SPARK Matrix™

Supply Chain Management, Retail & eCommerce

SPARK Matrix™: Autonomous Mobile Robot (AMR), 2021

Market Insights, Competitive Evaluation, and Vendor Rankings

July 2021

Quadrant Knowledge Solutions

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Executive Overview

This research study includes a detailed analysis of the global Autonomous Mobile Robot (AMR) market dynamics, major trends, vendor landscape, and competitive positioning. The study provides competition analysis and ranking of the leading AMR vendors in the form of the SPARK Matrix. This research provides strategic information for technology vendors to better understand the market supporting their growth strategies and for users to evaluate different vendor's capabilities, competitive differentiation, and their market position.

Key Research Findings

Followings are the key research findings:

Technology Trends

The Autonomous Mobile Robots (AMR) vendors continue to invest heavily in improving their capabilities by upgrading various aspects of autonomous mobile robots such as seamless facility navigation, enhanced environment state perception, safety, speed, and payload capacity. Vendors are focusing on incorporating wide range of tops, enabling robots to perform multiple tasks. AMR vendors are equipping robots with advanced sensors, indicators, and stop buttons in order to intelligently detect their surroundings and collaborate with humans. Additionally, AMR vendors are focusing offering advanced robots by embedding 3D-cameras for building facility maps, identifying objects in real-time, supporting 5G connectivity for better wireless experience and supporting fast-changing technologies. Vendors are also leveraging AI, ML, automation, and advanced analytics technologies to enhance the fleet management software for intelligently managing and maintaining robots.

Key Market Drivers Trends:

- Global growth opportunities from the e-commerce and retail sectors and growing operational challenges to address dynamic market fluctuations.
- Increasing challenges to cope-up with ever-shrinking order cycle time and complex ordering scenarios.
- The dynamics of Covid-19 ensured a strong business case for autonomous robots to cope up with operational uncertainties and continued focus on improve service capabilities and customer experience.
- Improve workforce productivity and overcome challenges due to labor shortages.

- Cost efficiency and quick ROI of AMR investment.
- AMR's value proposition of providing necessary flexibility and adaptability to meet dynamic business enviroment.
- Growing emphasis on improving customer service experience and efficiencies of warehouse operations.
- Increasing market penetration with emerging OpEx-oriented robots-as-a-service (RaaS) business model.
- Growing focus on adoption of AMR due to its scalability (add or remove robots) based on the current or seasonal-peak business requirements.

Competition Dynamics:

- This study includes analysis of key vendors, including 6 River Systems, Eiratech Robotics, Fetch Robotics, Geek+, Gideon Brothers, GreyOrange, IAM Robotics, inVia Robotics, Locus Robotics, Magazino, Mobile Industrial Robots (MiR), Omron, OTTO Motors, Prime Robotics, Scallog, Seegrid, and Vecna Robotics.
- 6 River Systems, Fetch Robotics, GreyOrange, IAM Robotics, inVia Robotics, and Locus Robotics are the top performers and 2021 technology leaders in the global Autonomous Mobile Robot (AMR) market. Magazino has been recognized and positioned as an emerging AMR technology leader.
- Geek+, MiR, Omron, and Vecna Robotics are amongst major challengers in the 2021 SPARK Matrix of the global AMR market. The SPARK Matrix also provides an analysis of the vendors, including Gideon Brothers, Seegrid, OTTO Motors, Prime Robotics, Scallog, Eiratech Robotics.

Market Overview and Technology Trends

Amazon introduction of Prime in 2005 and acquisition of Kiva Systems in 2012, an autonomous mobile robot for warehouses, has played as a driving force in automating warehouse operations. Amazon, with the global success of Prime services, has significantly raised the consumer expectation as same-day delivery or next-day delivery are increasingly becoming the norm. Therefore, eCommerce and retail organizations are increasingly looking at building an efficient, flexible, and automated supply chain processes to satisfy ever-increasing customer expectations. Adoption of warehouse automation technologies to enable faster, efficient, and dynamic order fulfilment is amongst the primary target for automating supply chain operations.

Traditional heavier mechanized automation systems deployment was limited to large warehouses and often associated with significant upfront investments and more extended payback time. Advancements in robotics technology have led to the emergence of affordable robotics and automation systems, such as an automated guided vehicle (AGV), autonomous mobile robots (AMR), drones, automated storage and retrieval systems (AS/RS), and other flexible automation systems that can be deployed in various warehouses. Consequently, the number of companies deploying robotics and automation technologies to improve warehouse operations and address workforce challenges is increasing. The current geopolitical scenario is seeing e-commerce and retail organizations increasingly look at building efficient, flexible, and automated supply chain processes to satisfy the ever-increasing customer expectations. The adoption of warehouse automation technologies to enable faster, efficient, and dynamic order fulfillment is amongst the primary target for automating supply chain operations.

Autonomous mobile robots' fundamental value proposition of improving warehouse efficiency and productivity by automating various non-value-adding material movement activities and freeing up the human workforce for value-adding activities, helping organizations address labor shortage challenges, and providing quick ROI, are driving the market growth across the geographic regions. Driven by the exponential growth opportunities, several new entrants are emerging in the AMR market with regional-specific market focus and use-case-specific robot offerings. Additionally, existing AMR vendors are making significant investments in improving the technology value proposition of their offerings to overcome anticipated competition.

With the impact of the ongoing Covid-19 pandemic, many industries continue to post negative growth. However, the eCommerce industry continues to witness a surge in online ordering during this time. Retailers are adopting various order fulfillment strategies and operational models to meet the increasing online retail demand and deliver a seamless customer experience. While the Covid-19 situation and the

subsequent lockdown across various countries had a temporary impact on the AMR market, the long-term market outlook remains promising. Retailers across product categories and geographical regions have well understood the importance of deploying automated systems to automate non-value adding processes, improve warehouse efficiencies, reduce cost, and overcome the ever-growing challenge of labor shortage.

Quadrant's research on autonomous mobile robots focuses on exploring the current market scenario, market dynamics, and short-term and long-term growth opportunities across various industries and geographical regions.

Market Definition and Overview

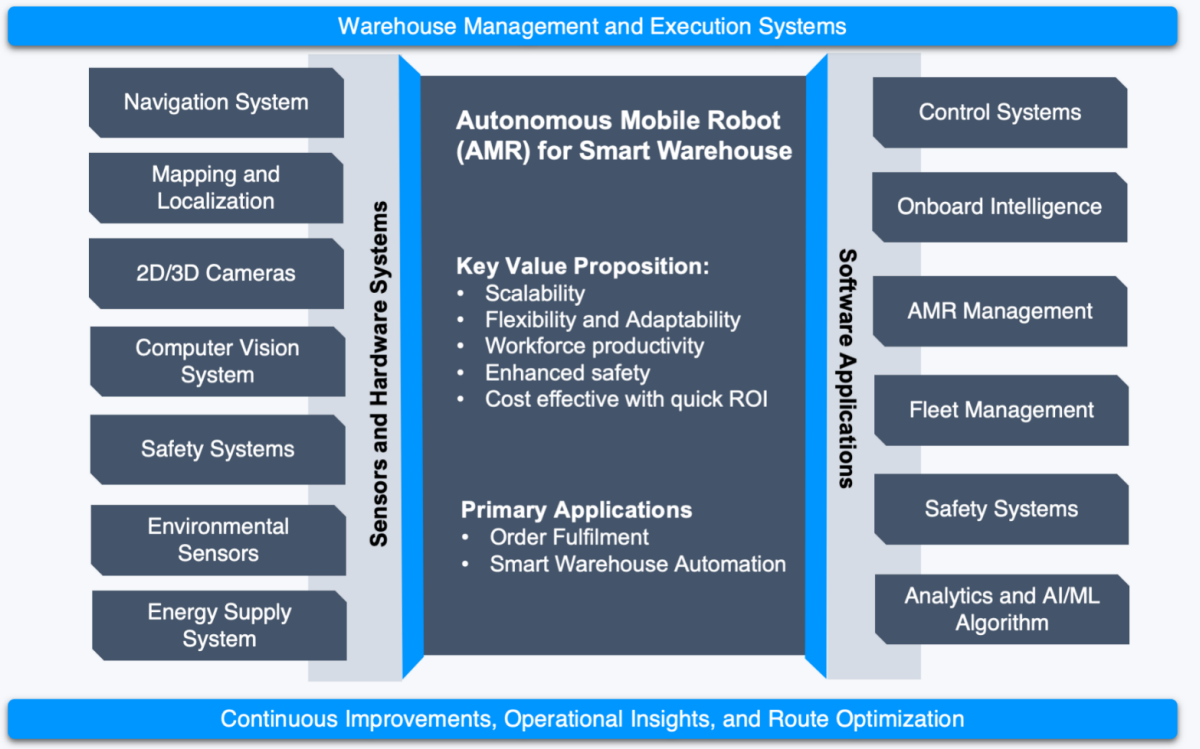
An Autonomous Mobile Robot (AMR) is a robot that is equipped with numerous sensors and software applications for interpreting and understanding its surrounding environment in order to navigate through various obstructions, automatically determine an optimum route to accomplish tasks and work collaboratively with operators for performing a range of operations, including order picking, sorting, and other material movements within the warehouse without the need for human supervision.

The AMR is an upgraded version of the automated guided vehicles (AGVs) that utilizes advanced sensors and software applications with sophisticated algorithms to perform efficient material movement tasks, either independently or in conjunction with the human workforce. Automated guided vehicles (AGVs) are equipped with simple sensors and follow fixed routes using magnetic tapes, wires, or other markers implanted on the floor. AGVs are deployed across a range of warehousing facilities to automate various material movement operations. However, in the age of growing e-commerce, increasing complexities of ordering scenarios, ongoing labor challenges, and requirements for omnichannel fulfillment, retailers are looking at adopting advanced automation technologies to improve operational performance and optimize costs. AGVs often lack the flexibility and adaptability to handle the growing complexities of logistics and supply chain operations.

An AMR is equipped with an array of sophisticated sensors and embedded intelligence that allows the bot to understand its operating environment to effectively perform complex material movement operations and collect operational data to provide advanced insights for route optimization. An AMR may include sensors for mapping, navigation, localization, computer vision, 3D cameras, and other environmental sensors. Most AMRs use LiDAR sensors for dynamic navigation and avoiding various fixed and moving obstructions. AMR navigation within a specific warehouse environment is often achieved by building comprehensive maps that are either developed by AMR or by uploading prebuilt warehouse maps into the AMR

system. Hence, while an AGV may just stop if it detects an obstacle in its path, an AMR can move around the obstacle to continue its operations.

Figure: Autonomous Mobile Robot (AMR) for Smart Warehouse



Source: Quadrant Knowledge Solutions

Leading AMR vendors are leveraging artificial intelligence and machine learning algorithms for real-time decisioning on path optimization, improved object recognition, and enhanced collision avoidance with people and other fixed and moving objects within the operating environment. The AMR system often integrates with other mobile robots, warehouse control systems, warehouse management systems, and other warehouse execution systems for tracking, monitoring, governance, and control functions. Depending on the vendors' capabilities, AMR solutions may also offer fleet management capabilities to organize, manage, and orchestrate the movement of the AMR fleet to avoid collision with other vehicles, people, and other objects.

Based on the AMR vendors' offerings and use cases, the AMR market is primarily grouped based on the bots' application, including:

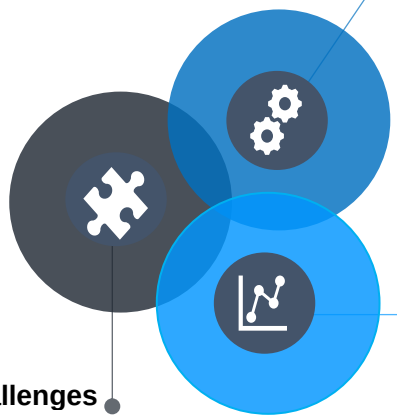
- **AMR for Order Fulfillment** includes collaborative robots to automate various order fulfillment processes within the warehouse or the fulfillment center environment by working collaboratively with warehouse associates.

- **AMR for Smart Warehousing** includes a variety of autonomous mobile robots designed to automate a variety of material movement operations within the warehouse environment.

Quadrant Knowledge Solution's Autonomous Mobile Robot study includes vendors who provide AMR solutions for order fulfillment as well as for smart warehousing applications. The AMR market is in the emerging stage and is quickly moving into the growth stage of the overall product lifecycle maturity model. The overall market, as well as the vendors positioning, is expected to change significantly in the coming years.

Growing e-commerce and Omnichannel Fulfillment Requirements are Driving Investments into Automation Systems

Growing Challenges Due to e-commerce and Omnichannel Fulfillment Requirements are Driving Investments into Automation Systems



Market Developments

- Global growth of e-commerce and omnichannel fulfillment are driving the requirements for mass-customization with the increasing volume of individual orders with tight delivery schedules.
- The warehouse operations demand for a higher level of responsiveness, adaptable, and flexible fulfillment operations to meet increasingly demanding customer expectations.

Trends

- Organizations are increasingly adopting/upgrading various supply chain technologies to optimize end-to-end supply chain and warehouse operations and boost their capabilities to improve the overall customer experience.
- AMR is increasingly becoming popular for optimizing fulfillment operations as well as for various smart warehouse applications.

Challenges

- Retail and e-commerce organizations are increasingly facing challenges due to growing order complexities, shrinking order cycle time, and ever-increasing workforce challenges.
- Driven by growing global competition, customers are increasingly becoming demanding, and thereby customer experience is becoming the primary differentiating factor amongst businesses.

Challenges | Market Developments | Trends & Outlook

Source: Quadrant Knowledge Solutions

The global growth of e-commerce and omnichannel strategies to service customers across digital and physical buying channels with real-time order fulfillment is driving the adoption of advanced supply chain technologies. Global organizations across industry verticals and geographical regions are facing challenges to optimize their processes and improve overall customer experience to survive and succeed in a dynamic market environment. Followings are the key challenges driven by omnichannel fulfillment leading to the overall investments in automation systems to improve warehouse operations and overall efficiencies:

- **Growing Order Complexities and Shrinking Order Cycle Time**: Global growth of e-commerce and omnichannel fulfillment is driving the requirements for mass customization with the increasing volume of individual orders with tight delivery schedules. The success of the omnichannel strategy requires a

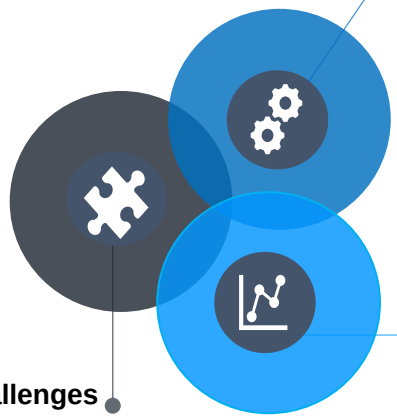
greater emphasis on inventory visibility and optimization of end-to-end supply chain execution processes to improve service levels and optimize fulfillment time across channels. The warehouse operations demand a higher level of responsiveness, adaptability, and flexible fulfillment operations to meet increasingly demanding customer expectations.

- **Growing Emphasis on Customer Experience**: Traditional automation systems and manual methods of managing warehousing operations are no longer effective in addressing today's complex and dynamic business environment, with customer experience being central to business success outcomes. Customer expectations are rising significantly with an increasing emphasis on personalized and consistent experience across sales channels. Growing global competition is further adding to the challenges with bad customer experience resulting in substantially higher customer churn rates. Organizations are increasingly adopting/upgrading various supply chain technologies to optimize end-to-end supply chain and warehouse operations and boost their capabilities to improve the overall customer experience. AMR is increasingly becoming popular for optimizing fulfillment operations as well as for various smart warehouse applications.

- **Ever-Increasing Workforce Challenges**: Omnichannel fulfillment requires significant labor resources if the warehouse and distribution centers are not equipped with advanced automation systems to support operational complexities. The challenges of attracting and retaining a qualified workforce remain an age-long industry issue and are expected to rise even further. The ever-growing transaction volumes and order complexities are significantly adding labor challenges and are driving industries towards the increasing use of automation.

Emergence of Robots-as-a-Service (RaaS) Model for AMR Deployment

Emergence of Robots-as-a-Service (RaaS) Model for AMR Deployment



Market Developments

- RaaS allows organizations to effectively balance their CapEx and OpEx strategies for effectively managing varying warehousing needs amid fluctuating demand scenarios throughout the year.
- RaaS promotes an OpEx-based approach to address temporary or seasonal demands and provides immediate ROI. It enables organizations to add or remove robots based on seasonal requirements and minimizes capital barriers.

Trends

- AMR vendors are offering RaaS business model that includes subscription-based payment that includes maintenance & support service, may consist of remote monitoring, and offer flexibility to scale up consumption with changing business needs.
- RaaS is expected to play a major role in the overall growth of the AMR market during the forecasted years of 2021-2026.

Challenges

- The contractual requirement involving CapEx investment and lengthy approval cycle hinder the adoption of AMR solution from harnessing seasonal demands to the full potential.
- SMB and mid-market organizations are often sensitive to commit to huge capital investment in acquiring assets. Robot maintenance and support adds further to the challenges.

Challenges | Market Developments | Trends & Outlook

Source: Quadrant Knowledge Solutions

Robots-as-a-Service, as the name suggests, is a subscription-based business model where robots are offered to the clients as a service, just like Software-as-a-Service (SaaS). Instead of significant capital investment, RaaS promotes an OpEx-based approach to address temporary or seasonal demands and provides immediate ROI. The RaaS model allows organizations of any size to purchase AMR subscriptions for immediate deployment. It enables organizations to add or remove robots based on seasonal requirements and minimize capital barriers.

Warehouse managers often face challenges in accurately forecasting the warehouse throughput requirements in advance, considering the sudden surge in demand due to upcoming festivals, black Friday sales, and others. RaaS allows organizations to effectively balance their CapEx and OpEx strategies for effectively managing varying warehousing needs amid fluctuating demand scenarios throughout the year. While large retailers often prefer the CapEx approach for automating warehousing

operations, a large number of small to mid-market retailers are expected to find the significant value of the RaaS model. As purchasing a RaaS subscription is generally quick with significantly reduced complex contractual processes, large retailers may also find the RaaS model attractive to gain necessary flexibility during the sudden surge in demand.

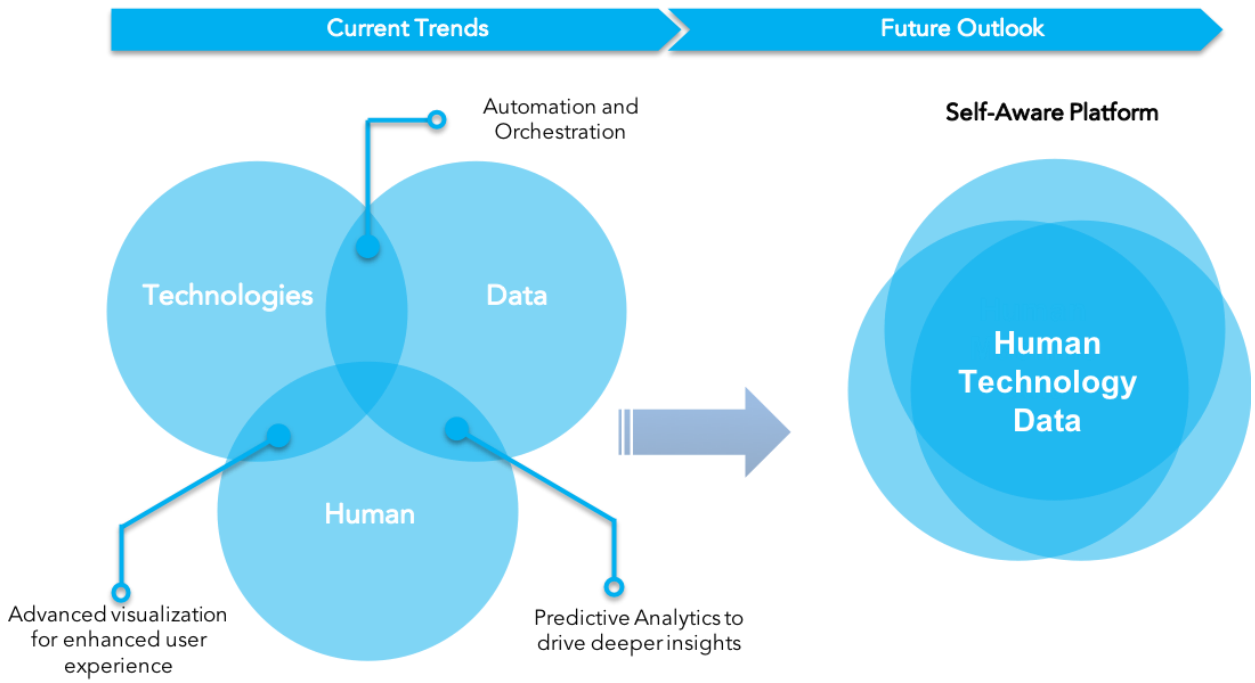
A few AMR vendors are already offering RaaS, and others are gearing up to provide the same in the coming years. RaaS is expected to play a major role in the overall growth of the AMR market during the forecasted years of 2021-2026. AMR vendors are providing a RaaS business model that includes subscription-based payment that includes maintenance & support service, may consist of remote monitoring, and offer flexibility to scale up consumption with changing business needs.

The Convergence of Automation, Machine Learning, and AI

Quadrant Knowledge Solutions continuously tracks key market and technology trends of major IT and supply chain technologies. Megatrends' analysis provides key insights into future technology developments based on the present market scenario. As per Quadrant's analysis, supply chain industries are expected to undergo significant transformation with the application of blockchain, machine learning, and artificial intelligence technologies. IT and Supply chain management technology vendors are increasingly leveraging automation, machine learning, and AI in automating repetitive tasks and manual processes to improve process efficiency, resource utilization, and productivity.

As per Quadrant's analysis of the overall market, supply chain management technologies are becoming collaborated, automated, and intelligent. The adoption of automation, machine learning, and AI is amongst the most significant trend and is expected to grow in the upcoming years significantly. Machine learning and artificial intelligence are expected to drive the next generation of supply chain management solutions with the emergence of a self-aware platform integrating humans, data, and technologies.

Figure: MegaTrend and Technology Convergence
Supply Chain Technologies are Becoming Collaborative, Automated, and Intelligent



Growing Adoption of Automation, Visual Navigation, Machine Learning and Artificial Intelligence to Optimize AMR Functionality and Performance.

AI/ML technologies are playing a significant role in augmenting the capabilities of smart mobile robots. By leveraging AI technology, AMR vendors can offer more flexible, reliable, and safe robots that can perform a variety of tasks by collaborating with humans, ensuring reduced errors and improved safety in high-risk environments. Vendors are offering AI-driven AMRs with built-in 3D cameras, advanced sensors, and voice & gesture navigation support to help organizations efficiently and seamlessly navigate across the fulfillment centers. These built-in 3D cameras are providing robots with real-time 360-degree visibility of nearby objects, helping them to intelligently identify and differentiate objects, enabling navigation in the narrow aisle, and easily acclimatizing its movements in a low-light environment. The AI capabilities are helping the bots to simultaneously develop a 3D map of the entire facility and transfer this critical information to new/existing bots for quick deployment and task execution.

Organizations are constantly working towards powering their material handling software with leading technologies such as artificial intelligence (AI) and machine learning (ML) to gather real-time data from various material handling devices. Vendors are offering AI-driven fleet management software that is helping organizations understand the patterns of a robot's battery performance and develop a systematic workflow for battery management and smart docking. This will allow robots to intelligently perform numerous tasks with limited battery power and autonomously navigate to a charging dock before battery exhausation. AI technology is also helping organizations to determine the maintenance and service requirements of the bots. Organizations are increasingly adopting AI and automation-powered AMR to intelligently develop path planning, task distribution, battery management, group order, zone picking and gain valuable insights through AI-powered, advanced data analytics and dashboarding capability. Organizations are shifting towards AI-powered robots that leverage deep learning algorithm to accomplish various labor intensive warehouse tasks (picking, packing, and more) and minimize costs on the long-term basis. Considering the potential benefits offered by AI/ML-powered AMR systems, organizations will continue to deploy AMR systems for increasing warehouse productivity with minimum human interference and drive ROI.

Figure: Artificial Intelligence and Machine learningTechnologies are enhancing AMR Functionality & Performance

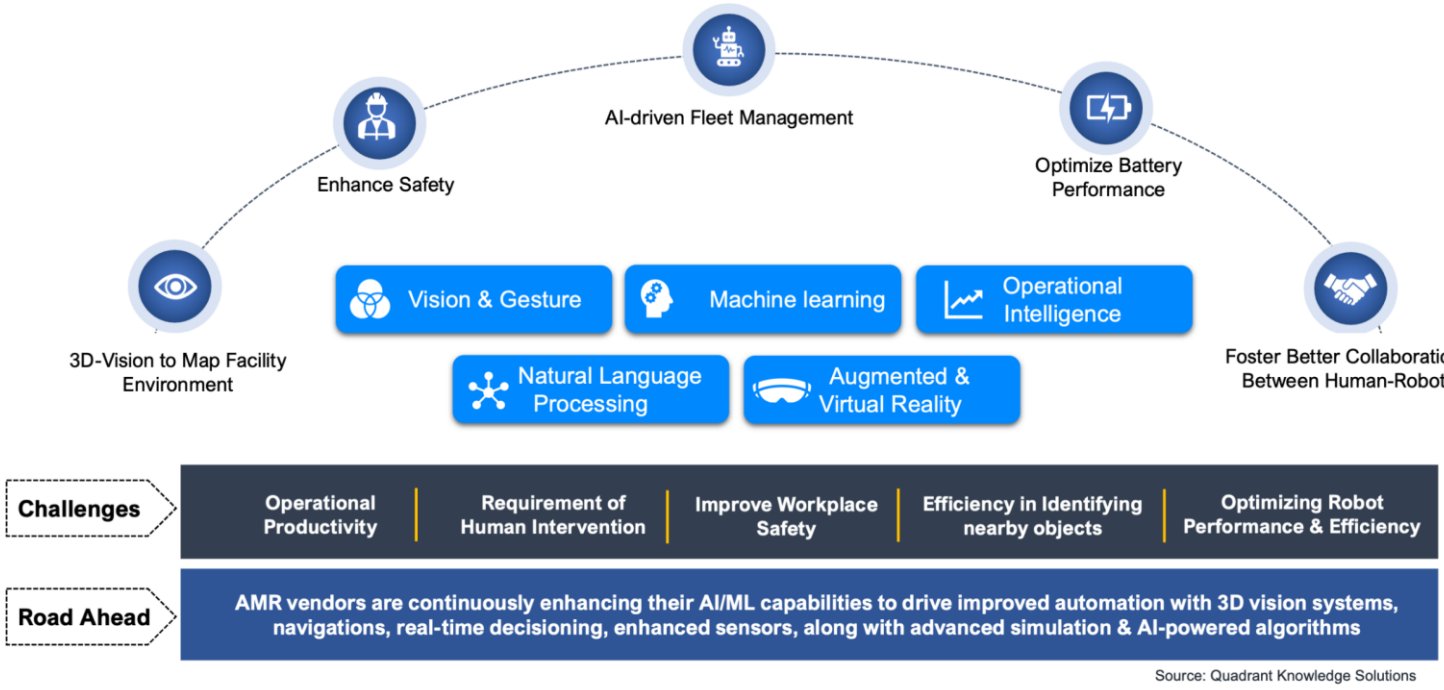


Figure: Artificial Intelligence & Machine Learning Technologies are enhancing AMR Functionality & Performance

The Dynamics of Covid-19 is Contrinuting to Significant Growth of AMR Market

The Covid-19 pandemic has caused global supply chain disruptions, and humans are advised to adhere to social-distancing norms. With the necessity to maintain social-distancing, labor shortage in the facilities are generating the need of autonomous mobile robots to intelligently perform various warehouse operations such as picking, packing, moving of goods, sorting, and replenishment. As a result, there is the significant rise in adoption of autonomous mobile robots. Organizations are focusing on increasing overall operational productivity and minimizing human intervention to maximize ROI. Organisation are levaraging AI/ML capabilities to intelligently develop path planning, task distribution, battery management, group order, zone picking, and gain insightful data through intuitive AI-powered data analytics and dashboards.

The Covid-19 control measures has imposed restriction on the installation, training, or maintenance of industrial AMR's. This has provoked AMR vendors to support virtual deployments of robots, eliminating the need for vendors to visit warehouse to set up the robots and train the warehouse associates. With this virtual deployment support, organizations are able to manage robots virtually from any location, intelligently allocate tasks and monitor robot's performance.

The pandemic crises has caused a significant reduction in the trade, cash flow and dedicated workforce across the supply chain businesses. With capital and workforce deficiency, there is an increased adoption of Robot-as-a-Service (RaaS) model. The RaaS model helps organizations to pay only for system services, removing the burden of owning robot equipment and making robotics economical to businesses of all sizes.

Growing Collaboration and Partnership to Transform Warehouse Operations

Organizations are deploying AMR separately across their warehouse to automate the repetitive warehouse tasks for a while now. But to automate picking replenishment, inventory movement and improve the warehouse productivity in a more holistic way, AMR vendors are now focusing on supporting AMR integration with supply chain technologies such as WMS, WES, ERP and MES systems. In order to drive operational flexibility, vendors are focusing on collaborating and partnering with these supply chain leaders to enable organization quickly fulfil order in an omni-channel environment. It is also helping organizations to leverage real-time data/ insights regarding robot's throughput and current operational status, workforce performance and more, to devise optimal fulfilment strategies. Vendors offering cloud-based robotics software/fleet management software are collaborating with leading WMS vendors to support quick and secure deployment of AMR's. Many supply chain technology vendors are partnering with AMR vendors to offers end-to-end AMR capabilities to meet increasing demand for low-cost automation. Vendors are offering pre-developed integration modules/APIs to seamlessly integrate with leading WMS vendors.

WMS suppliers are looking forward to merge WMS and AMR capabilities to create smart warehouses. Leading WMS companies such as Manhanttan Associates, Körber Supply Chain, Blue Yonder, and others are increasingly investing in building end-to-end AMR solution portfolio consiting of solution designing to architecture planning, complete implementation to offer customized solution and after-sales services.

Competitive Landscape and Analysis

Quadrant Knowledge Solutions conducted an in-depth analysis of major autonomous mobile robot vendors by evaluating their products, market presence, and value proposition. The evaluation is based on primary research with expert interviews, analysis of use cases, and Quadrant's internal analysis of the overall AMR market. This study includes analysis of 17 key vendors, including 6 River Systems, Eiratech Robotics, Fetch Robotics, Geek+, Gideon Brothers, GreyOrange, IAM Robotics, inVia Robotics, Locus Robotics, Magazino, Mobile Industrial Robots (MiR), Omron, OTTO Motors, Prime Robotics, Scallog, Seegrid, and Vecna Robotics.

6 River Systems, Fetch Robotics, GreyOrange, IAM Robotics, inVia Robotics, and Locus Robotics are amongst the top performers and technology leaders in the 2021 SPARK Matrix analysis of the global autonomous mobile robot market. These companies provide sophisticated products and solution portfolios to enable organizations to automate various material movement operations to improve warehouse efficiency, workforce productivity and gain operational agility to respond to dynamic market requirements. These companies also provide comprehensive technology capabilities and are gaining significant market traction in the global AMR market. Magazino is amongst the emerging technology leaders and is leading the market with effective competition and growth strategy execution.

Geek+, MiR, Omron, and Vecna Robotics have been positioned as the primary challengers in the global AMR market. Geek+, MiR, Omron, and Vecna Robotics offer a broad portfolio of autonomous mobile robots to automate various material movement applications within the warehouse environment. These companies support a variety of use cases to optimize order fulfillment efficiencies and support general warehouse automation use cases. Gideon Brothers, OTTO Motors, Seegrid, Prime Robotics, Scallog, and Eiratech Robotics are some other key vendors positioned in the 2021 AMR SPARK matrix.

As per Quadrant research analysis, the AMR market is in the emerging stage and is quickly moving into the growth stage of the overall product lifecycle maturity model. The overall market, as well as the vendors positioning, is expected to change significantly during the forecasted years. With the presence of multiple AMR products and vendors with varying capabilities, organizations often face difficulties in finding the right product and vendor partner suitable for their industry-specific and organization-specific use cases. Depending on the vendors' target market for warehouse automation applications, most AMR vendors may provide all the core functionalities of automating various material movement operations within a warehouse environment. The breadth and depth of functionalities may differ by different vendor's offerings.

Key Competitive Factors and Technology Differentiators

Followings are the key competitive factors and differentiators for the evaluation of autonomous mobile robots and vendors. While the majority of the AMR vendors may provide all the core functionalities, the breadth and depth of functionalities may differ by different vendors' offerings. Driven by increasing competition, vendors are increasingly looking at improving their technology capabilities and overall value proposition to remain competitive. Some of the key differentiators include:

- **Integration & Interoperability :** Users should evaluate AMR products that offer ability to easily integrate into any type and size of facility. They should consider vendors ability to support rapid physical and virtual deployment of robots without additional infrastructure and systems requirements. AMR's should include an easy to use integrated touch screens which can be operated without any prior training. Users should consider AMR's that runs in the secure cloud, accessible via a web-based interface from any location. AMR vendors should provide a range of built-in, out-of-the-box integration connectors, data integration framework, and APIs to deliver a seamless end-user experience. Vendors should offer open AMR's that enable users or third parties to build and configure solutions based on their facility requirements. AMR vendors may offer out-of-the-box integrations with existing WCS and robotic fleet management software, which are in turn linked to WES and WMS. AMR vendors may also offer a partner ecosystem comprising of technology partners, service partners (maintenance and installation), third-party hardware and software integrators to deliver value-added services and offer collaborative business growth opportunities. Users should condier vendors that offer wide range of add-ons (such as grippers, hooks, pallets, shelf carrier, conveyor, weight measurements, and more) within the robots and also provide flexible and configurable tops to accommodate their warehouse requirements. Also, users should assess the vendors ability to integrate with their existing tools and infrastructure seamlessly. Furthermore, AMR platforms should facilitate users to sync with their native and existing technology offerings. Vendors should have clear understanding to integrate legacy infrastructure with new technologies.

- **Vision and Roadmap:** Vendor's capability to formulate a comprehensive and compelling technology roadmap, market, and growth strategy is a crucial factor for users prior to the adoption of the AMR platform. The vendors should possess an in-depth understanding of the market dynamics to analyze the potential investments of their assets. Users should evaluate vendors that are adopting workflows and technologies core to their business in the future. Users

should evaluate vendors that have a customer-centric approach and engage with their customers to understand the critical needs and requirements to design a comprehensive roadmap. AMR vendors may focus on upgrading its robots and fleet management software by incorporating advanced fulfilment algorithms and various leading technologies. The roadmap may include upgrading existing technology, implementing modern AI/ML-driven technologies, leveraging industrial IoT, 5G technology, enhancing 3D vision technology, voice, and gesture support and more. It should also include addition of various new robots to vendor's existing portfolio for executing diverse range of task and fulfil customer requirements in complex business environment. Users should consider the vendor's focus on potential investments in mergers and acquisitions and partnerships, as well as R&D of new platform features and functionalities. Users should also evaluate the vendor's ability to adopt capabilities of AI/ML, analytics, transformation, and automation across their business and applications. It is also critical for users to evaluate vendors with the necessary expertise to execute the outlined roadmap.

- **Maturity of Analytics, Reporting, and AI Capabilities:** AMR solution vendors capability in offering sophisticated analytics, reporting, and AI capabilities may significantly differ from vendor to vendor. Many leading AMR platform providers have integrated AI, machine learning, and predictive analytics capabilities to offer deep-dive analytics/actionable insights functionalities to help organizations understand the robot's performance, task allocation, resource utilization, path planning and overall warehouse performance KPIs. These insight may help organizations to leverage real time data and make informed decisions and take quick actions. Vendors may offer strong data support by using various data lakes and data warehouses to provide comprehensive visual reports, simulation, smart robot maintenance, and business and market intelligence. Users should also assess the AMR platforms that support predictive analytics with what-if capabilities to anticipate key drivers and variables influencing robots performance. Vendors should support simulation of robot systems to enable users determine ideal configurations and algorithms, build plans, and understand its efficiency, prior to actual deployment. It also helps organizations to understand suitable warehouse layout, quantity of robots and design and implement ideal fulfillment strategy. Organizations should evaluate an AI-driven AMR platform that helps them to understand robot's current operational status and adjust operational processes based on the facility requirements. AMR should be equipped with advanced set of real-time, ML algorithms and models for efficient obstacle detection, order clustering/distribution, picking & replenishment, inventory audit, and advance workflow designing. Vendors should support self-

supervised learning algorithms to train the robots for intelligently identifying the objects in real time through 3D cameras and advanced sensors.

- **Vendors Expertise and Domain Knowledge :** Organizations should evaluate vendors' expertise and domain knowledge to understand their ability to address unique and complex business challenges, use cases, and industry-specific requirements. It is critical for users to consider vendors in-depth knowledge of a specific industry, including how it is evolving, the emerging trends, and the factors that will influence it. Users should look for ease of use, comprehensiveness of offering, software's flexibility to adapt with constant market changes and regulatory requirements, minimizing total cost of ownership, and transparency. Users should consider the vendors' ability to acknowledge various technical challenges that arise as a result of the complex and dynamic environment of the autonomous systems and integration between hardware and software systems. Vendors should have the ability to understand and uncover unmet business requirements as well as bridge the technology and service gaps. They should also be well versed with potential business and technology risk and formulate an effective strategy to mitigate high risk which may impact business growth. Users should also look for a solution with a history of successful large-scale deployments and carefully analyze the existing case studies of those deployments. This should form the basis to prepare the best-practice for AMR deployments.

- **Adapatibility and Flexibility**: AMR vendors should offer an automated and scalable product having capability to handle wide range of operations such as picking, packing, replenishment, sorting, and material movement. The platform should be scalable enough to support high volume of orders and run robots in multiple shifts. Users should consider AMR platforms that provide high-level customization/ configuration to deliver a significant level of availability to cater wide range of industries. Vendors should offer range of robots for performing various dedicated multiple operations. The AMR platform should have the flexibility to support secured cloud-based deployment models. The platform should include a sophisticated system failure detection and recovery mechanism to tackle any possibilities of robot and service disruption. It should include an intuitive and modular user interface and support enterprise readiness, robust security, and compliance needs. The platform should be based on an open architecture to support the development of new functionalities, smooth transition of existing platform capabilities post-merger and acquisition activities and allow professional service teams and business partners to accommodate unique customer needs. Ability to offer multi-language support as well as intuitive and user-friendly UI to reduce total training time and increase overall throughput. Almost all major AMR vendors

claim to support a large-scale enterprise-class deployment capability. However, the depth of technical functionalities and capabilities for smooth up-scaling and down-scaling with multiples of hundreds/thousands of data transactions may differ from vendor to vendor.

- **Flexible pricing model (CapEx vs OpEx):** Users should consider AMR vendors that support Robotics-as-a-Service (RaaS) model to help organizations by reducing costs and eliminating the burden of equipment ownership. Users should evaluate vendors that provide packages which consist of an AMR fleet, 24/7 dedicated support, timely maintenance, accessories, various add-ons, and other benefits based on subscription plans. The RaaS model's subscription plans should offer easy adding/removing of robots and configuring them based on order volume and seasonal peak with minimal service charges. In addition, users should also consider AMR vendors that enable them to update and maintain robots from remote location within the SLA's. User should also consider vendors that offers lifetime updates, upgradation, modification of AMR and fleet management software to stay aligned with changing business needs.

- **Sophistication of Technology Capabilities**: A primary factor for adopting an AMR platform is its ability to provide comprehensive technology capabilities to cater diverse and changing needs of organizations across industry sectors. User should evaluate AMR's equipped with end-to-end automation and material handling equipment capabilities. Major AMR vendors are providing autonomous mobile robots that do not require any additional infrastructure changes in the facility. While few other vendors are also offering robots that require markers, wires, and magnetic tapes to seamlessly navigate within the facility or warehouse. Users should evaluate AMR vendors that provide strong battery support including autonomous charging dock and hot-swappable batteries. The AMR platform should provide complete control to users for configuring the robots' tops, accessories, add-on modules and features based on their warehouse requirements. Vendors should offer AMR's packed with LED indicators to understand the status of battery and robot's location inside the facility. Many vendors are providing zone picking, batch picking, cycle counting, replenishment, conveyor picking/put-away, packing and return order management capabilities. Vendors are also offering robots equipped with handled-scanners and intuitive screens to work collaboratively with workers and understand the right product and guide them to next pick up/put away location. Vendors are also focusing on equipping their robots' with multiple light sensors to work under low-light conditions and avoid any obstacles. Furthermore, vendors are also offering several shelves to carry wide range of totes, bins and packages to the workstation.

SPARK Matrix™: Strategic Performance Assessment and Ranking

Quadrant Knowledge Solutions' SPARK Matrix provides a snapshot of the market positioning of the key market participants. SPARK Matrix provides a visual representation of market participants and provides strategic insights on how each supplier ranks related to their competitors, concerning various performance parameters based on the category of technology excellence and customer impact. Quadrant's Competitive Landscape Analysis is a useful planning guide for strategic decision makings, such as finding M&A prospects, partnerships, geographical expansion, portfolio expansion, and similar others.

Each market participant is analyzed against several parameters of Technology Excellence and Customer Impact. In each of the parameters (see charts), an index is assigned to each supplier from 1 (lowest) to 10 (highest). These ratings are designated to each market participant based on the research findings. Based on the individual participant ratings, X and Y coordinate values are calculated. These coordinates are finally used to make SPARK Matrix.

Technology Excellence	Weightage
Sophistication of Technology	20%
Competitive Differentiation Strategy	20%
Application Diversity	15%
Scalability	15%
Integration & Interoperability	15%
Vision & Roadmap	15%

Customer Impact	Weightage
Product Strategy & Performance	20%
Market Presence	20%
Proven Record	15%
Ease of Deployment & Use	15%
Customer Service Excellence	15%
Unique Value Proposition	15%

Evaluation Criteria: Technology Excellence

- **The sophistication of Technology**: The ability to provide comprehensive functional capabilities and product features, technology innovations, product/platform architecture, and others.
- **Competitive Differentiation Strategy**: The ability to differentiate from competitors through functional capabilities and/or innovations and/or GTM strategy, customer value proposition, and such others.
- **Application Diversity**: The ability to demonstrate product deployment for a range of industry verticals and/or multiple use cases.

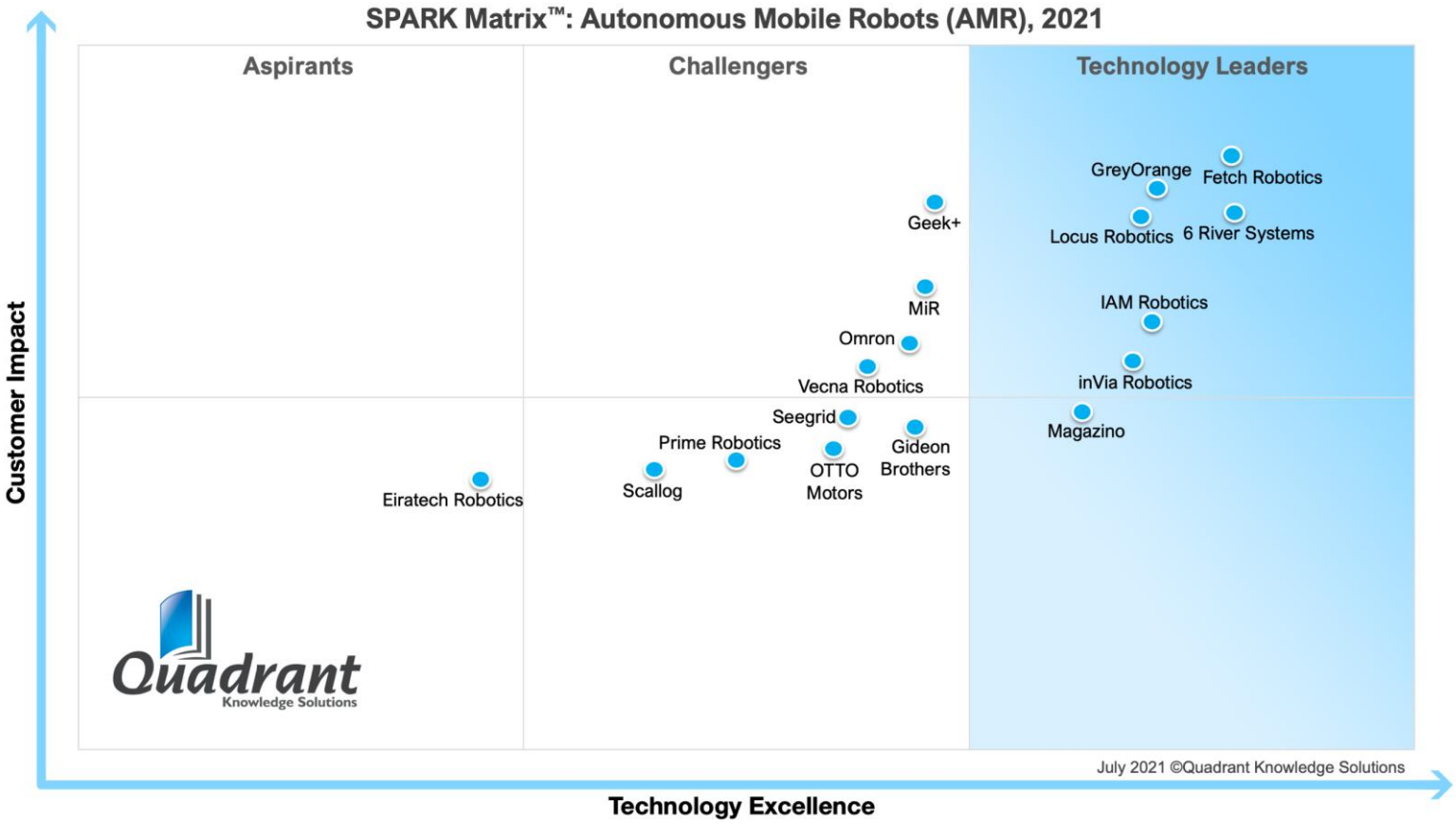
- **Scalability**: The ability to demonstrate that the solution supports enterprise-grade scalability along with customer case examples.
- **Integration & Interoperability**: The ability to offer product and technology platform that supports integration with multiple best-of-breed technologies, provides prebuilt out-of-the-box integrations, and open API support and services.
- **Vision & Roadmap**: Evaluation of the vendor's product strategy and roadmap with the analysis of key planned enhancements to offer superior products/technology and improve the customer ownership experience.

Evaluation Criteria: Customer Impact

- **Product Strategy & Performance**: Evaluation of multiple aspects of product strategy and performance in terms of product availability, price to performance ratio, excellence in GTM strategy, and other product-specific parameters.
- **Market Presence**: The ability to demonstrate revenue, client base, and market growth along with a presence in various geographical regions and industry verticals.
- **Proven Record**: Evaluation of the existing client base from SMB, mid-market and large enterprise segment, growth rate, and analysis of the customer case studies.
- **Ease of Deployment & Use**: The ability to provide superior deployment experience to clients supporting flexible deployment or demonstrate superior purchase, implementation, and usage experience. Additionally, vendors' products are analyzed to offer a user-friendly UI and ownership experience.
- **Customer Service Excellence**: The ability to demonstrate the vendor's capability to provide a range of professional services from consulting, training, and support. Additionally, the company's service partner strategy or system integration capability across geographical regions is also considered.
- **Unique Value Proposition**: The ability to demonstrate unique differentiators driven by ongoing industry trends, industry convergence, technology innovation, and such others.

SPARK Matrix™: Autonomous Mobile Robot (AMR)
Strategic Performance Assessment and Ranking

Figure: 2021 SPARK Matrix™
(Strategic Performance Assessment and Ranking)
Autonomous Mobile Robot (AMR) Market



Vendor Profiles

The following vendor profiles have been written based on the information provided by the vendors' executives as part of the research process. The Quadrant research team has also referred to the respective company's website, whitepapers, blogs, and other sources for writing the profile. A detailed vendor profile and analysis of all the vendors, along with various competitive scenarios, are available as a custom research deliverable to our clients. Users are advised to directly speak to respective vendors for a more comprehensive understanding of their technology capabilities. Users are advised to consult Quadrant Knowledge Solutions before making any purchase decisions regarding autonomous mobile robot technology and vendor selection based on research findings included in this research service.

Fetch Robotics

URL: https://fetchrobotics.com/

Founded in 2014 and headquartered in San Jose, California, Fetch Robotics is a provider of a wide range of autonomous mobile robots (AMRs) and a cloud-based robotic management platform for both commercial and industrial environments. The cloud robotics platform delivers on-demand warehouse automation support.

Fetch Robotics has designed a cloud-based interconnected ecosystem for warehouse & manufacturing automation solutions. The series of AMR portfolio at Fetch Robotics for end-to-end automation solutions includes:

- HMI Shelf: HMIShelf is an autonomous mobile robot with configurable and customizable shelves. The bot capable of carrying a variety of bins, totes, and packages sizes. The robot is equipped with a built-in intuitive touchscreen for point-to-point manual material handling tasks. The robot leverages the Fetch robotics dynamic obstacle avoidance feature to navigate alongside people, forklifts, and other material handling equipment.

- CartConnect100: CartConnect100 is an AMR that is capable of picking up or dropping FetchCarts within the facilities. FetchCarts are warehouse carts designed for use with CartConnect. The FetchCart is capable to support a payload of up to 150 lbs and can be flexible adjust the middle shelves as per requirements. It can navigate at a speed of 1.5 meters/s and can carry up to 150 lbs weight. CartConnect100 is equipped with multiple sensors and 2D/3D cameras that help the bots to understand the nearby environment to dynamically avoid obstacles and collisions. CartConnect100 maneuver at speed up to 1.5 m/s and uplift payload up to 150lbs.

- CartConnect 500: CartConnect500 is an AMR that is capable of transporting a payload of up to 500lbs within the facilities. The CartConnect500 is equipped with a lift module that picks up and drops off the payload. CartConnect500 can autonomously set up recurring workflows to pick up and drop off payloads and collect the empty cart for replenishment. This capacity leads to reduced cycle count and enhanced warehouse productivity.

- RollerTop: The RollerTop autonomous mobile robot offers conveyor-to-conveyor material transport. These robots can autonomously pilot their way to conveyor ends and/or ASRS ends to load and unload totes and bins.

- Freight 500 & Freight 1500: Fetch Robotics offers two-size industrial AMRs to enable on-demand pallet transport within the facility. The Freight500 can carry up to 500kg weight and has a battery capacity of 9hrs. Frieght1500 can carry

up to 1500 kg and work up to 9hrs on a single charge. Both the bots are equipped with multiple sensors that help the bots to easily maneuver on mezzanine floors.

- TagSurveyor: TagSurveyor is an AMR that helps organizations in continuous cycle counting and inventory tracking. The bot is packed with three RFIDs, 82 degrees of sensor coverage, and a read range of up to 25ft.

- Freight100 Mobile Base: This bot can be customized and configured as per customer demands to cater to a wide range of industries. The bot can work up to 10 hours on a single charge and is packed with: LiDAR sensors, a 6-axis gyro, accelerometer, and two 3D depth cameras for navigation.

Fetch Robotics also offers customizable Fetch Mobile Manipulator and Freight Mobile. It also offers disinfection AMRs, including BreezyOne and SmartGuardUV.

Analyst Perspective

Following is the analysis of Fetch Robotics' capabilities in the global Autonomous Mobile Robots market:

- Fetch Robotics' autonomous mobile robots (AMRs) help organizations optimize their warehouse operations, respond to e-commerce volume growth and seasonal peaks while giving organizations control over their labor costs. These AMRs can collaboratively work alongside warehouse associates to enhance warehouse productivity, operational efficiency, and overall throughput. The company also offers a cloud-based autonomous mobile robot (AMR) solution for warehousing and intralogistics environments that addresses material handling and data collection requirements. The company owns ten patents and continuously works for innovation on robots and their implementation. It company helps organizations to deploy autonomous mobile robot solutions in any facility regardless of size or any change in infrastructure and provides unified data across fulfillment centers. This enables organizations to quickly deploy autonomous robotics solutions in hours instead of days or months. Fetch robotics can perform a wide variety of warehouse operations such as picking, replenishment, put away, cross-docking, packing, sorting, return, and cycle counting.

- Fetch Robotics' top key differentiators include FetchCore Enterprise Robot Planning (ERoP), FetchLink controller, and workflow builder.

- FetchCore Enterprise is a cloud-based application that helps organizations manage and monitor the entire Fetch Robotic AMR fleet. Fetch Robotics also offers the FetchLink controller, which is a networked industrial I/O device that

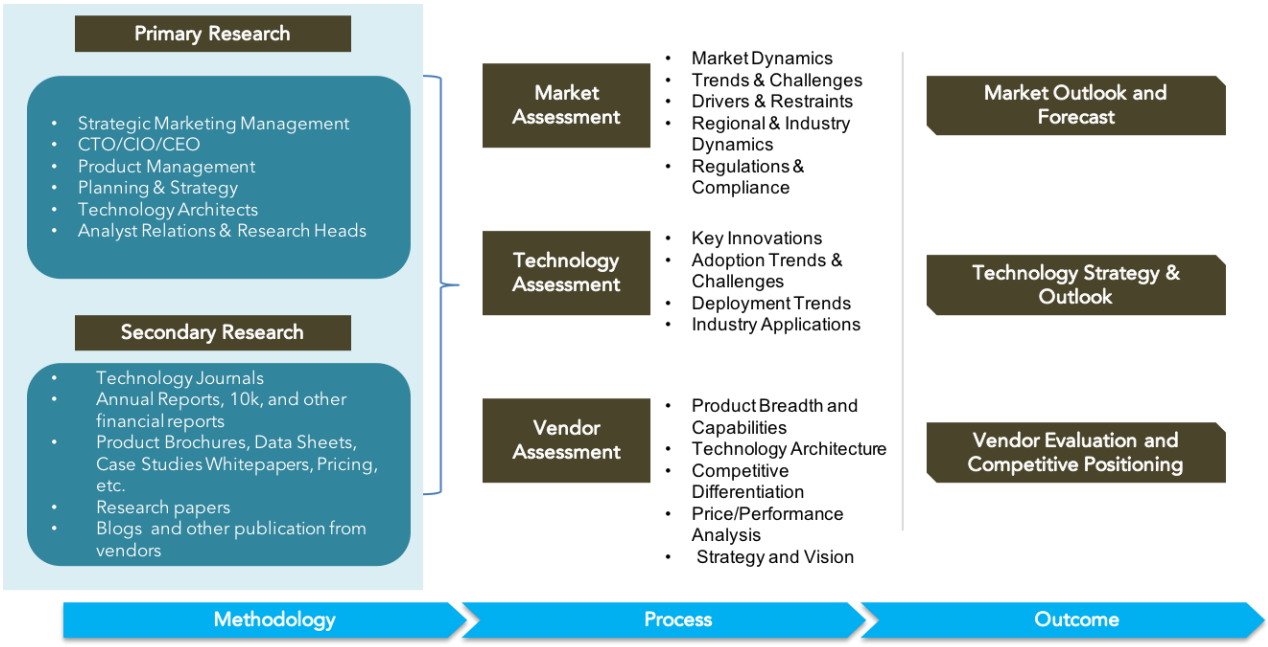
connects the Fetch Cloud Robotics Platform with other industrial equipment like conveyors, doors, and air showers. The company offers a drag-and-drop development tool kit that helps organizations develop a customized automation workflow.

- From a geographical presence perspective, Fetch Robotics has a strong presence in North America and Europe, followed by APAC. From an industry vertical perspective, the company caters to various Warehousing and Manufacturing facilities, including 3PL, retail, healthcare, manufacturing, electrical, and various other industries. The company has an extensive partner ecosystem that includes a range of integrators, consultants, and value-added resellers. To expand its presence beyond its current market, the company is focusing on building a strong network of partners and integrators.

- The primary challenge for Fetch Robotics is growing competition from well-established automation and AMR players as well as emerging AMR vendors continuously focusing on innovation. These companies are increasingly broadening their AMR portfolio and solutions offerings by developing strong partnership ecosystems and onboarding specialists from the supply chain planning and execution domain. With its wide range of AMR portfolio, advanced Fetch cloud robotics solutions, strong track record, trusted partner ecosystems, strong customer value proposition, enterprise customer engagement, and highly scalable and adaptable offering, Fetch Robotics is well-positioned to expand its market share and customer base in the global AMR market.

Research Methodologies

Quadrant Knowledge Solutions uses a comprehensive approach to conduct global market outlook research for various technologies. Quadrant's research approach provides our analysts with the most effective framework to identify market and technology trends and helps in formulating meaningful growth strategies for our clients. All the sections of our research report are prepared with a considerable amount of time and thought process before moving on to the next step. Following is the brief description of the major sections of our research methodologies.



Secondary Research

Following are the major sources of information for conducting secondary research:

Quadrant's Internal Database

Quadrant Knowledge Solutions maintains a proprietary database in several technology marketplaces. This database provides our analysts with an adequate foundation to kick-start the research project. This database includes information from the following sources:

- Annual reports and other financial reports
- Industry participant lists
- Published secondary data on companies and their products
- Database of market sizes and forecast data for different market segments

- Major market and technology trends

Literature Research

Quadrant Knowledge Solutions leverages several magazine subscriptions and other publications that cover a wide range of subjects related to technology research. We also use the extensive library of directories and Journals on various technology domains. Our analysts use blog posts, whitepapers, case studies, and other literature published by major technology vendors, online experts, and industry news publications.

Inputs from Industry Participants

Quadrant analysts collect relevant documents such as whitepapers, brochures, case studies, price lists, datasheets, and other reports from all major industry participants.

Primary Research

Quadrant analysts use a two-step process for conducting primary research that helps us in capturing meaningful and most accurate market information. Below is the two-step process of our primary research:

Market Estimation: Based on the top-down and bottom-up approach, our analyst analyses all industry participants to estimate their business in the technology market for various market segments. We also seek information and verification of client business performance as part of our primary research interviews or through a detailed market questionnaire. The Quadrant research team conducts a detailed analysis of the comments and inputs provided by the industry participants.

Client Interview: Quadrant analyst team conducts a detailed telephonic interview of all major industry participants to get their perspective of the current and future market dynamics. Our analyst also gets their first-hand experience with the vendor's product demo to understand their technology capabilities, user experience, product features, and other aspects. Based on the requirements, Quadrant analysts interview more than one person from each of the market participants to verify the accuracy of the information provided. We typically engage with client personnel in one of the following functions:

- Strategic Marketing Management
- Product Management
- Product Planning
- Planning & Strategy

Feedback from Channel Partners and End Users

Quadrant research team researches with various sales channel partners, including distributors, system integrators, and consultants, to understand the detailed perspective of the market. Our analysts also get feedback from end-users from multiple industries and geographical regions to understand key issues, technology trends, and supplier capabilities in the technology market.

Data Analysis: Market Forecast & Competition Analysis

Quadrant's analysts' team gathers all the necessary information from secondary research and primary research to a computer database. These databases are then analyzed, verified, and cross-tabulated in numerous ways to get the right picture of the overall market and its segments. After analyzing all the market data, industry trends, market trends, technology trends, and key issues, we prepare preliminary market forecasts. This preliminary market forecast is tested against several market scenarios, economic scenarios, industry trends, and economic dynamics. Finally, the analyst team arrives at the most accurate forecast scenario for the overall market and its segments.

In addition to market forecasts, our team conducts a detailed review of industry participants to prepare competitive landscape and market positioning analysis for the overall market as well as for various market segments.

SPARK Matrix: Strategic Performance Assessment and Ranking

Quadrant Knowledge Solutions' SPARK Matrix provides a snapshot of the market positioning of the key market participants. SPARK Matrix representation provides a visual representation of market participants and provides strategic insights on how each supplier ranks in comparison to their competitors, concerning various performance parameters based on the category of technology excellence and customer impact.

Final Report Preparation

After the finalization of market analysis and forecasts, our analyst prepares necessary graphs, charts, and tables to get further insights and preparation of the final research report. Our final research report includes information including market forecast; competitive analysis; major market & technology trends; market drivers, vendor profiles, and such others.