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Amazon Robotic Service (ARS)

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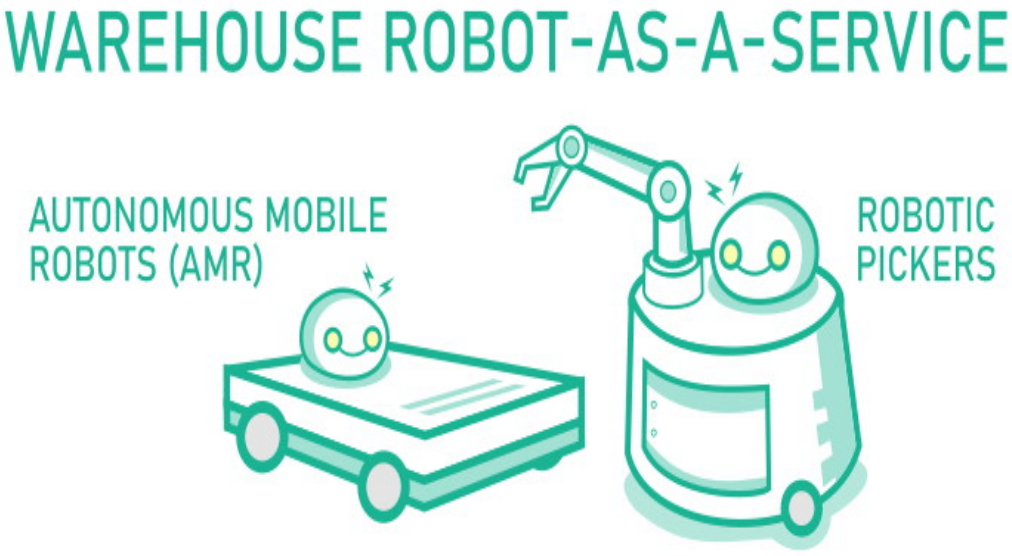

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Abstract

Warehouse robots are the most effective replacement to minimize the pressure and availability of manual labor. The warehouse robots are mainly used for heavy lifting, picking up packages, transporting, and other tasks in the facility. The growing market of Internet of Things, Artificial Intelligence, and machine learning in the warehouse industry is forecasted to grow in the robots market in the near future. In order to build the final product i.e technology roadmap our team did market research, analysed competitors for the company, identified target customers, analyzed market, product and pricing strategy and at the end came up with the Technology Roadmap.

Mission Statement

Our mission is to propose to Amazon to add a new branch to their service department called Amazon Robotics Services. They could either provide Robots as a service or rent the robots to small to medium-sized companies. We think that Amazon could make use of the AWS service which they already have with Robotics technology. We are coming up with the Technology roadmap for Amazon to deliver this ARS in the next 2-5 years.

Introduction

The main purpose of Amazon bringing the automation in the warehouse was not to eliminate jobs but to automate tasks so that companies could reassign their people to build new technology or new products.

With the increase in demand for products Because of changing trends, Amazon needs a robotic system to supercharge its order fulfillment process and make same-day delivery a widespread reality.

In 2012, Amazon spent $775 million to purchase a young robotics company called Kiva Systems that gave it ownership over a new breed of mobile robots that could carry shelves of products from worker to worker, reading barcodes on the ground for directions along the way.

Launch of Kiva robotics

Amazon has been the biggest competitor to other e-commerce companies like Walmart and Target. Because of this tough competition, other e-commerce companies have invested substantially to catch up with Amazon. Seeing this growing market, software and hardware vendors started their warehouse-related products to solve this issue. These robots and services have been helping warehouse workers find shelf towers of goods in warehouses, lift things from the ground, deliver goods to people in the delivery department, and so on. In Amazon's warehouse robotics history, they used Kiva, a robotics company launched in the 2000s. Initially, Kiva Systems had customers including Amazon, Crate & Barrel, GAP, and Diapers.com. Amazon bought off Kiva robots in 2012, and Kiva has been exclusively used for Amazon after other customers' contracts expired. [1]

Figure 1: Kiva Robots [2]

Amazon Robotic Family

There are many robots other than the Kiva robots used in Amazon warehouses for many different purposes.

***The original Kiva*:** This is the orange color robot initially called DU1000 because they are capable of 1000 pound lifting capacity. These robots are called Amazon robotics now, but most people know them as Kiva robots. These robots are used for moving pods and shelves faster and cheaper. Each robot is about 75cm long and 60 cm wide (2.5 by 2 feet), and it fits nicely underneath a pod that measures roughly 1x1m. Each robot is only 30cm (1 foot) high, weighs around 110kg (250 pounds) and it can lift 450kg (1000 pounds). The robots can move 5 km/h (3 miles per hour) or walk comfortably [2].

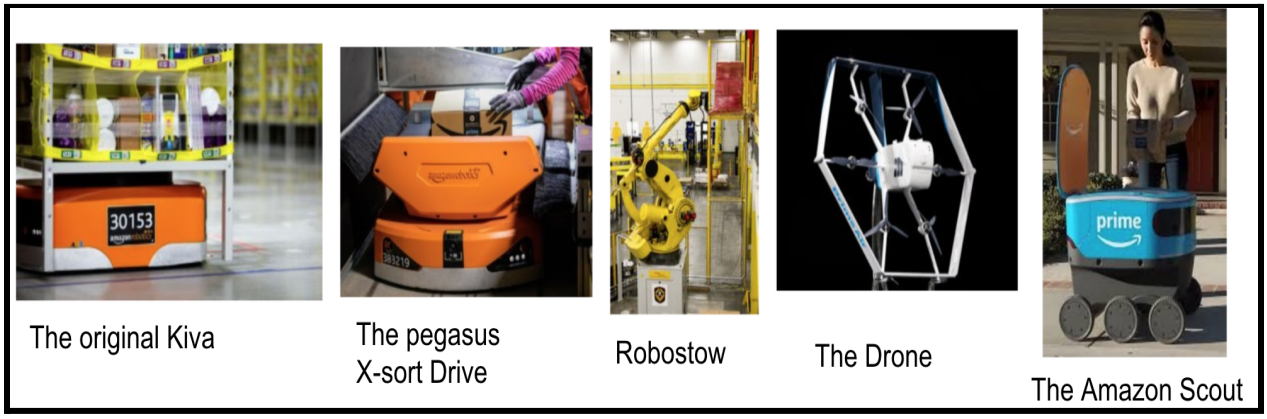
The Hercules: These robots were introduced in 2007 and they were called DU 3000 since they have a 3000-pound lifting capacity. The Hercules are designed for heavy lifting. These robots are similar to Kiva robots, but they are capable of lifting much more weight. The Hercules are larger as compared to their original robot, and they have larger pods [2].

The Pegasus: They were named pegasus after mythical winged horses. They perform similar tasks compared to Kiva. However, they are only 19 cm, 10cm less than the original Kiva. That is why they have more space to store stuff. It can lift 560 KG, and they have only half the parts and are very economical. There are speculations that Amazon will use these robots in their new fulfillment centers, especially close to the city centers. The beliefs are that these robots would have more work in the high-density population areas and the robots need to get the assigned tasks done faster. With high efficiency, this would allow more products to fit into a warehouse and reduce investment costs [2].

***The Robostow**:* These are the "normal-looking" robots who do not move from the place because they are installed in. The Robostow are bought from third-party vendors, and they are used to move the pallets around. The Robostow are found in many fulfillment centers [2].

Drones: Amazon has plans to use them to deliver packages the last mile from the warehouse to the customers. They are right now in the testing phase. These drones can fly up to 15 miles carrying 5 pounds. They will be tested more over the coming years before being implemented in delivery services [2].

Figure 2: Amazon Robotic Family [2]



Initial Market Segmentation

Our market research identified the Global Robotics market segmented by robot type, function, end-users, and geography shown in the picture. The type of robots is classified into SCARA, cylindrical, parallel, mobile, cartesian, and stationery articulated robots. Among these robot types, mobile robots are most popularly used in 2017, followed by articulated robots. The primary reason is that mobile robots are smart and autonomous. The growth of warehouse house robots is due to the increase in e-commerce, food & beverage, pharmaceutical, and automotive industry.

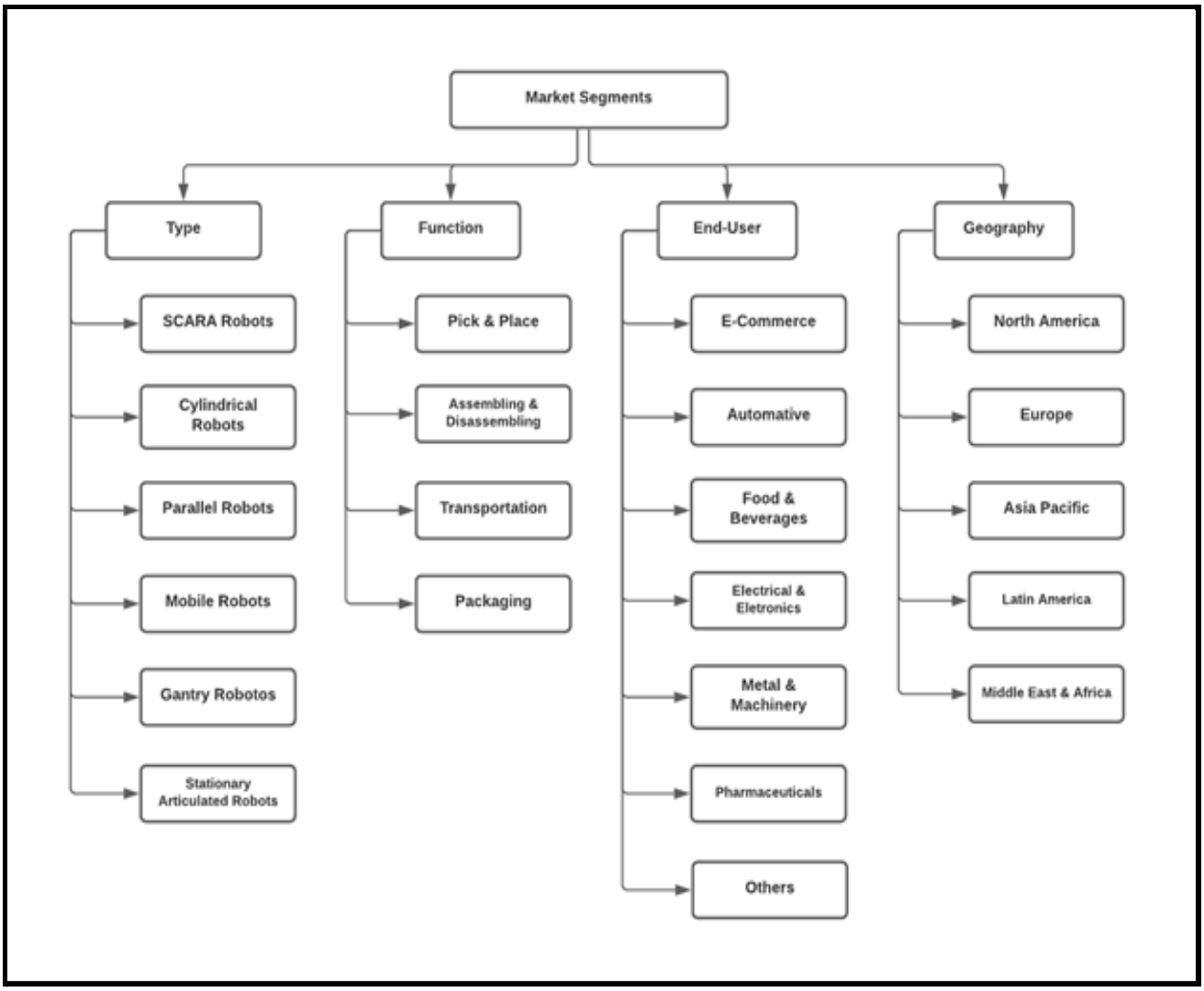
The robotics market is categorized into pick & place, assembling, disassembling, transportation, and packaging based on function. The most used function by warehouse robotics is the pick & place, followed by packaging. The transportations' function is growing more complex due to the growing demand for mobile robots and increased use in various e-commerce, food & beverage, metal & machinery, pharmaceutical, and automotive industries.

Based on the end-users' perspective, the warehouse robotics market is segmented into e-commerce, automotive, food & beverages, electronics & electrical, metal, pharmaceuticals, and others. Among these, the E-commerce industry uses the most warehouse robots, followed by the automotive industry. The demand for same-day delivery or pickup increased the use of warehouse robots for packaging, palletizing, and transportation in the food and beverage industry.

The warehouse robotics market has been segmented based on geography as North America, Europe, Asia-Pacific, and LAMEA. North America is the most dominant and largest in the warehouse robotics market, which accounted for $805 million in 2016 [3].

The Asia-Pacific market is the fastest-growing warehouse robotics market due to increased e-commerce, food and beverage, metal & machinery, and automotive industries in China, South Korea, and Japan [3].

Figure 3: Initial Market Segmentation

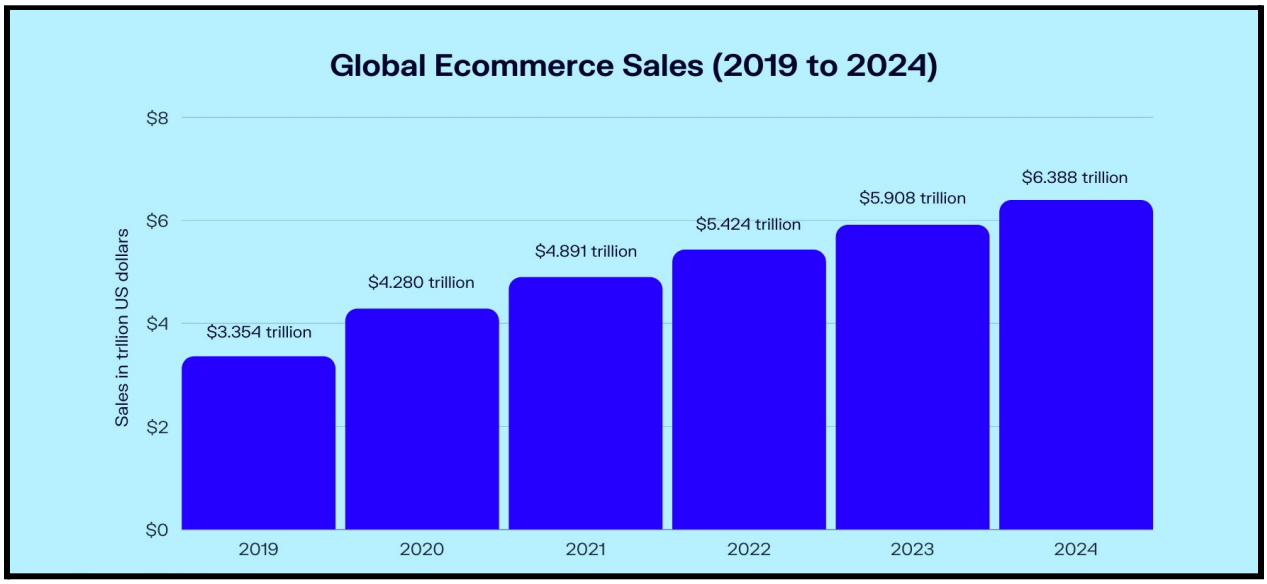


Market Need

COVID changed the customer purchase behavior, and the customers are now inclined more towards online ordering. This trend has pushed retailers to compete to provide better customer service. Better customer service would demand more inventory transparency, quick delivery cycles, etc. Online retail sales increased 32.4% year over year in 2020 and are up 39% in Q1 2021 [4]. According to industry experts, the demand is going to increase further. Retailers have reacted to the situation by increasing the inventory levels to hedge against future disruptions.

Experts suggested that businesses in the long term may increase inventories by 5-10% to minimize the risk of demand shocks [5].

Figure 4: Global Ecommerce sales growth [19]



The retailers and 3rd party logistics companies realized that there is a need to add more warehouse capacity to manage inventory and achieve fast fulfillment rates. The capacity will be spread out in smaller, more local, or decentralized warehouses to meet the customer's delivery expectations. Analysts predict that 1 billion square feet of demand for warehouse space by 2025 owing to e-commerce sales will reach $1.5 trillion by 2025 [6].

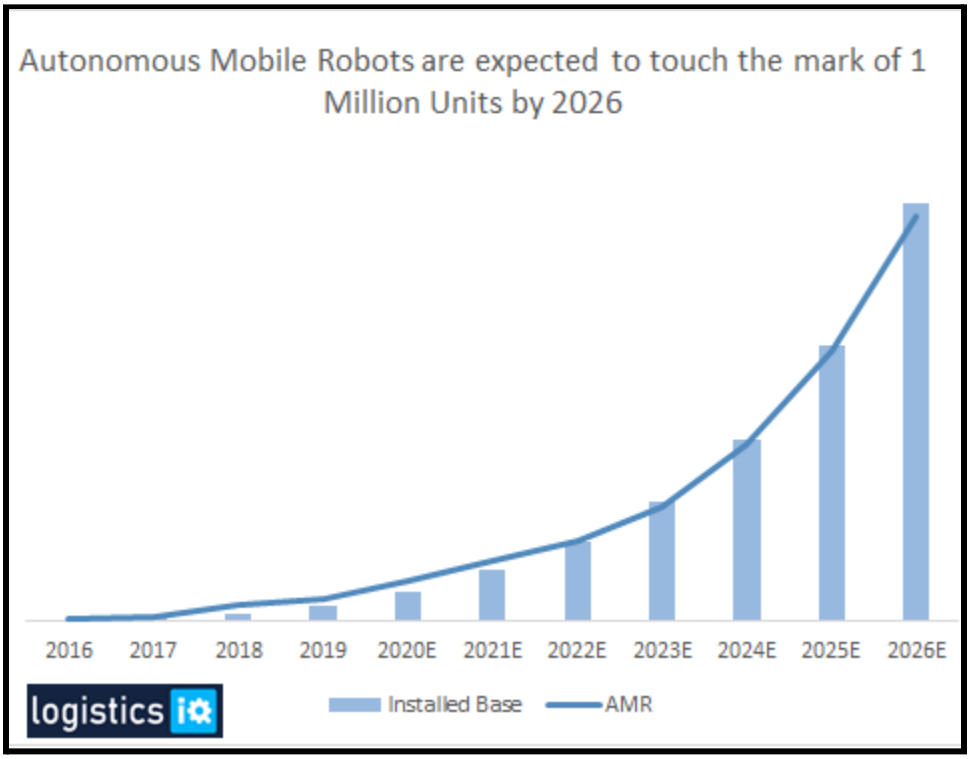
With an increase in warehouse space, there is a need to make these facilities more operationally efficient to meet order fill rates. With the adoption of warehouse technologies like warehouse management systems, automated picking tools, automated guided vehicles, and automated inventory control platforms, IoT platforms are rising. These technologies would help mitigate issues like labor availability, inventory inaccuracies, slower picking processes, etc.

The commoditization of technologies like cloud computing, 5G, Internet of things, which are the backbone to develop automated warehouse robotic tools or devices, pushed more companies to offer solutions in this space. Also, customers started to view warehouse technologies as necessary investments to achieve operational goals and meet customer demand on time. Warehouse automation is a space to thrive in the coming years, and there is a good market demand for the right solutions.

Market Trend

To meet ever-growing customer expectations and improve operational efficiencies, retailer and e-commerce companies are looking towards **Autonomous Mobile Robots (AMRs).** These robots are used to pick, transport, and sort items within the distribution facilities without any manual intervention. The AMRs leverage the vision cameras, sensors, integrated warehouse maps, and execution software system to perform various operations.

Figure 5: AMR Global Market trend [25]



Another trend in warehousing is adopting Micro fulfillment centers or decentralized warehouse locations which can help to provide same-day or next-day delivery. Grocery retailers are the frontrunners in adopting Micro fulfillment centers. A forecast suggests that micro-fulfillment centers will fulfill approximately 8% of total US online grocery sales in 2025 [7].

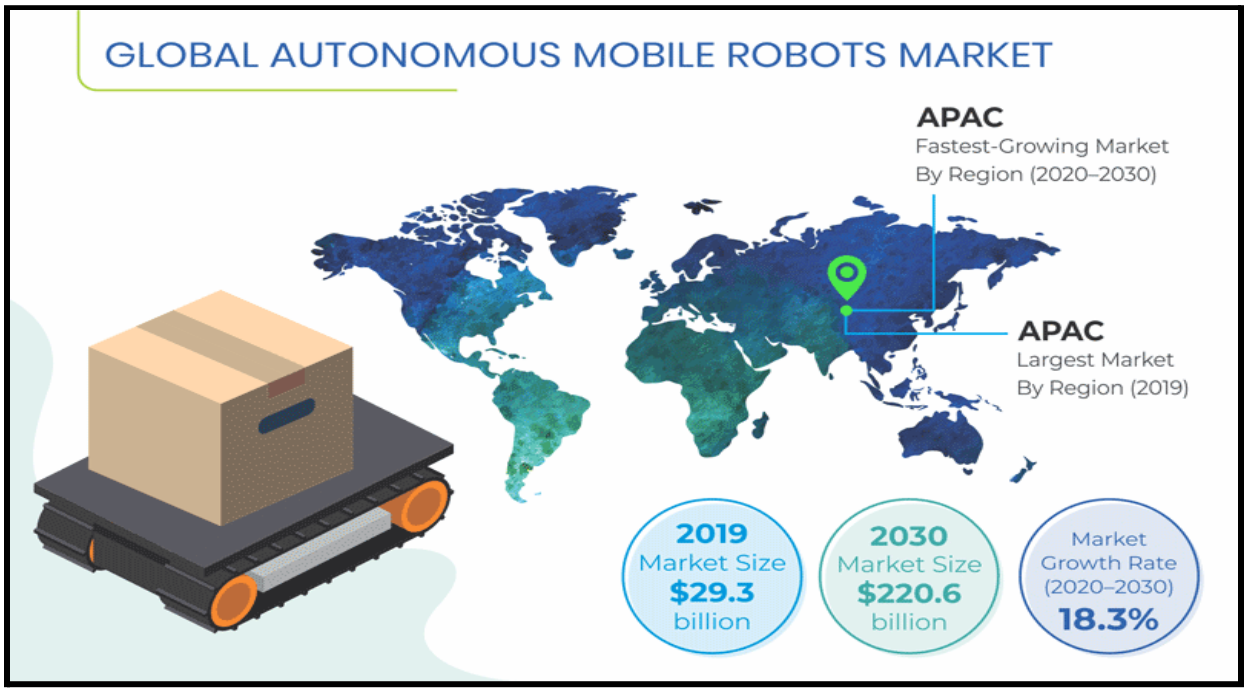
Amazon, the pioneer in warehouse robotics, started using AMRs for cases where strenuous movements of goods were needed. This strategy helps to prevent injuries and promote warehouse safety for workers. By 2025, it has plans to invest over $300 million into safety projects using Autonomous Mobile Robots (AMRs) [8].

Market Opportunity

Total Available Market:

The global autonomous mobile robots market size was valued at USD 29.3 billion in 2019, and the market size is expected to reach $220.6 billion at a compound annual growth rate (CAGR)of 18.3% from 2020 to 2030 across all industries like logistics, healthcare, manufacturing, military, mining, etc. Logistics & warehousing industry is the frontrunner with almost 30% of Global AMRs market share [4]. Globally, the Asia-Pacific region dominated the AMR market in 2019. This is due to the growth of the e-commerce industry in countries such as Japan, China, South Korea, India, and these countries have an increasing demand for smart and efficient warehouses [6].

Figure 6: Global AMR Market [18]



Service Available Market:

With Covid, the additional warehouse space is increasing faster in the U.S. It is estimated that 200 million square feet of warehouse space will be added in the next couple of years. Issues like the labor shortage and the demand to fulfill orders on the same day push the retailers in this region to go the extra mile to develop solutions to automate the processes. Amazon is raising the bar, which is using almost 200,000 AMRs across its warehouses. The Warehouse robotics market is likely to be worth $4.6 billion globally this year. The North American autonomous mobile robot market is expected to reach $25.14 billion in 2025, growing by 12.6% annually over the forecast years[8].

Online Grocery has unique needs to fulfill orders quickly - within hours of order placement, looking towards building decentralized warehouses, automating the locations with the help of warehouse technologies.

Service Obtainable Market:

During the pandemic, e-commerce has seen rising volumes of orders, higher demand for same-day delivery, and delivery within hours in the grocery industry. This can be achieved by installing MFCs in existing premises. The automated MFC market is forecast to grow to just above $5.5bn in 2025. Up from $136m in 2020 - a CAGR of 104% (including project and recurring revenues). Interact Analysis forecasts that by 2025 over 2,100 micro-fulfillment centres will be installed, among which 69% will be built between 2024 and 2025[9]. It is also predicted that in 2025 the grocery sector will account for 45% of micro-fulfillment automation revenues[9]. Retailers will make use of their existing real estate assets before constructing purpose-built micro-fulfillment centers. For this reason, grocers will favor retail-based MFCs, where the MFC is co-located with the retail store, due to their extensive real estate networks. On the other hand, general merchandise retailers, tend to have fewer and smaller real estate assets, will favor distribution center-based MFCs.[9]

The number of new automated micro-fulfillment centers is growing at a tremendous rate in the United States. This gives a significant market opportunity for Amazon Robotics to provide warehouse robots (Kiva robots) for MFC automation in a fulfillment-as-a-service model.

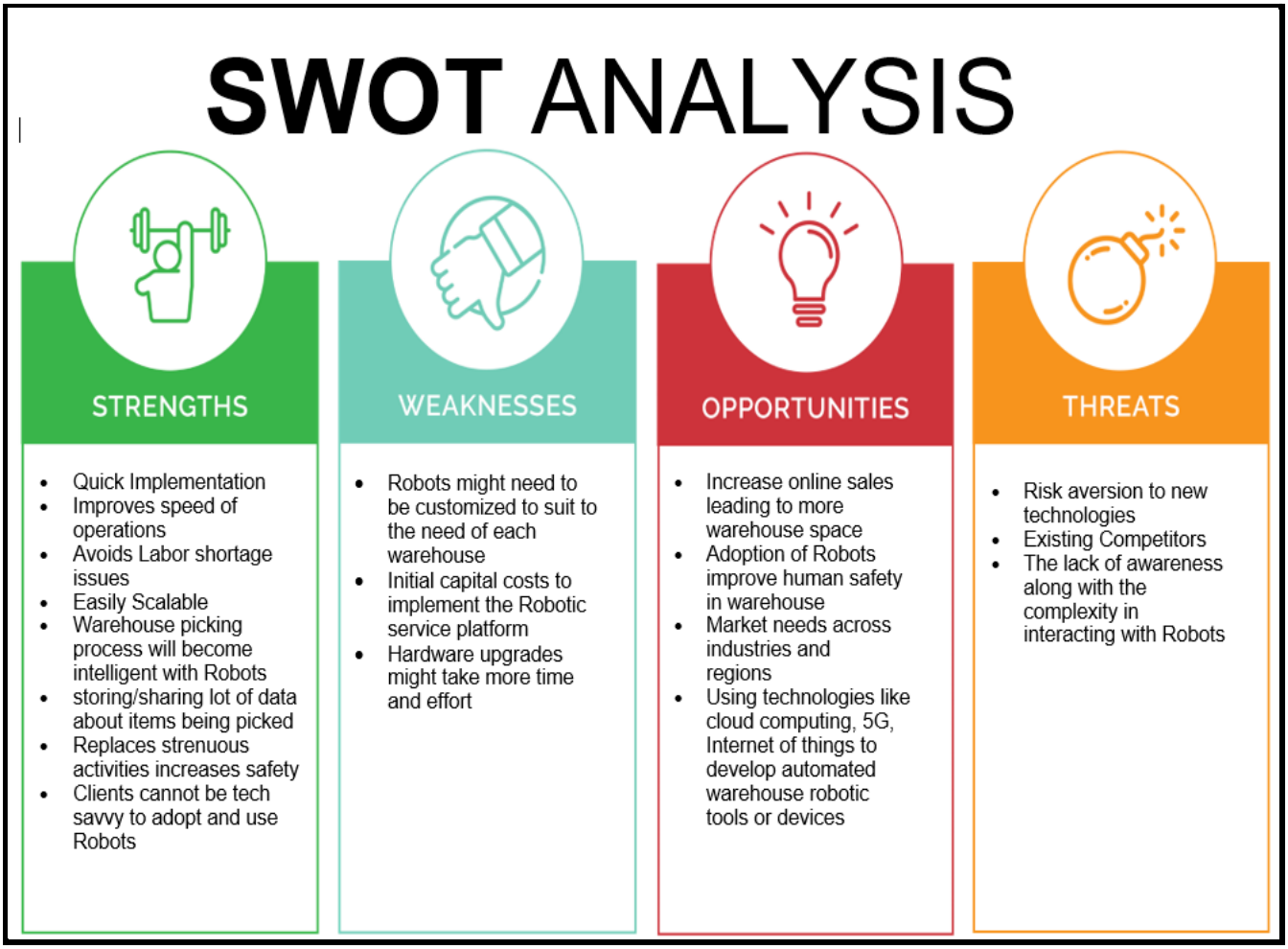
Market Research

SWOT Analysis:

The SWOT analysis in Fig.7 provides thorough research on Amazon RaaS. Amazon has undoubtedly improved its efficiency and safety and can automate inventory flow at Amazon fulfillment centers by using Amazon Robots. Amazon Robots are built with Artificial Intelligence and Machine Learning(ML) to automate the critical functionalities at the Amazon warehouse. The Kiva robots (Autonomous Mobile Robot), the Little Orange Robot and busiest employee at the Amazon fulfillment centers, which are capable of moving shelves or pods around the warehouse for faster and cheaper stowing and picking.

The lack of knowledge in interacting with the robots and job displacement are major challenges that could affect the warehouse robotics market. The other challenge is that the robots still cannot compete with humans' intuitive knowledge when they need to identify items in a bin.

Figure 7: Amazon Robots SWOT Analysis [10-11]

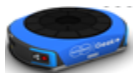


Competitor Analysis

Amazon has gained a competitive advantage by purchasing a robotics company -Kiva Systems. This move gave Amazon the technical foundation to build new warehouse robots. Today, Amazon has 200k mobile robots working at their warehouse centers. These autonomous mobile robots are mostly used to pick, transport, and sort items within the distribution facilities without manual intervention. The global key players in making autonomous robots and providing them Robot-as-a-service are Ronavi Robotics (Russia), 6 River(USA), Fetch Robotics(USA), Geek+ Robotics(China), InVia Robotics(USA), Locus Robotics(USA) and Magazino(Germany) [12].

The thorough competitor analysis of autonomous mobile robots is as shown in Figure 8. Here we compared amazon's autonomous mobile robot, the Original Kiva with the seven significant competitors.

Figure 8: Competitor Analysis [12]

Name	Country	Price	Function	Payload Capacity	Areas served	Operational Speed	Picking Efficiency	Used to	Battery run time(hours)	Go live in	Has RaaS
Ronavi Robotics 	Russia	Per transaction/per pick	Pick/Fetch Robot	1500 kgs	Europe	1.5 m/s	300-350 pcs/hour	Towing, Lifting, Picking	6	4-5 weeks	Yes
6 River 	USA	US$250K for 8 robots (1st yr) + $50K/annual	Pick/Fetch Robot	160lbs	North America	3.0 m/s	300-400 pcs/hour	Put away, picking, Counting	7	4-6 weeks	Yes
Fetch Robotics 	USA	annual or monthly license/robot	Pick/Fetch Robot	500-1500 kgs	North America	2.0 m/s	200-300pcs /hour	picking &removal Recycling	8	2-3 weeks	Yes
Geek+ Robotics 	China	Per transaction/per pick	Pick/Fetch Robot	1000lbs	Asia	2.0m/s	300-600 pcs/hour	Towing, Lifting, Roller,	6-8	3-4 weeks	Yes

Name	Country	Price	Function	Payload Capacity	Areas served	Operational Speed	Picking Efficiency	Used to	Battery run time(hours)	Go live in	Has RaaS
Amazon Robotics 	USA	annual or monthly license/robot	Pick/Fetch	1000-3000 pounds	North America	1.3 m/s	600-700 Pcs/hour	Towing, Lifting, Picking	8-10 hours	1-2 weeks	No
Locus Robotics 	USA	annual or monthly license/robot	Pick/Fetch Robot	4	North America	2 m/s	400-500 pcs/hour	Faster Picking	6	4-5 weeks	Yes
Magazino 	Germany	6 cents per pick	Pick/Fetch Robot	5.8 kg	Europe	1.5 m/s	300-400 pcs/hour	Pick up, lift and deposit boxes	Max. 8	2-3 weeks	Yes
InVia Robotics 	USA	10 cents per pick	Pick/Fetch Robot	40lbs	North America	25 m/s	200-300 Pcs/hour	Lifting, Picking	10	1-2 weeks	Yes

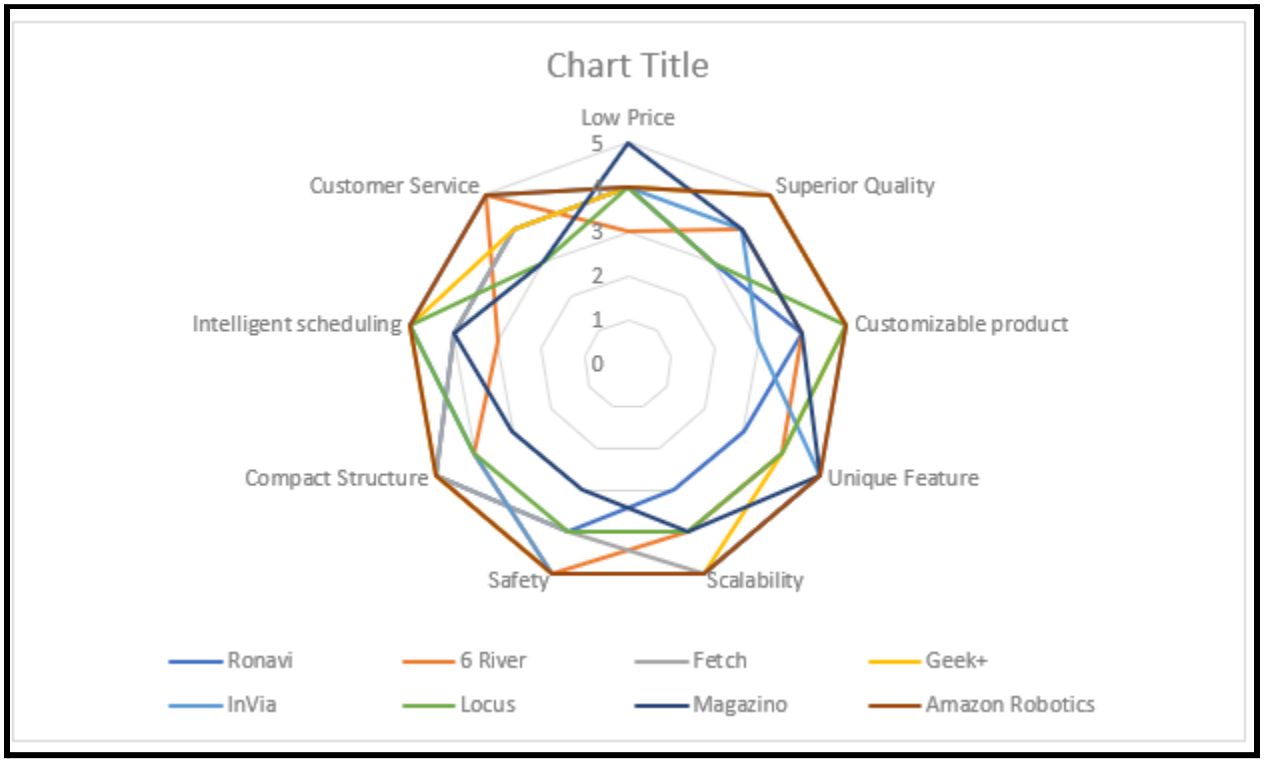
We were able to rank the price, quality, customizable product, unique feature, scalability, safety, compact structure, intelligent scheduling and customer service based on the competitor analysis on a five-point scale (5 represents very strong, 1 represents very weak) in Figure 9.

Figure 9: Competitor Factor Analysis (use point system)

	Ronavi Robotics	**6 River**	**Fetch Robotics**	**Geek+ Robotics**	**InVia Robotics**	**Locus Robotics**	**Magazino**	**Amazon Robotics**
Low Price	4	3	4	4	4	4	5	4
Superior Quality	3	4	5	5	4	3	4	5
Customizable product	4	4	5	5	3	5	4	5
Unique Feature	3	4	5	4	5	4	5	5
Scalability	3	4	5	5	5	4	4	5
Safety	4	5	4	5	5	4	3	5
Compact Structure	5	4	5	5	4	4	3	5
Intelligent scheduling	4	3	4	5	5	5	4	5
Customer Service	4	5	4	4	5	3	3	5

From the radar chart shown in Figure 10, Amazon's Kiva Robot gains advantageous position in almost all the features.

Figure 10: Competitor Analysis using Radar Chart



Target Customers

Some of the customers that Amazon should target for providing ARS (Amazon Robotics Service) includes customers from the following industries:

- **Logistics**: Material transportation is a labor-intensive task. AMRs can take over the repetitive and non-value-adding tasks within productions and shipping facilities, freeing up employee time and enabling them to focus on more important work. AMRs are widely used to transport material and orders across warehouses and/or shipping facilities [13]

- **E-commerce:** Typical e-commerce tasks like order fulfillment, returns handling, material transport, and inventory management can be easily performed by AMRs. Since multiple accessories can be latched onto the AMR platform, their flexibility makes them suitable for specific applications like sortation. In addition to the flexibility offered, another vital consideration for e-commerce businesses today is safety, particularly given the ongoing pandemic. Safe operations call for measures to protect employees as well as prevent packages and products from being contaminated. Solutions integrated with robots can automatically change pallets of sorted items, providing uncrewed, continuous and safe operations [13].

- **Warehousing**: Distribution centers and warehouses can be massive, with the average warehouse in the United States spanning across an area of more than 25,000 square feet [13]. In warehousing, AMRs are best suitable for heavy lifting and goods transporting applications. By utilizing AMRs for essential warehousing operation saves time and sequencing movement ensures maximum efficiency. Automating warehouses also allows for scalable operations depending on fluctuating demand [13-15].

  Palletizing, another monotonous, repetitive task is another process suited for automation. “With AMR platforms, lift plates, and robotic arms, palletizing can be almost completely automated. Palletizing robots can complete every step of the process – loading, transport, and unloading – autonomously, efficiently, and accurately [13]”

- **AMRs and Mobile Manipulators for Manufacturing:** There is no specialised infrastructure required for operating AMRs [3]. They function seamlessly inside an existing layout without the need for major modifications to existing operations. The adaptability of AMRs make them apt for the dynamic nature of the manufacturing industry[1].

  AMRs integrated with accessories such as robotic arms or conveyors can help in the production process in addition to transporting in-process parts and finished goods. Mobile manipulators or cobots which are AMRs with robotic arms, for example, can sort, pick, and pack products while also moving dynamically to multiple locations [13].

  Static conveyors are typically used in line work to help accelerate production and sorting. By adding a conveyor to an AMR, conveyor capabilities become more flexible and mobile. AMRs with built-in conveyors can be linked to static conveyors to move products more efficiently throughout a facility. AMRs equipped with attachments that can lift pallets and connect to carts enable the robots to load/unload payloads and, in some cases, connect to carts without the need for human intervention. This combination of cart transport and loading/unloading in a single AMR is a relatively new capability, but it will open up new possibilities for autonomous robots [13].

- **Data Centers:** Secure autonomous transportation has become an important part of operations at data and research centers, resulting in a new application for AMRs. Autonomous robots equipped with lock boxes and cabinets can be used to transport high-value materials securely while guaranteeing that the proper protocol is followed. This also allows for quick, precise, and easy documentation of the process [13].

- **Healthcare**: Another innovative application of robots is its utilization in healthcare - AMRs are an efficient way for streamlining the transport of supplies and medications throughout a medical facility. This is especially important in infectious disease units because it prevents nurses from coming into contact with potential contaminants while still ensuring that patients receive proper treatment. Additionally, “medical AMRs can be used in sanitation by outfitting robots with virus-killing UV lights or decontamination sprays that clean up a room or space without exposing people to potential harm [13].”

Porter's Five Forces

Porter's Five Forces is a simple framework for assessing and evaluating the competitive strength and position of a business organization. Following is the analysis of Porter's Five forces:

- **Threat of New Entrant:** The threat of new entrants is low as it would require huge investments for procuring robots/systems needed for automating warehousing. Amazon has an advantage over other brands on economies of scale because of its large number of fulfilment centers and logistics capabilities. Although new robotics service providers can enter the market, they will not be able to benefit from economies of scale to the same extent as Amazon.

- **Customer Bargaining Power**: Bargaining power of buyers is medium. Customers can be price conscious. If Amazon does not provide high-quality service at the best price, customers will seek alternatives in the market., they will go for its alternatives in the market. Amazon can overcome this by clearly positioning its service offering as discussed in the Market Strategies Section.

- **Threat of Substitute:** Threat of substitute is medium. Customers being indifferent to price-performance may opt to go with traditional transportation equipment like conveyors, forklifts, dollies etc.

- **Supplier Bargaining Power:** Bargaining Power of Suppliers is low as Amazon has acquired Kiva robotics and already possess the technology know-hows for developing robots.

- **Competitive Rivalry**: Competitive Rivalry is moderate to high as there are multiple players entering the warehouse automation market as identified in the Competitor Analysis Section.

Market Strategies

Product Strategy

The team's initial goal is to develop a technology for Amazon to deliver Amazon Robotic Services (ARS) in the next 2-5 years. In order to do this, the team has decided to focus on a technology roadmap for improving and increasing Amazon Robotic Services (ARS) performance and will be providing Warehouse Robotics as a Services (RaaS) or the Robotics Rental Business for small E-commerce companies. The team has brainstormed some new technology features such as Artificial Intelligence, Mobile Access, Predictive Maintenance, Warehouse on-demand and Wearable computers. Those features will be useful for Amazon to advance their future robotics warehousing.

Amazon's Robotic Fulfillment Center where they are using robots to assist employees with tasks like carrying shelves of products from worker to worker across massive warehouse spaces, reading barcodes on the ground for directions along the way to travel in place of workers. Amazon has set up their intelligent warehouse based on the Kiva system.

The Kiva System robot is making inventory items come to the warehouse workers and they can fulfill orders faster. It has a computer cluster to keep track of all robots and racks on the floor, and it can be used for resource-allocation algorithms efficiently. Moreover, it provides hundreds of mobile robots to bring inventory to warehouse workers and save them from walking daily marathons. However, some E-commerce companies are struggling with the problem of order handling inefficiencies in warehousing. To solve this problem, some E-commerce companies employ the Kiva robot fulfilment system to enhance order picking efficiency, improve customers services and reduce operational costs. As far as how to increase the awareness, the team will be advertising directly to the target market via social media and other outreach advertisements.

Pricing Strategy

Based on our competitor analysis and Amazon's brand success, we determine that Amazon RaaS services are a full-service warehouse automation solution, and this service would be positioned as a premium pricing service. The reason is that not only does Amazon provide the robotics hardware, it also offers additional AWS services that other robotics services do not provide. Amazon Robotics Services would be a one-stop warehouse automation solution for many customers in different industries. Comparing other company's offerings, Amazon Robotics Service will offer one price to the customers and this price will cover the annual maintenance cost and supportive software cost. The price for each robot is estimated to be $50,000 for the first year and later on being a monthly subscription charge(pay-as-you-go model). Even though Amazon RaaS will be a complete turnkey solution, Amazon robotics services will provide employee training to help the staff be familiar with the system for the first three months. After the training period, the system will be handed off to the warehouse managers and operators. The supporting personnel from the Amazon side will transition into 24/7 remote support with weekly or monthly client meetings and back-end equipment monitoring[16].

Demand Generation

Since Amazon has already established its brand identity, it doesn't need to spend additional money on increasing brand awareness. However, for the success of Amazon Robotics Services, it is crucial to reach out to potential customers by correctly identifying and outlining their buyer personas. By implementing native advertising and sponsored content on the platform, potential customers will be introduced to Amazon's technology and services. When potential customers have enough interest and consider implementing ARS technology, they will be provided with logistics experts and consultants to discuss the consents. Experts will then assess the current warehouse's needs and later offer specific recommendations tailored to match the warehouse schema. To continue and strengthen ongoing partnerships with existing customers, the account manager, and the customer service teams will make iterations and service adjustments through

customer feedback and ensure customer satisfaction. Here we list out different ways for conducting B2B promotion and marketing campaigns to reach potential costumes in Figure 11.

Figure 11: Marketing Communication

CATEGORY	TOOLS	RESULTS
Online Advertising	Google ads, Industry publication and websites, Search engine optimization, Sponsored content	Clicks, Asking for quotes
Social Media Advertising	Youtube	Promotion, Website visit, clicks
Blogging	LinkedIn	Promotion, Website visit, clicks, Asking for quotes
Logistics and engineering companies	Consulting services and engineering services	Promotion and consultation, Referral marketing
Robotics Warehousing Conferences	Bouchers, flyers, demo room	Registers, clicks, email signups, interactions with potential customers
Customers Outreach	Customer Relationship Management System(CRM)	Find potential customers and collaboration opportunities

Place and Distribution Strategy

Our primary strategy is to use the direct distribution channel to sell RaaS directly to businesses. Amazon RaaS will mainly focus on e-commerce warehouses in the initial trial period, and in the future partnering with other companies in other industries of choice. In this case, Amazon would be directly doing transactions with other businesses for sales. This is a business-to-business distribution model. Only selected customers would be approached by online customer service representatives or warehouse consultants to explain the benefits of this service for a web-based introduction. Using web-based sales channels, the sales and marketing team will use the existing client relationship through internal databases to discuss the clients' needs or establish a new client base via email, SEO(search engine optimization) content, social media [17].

The physical sales channels would include trade shows, conferences, demonstration rooms as these environments would give the customers a more immersive experience to see how a warehouse could be transformed. Customers can make more requests and modifications based on the company's needs and other opinions from experts. Once the contract is finalized,

door-to-door delivery will be scheduled for robots and other machinery delivery in 4 weeks. Because no new infrastructure will be needed from the customers' side, this would be a quick and agile implementation. Amazon RaaS will also allow customers to quickly scale up and down based on seasonality or other factors.

Technology Roadmap

Based on our research and analysis results, the first layer we came up with is the drivers, which had two parts: Internal market drivers and External market drivers. These drivers were identified from market and industry analysis, market segmentation, changes in technology, SWOT analysis of the business, and customer requirements. We identified varieties of drivers through brainstorming, market research, and analysis. Then we prioritized them according to the importance of the business into a list of 20, as seen in Figure 12. The priorities were determined by peer review and research analysis [20].

The second layer consists of the product and features aligned with the current and future drivers identified above. This is followed by technologies that enabled Amazon to achieve the products/service and the strategic direction Amazon needs to take to acquire and develop future technology to support the development of its future offerings. The QFD technique was applied to calculate the scores (obtained by the product attributes and market drivers after analyzing their relationship as well as technology on product attributes). This technique was used to condense the information and provide a simple visual comparison of priorities across the tables. The weights assigned to the drivers at the top of the spreadsheet in Figure 13 are based on the team's conclusion of the analysis performed on the market drivers and their respective prioritization. The weights in the Products vs Technology QFD seen in Figure 14 is from the result of Drivers vs Products QFD [20].

The fourth layer is the resources in place that would help Amazon close the gap between current and future technology. Finally, we mapped the drivers to products and services, technology to products and services, and resources to technology. All the information in the research and analysis steps were gathered, and a technology roadmap was built for current, present, and future timelines. Integration and alignment between layers were finalized by peer review and market research [20].

Figure 12: Drivers [21-49]

Category		Label	Driver	Definition	Weight
MARKET DRIVERS	Technology	D1	Data storage	No need for onsite warehouse servers. Customers can utilize the cloud storage to access data at any point of time from any location	4
		D2	Lower margin of error	Quality, safety, cost reduction and customer service	4
		D3	Accessibility	Place an order from any device(one click buttons,subscription, etc)	3
		D4	Data Analytics	Restocking, data sharing, prediction	4
		D5	Big Data - F	The patterns and trends observed from the enormous amount of data are used by several machine learning algorithms and help in making predictive analytics with data-based learning. Large complex data set from from different data sources	4
		D6	Security -F	Better identify, analyze and mitigate the risks inherent in the process	4
		D7	Augmented reality - F	The next step may perhaps be AR, with smart goggles guiding the picker through the route and telling him or her what to pick.	2
		D8	Wireless technology -F	Improvements in GPS, RFID, bluetooth, 5G technologies	4
	Productivity	D9	Productivity	Warehouse optimization activities(picking, packing, shipping...)	4
		D10	Efficiency	Customers expect shorter delivery time	4
		D11	Inventory management	Decrease inventory excess risk but matching demand rates	3
	Economic	D12	Labor Shortage	Retention of labors and challenges due to pandemic	4
		D13	Profit margin	Increase profit margin for company	3
	Social	D14	Pandemic	Safety and health concerns, social distancing	4
		D15	Trends	More ecommerce orders, higher customer expectations for fast delivery	3
	Environmental	D16	Waste management	Reusable packaging, and reduce paper billing	2
		D17	Sustainability/ Rechargeable	Solar powered equipment	2
BUSINESS INTERNAL		D18	Collaborations and partnerships	Collaborate with third party robotic suppliers. Partner with more retail outlets to support multi channel fulfilment	2
		D19	Business Expansion	Expand Business unit to increase revenue streams	2
		D20	Modular and Plug-and-Play Solutions - F	Think of modular solutions in terms of Lego blocks, which can be assembled, deconstructed, relocated and rearranged as needed.	3

Figure 13: Drivers vs. Products QFD [21-49]

			Drivers																			
			Data storage	Lower margin of error	Accessibility	Big Data	Data Analytics	Collaborations and partnerships	Prescriptive Analytics	Inventory management	Sustainability/ Rechargeable	Waste management	Pandemic	Business Expansion	Labor Shortage	Trends	Profit margin	Augmented Reality	Wearable wireless technology	Modular and Plug-and-Play Solutions	Blockchain	Score
Rank		Weights	4	4	2	4	4	2	4	2	2	2	4	2	4	2	2	2	4	4	2	
6	Products and Services	Amazon Inventory Management Softwares	4	4	2	4	2	1	4	4	2	1		1	1	4	2	1	4	2	2	140
3		Cloud computing	4	2	2	4	4	1	4	2	2	2	4	1	1	4	4	4	1	2	2	148
8		Tech vest	2	4	4	2	2	4	2	2	1	1	1	1	2	4	2	1	1	2	2	112
2		Robots	4	4	4	1	2	4	4	4	2	4	4	1	4	4	4	4	4	4	2	182
7		Logistics	4	4	1	2	4	1	1	4	1	2	2	2	4	2	4	1	1	1	1	128
4		Amazon Warehouse Simulator	4	4	2	4	4	2	2	1	1	1	1	1	2	2	1	4	4	4	4	146
1		RAAS	4	4	4	4	4	4	4	2	4	1	4	1	1	4	4	4	4	4	4	188
9		Communication	1	4	1	2	2	4	1	1	1	1	4	4	1	4	4	1	1	1	1	110
11		Wearable sensor and smart glasses	1	1	2	1	1	2	1	2	1	1	2	2	2	2	2	2	4	2	2	92
10		Warehouse Drones	1	1	1	1	2	2	1	2	2	2	2	4	2	2	2	1	2	2	4	96
12		Optical Recognition	1	1	1	1	1	2	2	2	1	1	2	2	2	2	1	4	2	2	2	88
5		Smart Storage	4	4	2	4	4	1	4	4	1	1	1	2	1	2	4	1	1	4	4	144
13		Sustainable packaging material (future)	1	1	2	1	1	1	1	2	4	4	2	4	1	2	2	1	1	1	1	84

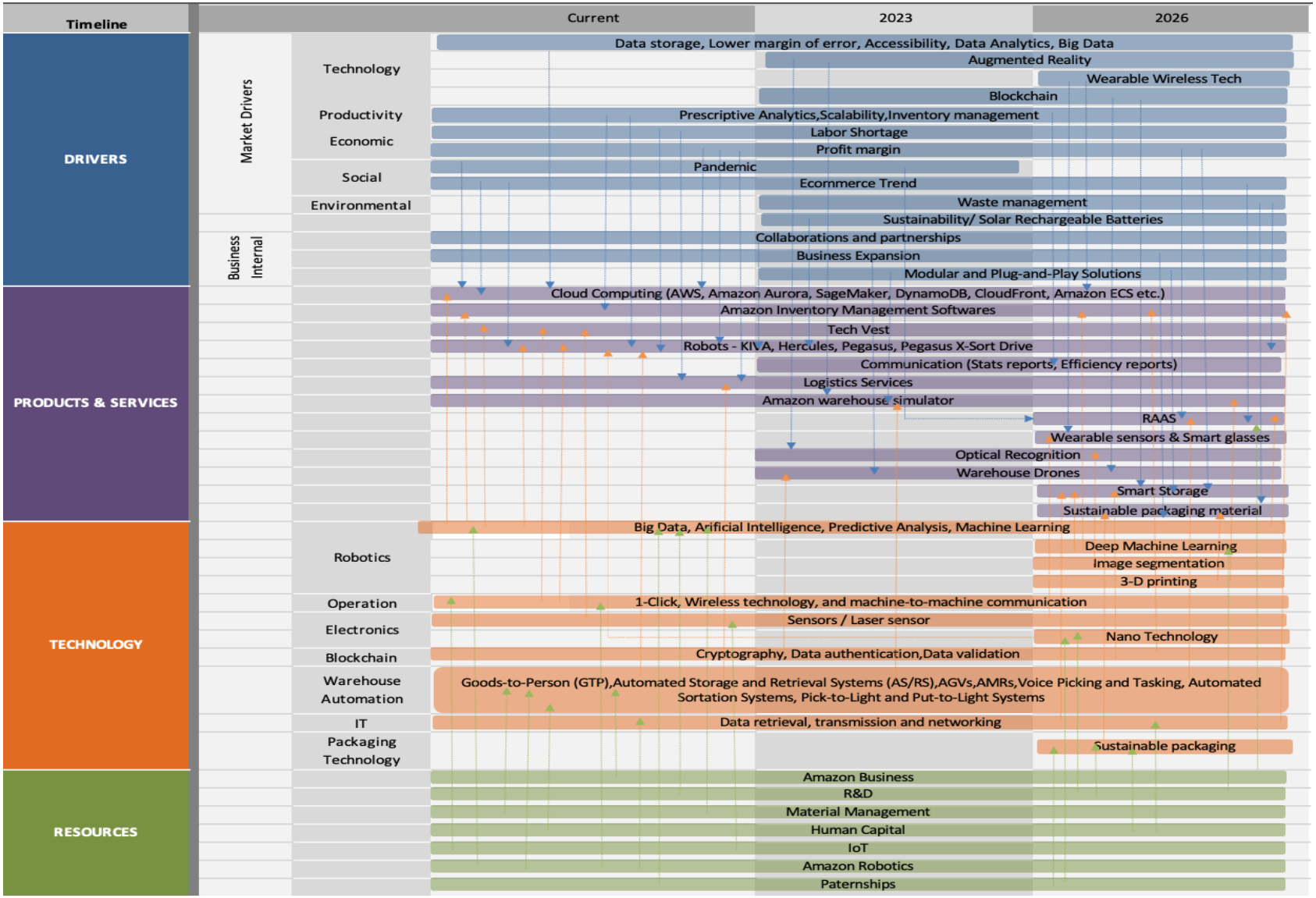
Figure 14: Products vs. Technology QFD [21-49]

			Products and Services													
			Amazon Inventory Management Softwares	Cloud computing	Techvest	Robots	Logistics	Amazon Warehouse Simulator	RAAS	Communication	Wearable sensor and Smart glasses	Warehouse Drones	Optical Recognition	Smart Storage	Sustainable packaging material (future)	Score
Rank		Weights	2	4	2	4	2	4	4	2	1	1	1	2	1	
2	Technology	Big Data	4	4	2	4	4	4	4	1	1	1	1	2	1	94
3		1-Click, Wireless technology, and machine-to-machine communication	4	4	2	4	4	2	4	1	1	1	2	2	1	87
4		Sensors,Laser Sensors	2	4	2	2	4	4	4	2	1	2	1	2	1	85
7		Blockchain	4	2	2	4	4	1	2	1	2	2	2	4	2	74
9		Warehouse Automation	2	2	1	2	1	1	4	1	1	2	1	1	4	56
10		Data Networking	1	2	1	4	2	1	1	1	1	2	1	1	4	52
1		Deep Machine Learning	4	2	4	4	4	4	4	4	1	1	1	2	1	96
7		Image Segmentation	2	2	4	4	1	2	4	1	2	1	1	2	2	74
6		3D printing	4	4	2	1	2	4	4	2	1	1	1	2	1	80
8		Nano Technology	1	1	4	4	1	2	4	4	2	2	2	1	1	73
5		Packaging Technology	4	4	1	4	2	1	4	4	2	2	2	1	2	84

Figure 15: Technology Gap Analysis[21-49]

Technology	Current level	Where we want to be	Gap
Robotics	Big Data, Arificial Intelligence, Predictive Analysis, Machine Learning	Deep machine learning, Image segmentation,3-D printing,Virtual reality (VR),optimize operation	Ablility to learn, adapt, and provide results quickly and accurately to new changes
Operation	1-Click, Wireless technology, and machine-to-machine communication	Low powered, wide-area network connections, 5G	Security and Privacy issues yet to be solved
Electronics	Sensors, Laser sensor, IoT sensors	Nano technology connect to sensors; Able to work autonomously in the same manner; Predictive maintenance for machines and devices will become increasingly more efficient, easier, cheaper, and improve uptime	Sensor utilizations allow real-time feedback to the control system, inferring desired the result sooner; more complex detections
Blockchain	Cryptography, Data authentication, Data validation	Smart contracts, identity management, supply chain uses	High energy comsumption and scaling issues
Warehouse automation	Goods-to-Person (GTP),Automated Storage and Retrieval Systems (AS/RS),AGVs,AMRs,Voice Picking and Tasking, Automated Sortation Systems, Pick-to-Light and Put-to-Light Systems	Warehouse Drones, Cobotics	Safety, payload capacity restrictions and political acceptance
Information technology	Data retrieval, Transmission and networking	Seemless connection, no delays or interference	Coverage holes/gaps, keep signal strength high
Packaging Technology	Traditional packaging material(carboard box, recylcable paper)	Sustainable packaging material	Package is excessive and wasteful.

Figure 16: Technology Roadmap



Appendix

Market Opportunity - TAM,SAM,SOM

Figure 17: Global Warehouse Automation Market size

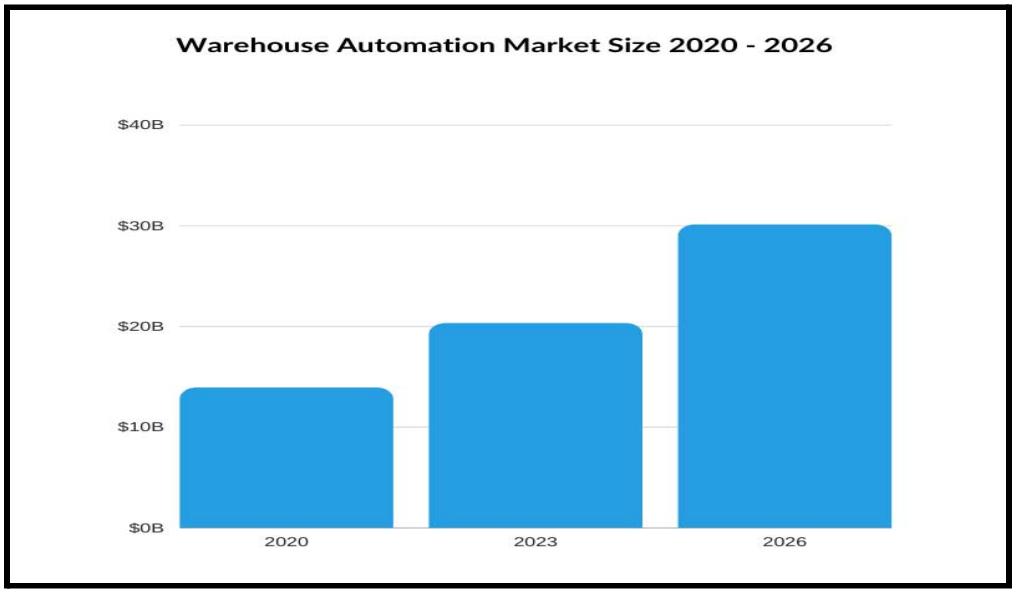


Figure 18: Total Availability Market(TAM)

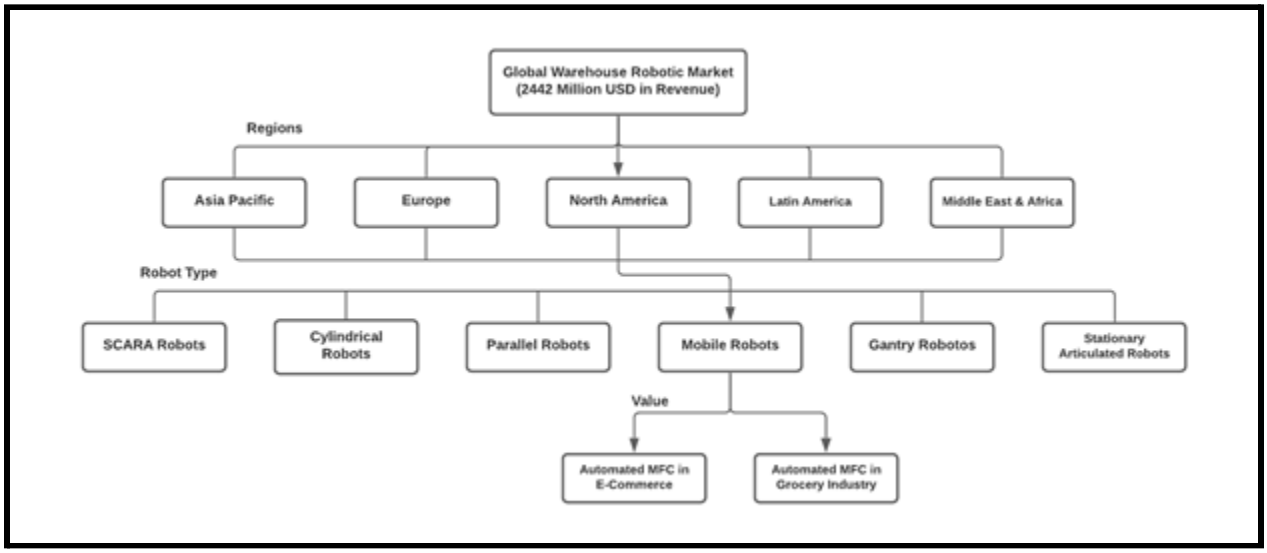


Figure 19: Service Availability Market(SAM)

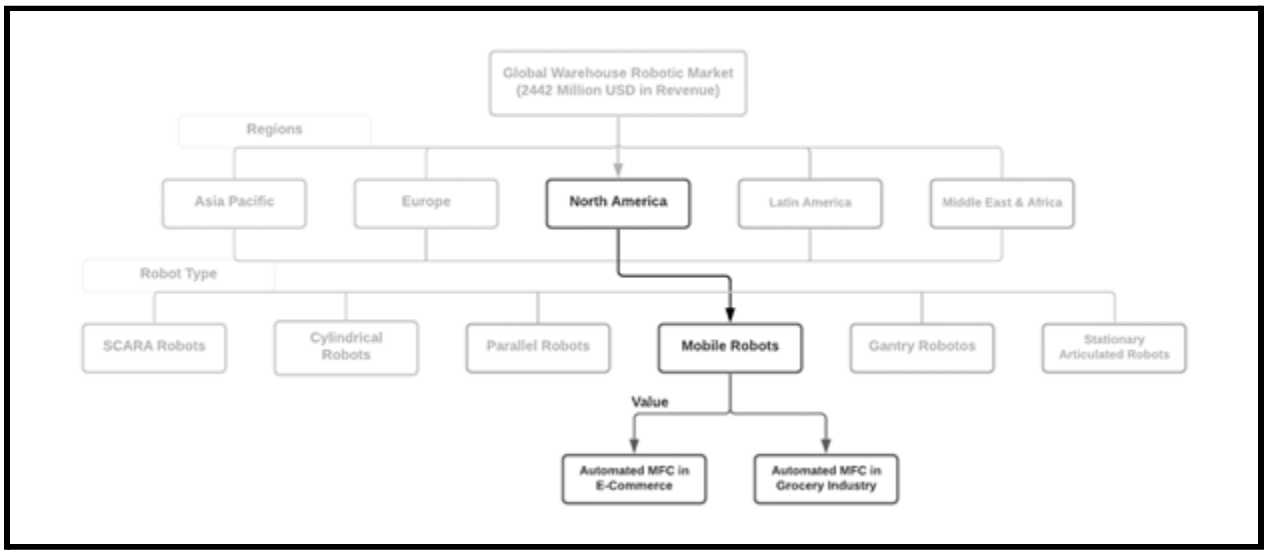
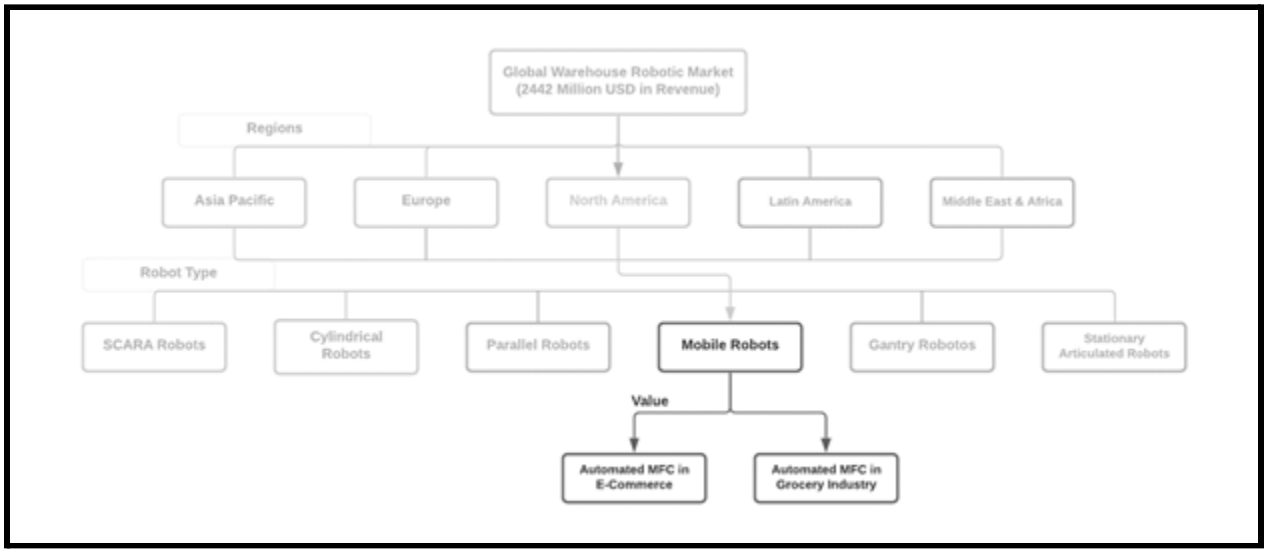


Figure 20: Service obtainable Market(SOM)



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