to outsource this element of the supply chain, with flexibility as a key business goal.

AMAZON DOMINATE THE FULFILMENT WAVE

Amazon is the leader in G2P robotics. New warehouse planning take into account robotics. A number of online retailers have attempted to mimic the Amazon end-to-end business model, but a lack of scale and cost effective automation have rendered many of these obsolete.

At the moment Ocado is one of the very few suppliers to offer a true end-to-end. We expect more action in the end-to-end space as the fulfilment wave gathers pace. For example, Boozt.se recently opened the largest AutoStore deployment in the world a year after having lost a number of end-to-end customers.

"Manufacturers are used to cutting costs in the manufacturing process and buying tools to improve efficiencies. Retailers traditionally ask suppliers for a larger discount and may not have the same experience of improving efficiencies." (Canvas technology)

As other G2P suppliers gain access to more and more clients, system maturity will also accelerate new use cases.

ASRS, A READY MADE MARKET

The ASRS segment is mature by virtue of its long exposure to manufacturing. Ocado and AutoStore are challenging the sector, especially in the high density niche. ASRS' are often part of new warehouse construction plans.

PA-AMR BREAKING INTO AGV FOR GROWTH

PA-AMR's operate in a human-collaborative environment and require the highest level of safety systems. Adoption rates in fulfilment are relatively low, but the segment experience

significant traction from the manufacturing industry replacing legacy AGV's and as new installations. Success in manufacturing will spur on maturity of PA-AMR systems in fulfilment too.

"Our impression of suppliers is a focus on the technology. A passion for the technology is obviously a good thing, but we are trying to solve a problem. It is a complex problem to solve. The sector probably has to evolve for a few more years before we see a reasonable ROI. (PFS)

AMR's TO DEVELOP FAST

Maturity in the wider AMR segment has been held back due to a lack of large scale warehouse deployments. However, suppliers run in-house warehouses to simulate operating environment. Software is the key USP and difference between suppliers as hardware is often off-the-shelf components. Most AMR deployments are retrofitted. This may change in the medium term as the benefits are more widely accepted.

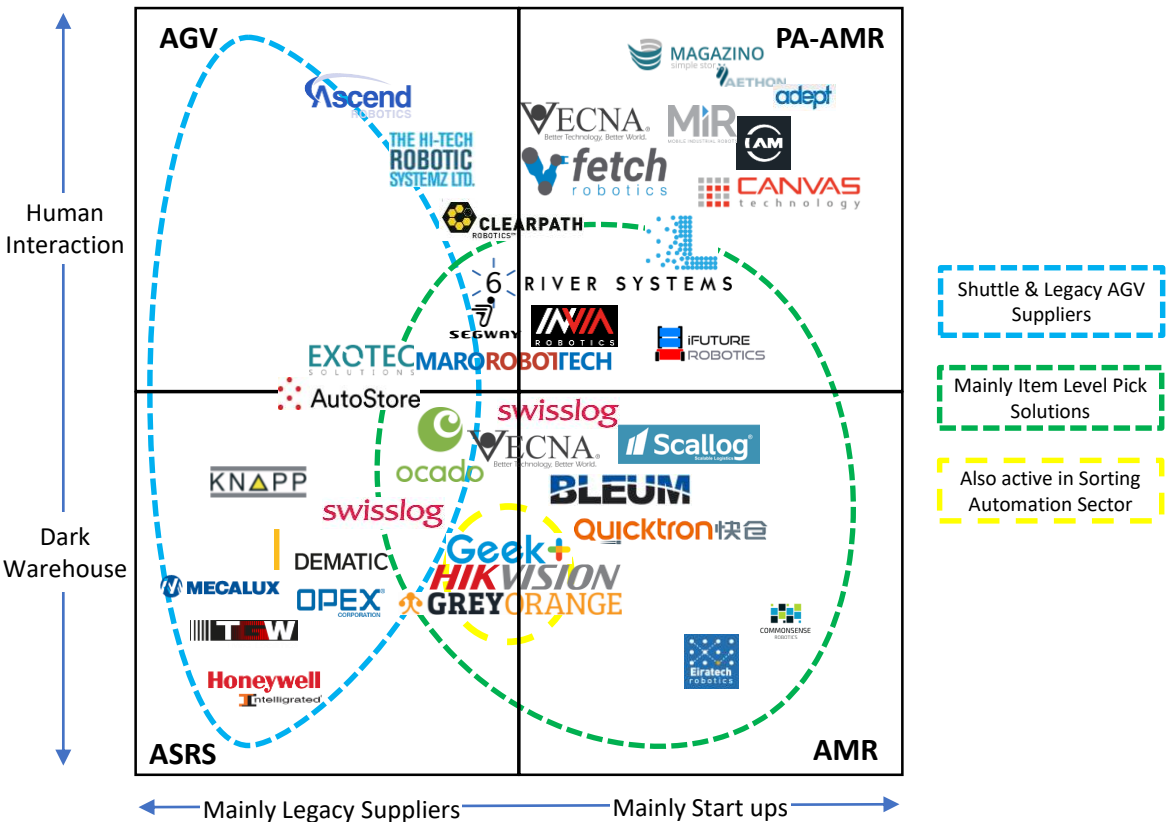
"Alibaba's aim is to deliver worldwide within 72 hours and have announced \$16bn investments over the next five years to this end. That's worldwide, not just China." (Cainiao, Flashhold)

A number of suppliers have transitioned from adjoining sectors, joining start ups in the growing G2P competitor landscape

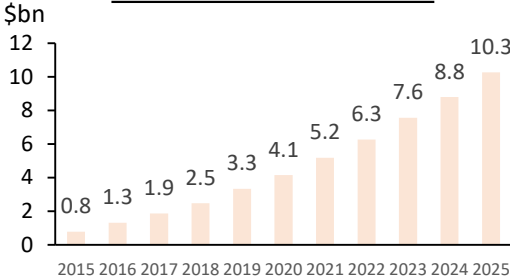
Flexibility in use cases and industry applications will be important to new entrants; offering flexible business models for existing competitors



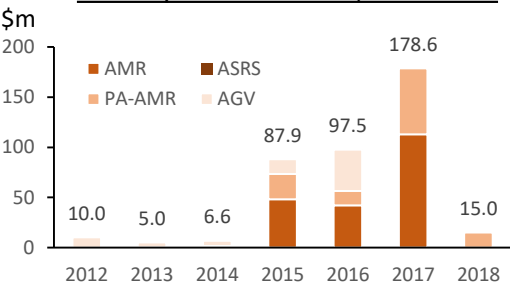
Goods to Person Robotics Supplier Landscape ¹



The Global AGV Market ²



Start up Funds Raised, 2012-18 ³



offering different add-on modules to go on top. Without any WMS or other system integration these machines can be deployed and fully functional within days, if not hours. Thanks to its proximity and overlapping use case in manufacturing applications, competition in the PA-AMR segment is relatively intense.

AMR COMPETITION MAINLY START UPS

AMR systems locate a pod, lift and transport it to a picking/put-away station and return it to a suitable and optimised location. Competitors include relatively young suppliers from a variety of backgrounds, warehouse software companies, sorting automation suppliers and pureplay AMR start ups. None of the suppliers profiled have sold AMR's actively for more than three years. Software, reliability and flexibility of business models are important factors setting suppliers apart from each other.

ASRS COMPETITION FROM SHUTTLE SYSTEMS

The ASRS segment is the most developed among all G2P segments covered in this report and new entrant activity is very low due to the high costs associated with developing ASRS. However, AutoStore, and more recently also Ocado, are two companies challenging the segment, especially in higher density requirements (AutoStore) and in the grocery sector (Ocado).

THE COMPETITIVE LANDSCAPE

G2P robotics has experienced significant influx of start ups and from companies active in adjoining sectors such as healthcare logistical robotics and industrial automation. Software has become the key differentiator between companies. However, hardware often define use cases.

AGV's are included on this slide to illustrate the overlap into industrial & manufacturing sectors where most of the PA-AMR suppliers we interviewed indicated significant interest and traction. Some of the PA-AMR suppliers generate the majority of their revenue from AGV-type applications. There are a number of AGV competitors. These

tend to be legacy suppliers (not included in this report). Loup Ventures estimate the global market for AGV's at \$2.5bn in 2018.

PA-AMR COMPETITION IN AGV SEGMENT

Most of the PA-AMR competitors are US-based start ups or relatively young companies. Most suppliers have focused on building an AMR base

¹ Styleintelligence Research & Analysis. ² Loup Ventures. ³ Crunchbase, Styleintelligence Research & Analysis

Very little overlap between G2P segments; robotic management software (RMS) often the key USP

Minimal overlap may be a sign of a market still n its infancy and competition for clients may intensify as sales increase



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Headline	Quote
Very little overlap between the types of robots	<ul style="list-style-type: none">“The main competition we come across in terms of warehouse solutions are shuttles and conveyor belts and so on. There is plenty of competition for individual pieces of the fulfilment piece. However, in terms of the whole system there are very few competitors with the capability to supply the web front as well as the back end warehousing hard and software.” (Ocado)“There is a ready-made market segment for shuttle system, there is also a ready-made segment for ASRS systems and there is a ready made market for AutoStore. The AMR market is still in its infancy but we expect and know this will change quickly.” (GreyOrange)“Shuttles definitely has the advantage when it comes to speed. If you are talking about density then AutoStore win all day long. They offer the best density of any systems out there. They stack crates on top of each other. In a shuttle you need an isle for the shuttle to move in. When it comes to picking speed I think both AMR’s and AutoStore perform in the low to medium range.” (Swisslog)
However, not all use cases are about speed	<ul style="list-style-type: none">“We won one project where we quoted against an ASRS provider. Our quote was \$5m and a pick rate of 190/hr compared to \$15m and 240/hr. In addition, the client did not have to close down a part of their warehouse for a long time to construct the shuttle system. We won the project partially as the difference in pick rate did not warrant the difference in price.” (6 River Systems)
Software is the main USP with off-the-shelf hardware components	<ul style="list-style-type: none">“The major part of our technology components is sourced globally. German gear boxes, German optics, sensors, Chinese batteries, etc. And it takes only few hours to put all these things together to produce one robot. After this you do some testing and it becomes a software issue.” (GreyOrange)“The main thing is the software. I refer to Kiva type robots as Bots. There is really nothing robotic about them. Bots are interesting, but they are not really there yet. There is more to come though. ” (Invata Intralogistics)“We don’t sell robots, we are selling a system to manage your workflow, from autonomous fork lifts to the AMR’s delivering goods from A to B. What we sell is an optimisation of your workflow. Robots is just a part of that.” (Vecna Robotics)“The cost of Lidar is currently high. When this comes down robots will also become cheaper. We are currently using off the shelf products and our key competency is in the software.” (Locus)

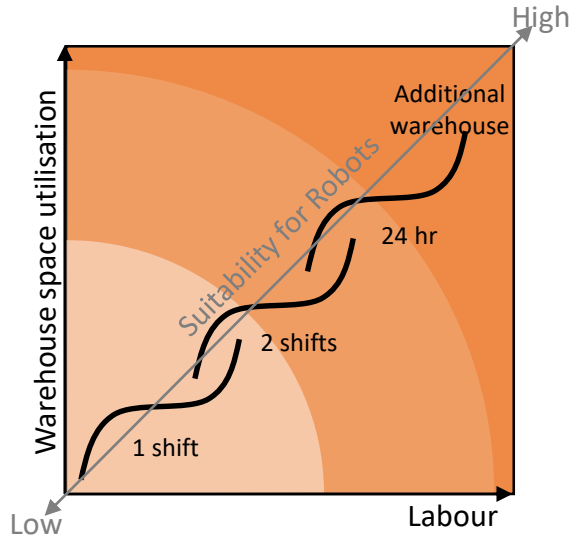
Headline	Quote
Amazon has influenced a lot of the industry activity and taken a giant’s step advantage	<ul style="list-style-type: none">“I think part of the recent trend in robotics start ups is that Amazon has pushed out more and more warehouses and retailers are probably worrying about this right now, more so than last year I think. Faster and faster delivery is definitely required.” (Canvas Technology)“The Amazon patents are US only and relate to the good-to-person functionality. Our solution is an AMR but goes to the shelf picking space and wait for an operator to pick and add to the carts sitting on the robot. However, saying that, our founders worked extensively and closely with Kiva robots before Amazon acquired Kiva. Once they [Amazon] withdrew Kiva’s product from general sale there was a vacuum in the marketplace. Amazon acquired Kiva at a point where they were growing fast. I think they saw what it could do and simply bought them. They have built up a significant advantage on everyone else with that acquisition.” (Locus)
Competition in China spurred on by large investments	<ul style="list-style-type: none">“In November 2017 we opened our first robot showroom in Denver. We are focusing on the US market. Working in the Chinese market has other demands and we think the US is starting to become very interested in this type of robots again. There is also a law in China that state you can reverse engineer products and this is actively encouraged.” (Bleum)“On our latest visit to a robotics trade show in China we saw 15 different Kiva-type systems, or robots with a very similar look. This was in 2017. The year before we saw four.” (AutoStore)
Three suppliers dominate China	<ul style="list-style-type: none">“The market in China is moving very fast. We think it will triple next year. The main competitors are HIK and Quicktron. We call these tier 1 competitors. There are also a number of tier two players. Geek+ and Quicktron have 30-40% market share each and HIK have about 10-20%. I think Tier 1 players have at least 90% of the market.” (Geek+)
... and the safety aspect is still very important for PA-AMR’s	<ul style="list-style-type: none">“There is definitely a lot of new companies coming to the market in China. However, what we have found is that the Chinese market are also very interested in the safety aspect. In absence of any global safety standards for collaborative robots, we think that our machines offer a very high degree of safety for humans.” (MIR)

Multi-shift single brand 3PL facilities and pureplay ecommerce retailers showing most interest in G2P robotics

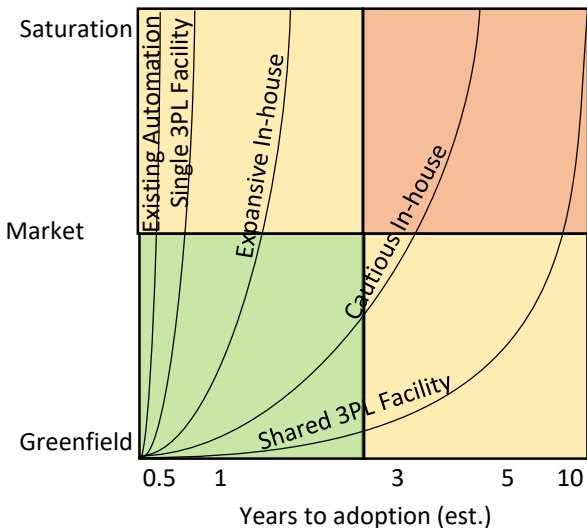
3PL operators with shared facilities require high levels of flexibility and affordability to accommodate the business model



Goods to Person Automation [perceived] Suitability



[Perceived] Time Scale of G2P Robotics Adoption



WAREHOUSE UTILISATION & ROI

Interviews suggest a G2P roll-out ROI at circa 3 years for a client running a 2 shift fulfilment warehouse. Those running a 24 hour or 24/7 fulfilment warehouse will notice a significantly faster ROI. Multiple suppliers have indicated that single shift fulfilment warehouse will experience a longer ROI and are less suitable for robotics. However, this may be different in high value & touch environments and for different regions.

BOARD APPROVAL OR NOT?

Interviews suggest companies with no prior automation experience have to gain board approval for trials extending the sales process.

Companies already using automatics often do not require board level approval for the process, depending on total costs.

THE MOST LIKELY G2P ADOPTERS

Two types of early adopters exist; online pureplay retailers and forward looking 3PL's (most often with an anchor client). However, such customers have high demands on integration with current technologies and may already have G2P or similar automation installed.

IN-HOUSE FULFILMENT RETAILERS

Retailers operating their own warehouses are rare. Such companies often compete at the value end, produce their own

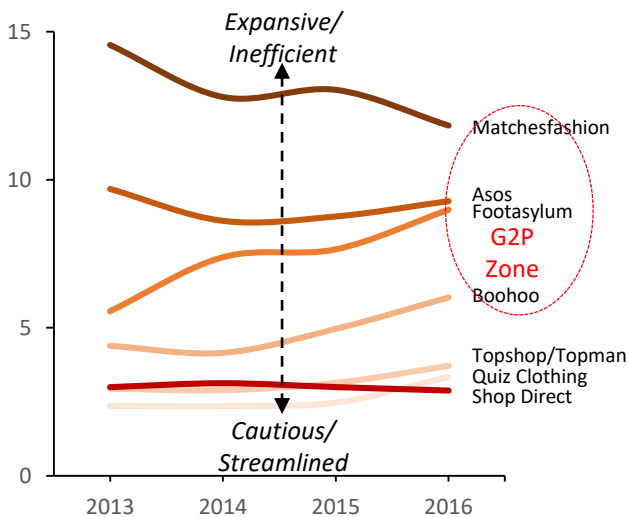
brand labels, operate brick & mortar stores and have a culture of vertical integration. Two samples are Boohoo and Quiz Clothing (none of these currently use robotics, but are at the stage where they ought to).

Examples of expansive in-house warehouse retailers are Footasylum and Matchesfashion.

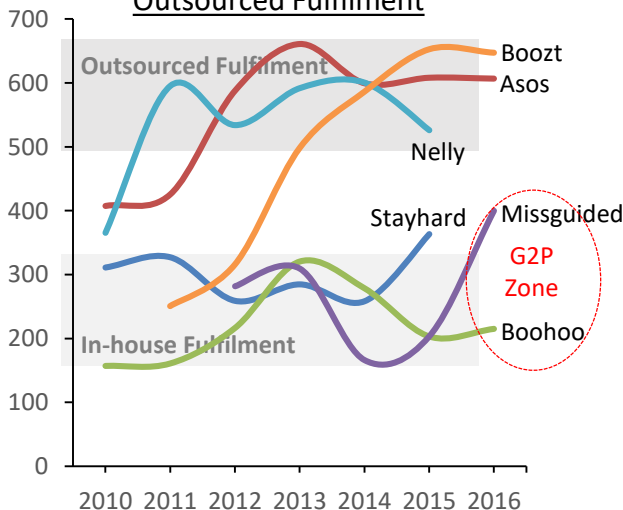
3PL USERS

3PL businesses only offering shared facilities are the least likely to adopt G2P robotics in the short term. However, the feedback from such users is that they are monitoring the sector and are ready to change should early adopters expose extraordinary results.

Stock Cover (weeks) [Sales/Inventory]



Sales per Employee for In-house and Outsourced Fulfilment



"Ecommerce is highly suitable for robotics and automation. However, unless a company operate two or three shifts I don't think the ROI is there yet. Our main target is ecommerce retailers whom operate 2-3 shifts per day." (GreyOrange)

Consumer demand and faster order turnaround requirements will push wider adoption rates of G2P robotics

Single client 3PL's are key to growth in the marketplace with in-house operated warehouses monitoring the sector with few active projects



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Headline	Quote
Consumers are driving demand for a faster fulfilment processes	<ul style="list-style-type: none">“Customers are becoming more and more demanding and everyone wants to have next day delivery. This is pulling the market towards improved optimisation... and goods to person robots are part of that.” (AutoStore)“Automation is coming. There is a requirement for faster and more accurate picking and delivery, getting the goods out of the warehouse.” (Eiratech)“Faster and faster delivery is definitely a market requirement.” (Canvas Technology)“Market drivers include a growing acceptance of buying your groceries online. Consumers also want more same day delivery and different diets. We can incorporate a whole Swedish aisle for example, where a physical store would not be able to offer this.” (Ocado)“The trend is definitely moving towards increased outsourcing of fulfilment and logistics. This is driven by consumer demand which means operating stocking locations closer to consumers and in several locations. For 3PL's flexibility is key. Being able to close one location or move robots from one location to another is important. It is very important to have that additional flexibility.” (UKWA)“There are huge pressures on 3PL's to get products out of the doors faster and faster.” (Ascend Robotics)
Traction in multi-shift warehouse environments	<ul style="list-style-type: none">“The ecommerce business model is highly suitable for robotics and automation.when a company is working two to three shifts, a positive ROI is a no-brainer.Financial justification at One shift operation depends on salary level of the respective country.” (GreyOrange)“Most demand is coming from ecommerce businesses. We think someone like Cainiao will be using 10,000 robots on its own in the next few years. Warehouses are normally operating two picking shifts with the larger companies operating 24 hours.” (Geek+)
Retailers monitoring the sector but wary of potential write-offs	<ul style="list-style-type: none">“We will be looking at automation in the next 18 months or so. I remember looking at Kiva for another international fashion retailer I worked for around 2011, but decided against it and was relieved that I did not go for it. The warehouse automation market is riddled with large write-offs. Another project I worked on for a global retailer was a sorting machine. This had to be mothballed and written off within 5 years due to developments in direct to consumer sales.” (Anonymous Retailer)

Headline	Quote
3PL's are an important part of the customer acquisition process	<ul style="list-style-type: none">“It [G2P] is a technology we are looking at, but we have a strong relationship with our 3PL supplier and anything we do would have to be discussed with them.” (Anonymous Retailer)“No customer is requesting it [robotics], but it is an exciter factor for customers who either have high value products with very sharp peaks (seasonality or New Product Initiation) or a very large SKU base with many slow moving products.” (Ingram Micro)
3PL clients with knowledge and interest in robotics helps	<ul style="list-style-type: none">“It definitely helps if the retailer is also aware of G2P when we talk to 3PL's.”“Pureplay online retailers are very interested in our technologies. The main reason for that is often that they are growing faster than they can manage and need to implement robotics or other forms of automation. They are also technologically aware which helps a lot.” (Canvas Technology)
Some market players anticipate and others already have hands-on experience of the 'ketchup effect'	<ul style="list-style-type: none">“3PL's are working on very tight margins, perhaps as thin as 2-3% at the moment. If the competition invests in robots and achieve 20% margins then we will see a rapid uptake of robotics throughout the industry for sure.” (Bleum)“We experienced the ketchup effect and wanted to turn it into the tech company it can be and realised we cannot do this on our own. We entered a sales process with interest from numerous global players both private equity companies and industrial investors.” (AutoStore)
However, ecommerce is not the only application	<ul style="list-style-type: none">“We see a lot of potential in ecommerce and also in industrial applications.” (AutoStore)“Over 90% of our business is in the manufacturing industry. However, saying that, we see a lot of interest coming from the ecommerce warehouse sector.” (MIR)“We also see a lot of interest in manufacturing. Manufacturers are used to cutting costs throughout the manufacturing process and buying tools to improve efficiencies.” (Canvas Technology)“Ecommerce and pharma are the main customers.” (Geek+)“We have received a lot of interest from outside the warehouse and logistics sectors from manufacturers and OEM suppliers. Soto is our next robot which is much larger than our current model and is made specifically for manufacturing and industry use.” (Magazino)“Ecommerce is only one component of the customer landscape. There are other industries interested in our products as well.” (Fetch Robotics)

Indicative key purchase criteria are flexibility & reliability for 3PL's; ROI & reliability for in-house customers

Suggested and indicative KPC's were gathered from interviewees mentions during conversations; further research recommended



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RELIABILITY IS KEY PURCHASE CRITERIA

Styleintelligence pieced together key purchase criteria from the number of mentions each criteria had from our 25+ interviews for this report. To get a better view of KPC's we recommend a more thorough research methodology.

MAINTENANCE AN ISSUE WHEN EXPANDING?

Maintenance is clearly a topic that needs to be addressed as suppliers grow. Suppliers have indicated that smaller deployments are often managed by the buyer's team after training.

"The main issue with the Kiva robotics was the maintenance. This was a hard piece to crack. I think this is something Amazon must have worked very hard on." (Wyncore)

Most suppliers offer maintenance and service in-house with Amazon being the only AMR manufacturer to have outsourced this part.

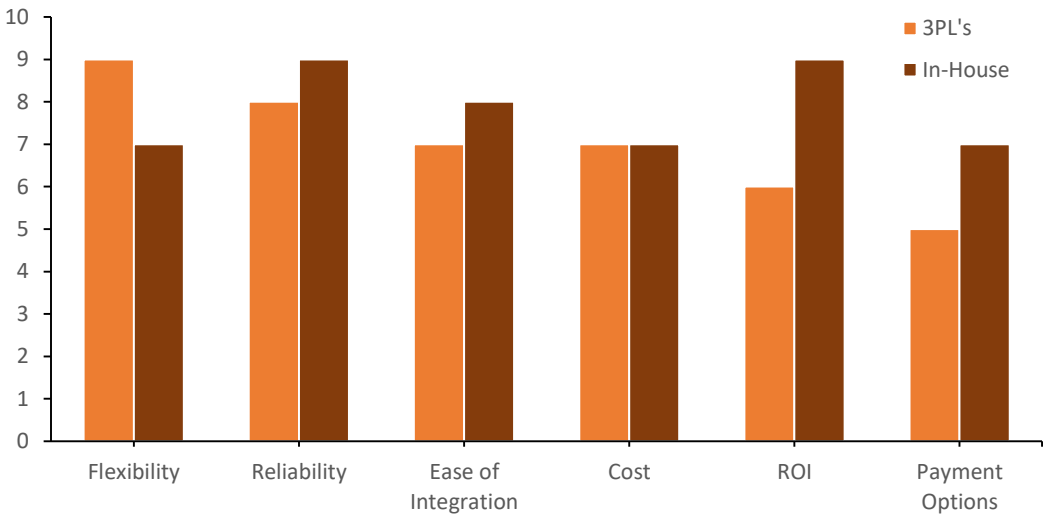
"The maintenance aspect is very important. You don't want to have a guy sitting waiting for a problem so you need an existing field workforce to maintain your robots. From what I have heard Amazon has outsourced the maintenance of its Kiva Robots on

a global basis. This is an often neglected part of IoT installations as well, the maintenance aspect. Someone needs to maintain these devices." (Anonymous)

3PL vs IN-HOUSE OPERATIONS

For 3PL's price is a big issue as cost savings is a huge issue. However, flexibility appears to be more important, possibly due to the nature of 3PL's and shared facilities. The ability to stock an ever changing merchandise range and to move robots between locations is very important to 3PL customers.

Indicative KPC's (based on interviews)



Headline	Quote
Reliability is a key issue and maintaining large deployments is a challenge	<ul style="list-style-type: none">“The main issue with the Kiva robotics was the maintenance. This was a hard piece to crack. I think this is something Amazon must have worked very hard on.” (Wyncore)“3PL’s are under pressure to grant shorter and shorter contracts and require flexible and cost-efficient solutions to help them manage that. CarryPick robots can be shut down so the area can be flooded with human labour. The pick faces are always available to humans as a backup option. 3PL’s like this. Shuttle systems are not as accessible when broken down.” (Swisslog)
... but, suppliers are actively addressing this issue	<ul style="list-style-type: none">“... and we also have a very high reliability. We can track all the robots from our head office and can see when they need maintenance. Our worldwide uptime is 99.6% and this is spread over 8000 robots.” (AutoStore)
Clients also report additional hidden benefits from robotics	<ul style="list-style-type: none">“The feedback we get from our clients is that there are hidden benefits such as less damage to their infrastructure. Robots do not tend to bang into stuff as much as humans do.” (Vecna Robotics)“We see a large impact during the night shift when staff are... a bit less cautious with handling merchandise.” (Ascend Robotics)
Budgets	<ul style="list-style-type: none">“Our clients require flexibility and fast ROI.” (Scallog)“We have 750 3PL’s as members in the UK and this is only a small proportion of the total operators. The 3PL’s running shared facilities will want to look at systems with great affordability and flexibility. It is symptomatic of the industry that it is moving at a quite fast speed and things change quickly. Product sizes and the merchandise you work with might change over night. Flexibility is definitely key.” (UKWA)

Three main business models have crystallised with the majority of suppliers maintaining a flexible approach to terms

Relative market immaturity and increasing competition for clients have created a current buyers market; further growth will reverse this trend



The Main [Current] AMR & PAAMR Business Models

High ← ----- Perceived Popularity ----- → Low

RaaS	G2PaaS	Buy Straight Out
<ul style="list-style-type: none">Robots as a Service	<ul style="list-style-type: none">Goods to Person as a Service (Pay per Pick)	<ul style="list-style-type: none">Goods to Person System
<ul style="list-style-type: none">Preference for a known monthly costReasonable ROI	<ul style="list-style-type: none">Performance payments based on the # items picked or # picks, etc. Variable ROI	<ul style="list-style-type: none">Faster ROI required
<ul style="list-style-type: none">Lease of equipment and/or robotsAdd-on support or training to manage certain support level in-houseAdditional robots and capacity on demandRMS monitoring	<ul style="list-style-type: none">Fully managed solution including optimisation, maintenance and engineering supportAdditional resources to increase output on demandFully monitored integrated (ERP, WMS, etc) RMS solution for optimal in- and output	<ul style="list-style-type: none">Full ownership of hardwareAdd-on maintenance or training of in-house staff to perform functionRMS monitoring

THE MAIN BUSINESS MODELS

Interviews suggest three key business models have crystallized in the G2P Robitics market: Buying straight out, Robots as a Service (RaaS) and G2P as a Service (G2PaaS). The most popular model is RaaS, allowing customers transparency of costs

With the sector at a relatively immature stage, suppliers remain flexible with terms to get a foot in the door with clients to build case studies.

BUYING STRAIGHT OUT FAVOURED

The option to buy the equipment straight out was the most popular with only a single supplier not offering this model (Ocado). Clients buy the hardware and subscribe to a SaaS platform RMS (Robot Management System).

RAAS, THE 2ND MOST POPULAR MODEL

Nine of the 17 companies we interviewed offered Robots as a Service when prompted.

Spreading the payment out over a longer period provides better transparency and is leaner on cashflow for customers. It also provide budget certainty for suppliers.

While not all suppliers offer RaaS, it appears to be the most favoured by customers.

PAY PER PICK INCREASINGLY POPULAR

Goods to Person as a Service (aka Pay per Pick) is a highly capital intensive model and is offered by a small number of well funded or backed suppliers. The model provides certainty and transparency for clients and suppliers.

Geek+, Ocado and Swisslog (AutoStore) offer the Pay per Pick model. However, Ocado is the only company not offering any other model while both Geek+ and Swisslog also offer customers to buy the equipment or RaaS.

Ocado’s model is a fully managed end-to-end solution, from managing the website to warehouse fulfilment. The company does not currently plan to offer any other type of business model at the moment.

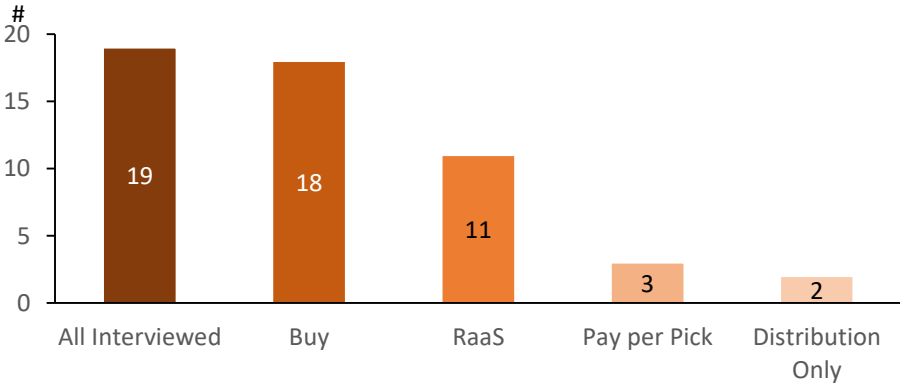
THE DISTRIBUTION MODEL UNDER-UTILISED?

MIR and AutoStore share their roots in Scandinavian countries and the business model of using distributors to sell products while focusing its efforts on R&D.

It should be noted that MIR and AutoStore are two of the more successful businesses in each of their segments.

“We offer a starter kit to customers as a way to drive interest and allow ROI discovery. The rental, or lease, option is the most popular among our clients.” (Scallog)

Business Model offered by Suppliers Interviewed



Innovation in pricing models will help accelerate growth and create recurring revenue in a traditionally up-and-down industry

However, some 3PL's indicate a slight lack of supplier marketing and growth may simply be a case of engaging potential clients with standard sales activities



Headline	Quote
Most suppliers take a flexible approach to pricing and models	<ul style="list-style-type: none">“There is never a straight forward model for how we price our product. We are open to discuss this depending on the requirements of the client.” (Eiratech)“We offer our robots as an RaaS system on a leasing program which gives clients huge flexibility to increase the number of robots at short notice. We implement with WMS through our own RMS. There is huge flexibility in how you set up the robot to function. It depends on the type of picking you want and how your warehouse staff work together with the robots.” (Locus Robotics)“We do not offer Pay per Pick at the moment. The list price for our AMR's are \$25k and \$35k at the moment. We have two sizes of robots. A light and a heavy version. The price is obviously dependent on the quantity as well.” (Bleum)“We offer a starter kit to customers as a way to drive interest and allow ROI discovery. The rental, or lease, option is most popular among our clients.” (Scallog)
Few suppliers offer every purchasing model	<ul style="list-style-type: none">“Buying outright is favoured by the larger players like Cainiao, Alibaba and JD.com, but for other companies the leasing model is more interesting. It also allows a level of flexibility to the clients. For example, if 30 robots is enough to manage the day to day picking and they have a campaign or get into peak we can quite easily ramp up with an additional 20 robots. Leasing and Pay per Pick probably account for 50% of our deployments.” (Geek+)“Choosing the right partner when offering leasing options is very important. You have to have the right client which is stable and growing and then the right financing partner as well. In Germany we have not found the right partners to do this with yet.” (GreyOrange)
The Pay per Pick business model is relatively young in warehouse environments	<ul style="list-style-type: none">“We have just sold a Pay per Pick (PP) installation to a UK retailer using AutoStore technology. The PP business model is not new to us for AutoStore. This is also being used in the wider Kuka group with industrial robots... per cycle. We are looking at rolling out PP for CarryPick as well but are not offering this as an option right now. There is definitely a lot of interest in the model and we are also keen to develop a recurring revenue stream. It is very important to chose the right partner for this of course.” (Swisslog)“Our business models include Pay per Pick, Robots as a Service and clients can also buy the robots straight out. For the Pay per Click the charge is for presenting a pick face, so a customer can pick two items from one pick face and that is termed as ‘one pick’. This is a capital intensive model for us but we are well funded.” (Geek+)

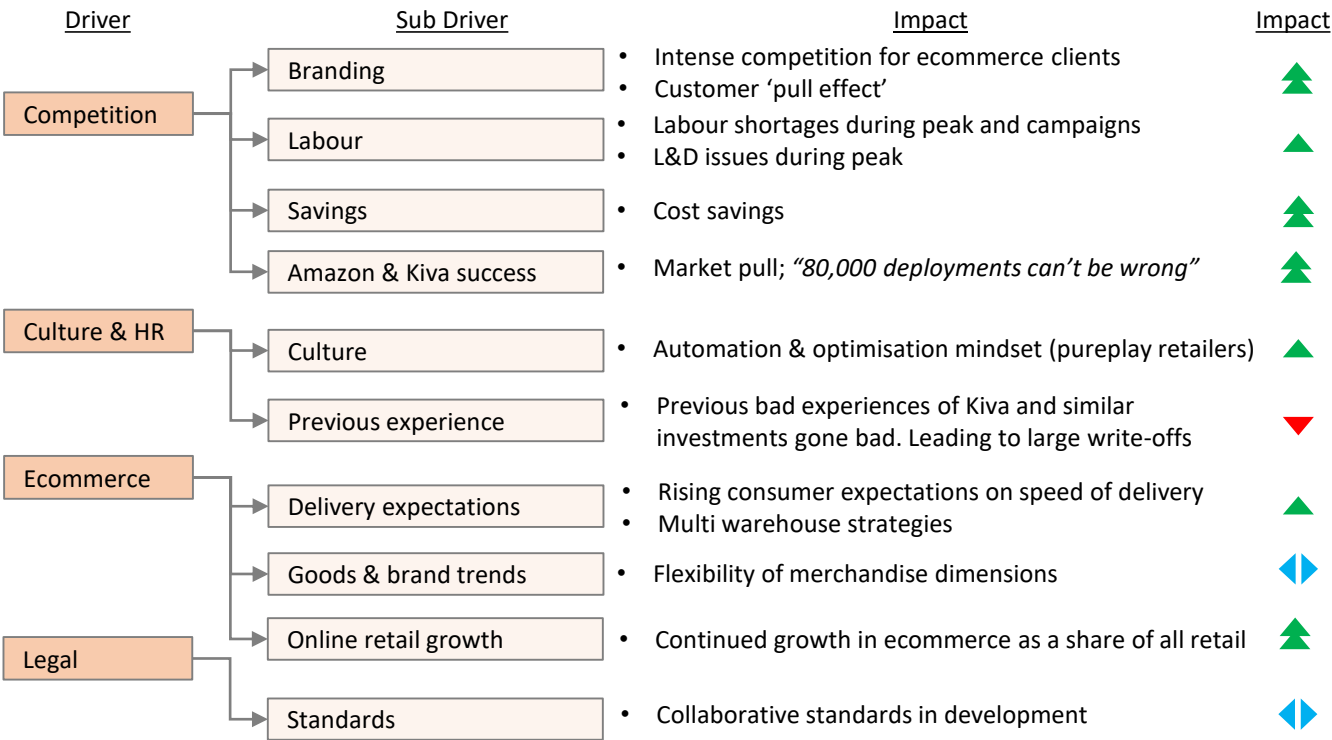
Headline can	Quote
The end-to-end solution is not as popular but may grow	<ul style="list-style-type: none">“Ocado are moving towards becoming a technology company. Our warehouse solution is part of a service. We do not sell the warehouse separately. It is part of the smart platform and include everything from website front end to the warehouse operation. We are becoming more than a B2C retailer, we're now also a B2B company, supplying an end-to-end online grocery solution.” (Ocado)
The length of the sales process vary between clients and projects	<ul style="list-style-type: none">“The C-level guys may be very excited about the technology and the ROI case. However, as soon as you step outside the board room and talk to the operational people some of these advantages become less clear. Lead times are normally long in this game, at least 6 months, many times longer.” (Eiratech)“We have a lot of projects ongoing where people want to run extensive trials in order to understand workflows and the ROI that can be achieved by using robotics. This takes a lot of time, but quite a few of these will mature in 2018.” (MIR)“The sales process can be very fast. For example, if a client is already using some form of automation the process can be faster and becomes an operational buying compared to clients new to robotics and automation where you would normally seek receive board approval. We have experienced anything from 3-4 weeks to 2 years.” (Fetch Robotics)
Low recognition in the market is a symptom of its relative infancy	<ul style="list-style-type: none">“We have not experienced any aggressive marketing from robotics suppliers. In fact, quite a few of the ones we know of have come to our knowledge through connections rather than anyone contacting us directly. I think there is certainly more these companies [robotics suppliers] can do in terms of marketing and selling themselves.” (PFS)

Perceived consumer immediacy is driving growth in G2P robotics; faster and more reliable deliveries market requirements

Competitive pressures likely to increase among ecommerce retailers driving demand for more automation and consumer proximity



Market Drivers for Goods-to-Person Robotics



COST SAVINGS, AN IMPORTANT DRIVER

While cost savings is a key consideration when looking at robotics, branding comes up as a very important part of the mix especially in 3PL sales & marketing.

"Internal savings is the main reason for the drive towards automation. Customers do not yet require automation within the physical network space, but are delighted by the promise of automation." (Ingram Micro)

The 3PL market is experiencing increased competition for clients. The ability to stay on top of ecommerce trends and integrating with clients systems has been a key USP for many 3PL's. However, the competition is catching up and one of the natural developments is to start looking at robotics.

Some of the larger 3PL's have already introduced automation, mainly focused on QA & Order Routing. Pick and put-away appears to be the next big development in the ecommerce fulfilment process and flexibility is a key driver in this space..

ROBOTS AS A MARKETING TOOL

Robotics can also indicate thought leadership and useful "tech branding".

"Our clients expect us to work to ensure their orders are fulfilled on time regardless of the infrastructure in the fulfilment center. Automation solutions are more of an internal decision. There is an element of tech credibility and leadership by using robotics." (PFS)

Headline	Quote
Access to labour is a key driver of warehouse automation	<ul style="list-style-type: none">"In Germany it is not allowed to work on Sundays. This creates a big backlog in the marketplace on Monday mornings when people have made online purchases during their time off on the weekend. There are no limits for robots as far as I know." (Magazino)"Our products are driven by limited access to staff and the cost of staff. Nowadays labour is getting more expensive. The gap is not very large nowadays." (Geek+)"Cost is not the only KPI. Reliability is high on the list of clients purchasing criteria. They have problems sourcing labour and especially to train them for peak business." (Vecna Robotics)"Labour shortage is a key issue now. Especially with Brexit we have already seen immigrants leaving the UK and this means our members are finding it more difficult to recruit for peak. There is a lot of uncertainty of what will happen with Brexit, but it doesn't look good for recruiting labour." (UKWA)
Lower salaries in Asia has not deterred market interest in robotics despite a longer ROI	<ul style="list-style-type: none">"Salaries are a bit lower in Asian markets so ROI is slightly longer than for European and US clients, but we are still seeing a lot of interest." (MIR)"The cost of labour in China is quite different. In North China the cost is almost half of the cost in South China. Human labour can reach picking accuracies of 80-99.5%, but this is not a fact. It depends very much on the industry and which company is managing. With our system you can achieve close to 99.9% picking accuracy." (Geek+)

However, a reluctance to adopt robotics in fulfilment warehouses remain one of the key challenges for suppliers

Increased competition for clients in 3PL sector likely to drive further adoption, but low margins and short term contracts key challenges



TWEET



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Headline	Quote
Suppliers expect the ecommerce warehouse sector to grow	<ul style="list-style-type: none">“The ecommerce fulfilment warehouse sector has not been as quick to adopt robotics as the manufacturing industry, but we definitely see increased demand and traction in ecommerce warehouses. This will be the next large market for sure.” (MIR)“Our cash cow was our sorting systems. This has been our primary source of revenue, but the robots are now growing as a significant share of our revenues and as a segment it is growing fast.” (GreyOrange)“The growth will come from internal logistics use cases in the manufacturing industry and also from ecommerce warehouses. We think there is a lot of potential in the ecommerce sector.” (MIR)“We consider the ecommerce and fulfilment space hot right now. There is definitely a lot of demand for our type of robots in the ecommerce sector. (Vecna Robotics)“At the moment we are having customers coming to us requesting more information. The market is really moving.” (Bleum)
Robotics can add brand value for 3PL’s	<ul style="list-style-type: none">“There certainly appears to be an element of being technologically on the front when we discuss robotics with 3PL’s; technology can distinguish them in what has become a very competitive market..” (Swisslog)“The 3PL space has become very competitive. Yes, you can say there is an element of 3PL’s using robotics as a way to market themselves to their clients.” (IAM Robotics)“Some 3PL’s may well be buying into robotics to have a shiny new tool and as a way to flag the thought leadership flag. I think part of the equation for 3PL’s is the demand from ecommerce retailers for shorter term agreements.” (Fetch Robotics)“Internal savings is the main reason for the drive towards automation. Customers do not yet require automation within the physical network space, but are delighted by the promise of automation.” (Ingram Micro)
Some retailers are not looking at automating pick & put-away	<ul style="list-style-type: none">“We are not looking to automate the picking process. Our warehouse works like a standard warehouse with bulk locations. I have heard of chaos stocking, but it’s nothing we use at the moment. At peak we operate 3 shifts, but the night shift is very light.” (Anonymous Fashion Retailer)

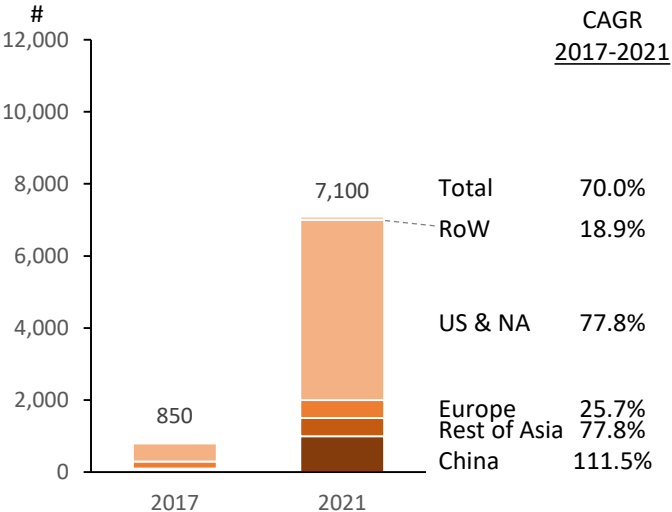
Headline	Quote
The length of 3PL contracts are declining and may affect the willingness to invest in robotics	<ul style="list-style-type: none">“3PL’s have a very short term relationship with their clients perhaps one or two years. They are unlikely to invest in something with an ROI of 2 to 5 years. However, this is starting to change and we are noticing more interest from 3PL operators than in the past.” (Element Logistics)“The main bottleneck is in the WMS integration. Many of the 3PL’s are also working on cost + margin and may not have an incentive to invest in a solution that decrease their margins. It is also about the length of contracts 3PL’s can achieve with their clients.” (Eiratech)“3PL’s are under pressure to grant shorter and shorter contracts and require flexible and cost-efficient solutions to help them manage that.” (Swisslog)
Legal frameworks are being drawn up to protect humans working alongside autonomous vehicles	<ul style="list-style-type: none">“As far as I know there are no safety standards for autonomous mobile robots. Our robots operate among human labour and are safe. We see a demand for safe operating robots globally, not only in Europe and the US, etc.” (MIR)“We are currently in the process of writing standards for collaborative robotics. We are aiming to release these towards 2019. These are global standards.” (Robot Industries Association)
Interest from 3PL’s vary	<ul style="list-style-type: none">“We are currently in discussions with five UK 3PL’s on projects.” (Swisslog)“What we have found is that there is less interest from 3PL’s. I think this is very interesting. The main interest tends to be from in-house fulfilment warehouses.” (Canvas Technology)“We are seeing glimmers of changes in the 3PL industry. There is definitely more interest from the more forward leaning 3PL’s.” (Vecna Robotics)
Being an early adopter can have its advantages	<ul style="list-style-type: none">“Robotics will play a huge part in the future of the supply chain, both for outbound and returns processing. What is really interesting is the ability to combine autonomous warehousing, vehicles, pick, pack and despatch together with analytics and machine learning algorithms that improve the process and efficiency in real time every day. If retailers, couriers and 3PL’s are not investing now they are already late.” (ZigZag Global)

China to experience accelerated deployment of AMR's growing the market by 10X in four years; growth in PAAMR's in the US

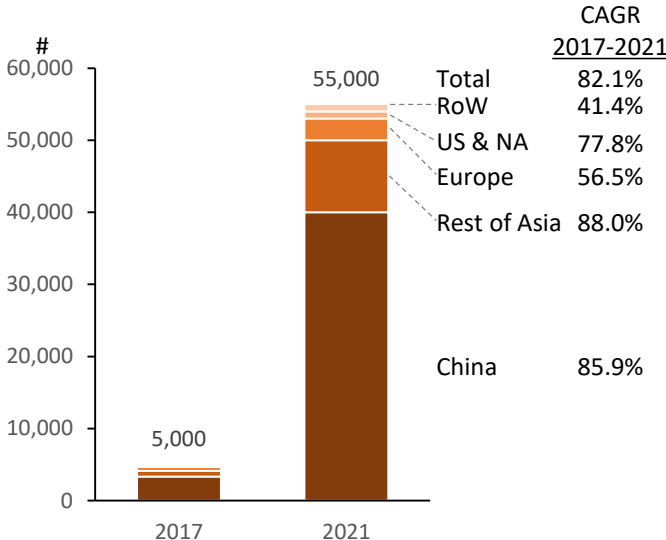
Styleintelligence [cautiously] forecast close to 80% CAGR 2017-2021 of AMR deployments in China accounting for 75% of all AMR deployments by 2021



Annual PA-AMR Deployments ¹



Annual AMR Deployments ¹



would mainly encourage growth in Asian markets and feed its competitors.

in the US market currently; Bleum and Swisslog.

"We expect the market to triple in the next 12 months." (Geek+)

HIGH-DENSITY USE CASES FOR ASRS

AutoStore is moving towards leadership in the high density-end of the market and have experienced 50%-100% yoy growth over the past 4-5 years, with c. €100m revenue in 2017. Ocado has just signed up two clients for its end-to-end system and is transitioning into a B2B supplier. The main competition for both of these come from legacy shuttle suppliers.

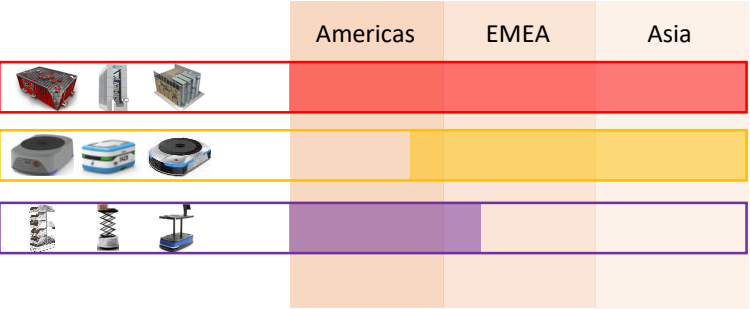
NORTH AMERICA TO LEAD PA-AMR

PAAMR's that work in conjunction with, or collaborate with, warehouse staff is the main product. However, due to the additional level of safety, these often have to be equipped with Lidar scanners (or similar) for health & safety reasons as they operate among humans. An estimated 850 PAAMR's were deployed worldwide in ecommerce warehouse fulfilment warehouses in 2017. This is forecast to grow to 7,100 in 2021 with North America accounting for 70% of the market in 2021.

"We expect to deploy 100's of machines this year alone." (6 River Systems)

Note: These figures cover deployments in ecommerce fulfilment warehouse environments.

Geographic Spread of G2P Robots by Type ¹



THE GLOBAL G2P ROBOT MARKET

ASRS compete in a ready-made global market while PA-AMR occupy a growing share of the AGV market. Both of these G2P segments will experience growth in the short term with ASRS suppliers reporting the largest growth by value.

The AMR market is still in its infancy but we expect this to change quickly in the next four years with large scale deployments in China and other Asian countries. The US and European markets are harder to forecast and may be held back in the short term by the potential for Amazon legal disruption. However, in our view, any such action by Amazon is likely to be an own goal as it

JD.com raised \$2.5bn for its JD Logistics subsidiary in Feb 2018 to expand its logistics warehouses and continue investing in drones and robotics. (FT.com, Feb 14, 2018)

The main players are HIK Vision, Geek+ and Quicktron, accounting for close to 90% of the local Chinese market. European AMR deployments are currently at an early stage. Scallog, Swisslog, GreyOrange and are the main competitors. We understand there are two AMR suppliers

¹ Excluding Amazon Robotics. Styleintelligence Research & Analysis.

AMAZON: The continuously evolving nature of AMR’s will require intimate client relationships; Amazon’s in-house advantage

For larger users/clients it may make sense to acquire a supplier or develop in-house capability; will a 3PL be the next acquirer?



Approximate timeline of AMR R&D Requirements; the evolution from Kiva Systems to Amazon Robotics

2004	2012	2013	2014	2015	2016	2017
Images (may not be in chronological order)						
Key events	<ul style="list-style-type: none">Acquired Kiva SystemsRobot facility retrofit	<ul style="list-style-type: none">Reliability improvementsManufacturing ramp-up	<ul style="list-style-type: none">Purpose built facilitiesRobotics Cloud on AWS	<ul style="list-style-type: none">International roll out of roboticsAS/RS developments	<ul style="list-style-type: none">Large recruitment driveFurther Intl roll-out	
Features and amendments	<ul style="list-style-type: none">ROI exceeding that of humansBasic open PodsFour-sided pick faceSorting out reliability issues + sort out mass manufacturing	<ul style="list-style-type: none">Hard sided PodsTwo-sided pick face with protective bands; robot acceleration issue (falling goods & unstable pod)Ladder to pick from top shelves	<ul style="list-style-type: none">Four-sided pick face with bandsEvolved pick stations & robot queueing'Chaos-based inventory' with same items in several pods	<ul style="list-style-type: none">Soft fabric Pod structure to allow for storage flexibilityDouble and triple bandsMultiple sized compartments, optimised layout	<ul style="list-style-type: none">Next generation AMRCompact robot design with minimal lift heightNew 1m+ sqft warehouses included one or more robot floors	
Issues	<ul style="list-style-type: none">A single SKU need to be distributed in several shelf locations to engage efficienciesRobots accelerate and break as usual without any regard to contents. Pod spillage cause delays as the floor space needs to be clear for robots to travel in a straight line.To fit maximum number of products on each shelf the sides need to beUnderstanding of how many robots are required to create a pick with >1 product?					
KPI's	<ul style="list-style-type: none">Pre-acquisition Kiva had ~30 deployments across North America and Europe. Clients quote \$3m for 15 robots, 200+ pods	<ul style="list-style-type: none">Cutting fulfilment cycles from 90 min to 15 min.Manual picking 100-150pcs/hrAMR-augmented picking 300-600 pcs/hr	<ul style="list-style-type: none">Robot custom space ceiling height 3m (10ft)	<ul style="list-style-type: none">Amazon deploy 4,000 robots in a single warehouse9-13 pods per robotCutting fulfilment cycles from 90 min to 15 min.	<ul style="list-style-type: none">Amazon ~80,000 AMR's active with >1,000 robotics staff¹Prices of AMR's dropping below \$30,000Outsourced robot maintenance	

¹ Note: Our sources indicate the number of Amazon Robotics AMR deployments in the public domain is very conservative and that the real number is closer to 140,000 robots (Feb 2018)

AMAZON: With a current fleet of 80,000 robots, acquiring Kiva for \$775m in 2012 now appear a bargain for Amazon

With a fleet of 80,000 robots, Amazon would have spent >\$2.4bn on AMR's alone, not including software development or fixtures

TWEET

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Amazon Robotics Work Station Details



AMAZON ROBOTICS KPI's

From our research of publicly available material we estimate that the required [Amazon] number of Pods per Robot is about 8-10 and Robots per work station around 8-12. In addition one charging station is required per every 10-15 robots. With 80,000 robots (source: FT, Gartner, August 2017), our estimate is that Amazon operate c. 8,000 robot-augmented work stations (for pick & put-away). Amazon are deploying 4,000 robots alone in their UK Tilbury warehouse together with an estimated 1,500 FTE's.

KIVA – A BARGAIN FOR AMAZON?

Amazon acquired Kiva for \$775m in 2012. By the end of 2016, Amazon operated an estimated 45,000 robots increasing to 80,000 by end of 2017. At this growth rate, the investment in Kiva now appears to have been a bargain.

A single robot cost c. \$30,000 which means Amazon would have spent c. \$2.4bn on robots alone (not including software, charging stations, work station, installation, etc).

ACCELERATED ROLL-OUT OF ROBOTICS

Amazon is accelerating the pace of new robot augmented warehouses and have around 20 such warehouses around the world, including the UK, Japan, Germany, Italy and other places. Our estimate is that Amazon will have in excess of 100,000 AMR type robots in operation by 2020

Picking from a shelf takes about 5-10 seconds for a person. Robotics are currently doing this at 30 seconds at the very best. Amazon has a competition going for this purpose.

A new Pod can be presented to the

worker/picker every 6 seconds representing up to 600 picks per hour. In comparison, a human walking between shelves to pick products would make on average 100-150 picks.

“Kiva revolutionised the ecommerce fulfilment space with the goods to person concept and randomised inventory dispersion. They were far ahead of anything else the marketplace.” (6 River Systems)

AMR: Amazon has deployed circa 80,000 AMR's and is the clear leader; the rest of the market has taken notice

A number of ex-Kiva staff have joined other robot start ups or founded their own companies ,such as 6 River Systems



Company	Revenue	Country	Founded	Product/ Capability	Financials, Clients, Offices	Numbers
Amazon Robotics (Kiva Systems)	-	US	2003	<ul style="list-style-type: none">Thought to have produced its 4th generation AMRAppears to be using two sizes of AMR's	<ul style="list-style-type: none">[Kiva] Raised \$18.1m; backers: Meakem Becker VC, Sharon Knight, Bain Capital Ventures.Acquired by Amazon in 2012 for \$757m.Amazon had 214 fulfilment centres in the US in January 2017. Of these, 13 are 8th generation warehouses including Amazon AMR robotics.Media reports point towards >20 warehouses with deployments in excess of >1,000 AMR'sAmazon stopped selling Kiva to external customers soon after acquiring them. Kiva had about 5-10 large clients at the time of the acquisition.	<ul style="list-style-type: none">Amazon indicated it has deployed in excess of 80,000 AMR's by the end of 2017.The company does not sell its robotics systems on the open market and keep its production wholly internal.Author's Note: there were no plans on selling robots to external buyers, but it is not an impossibility.
Bleum	-	US	2001	<ul style="list-style-type: none">Two AMR models for lifting Pods: light and heavy	<ul style="list-style-type: none">Self financed development.Showroom in Denver, USANow securing POC's with a number of clients. Experiencing strong inbound interest.	<ul style="list-style-type: none">Outsourced software developer working for enterprise high volume transaction companies. JDA key client.Developed AMR's since 2015, on market since November 2017.Extensive experience (10yrs+) of WMS development and integrations, especially with RedPraire and JDA, but also others. Have integrated WMS at clients with Kiva Systems robot deployments.
Clearpath/ Otto Motors	-	Canada	2009		<ul style="list-style-type: none">Raised \$41.4m; backers: Hedgewood, SVB, Eclipse, GE Ventures, RRE Ventures, Caterpillar Ventures, iNovia CapitalClients: The company lists it is service clients in 40+ countries around the world, including GE Healthcare, Hirotec America (unknown if clients are listed for Otto or Clearpath)Sectors: Mining, Defence, Aerospace, Academia and Agricultur	<ul style="list-style-type: none">Clearpath provides unmanned vehicle robotics for R&DOtto Motors provides AGV's for material handling.In 2014 the company surpassed sales of its 1,000th robotIn 2015 launched the Otto 1500 self driving vehicle

AMR: Quicktron and Geek+ are two of the three leaders in the Chinese market; no extra-Asian operations

Alibaba, JD.com are among the backers of local technology companies



Company	Revenue	Country	Founded	Product/ Capability	Financials, Clients, Offices	Numbers
Eiratech Robotics	-	Ireland	2014	<ul style="list-style-type: none">Three systems:<ul style="list-style-type: none">Eirasystem; G2P, moving pods to personEiraparts; industry 4.0Eiracube; B2C, to be used in-storeLaunched its latest AMR robot version ‘Gen. 5’ in July 2017	<ul style="list-style-type: none">Raised \$5.3m; backers: Alexandr Boyko, Enterprise IrelandClients: two commercial clients and >5 trials.	<ul style="list-style-type: none">30 staff of which 80% in R&D.1,200sqm warehouse setup in Dublin. For internal trials and demo’sEiratech RMS comes with pre-built connectors for a number of ERP’s
Flashhold (t/a Quicktron)	-	China	2014	<ul style="list-style-type: none">Two sizes of AMR’s for lifting Pods. The company also make a smaller mail sorting AMR and modifications of the AMR’s with various add-ons.Lightest version weigh 150Kg and can carry 750Kg; size is 91x71x30cm; max speed 2m/sHeavy duty version weigh 180Kg and can carry 1000Kg; size is 110x88x30cm; max speed 1.2m/sAppears to be in 2nd or 3rd generation development (based on image search)	<ul style="list-style-type: none">Raised \$36.3m; backers: Alibaba (via Cainiao Network Technology), SB China Venture CapitalClients: Tmall, Unilever, China Post, JD.com, VIP.com, Sinopharm	<ul style="list-style-type: none">Advertised 39 open positions in end Jan 2018, mainly in soft and hardware engineering.Flashhold is one of two companies backed by Alibaba through its share in Cainiao Network, a logistics company. The other is Geek+.Focus on SME’s targeting warehouses 2,000-24,000 sqm
Geek+	-	China	2014	<ul style="list-style-type: none">Three categories of robots: Picking, Moving and Sorting systems.The company produce 3 sizes of AMR’s;<ul style="list-style-type: none">P500; lift load 500kg, P1000; lift load 1000kg and the M100Picking rate 300-600pcs/man hourSupply Picking Robots (AMR’s), Picking & put-away stations, backstage control systemSales USP’s: Customised solutions, lease options, 3 months implementationAMR unit price roughly equal to one operator’s yearly salaryIn 2015 the company launched the ‘Geek Picking System’ (GPS)	<ul style="list-style-type: none">Raised: \$84.6m; backers: Warburg Pincus, Vertex Ventures, Banyan Capital, Volcanic Stone Ventures, Volcanics Ventures.<ul style="list-style-type: none">Geek+ is one of two companies backed by Alibaba through its share in Cainiao Network, a logistics company. The other is Flashhold/Quicktron.Clients: Tmall & ALOG, VIP.com, Suning, Fenteng, Fisher, Fast, Wandong Medical, Joinscience Medical, Zhongding TechnologyOffices in China, Japan	<ul style="list-style-type: none">Geek+ has deployed in excess of 2,000 AMR’s and is one of the top three providers in the Chinese marketplaceAdvertised 4 open positions in end Jan 2018.Sample deployments: Suning, 40 robots; LianHua, 30 robots; Fiser 30 robots, 700 pods; Tmall, 50 robots, 668 pods;Have won several awards in China for its logistics and warehouse robotics in 2016 & 2017~200 employees in 2017, up from 60 in 2016One picker per 8 robots improves productivity by a factor of x3

AMR: GreyOrange and HIK Vision both originated in package sorting automation, now with international offices

Sorting technology mainly a “cashcow” rather than a G2P complimentary technology; separate systems, but knowledge transfer opportunity exist



Company	Revenue	Country	Founded	Product/ Capability	Financials, Clients, Offices	Numbers
GreyOrange	-	India	2011	<ul style="list-style-type: none">The Butler’ is the company’s AMR, speed up to 1.5m/s, payload 500KgPods have a typical capacity of 2cbm and can be adapted over time o suit new products. 300 variants.Pick-put stations enable 48 simultaneous orders. Own Pick-put-to-light softwareCharging station 8h operation/30min charging or 5hr operation/5min charging. Software for ‘opportunity charging’Warehouse Control System (WCS) to control robots and integrate with WMS, ERP, etc.Other products include sorting and conveyor type products. Sorting is key product.	<ul style="list-style-type: none">Raised \$30m from backers: Tiger Global Management, Blume Ventures, HoeltgenClients (mainly for sorting equipment): Myntra, Flipkart, Jabong, Pepperfry, DTDC, Aramex, Kerry Logistics, Delhivery, Gojavas, Ekart, Mahindra, Ninja Van, Sodimac, Home DeliveryOffices in Germany, Singapore, India, HongKong, Japan and UAE<ul style="list-style-type: none">Three co-founders. One based in Germany and two in India	<ul style="list-style-type: none">55 installations/deployments (2017)550+ employees with a third active in R&D in Gurgaon, India.Long term aim to generate 70% of revenue from outside IndiaThe company has invested in an integrator in Japan to stimulate local market demandPartnered with Godrej (India) and Ground Inc (Japan)Reports indicate GreyOrange has a 90% share of the addressable market in IndiaLargest deployment is about 300 robotsCurrently on 3rd generation robot
HIK Vision	\$5,100m	China	Company 2001 Robotics 2016	<ul style="list-style-type: none">The Qianmo smart warehouse system (including G2P AMR’s) was announced in February 2016 and is made up of a number of different AMR’s.HIK also a key player in order routing/ package sorting robots (not covered in this report)	<ul style="list-style-type: none">Listed on the Shenzen Stock Exchange since 2010.Clients include JD.com, STO Express~40 worldwide offices (not all dealing with robotics)	<ul style="list-style-type: none">Main product is CCTV, but more recently the company has developed cameras for machine vision AI together with a focus on drones and warehouse robots (sorting and G2P). The company has also developed a parking robot.HIK is the largest supplier of AMR’s in China for sorting and goods to person type use cases. The company’s main product is CCTV and vision products.The company is most well known for its mail sorting robotics.18,000 employees globallyHIK Vision is thought to be the market leader in both sorting and G2P AMR’s in the Chinese marketplace

AMR: Scallog is an exciting French company with traction; Swisslog recently acquired by global robotics group

Remains to be seen if Scallog can scale outside of France, but they are one of the leaders in Europe so far



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Company	Revenue	Country	Founded	Product/ Capability	Financials, Clients, Offices	Numbers
Hi-Tech Robotics Systemz	~\$10m (2017)	India	2004	<ul style="list-style-type: none">The company has a number of solutions including a Pod carrying AMR ‘Novus Carry’. Other products include AGV’s and the Novus Stacker (pallet)The company is also involved in adapting its technology to vehicles	<ul style="list-style-type: none">Website indicate the company is actively looking for distributors for its products	<ul style="list-style-type: none">From Hi-Tech’s social media feed it appears the company has focused on the automotive sector in the last few yearsPartnered with Daimler Benz India for automotive solution in 2017
Scallog System	<€10m	France	2013	<ul style="list-style-type: none">One AMR, now on the fifth generation platform.The AI powered RMS and R-WMS are optimising for best output and minimising the number of robots used.Pods can be customised for clothing, products, etc and come in a variety of configurations depending on client requirementsPicking station with pick location light	<ul style="list-style-type: none">Raised \$1.7m; backers: ITS GroupClients: Shophair, L’Oreal, Sanofi, Airbus, Decathlon. Circa 20 clients in all	<ul style="list-style-type: none">Started by a French Robotics graduateThe company has deployed around 100 AMR’s in France and have just recently landed a big contract for a 3-warehouse installation which may double the number of deployed AMR’s for the company.Aiming to develop the European market shortly20 full time employees and 5 part timeCurrently involved in large deployment for a French ecommerce in-house fulfilment warehouse in 3 locations
Swisslog	€594m (2016)	Switzerland		<ul style="list-style-type: none">Produce a number of different solutions including shuttle ASRS and AMR’sIts AMR’s are:<ul style="list-style-type: none">‘CarryPick’ is the company’s AMR Pod lifting solution including Robots, Pods, work stations and software‘RoboCourier’ is an internal mail robot collecting and delivering specimens, medications, etc targeting hospitals mainly‘TransCar’, a heavy transport robot	<ul style="list-style-type: none">Acquired by Kuka AG for \$335m in 2014Clients:<ul style="list-style-type: none">CarryPick: DB Schenker, Lekmer (market experts quotes 1-3 installations since 2013)RoboCourier: HospitalsRevenue of €594m in 2016, down from €621m in 2015	<ul style="list-style-type: none">Immediate parent is Kuka AG, a German robotics manufacturer with €2.9bn revenue in 2016. Ultimate owner is Midea, a Chinese enterprise.<ul style="list-style-type: none">The parent company, KUKA, produce articulated industrial robots.Swisslog also act as an integrator of AutoStore’s systems and Shuttle systems.

NOTE: Due to lack of response and publicly available information the following AMR suppliers has been omitted from this report: Commonsense Robotics (Israel) and MaroRobot (South Korea), but appear on slide 2

PA-AMR: Plenty of start up & fundraising with impressive founders and products in the US market

Commercial potential in ecommerce fulfilment to be discovered; industrial & manufacturing use cases the most likely immediate application



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Company	Revenue	Country	Founded	Product/ Capability	Financials, Clients, Offices	Numbers
6 River Systems	-	US	2015	<ul style="list-style-type: none">The company has developed a pick assistant with an AMR base which goes to the shelf location and wait for a human to pick an item, to return to packing once the item has been picked	<ul style="list-style-type: none">Raised \$21m; backers: Eclipse, Norwest Venture PartnersClients: 200 robots deployed at 10 sites	<ul style="list-style-type: none">The company was founded by former Kiva Systems employees targeting existing warehouse infrastructure clientsStarter pack with 8 robots cost \$250k. Additional robots can be hired or purchasedDeployment lead time 5 days - 6 weeks (incl. WMS integration)
Ascend Robotics	-	US	2015	<ul style="list-style-type: none">Pick assistant with picking face. Own development of AMR base. Navigation system in-sourced.	<ul style="list-style-type: none">Clients: Currently rolled out with its two funding partners and looking to commercialise the product in 2018	<ul style="list-style-type: none">The development of the robotics has been funded by two industrial clients/partners in the medical device and consumer industries7 full time staff supported by a number of part time staff
Canvas Technology	-	US	2015	<ul style="list-style-type: none">Pick Assistant robot with limited Lidar. Using computer vision to offset use of Lidar.Second generation robot being released in 2018. Currently in advanced development phase	<ul style="list-style-type: none">Raised \$15m; backers includeClients: Currently in trials with a number of partners	<ul style="list-style-type: none">Robots cost in the region of \$18-22k, but depends on clients preferences, such as leasing options, warranty, maintenance, etc.
Fetch Robotics	-	US	2014	<ul style="list-style-type: none">PA-AMR with a variety of add-on modulesUsed in warehouse/industrial, warehouse and in-store retail settings	<ul style="list-style-type: none">Raised \$48m; backers: Sway Ventures, O'Reilly AlphaTech Ventures, Shasta Ventures, SoftBank's SB Group USClients: Wartsila (DHL), Microsoft, Google, Panasonic, Toyota, Surgere, RK Logistics	<ul style="list-style-type: none">The company does not release any figures. However, our estimate is that the company have deployed 100's of PA-AMR's in the USLinkedin listed 74 employees for Fetch Robotics in Feb 2018
IAM Robotics	-	US	2012	<ul style="list-style-type: none">The product is an AMR with a picking arm on top; appears most suited to FMCG picking applications with solid packaging.	<ul style="list-style-type: none">Raised \$1.0m; backers: Newgen Capital, Innovation Works, Comet LabsClients: Rochester Drug Coop (RDC)	<ul style="list-style-type: none">Clients in the pharmaceutical sector make up a large share of revenue
inVia Robotics	-	US	2015	<ul style="list-style-type: none">One main AMR product which also pick items from shelves rather than transporting Pods	Clients: LD Products, Hollar	-

PA-AMR: Different approaches from three different companies with varied backing

MIR is a global company by virtue of its large distributor network while Siemens invested in Magazino. Locus is presently focusing on the US market



Company	Revenue	Country	Founded	Product/ Capability	Financials, Clients, Offices	Numbers
Locus Robotic	-	US	2014	<ul style="list-style-type: none">The Locus product is a Pick Assistant based on an AMR, delivering hand picked boxes, items, carts, etc from an isle to the picking station.The machine moves to a pick location and wait there for a picker to pick and item and send it on to the next pick or go to the packaging station.	<ul style="list-style-type: none">Raised \$33m; backers: Scale Venture PartnersClients: The company quote 8 clients including DHL Supply Chain and Quiet Logistics.Have deployed about 300 robots AMR's in the US in 11 locations with 9 clients.	<ul style="list-style-type: none">The company was started by Quiet Logistics, a company that worked extensively with Kiva Systems from 2009. Bruce Welty is the CEO of both Quiet and Locus.Entered resale agreement with Supply Chain PartnersRaaS (Robots as a Service) system
Magazino	-	Germany	2014	<ul style="list-style-type: none">The company make two PA-AMR's with box/ carton picking capability. The second generation [Soto] will be released shortly.'Toru' is Magazino's first robot targeting book retailers. It has been modified for use with shoe retailers and can pick standard shoe boxes from shelves and deliver to a packing station. Each robot is capable of picking and transporting up to 16 boxes. This also works for put-away processing.'Soto' is another similar robot for use in manufacturing/industrial purposes able to pick 15Kg's.	<ul style="list-style-type: none">Raised \$0.6m; backers: HTGF (High Tech Gruenderfonds), EIT Digital Accelerator, Siemens<ul style="list-style-type: none">Currently raising new funds.Update Mar 2018: Raised \$24.8 from Zalando, Cellcom Israel, Korber (Lead), Fiege LogisticsClients: six clients including Fiege Logistics (33 robots). In total the company have sold 40 robots.Of the six clients 5 are shoe retailers and one is a book retailer.	<ul style="list-style-type: none">Started out with robotics for picking books from shelves. Realised ecommerce warehouse sector would be larger and developed product to this end. In 2015 Siemens acquired a 49.9% stake in the Magazino from HTGF (TBC). Siemens also own 27% in VEO Robotic Inc (US).Siemens internal VC division 'next47' appears to be behind the Magazino investment (unconfirmed). Part of the rationale for Siemens investment was access to technology.
MIR (Mobile Industrial Robots)	>€10m 2017	Denmark	2013	<ul style="list-style-type: none">The company has 2 [PA-AMR]models. These can either transport a shelf (no lifting) or pull a trolley.Comes with mobile app controlIts larger product, MiR 200; size 89x58x35.2cm; payload [on robot] 200kg; towing capacity 500kg<ul style="list-style-type: none">Running time 10hrs or 15km.Speed forward 4km/h, reverse 1km/h.	<ul style="list-style-type: none">Raised \$1.6m;Clients: 95% in automotive and electronics (also used within warehouses for internal logistics). Experiencing increased demand from ecommerce warehouse clients.Sales & Support Offices in US, Spain, Germany, Singapore, China. Head office in Denmark with 50+ employees. Total 70+ employees globally.	<ul style="list-style-type: none">Conceptualised by robotics professor targeting health & hospital industry around 2011/12. Started commercialisation of its product in 2014/15.Sell its products through a network of 130 distributors in 40 countries.R&D and assembly performed in Denmark.The company racked up losses of about €700k in 2014-2016. 300% growth year on year in 2017 and planned to continue into 2018.

PA-AMR & ASRS: Vecna spun out warehouse robotics less than a year ago and target clients with a broader requirement

Majority stake in AutoStore acquired by Scandinavian PE house EQT, set for fast growth. Current low recognition in the US market to be exploited



Company	Revenue	Country	Founded	Product/ Capability	Financials, Clients, Offices	Numbers
Vecna Robotics	-	US	VR 2017 (VT 1998)	<ul style="list-style-type: none">Vecna Robotics is focused on warehousing robotics operating together with humans.Four different types of warehousing robots;<ul style="list-style-type: none">Robotic Conveyor RC20 & RC500Robotic Lifter RL350 & RL3600Robotic Tugger RT4500Robotic Tote Retrieval System (TRS) (new)Vecna Robotics aim is to sell a system that improve and optimise client’s workflow rather than individual robots together with its internal workflow analysts.	<ul style="list-style-type: none">Does not disclose client numbers or names. Have a number of clients in material handling & manufacturing and in retail & logistics.Current business models offered; buying robots straight out and RaaS.	<ul style="list-style-type: none">Vecna Technologies started in 1998 developing robots mainly for use in healthcare. Vecna Robotics was spun out as a separate company in April 2017 focusing in the range of robots developed for warehousing applications.Vecna Robotics CEO, Dan Patt (ex-DARPA), was appointed in January 2018.Will listen to investment proposals. Currently wholly owned by Vecna Technologies.According to Linkedin Vecna Robotics employ 40 people and Vecna Technologies 190 people.

Company	Revenue	Country	Founded	Product/ Capability	Financials, Clients, Offices	Numbers
AutoStore	~€100m 2017	Norway	1997	<ul style="list-style-type: none">ASRS systemStackable crates system with AGV-type robots running on rails on top of a cubic shelf rack system<ul style="list-style-type: none">“we look at our system as a 3D chess board” (AutoStore)Robots do not require advanced technology as they move on rails, similar to shuttle systemsCurrently able to present 350 crates per hour. Integration with WMS can easily double the throughput of item level picking depending on how the integration is made and what requirements clients have.	<ul style="list-style-type: none">Founded by Hatteland, an electronics component distributor in Norway. Internal development and testing from 1999 up to 2005 when they sold to their first commercial installation.Internally funded by Hatteland up to 2017 when it was spun out as a separate company and acquired by EQT, the Swedish PE house, at a rumoured valuation of \$470m (source: Breakit.se). Hatteland remain a minority shareholder.Numerous international PE and industry investors interested to buy out the company during the process, but EQT was the best fit (possibly for cultural reasons as EQT is a Scandinavian PE house)	<ul style="list-style-type: none">Revenue €61.4m 2016, up from €40m in 2015 and €26m in 2014.<ul style="list-style-type: none">“2017 revenue will be around €100m, with the outlook for 2018 already looking pretty good.” (AutoStore)Opened US office in end 2017Have sold and deployed over 230 systems in 26 countries with >8,000 ‘robots’ active.Technology and R&D company. Rely on integrators for sales. Does not install themselves.Largest installations/ clients are currently Boozt.se in Sweden and Puma in LA, USA.Main customer segments in ecommerce and manufacturing.The company hold 22 patents (EPO)

ASRS: Ocado on the road to transform into a B2B technology company with end-to-end solution developed in-house

Potential legal case outstanding which may constrict growth; two impressive overseas clients signed up in the last three months



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Company	Revenue	Country	Founded	Product/ Capability	Financials, Clients, Offices	Numbers
Exotec	-	France	2015	<ul style="list-style-type: none">The product is a fixed ASRS type shelving system with AMR'sTwo different AMR/AVG products	<ul style="list-style-type: none">Backers: 360 Capital Partners, Breega CapitalClients: Cdiscount	
Ocado	\$1,750m	UK	2000	<ul style="list-style-type: none">End to end system for grocery retailers with two grid systems for ambient and chilled items.At the moment the solution is only sold as an end to end [managed] solution with Ocado embedded staff. No plans to sell the warehouse as a freestanding solution.Capacity from 50,000 SKU's; robots move at 4m/s. Two separate grids for ambient and chilled goods.An order with 50 separate items is picked in less than 15min's.	<ul style="list-style-type: none">The company is listed on the London Stock Exchange.Revenue increased 13.6% to £1,270m in 2016 from £1,115m in 2015. Net profits at £12m in 2016, similar to 2015.Clients: Morrisons, Groupe Casino, SobeysStarting to build Paris warehouse for Groupe Casino shortly and have just signed a deal with Sobeys in Toronto, Canada.	<ul style="list-style-type: none">Started out as an 'online only' grocer. Trialled several automation solutions until they developed their own solution rolled out in its Andover, UK location. Now also selling end to end B2B solutions to grocers in the UK, France and Canada.Raised \$150m from shareholders in 2017 to fund further development and construction of its technology.Ocado Technology employ 1,100 people to develop anything from website to WMS software. Ocado robotics [hardware] employ about 300 people.It is thought that AutoStore are disputing some of Ocado's IP and that this is in legal process now.

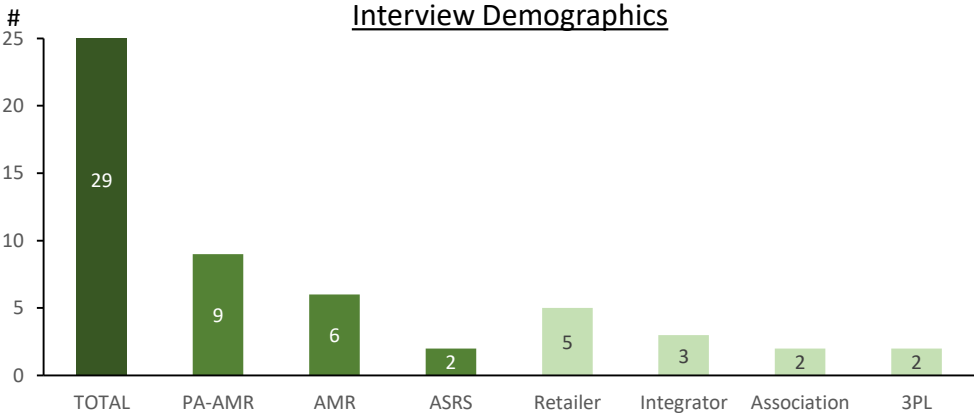


Suppliers

Company	Country	Name	Position
6 River Systems	US	Jerome Dubois	Co-Founder
AutoStore	Norway	Magne Hatteland	CMO
Ascend Robotics	US	David Askey	CEO
Bleum	US	Eric Rongley	CEO
Canvas Technology	US	Nils Alstad	VP of Sales and Customer Service
Eiratech	Ireland	Alexey Tabolkin	CEO
Fetch Robotics	US	Joe Lau	Director of Product Marketing
Geek+	China	Yunfan Gao	Marketing Director
GreyOrange	India	Wolfgang Hoeltgen	Co-Founder
IAM Robotics	US	Tom Galluzo	CEO
Locus Robotics	US	Kary Zate	Director of Communications
Magazino	Germany	Florin Wahl	Marketing & PR Director
MIR Robots	Denmark	Denise Innocenti	Global Marketing Director
Ocado Technology	UK	Alex Voica	Head of Technology PR & Comms
Scallog	France	Christine Philonenko	Marketing Manager
Swisslog	UK	Shane Faulkner	Head of Sales, Warehouse & Distribution Services
Vecna Robotics	US	Dan Patt	CEO

Market Experts

Company	Country	Name	Position
A3 Association	US	Bob Doyle	VP of Communications
Anonymous Retailers *	UK, US	-	Various Logistics Positions *
Apex Insight	UK	Frank Proud	Partner
Element Logistics	Norway	Havard Hallas	Sales Director
Fellow Robots	US	Marco Mascorro	CEO
Hitachi Europe	France	* Sales	Sales
Ingram Micro	US	Amir Noori	Network Solution Architect
Invata Intralogistics	US	James Cooke	Content Marketing Specialist
PFS	US	Mike Willoughby	CEO
UKWA	UK	Peter Ward	CEO
Wyncore	US	Siva Athiappan	Partner
ZigZag Global	UK	Al Gerrie	CEO





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