Hype Cycle for Supply Chain Execution Technologies, 2023

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Initiatives: Supply Chain Technology Strategy and Selection; Logistics and Fulfillment

Logistics plays a pivotal role in supply chain success, leading companies to seek innovations that can deliver transformational outcomes. Supply chain technology leaders should use this Hype Cycle to grasp the maturity, viability and riskiness of evolving supply chain execution technologies.

Strategic Planning Assumptions

- By 2027, over 75% of companies will have adopted some form of cyber-physical automation within their warehouse operations.
- By 2027, over 50% of logistics functions will readjust their CO2 emissions targets to be carbon-neutral or carbon-positive by 2040.
- By 2026, 80% of global and large enterprises will have adopted logistics control towers as the operating model of choice to improve shipment visibility and performance analytics.
- By 2027, more than 60% of large organizations will have implemented fourth-party logistics (4PL) as their preferred outsourcing model to accelerate their supply chain transformation.
- By 2027, over 75% of last-mile deliveries to end consumers in North America and Europe will have near-real-time visibility with delivery windows and ETAs.

Analysis

What You Need to Know

This 2023 Hype Cycle for Supply Chain Execution (SCE) Technologies covers technologies used to support logistics and fulfillment processes (e.g., warehousing, transportation and global logistics). The positioning of specific technologies on this Hype Cycle considers these technologies in the aggregate across various industries and geographies, but there can be notable differences in maturity, market penetration and projected demand across these dimensions.

Gartner Hype Cycles provide insight into the maturity, readiness and business impact of innovative technologies. Supply chain technology leaders should use Gartner's STREET methodology (see The STREET Supply Chain Innovation Playbook) with the Hype Cycle and Priority Matrix to decide when and which innovative technologies make sense for their companies.

When considering new SCE initiatives and investments, users should align their risk tolerance to the positioning of various technologies in this research. Some SCE technologies are lower risk and quite mature, and either have reached or are nearing the Plateau of Productivity on the right side of the Hype Cycle. However, innovation continues, and there are numerous emerging and valuable technologies on the left side of the Hype Cycle, although these are best-suited to more risk-tolerant organizations (see Understanding Gartner's Hype Cycles).

The Hype Cycle

Supply chains remain volatile. Turbulent and global economic conditions challenge companies to find new ways to drive process improvements, higher efficiencies and increasing business outcomes. Logistics organizations now look to technology to help them manage through supply chain disruptions, rampant inflation, rising energy costs, growing labor shortages and increasing risk due to geopolitical tensions and cybersecurity threats. Supply chain technology leaders recognize that competitiveness — and in some cases, an organization's survival — demands digital parity, if not leadership, so they now openly embrace exploratory IT investments.

Supply chain organizational risk culture has a significant influence on how users view the placement of technologies across this Hype Cycle. The 2022 Gartner Supply Chain Technology User Wants and Needs Survey [1] found that only 27% of respondents reported that their employees feel they are encouraged to, and can be rewarded for, taking risks with potentially high paybacks. These are the organizations most likely to invest in technologies on the far left of the Hype Cycle. Regrettably, 13% of all organizations surveyed discourage taking risks. For companies that identify as below-average, that figure rises to 18% of companies discouraging risk taking. These organizations should focus on the far right of the Hype Cycle or technologies that are fully mature.

Furthermore, Gartner's study found that the top business priorities for supply chain organizations over the next two years have a notable impact on logistics operations and thus supply chain execution technologies. They cited the following as their top business priorities:

- Increasing productivity and efficiency (29%)
- Improving resiliency, continuity, risk, and security (29%)
- Fostering innovation (new operating models or processes) (27%)
- Driving revenue/profit growth (26%)

Some macrotrends driving innovation in SCE are:

- **Improved decision making** — Logistics organizations have long focused on execution excellence and have trailed other parts of supply chain management in adopting more robust decision support capabilities. This is changing as organizations are forced to make critical decisions faster while considering more data and constraints. Innovation is accelerating in areas like warehouse resource planning and optimization, simulation and modeling, labor forecasting, transportation forecasting, and applied use of advanced analytics in logistics applications.
- **Agility** — Global logistics organizations will have to address the reality that their businesses will remain highly volatile and chaotic, where operating complexities are expanding exponentially. Many of the emerging technologies covered in this research, such as various intralogistics robots, warehouse execution systems or RTLS WMSs, are more flexible alternatives to what companies used in the past.

- **Automation** — Gartner's study found that 98% of respondents said they are either currently investing, or planning to invest, in cyber-physical automation within the next two years, with 59% saying that labor availability constraints are their primary motivation for investing in automation. Labor costs are rising at the same time that companies are struggling to find and keep people in lower-skilled positions. This is motivating people to seek flexible automation solutions, like many of the robotic systems covered in this research.

- **Ecosystem enablement** — Many companies are seeking technology not only to automate manual and labor-intensive processes, but also to digitize processes and capabilities that facilitate and improve connectivity and collaboration with stakeholders. Maturing technologies like real-time transportation visibility platforms (RTTVP), last-mile delivery solutions, multienterprise collaboration networks (MCNs) or digitized freight networks support multienterprise connectivity and process improvement.

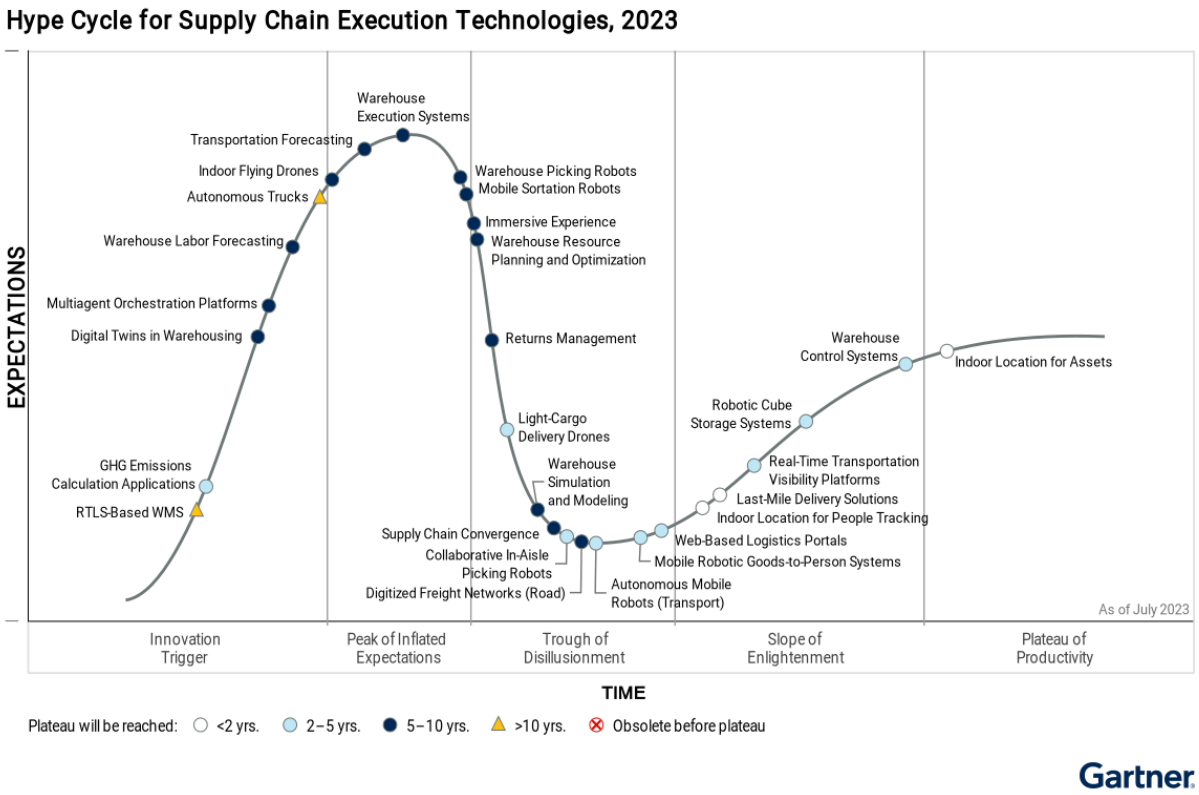
- **Sustainability** — Sustainability is a broader concept than just addressing climate change. It must also consider the complexities of the world and how humans interact with and affect it. Where labor was once viewed as fungible, it is now a constrained resource worthy of leveraging technology to improve utilization, productivity and employee engagement. Technologies like greenhouse gas (GHG) emissions calculation applications, labor forecasting, or any one of the transportation solutions or robotics platforms can help logistics operations achieve their sustainability goals and objectives.

Two technologies were added or changed name in the 2023 Hype Cycle:

- Indoor location for assets — After maturing off the Hype Cycle in 2022, this technology was added back to this year's Hype Cycle, recognizing its continued evolution.

- GHG emissions calculation applications — This innovation was added in recognition of the importance of sustainability.

Figure 1: Hype Cycle for Supply Chain Execution Technologies, 2023



The Priority Matrix

Risk-averse logistics and IT operations should focus on the technologies outlined in the left two columns of the Priority Matrix for supply chain execution technologies to identify those technologies that are suitably mature and proven. The two upper rows highlight technologies that will have maximum impact on the industry, based on the level of benefit (transformational or high benefit). Some technologies that offer transformational benefits are emerging technologies, with 10 or more years to maturity. Autonomous trucks are in this position in this year's Priority Matrix. They are evolving rapidly and have moderate risk, so sophisticated logistics organizations — even if somewhat risk-averse — should consider them.

Several technologies, such as autonomous mobile robots, show a time to plateau of five to 10 years, but this shouldn't be viewed as an indication that these technologies are immature. These technologies are maturing rapidly and have many viable providers and use cases today. However, the high-budget outlay and entrenched legacy systems mean it will take several years for these new technologies to replace legacy systems, despite the strong business case for them. In addition, these solutions continue to evolve and expand, which is extending their time to plateau.

Table 1: Priority Matrix for Supply Chain Execution Technologies, 2023

(Enlarged table in Appendix)

Benefit	Years to Mainstream Adoption			
↓	Less Than 2 Years ↓	2 - 5 Years ↓	5 - 10 Years ↓	More Than 10 Years ↓
Transformational			Supply Chain Convergence Transportation Forecasting Warehouse Picking Robots	Autonomous Trucks
High	Indoor Location for Assets Indoor Location for People Tracking Last-Mile Delivery Solutions	Autonomous Mobile Robots (Transport) Collaborative In-Aisle Picking Robots GHG Emissions Calculation Applications Light-Cargo Delivery Drones Mobile Robotic Goods-to-Person Systems Real-Time Transportation Visibility Platforms Robotic Cube Storage Systems	Digital Twins in Warehousing Multiagent Orchestration Platforms Returns Management Warehouse Labor Forecasting Warehouse Resource Planning and Optimization Warehouse Simulation and Modeling	RTLS-Based WMS
Moderate		Warehouse Control Systems	Immersive Experience Indoor Flying Drones Mobile Sortation Robots Warehouse Execution Systems	
Low		Web-Based Logistics Portals	Digitized Freight Networks (Road)	

Source: Gartner (July 2023)

On the Rise

RTLS-Based WMS

Analysis By: Dwight Klappich

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Real-time location systems (RTLS)-based warehouse management systems (WMS) leverage indoor awareness instead of manual scanning to identify the real-time position of assets and to manage and assign tasks and track assets in a warehouse.

Why This Is Important

RTLS-based WMS is a significant paradigm shift from traditional WMS. The latter had no explicit location awareness — the only location information being what was stored in a database — and relied on humans scanning items and locations at every interaction. In near real time, the best information on the location of assets was based on the last scan. RTLS can enhance usability and productivity in some environments, such as very large buildings or places where scanning is problematic, like yards.

Business Impact

Instead of scanning to know where something was to plot where it is supposed to be, RTLS can pinpoint exactly where assets (people, equipment or inventory) are in real time using locating technology. This can reduce time looking for assets, help better assign work to the right assets based on current location, and eliminate the need to scan multiple times to note where assets are at a point in time. This can improve productivity, especially in large distribution centers.

Drivers

- Technology like ultrawideband (UWB; 5G) technology or 3D cameras and vision recognition for tracking all in-motion assets. Solutions can include dynamic location sensors that are attached to various in-motion assets, resources and inventories, such as forklifts, automated guided vehicles (AGVs), robots or human operators.

- Unique IDs to locate and track assets and provide real-time information about performance and to pinpoint positioning (x, y, z coordinates) of all assets. Some solutions can create dynamic digital twins of the site's operation, tracking and controlling all inventory moves (manual and automated).
- Advanced software algorithms that take advantage of the RTLS capabilities to optimize the flow of material handling equipment and inventory across the site. These algorithms know where assets are, where they need to go, and how fleets of assets coexist in time and space.

Obstacles

- RTLS WMS is a radical departure from how companies have managed warehouses for the last 40 years, since the introduction of commercial WMS based around scanning.
- Convincing organizations of the value in adopting such a radical paradigm shift will be time-consuming and difficult. Very few companies have adopted this technology, which speaks to the challenge in educating customers on the value of adopting this radically new model of operation.
- While demand for real-time indoor asset locating is heating up as these types of technologies are maturing, work orchestration in real time requires a certain degree of integration with WMSs and warehouse execution systems (WESs). An RTLS bolt-on would add complexity to the warehousing technology stack.
- Quantifying the value proposition and ROI will be a notable barrier to adoption, especially in locations with strong existing scanning procedures.

User Recommendations

- Seek systems built from the ground up to exploit these technologies instead of trying to bolt them on to legacy WMS platforms. Such a transition will still require an educational sales process, but will lessen technical resistance.
- Analyze the productivity gains possible for very large facilities and lots of moving assets by investigating where assets are in real time, the performance of these assets and the activities that these assets have performed.
- Before progressing too far in the evaluation, develop a preliminary total cost of ownership and return on investment analysis to determine if it is prudent to continue forward or to help identify areas to focus more attention on.

- Determine if an unreasonable amount of time is wasted each day and week looking for assets, and if work is often inadvertently assigned to the wrong assets based on not knowing their location.
- Test how much time is spent scanning location information, and study if this information ages more quickly than needed.

Sample Vendors

EVS; IdentPro; Locanis; Motion2AI; Ubiquicom; Ubisense; Zebra Technologies

Gartner Recommended Reading

Market Guide for Intralogistics Smart Robotics

Predicts 2023: Supply Chain Technology

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 2, Handling Volatility and Complexity

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 3, Labor and Resource Challenges

Cool Vendors in Supply Chain Management Technology

GHG Emissions Calculation Applications

Analysis By: Kevin Lawrence, Federica Stufano

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Greenhouse gas (GHG) emissions calculation applications are API-enabled SaaS solutions that connect to transportation software applications and provide GHG emissions tracking. They leverage deep GHG emissions factor datasets, accounting for situational variations such as geography or fuel type.

Why This Is Important

Ambitious GHG emissions reduction goals are driving the need to integrate efforts directly in supply chain operations versus stand-alone initiatives. Operationalizing sustainability requires GHG emissions data to be available to inform decisions like routing planning. Use of GHG emissions calculation applications makes this feasible by providing emissions factors for calculating a broad range of transportation variables in near or real time.

Business Impact

GHG emissions calculation solutions allow for measuring of GHG emissions for both logistics in aggregate as a contribution to the overall supply chain footprint, and more importantly, as a specific factor in route/mode decisions. Shippers often consider carriers' emissions reports unreliable, prompting them to seek out alternative solutions. Calculation applications will benefit shippers who want to create consistent and/or persistent visibility of the emissions their operations are generating.

Drivers

- Availability of data, especially primary data, is a well-known obstacle for many sustainability efforts to succeed. Providers of GHG emissions calculation applications have recognized this and are filling the gap.
- Emissions from supply chains are 11.4 times greater than operational emissions as per CDP's Global Supply Chain Report. Transportation operations are high-impact areas of opportunity but need solutions to drive behavior changes.
- Applications provide critical data necessary to precisely calculate emissions leveraging global information system (GIS) positioning.
- Calculation applications also support other supply chain operations including planning and warehousing, offering beneficial economies of scale.
- Growing governmental regulations require enterprises to report and reduce carbon emissions.
- Customers and consumers are demanding more sustainable choices and service levels.

Obstacles

- The sustainability technology landscape is evolving quickly and is very fragmented. GHG emissions calculation applications providers are at risk of being displaced by larger players.
- Established technology vendors in the area of transportation like transportation management system (TMS) are developing their own solutions within their current applications, directly leveraging GHG calculation methodologies such as the Global Logistics Emissions Council (GLEC) framework.
- The possible creation of an interface that connects to other applications to automate data extraction may require a significant investment of time and effort.
- Additional software licenses for these applications are often required, so ROI can be difficult to measure and calculate based on the insights provided by the application.
- Calculation applications may require meeting prerequisites such as manual extraction and cleansing of needed data in order to be usable for calculation.

User Recommendations

- Evaluate where GHG emissions calculation applications will be most effective in the transportation operation. Determine the viability within existing technology and processes.
- Pilot a target activity such as route planning to determine how GHG emissions can be managed or reduced while maintaining other target KPIs such as service and cost.
- Analyze all areas across the supply chain that would benefit from using the applications, including sales and operations planning (S&OP), sales and operations execution (S&OE), and even network design, to maximize the ROI.
- Consider whether connecting the applications via API or as a stand-alone custom solution is best for the operation. Some vendors offer different application options.

Sample Vendors

BigMile; Climatiq; EcoTransIT World; GreenRouter; TK'Blue; Transporeon; VesselBot

Gartner Recommended Reading

Innovation Insight: How Specialized Tech Can Enable Sustainability Goals in Partnership With Mainstream Logistics Apps

Market Guide for Supplier Sustainability Applications

Digital Twins in Warehousing

Analysis By: Dwight Klappich

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Digital twins (DTs) are virtual representations of things, people, places or processes. In warehousing, a digital twin virtually replicates all entities, including people, equipment and infrastructure, that support fulfillment processes.

Why This Is Important

Warehouses and distribution centers are complex, and trying to visualize this complexity using unstructured and disconnected data trapped in traditional tables and parameters is ineffective. Companies can improve decision making and management of their warehouse assets by virtually replicating the physical and digital worlds using warehouse digital twins.

Business Impact

Warehouse DTs help improve the utilization of physical assets in the warehouse. As operations become increasingly automated, the ability to visualize and run simulations of how processes flow through the warehouse and automation will reduce the risks, costs, and time and effort to buy, build and maintain automation.

Drivers

- Historically, companies would infrequently redesign their warehouses, often going a decade or more without notable changes. Consequently, the appetite for things like a warehouse DT was low. However, supply chain operations are more volatile than ever, and warehouse operations need to respond more quickly to change. Today, information about the warehouse exists, but in forms less visual and accessible than leading edge companies want and need.
- Warehouse DTs allow companies to visualize their warehouse in 3D and run simulations of the models to test their validity and applicability. While consultants often use these tools in their work, historically they have not left the warehouse DT as an artifact that needs to change.
- As warehouse DTs evolve, there is strong potential that they converge with the emerging concept of the industrial metaverse creating transformation change within warehouses. Gartner defines a metaverse as a collective virtual 3D-shared space, created by the convergence of virtually enhanced physical and digital reality. A metaverse is persistent, providing enhanced immersive experiences.
- Over the next three to five years, we expect only the most mature supply chain organizations to have explicit warehousing DT strategies.

Obstacles

- Today most warehousing users do not yet see DTs as something separate and distinct from the solutions they own and operate today. They are not yet convinced that buying something stand-alone is warranted.
- Most warehousing organizations will continue to consume pseudo-DT simulations capabilities as part of warehouse management system (WMS) solutions. The most innovative vendors will lead the charge by branding some of their visual and process modeling capabilities as composite digital twin capabilities. However, these will often be integrated with underlying WMS and other systems, which may also incorporate discrete digital twin capabilities (for example, asset optimization). While these will be more appealing and easier to absorb tools, they will not fundamentally change what already exists within many systems, though in a more coarse-grained way.

User Recommendations

- Embrace the concepts of warehouse DTs today, even though most of what is currently used is not yet called “digital twins.” Because DTs are “virtual 3D digital representations of things, people, places or processes,” this will allow warehouse users to recognize and codify the value in virtually replicating warehouse entities that support their fulfillment processes.
- Focus first on the most obvious digital twin use cases thatcan virtually represent almost any physical entity associated with the warehouse. This includes mapping the warehouse layout or modeling the blueprints of physical assets, such as lift trucks or robots.
- Consider creating 3D virtual representations of all the material-handling equipment in the warehouse, with an eye to employing this to support simulation and virtual provisioning.

Sample Vendors

FORTNA; NVIDIA; Rockwell Automation (Emulate3D Technology); Schneider Electric (Xcelgo); Slot3D

Gartner Recommended Reading

Predicts 2023: Supply Chain Technology

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 1, Improving Upgrades

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 2, Handling Volatility and Complexity

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 3, Labor and Resource Challenges

Cool Vendors in Supply Chain Management Technology

Multiagent Orchestration Platforms

Analysis By: Dwight Klappich

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Multiagent orchestration platforms (MAO platforms) act like intelligent middleware that integrates and orchestrates work between various business applications, heterogenous fleets of operational robots, and other automated agents like doors or elevators. These solutions orchestrate and assign work, and monitor and coordinate the activities of diverse fleets of robots.

Why This Is Important

As companies expand their use of robotics, most will eventually have heterogeneous fleets of robots from different vendors performing various tasks, which will require standardized software that can easily integrate to a variety of agents and robot platforms. These solutions will assign work to the right robots based on the characteristics of immediate and prioritized tasks and communicate with other types of automation (agents) like door or elevator controls.

Business Impact

As robot fleets grow, simple point-to-point API integration will not be enough. Companies will need an accelerated integration and orchestration capability that can assign work to the right robots or agents based on near-real-time information and the type of activity. This will reduce the time, effort and cost to onboard new robots and will reduce support cost, ultimately making organizations more efficient because work will be assigned to the robot best-suited for the task.

Drivers

- Robotics is expanding the market for material handling automation (MHA) to companies that could not historically justify the high cost and long time to value of conventional MHA systems. Most companies (if they have invested in operational robots) have invested in a single robot offering, so integration and orchestration is not yet a compelling challenge for them. However, as companies expand their fleets of robots, the integration and, as importantly, the orchestration of work between robots will become a bigger challenge for companies. This will drive the need for orchestration platforms that can connect multiple robots with source systems as well as coordinate work between robot platforms.
- Tools are nascent and evolving, but the cost and risk of multiagent orchestration solutions are notably less than asynchronous hard-coded integration.
- The business logic is not overly complex and vendors are building and packaging API connectors to the most popular robot platforms, reducing the technical burden on the customer. These solutions are primarily an operational effectiveness opportunity with minimal impact on the overall strategy.
- As robot fleets expand, companies will have to transition management practices from a focus on people to a focus on automation design, which will drive the need for these types of solutions. As robots assume more responsibility for process execution, the process changes can be dramatic. Work assignment processes, which were largely built for people, will need to be completely redesigned. As robotic fleets become more heterogeneous, coordinating work between robot platforms becomes more difficult while important.
- Companies are already adopting robotic systems where different robotics solutions from a single vendor or multiple vendors are integrated to form a complete solution. Examples might be picking robots coordinating with sortation solutions.

Obstacles

- Companies will not recognize the need for these types of solutions until they move beyond one or two robot platforms.
- Companies will likely first look at their WMS providers or their robot provider's fleet management systems, which might or might not address the need for orchestration and integration to a variety of robot platforms.
- Many robot providers are concerned they will be commoditized by less expensive robot hardware, so many are moving more toward software and might push back on the emergence of these types of solutions.
- MAO platforms initially focused on integration but increasingly the need is to combine integration and orchestration. The challenge is various vendors will approach this differently, with some using their WES for orchestration and others having combined solutions under the MAO banner.

User Recommendations

- Analyze your integration requirements as you expand your robot fleet beyond a single vendor.
- Study how you will need to assign work to the various robots and what orchestration logic will be needed to support this simultaneously.
- Register and map out situations where work needs to be coordinated between two different agents, such as robots or other types of physical assets (agents) like doors or elevators. For example, an autonomous mobile robot (AMR) moving pallets has to go through a door and needs to send a message to open the door.

Sample Vendors

Amazon Web Services; GreyOrange; JASCI Software; Open Robotics; Softeon; SVT Robotics; Synergy Logistics

Gartner Recommended Reading

Market Guide for Intralogistics Smart Robotics

Predicts 2023: Supply Chain Technology

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Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 3, Labor and Resource Challenges

Warehouse Labor Forecasting

Analysis By: Dwight Klappich

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Warehouse labor forecasting is a specialized form of predictive analytics that uses qualitative and quantitative approaches to intelligently predict short-term, midterm and long-term warehouse labor demand in aggregate and by task, skills, process area and other factors.

Why This Is Important

Labor availability has supplanted labor cost as a key driver for looking at warehouse productivity tools like labor management systems, and more recently intra-day to medium-term labor forecasting. As labor availability constraints increase, the need for improved forecasting will explode.

Business Impact

Getting the labor forecast wrong, especially for highly seasonal businesses, can be as detrimental as getting the demand forecast wrong. Rudimentary labor forecasting tools like spreadsheets are no longer sufficient, given the volatile labor markets most companies operate in today.

Drivers

- Most warehouse operations currently use rudimentary spreadsheet-based models to roughly project labor requirements into the future. Some organizations have tried to convert product demand forecasts into labor forecasts, but this approach has failed because the data models are not the same. Vendors are starting to apply general-purpose, quantitative methods, leveraging statistical and mathematical analysis, but find that defining the proper data model is more difficult than first thought.
- Workforce and warehouse labor management system vendors have been focused on labor planning over the past few years but midterm to long-term forecasting remains nascent.
- General-purpose, human capital management authorities outline various methods for estimating labor needs. These include managerial judgment, work/time study techniques (also known as developing engineered standards), trend analysis, time series forecasting techniques, model-based simulation/analysis and, more recently, machine learning. Effective warehouse labor forecasting will likely combine several of these methods.

Obstacles

- Spreadsheets remain the dominant tools for labor forecasting in logistics, and while unsophisticated, they are ubiquitous and users are comfortable with these rudimentary tools.
- Furthermore, companies must have reasonably mature labor management capabilities, systems and competencies that will be prerequisites for moving to automated labor forecasting.
- Some companies have specialized workforce management (WFM) tools for their retail and other functions and try to extend these tools for use in their warehouses. While these solutions might not be a good approach for intraday logistics activity planning, they do offer some ability to forecast medium- to long-term labor requirements.
- The labor forecasting market is progressing slowly because low customer demand causes vendors to redirect their innovation budgets to places with more customer interest.

User Recommendations

- Structure your evaluations to be as flexible as possible given the small number of packaged solutions available today.
- Avoid defining rigid requirements unless you are willing to build a solution. There might not be anything even close to what you have thought of, but there might be a packaged solution that can still help and add value.
- Focus on vendors that have expertise in, and solutions built for, warehousing labor because the data model will be the gating factor, not the mathematical models that are ubiquitous in many cases.
- If you have a WMS with a labor management system built in, start here to see what capabilities the vendor offers for labor forecasting. If they do not support your forecasting needs then seek stand alone solutions.

Sample Vendors

Blue Yonder Group; Easy Metrics; Ehrhardt Partner Group (EPG); Manhattan Associates; Next View Software; TZA

Gartner Recommended Reading

Predicts 2023: Supply Chain Technology

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Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 2, Handling Volatility and Complexity

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 3, Labor and Resource Challenges

Autonomous Trucks

Analysis By: Jonathan Davenport

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Autonomous trucks use various onboard sensing and localization technologies, such as light detection and ranging (lidar), radar, cameras, global navigation satellite system (GNSS) and map data, in combination with AI-based decision making, to drive without human supervision or intervention.

Why This Is Important

The logistics industry sees autonomous trucks as an opportunity to improve safety and operational efficiencies, while also addressing the driver shortage challenge. Estimates for substantial deployments of autonomous trucks vary, but Aurora Innovation plans to launch driverless operations in late 2024. Autonomous trucking companies are looking beyond developing a safe AI-enabled system that can drive, to training the vehicle to navigate border checkpoints and ensuring operational support structures (such as maintenance) are in place.

Business Impact

Autonomous trucks will enable operating costs to be reduced. Over time, driver pay costs will be eliminated, and vehicle utilization will improve, meaning goods can be transported much faster to their destination because breaks are no longer necessary. Autonomous driving technology is maturing rapidly, but adoption for truck use cases will be constrained by regulatory restrictions and the difficulty of autonomously safely controlling these massive vehicles.

Drivers

- Driver pay is one of the largest operating costs for fleets associated with a commercial truck. Together with the current driver shortage, autonomous trucks will provide additional capability on top of the current trucking capacity and help address wage inflation.
- Companies like Embark Trucks are planning on charging a pay-per-mile subscription for its driver software, which moves autonomous trucking to an operational expense for shippers and carriers considering the technology.
- Safety regulations limit the amount of time a driver can operate behind the wheel. Autonomous vehicles will reduce transit time substantially by eliminating the driver's mandated rest breaks. This affects the decreasing lead times customers put on orders and also reduces the need to have the inventory placed within close proximity to the end customer markets.
- Autonomous trucks have already been used successfully in closed environments within vertical industries like mining and ports. They are currently being further tested on the road in the U.S., Europe and Asia/Pacific.
- Autonomous trucks can also improve environmental sustainability through more efficient driving.
- The scale of a truck means that its sensor suite can be mounted much higher than would be possible on a passenger vehicle. This gives the autonomous truck the ability to use its sensor suite to capture perception data over much larger distances (up to a mile).

Obstacles

- Autonomous technology is not yet ready for widespread deployment. Trucks are 75% wider than passenger vehicles, five times longer and 20 times heavier. This means that autonomous vehicle systems need to be much more precise in terms of positioning the vehicle on the road. The associated stopping distances, which can be up to 65% longer than a passenger vehicle, also means that the truck must plan the decisions it makes further in advance.
- It will be decades until autonomous trucks will be able to handle all road, traffic and weather conditions. As such, it is likely that autonomous truck services will operate on a hub-to-hub basis, with human drivers taking over for the last-mile delivery.
- Despite having the potential for addressing the transportation industry's most severe challenges, growth will be delayed by regulatory debates.
- Humans will still need to support the vehicle, handling activities such as refueling/recharging while en route — but these could be dedicated service station personnel.

User Recommendations

- Create an autonomous technology roadmap that will allow the right level of technology to be adopted over time.
- Undertake a cost-benefit analysis by building a business case that assesses how much can be invested in autonomous technology over a given time horizon to enable profitable future deployment.
- Study autonomous vehicles to understand whether, where and how this technology might impact supply chains.
- Start to engage in proof of concepts and trials by identifying parts of the world where exemptions to core vehicle regulations enable autonomous innovation.
- Allocate a small, technically competent team to research and evaluate government regulations and emerging autonomous capabilities being added to current vehicles.
- Talk to third-party logistics providers to see how they are embracing autonomous vehicles. Some firms may want to partner with shippers initially to pilot the new capability while sharing some risks.

Sample Vendors

Aurora Innovation; Einride; Embark Trucks; Plus; Torc Robotics; TuSimple; Waymo

Gartner Recommended Reading

Emerging Tech: The Future of Autonomous Vehicles

Emerging Tech Impact Radar: Autonomous Vehicles, 2022

Lessons From Mining: 4 Autonomous Thing Benefit Zones for Manufacturers

Supply Chain Brief: How Automation Can Decrease Truck Dwell Times

Use-Case Prism: Artificial Intelligence for Transportation

At the Peak

Indoor Flying Drones

Analysis By: Dwight Klappich

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Definition:

Indoor flying drones autonomously navigate indoors, moving vertically and horizontally, to support use cases like inventory management, intralogistics, inspection and surveillance. Solutions typically include the flying drone, onboard cameras or other sensors, and advanced AI-based software for navigation, using simultaneous localization and mapping (SLAM), and for data capture.

Why This Is Important

Inventory management tasks like cycle counting are time-consuming and unproductive, and there are safety concerns with having to lift people high in the air to count inventory. Automating this process through the use of indoor flying drones can have notable business benefits. It allows processes to be performed more frequently at an accelerated rate and at a lower cost and impact on the business.

Business Impact

Drones allow companies to increase the frequency and safety of doing cycle counts by making the process more productive and less labor-intensive. Other use cases, such as delivery or inspection, are less proven but could add to the value proposition of adopting indoor drones.

Drivers

- **Inventory management,** particularly cycle counting, is the most obvious and achievable use case today with multiple vendors offering solutions.

- **Intralogistics** is the movement of goods indoors and there is some potential to use flying drones that can follow a predefined flight path to deliver parts, tools or other items from a warehouse to the plant floor. The allure is the ability to support express delivery of items but there are notable limitations such as payload, grip, carrying capacity, dexterity for lifting and placing, and navigation, where mobile robots will continue to dominate.
- Drones could replace manual and often dangerous **inspection or surveillance** processes in warehouses and plants such as inspecting roofs, racks, pallet placements, or safety equipment like sprinkler systems. Indoor drones are particularly valuable for inspections in dangerous areas or elevated heights. Unlike inventory management these would be nonoperational and would be used periodically as needed. However, these drone use cases could potentially integrate with other warehouse audit and inspection tools/mobile apps to better facilitate inspection operations.

Obstacles

- Drone use is limited for inventory management. For companies with shrink-wrapped palletized goods, drones can work well for noting full or empty locations and for checking the rack location of a particular pallet. However, the drone cannot count all the cases on a pallet or the number of items in a box or tote.
- Battery life can be an issue with only about 20 to 30 minutes of flight time for fully autonomous drones. A limited amount of real estate can be covered in that amount of time so companies will either need larger drone fleets or they will need to count less frequently.
- Inspections are a likely secondary use case target for drones; however, these will be limited and much like similar use cases for mobile inspection robots.
- Drone use for indoor delivery (i.e., intralogistics) is very immature, and technical limitations and availability of better alternatives like mobile robots will limit adoption for these use cases.

User Recommendations

- Pilot flying drones for inventory management and cycle counting if your goods are palletized and especially if they are shrink wrapped. Test in one site and roll out rapidly to others if the business case is proven.

- Approach using drones for inspections just like you might for other inspection use cases by leveraging the drones to supplement the skilled workforce already doing inspection in other ways.
- Focus on autonomous mobile robots for intralogistics use cases for the foreseeable future, though very limited proofs of concept could be conducted.

Sample Vendors

B GARAGE; doks.innovation; DroneScan; EyeSee; FlytWare; Gather AI; Infinium Robotics; Lone Drone Solutions; Verity; Vimaan

Gartner Recommended Reading

Market Guide for Intralogistics Smart Robotics

Predicts 2023: Supply Chain Technology

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 1, Improving Upgrades

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 2, Handling Volatility and Complexity

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 3, Labor and Resource Challenges

Transportation Forecasting

Analysis By: Brock Johns, Dwight Klappich

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Definition:

Transportation forecasting solutions apply demand-sensing/forecasting techniques specifically aligned with transportation networks, hierarchies and planning constraints. Specialized transportation forecasting solutions offer robust, transportation-specific allocation methodologies that can translate customer, location and product demand into lane- and mode-specific shipping-demand projections.

Why This Is Important

Shippers and carriers are shifting from a singular emphasis on cost reduction to better address efficiency and productivity, with a focus on the impact of transportation and logistics on company growth, profitability and sustainability. Shippers are also looking for ways to address fluctuations in capacity and rates due to the increasing volume of supply chain disruptions.

Business Impact

Transportation is a significant cost to most shippers, yet it largely remains unplanned beyond the operational execution window, which is normally one to five days. Shippers continue to invest in operational transportation planning and optimization, and these solutions deliver cost reductions based on their ability to efficiently route and consolidate shipments, and enforce least-cost carrier strategies. However, most companies plan only a couple of days into the future.

Drivers

- Shippers struggle to understand their real capacity needs in the short to medium term. In times of tight capacity, carriers become more selective about what freight they want to handle.
- Even in times when the balance of capacity and demand are more even, forecasting demand and volumes more realistically can help shippers negotiate better price and service with carriers and help to position them more as a shipper of choice.
- This struggle requires shippers to more effectively look beyond the operational planning horizon to project their future transportation requirements on a lane-by-lane basis. The needed granularity of freight forecasts will vary over time. In the near term (one month to a quarter out), companies will need specific lane-by-lane, carrier-by-carrier forecasts down to the day. In the longer term (up to a year or more), less exhaustive information, but still lane-specific, will often suffice.
- If done at all, most companies rely on spreadsheets to forward-plan freight, and there are many flaws in this approach. Most companies have instituted product forecasting systems, but product demand hierarchies (for example, SKU, product, product line and brand) do not align with transportation hierarchies, which might look like products, shipments, loads, modes, lanes, equipment and carriers.
- Transportation forecasting will supplement — not replace — holistic multimodal transportation management systems. In fact, some TMS solutions have already developed forecasting capabilities while others are actively working to further develop forecasting capabilities within their solutions.
- Although transportation forecasting solutions must be designed to address the specific and unique needs of transportation, the processes will be similar to those used in product supply chain planning.
- Consequently, supply chain planning processes need to be extended to transportation, and transportation deserves things like sales and operations planning (S&OP) meetings.

Obstacles

- Transportation and logistics leaders struggle to see transportation forecasting as an essential part of their overall supply chain planning as they are typically more execution focused.
- Transportation operations often have a narrow focus on the day-to-day planning and execution, versus a longer-term view.
- Organizations may not have the mindset or the supply chain maturity to look at transportation planning and forecasting several weeks ahead.
- Many organizations lack the infrastructure to see ahead, which could require operations changes to achieve this level of visibility.
- Organizations may recognize the benefits of supply chain convergence and the coupling of supply chain planning and execution on a single platform, however, existing technical debt hinders a true convergence strategy.

User Recommendations

- Accept that the volatility of business conditions and frequency of disruptions will continue to increase, and look to be more proactive to understand capacity needs and collaborate with carriers and logistics partners to ensure freight capacity, better freight rates and service.
- Shift from manual processes and spreadsheets and consider transportation forecasting tools if your company has current or projected freight capacity shortages. Examine existing technology, particularly holistic multimodal TMS solutions, for transportation forecasting capabilities before investing in other stand-alone options.
- Make transportation planning part of the S&OP process and understand that operational transportation planning is not enough. Start planning freight further into the future by implementing a strategy for supply chain convergence.

Sample Vendors

4flow; Blue Yonder; e2open; flexis; Manhattan Associates; MercuryGate; MIXMOVE; Oracle; SAP; Uber Freight

Gartner Recommended Reading

Magic Quadrant for Transportation Management Systems

Critical Capabilities for Transportation Management Systems

Gartner's Model for Holistic Multimodal Transportation Management Systems — Part 2: Extended Capabilities

Use Scenario Planning to Budget for Elevated and Unpredictable Transportation Costs

Warehouse Execution Systems

Analysis By: Dwight Klappich

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Warehouse execution systems (WESs) are a hybrid technology that blends capabilities from traditional warehouse management systems (WMSs) and warehouse control systems (WCSs). WESs enhance work management in automated warehouses and manage the interplay between automated and manual processes. WESs leverage near-real-time insight into work in the automated warehouse, combined with advanced business process logic, to improve the flow, orchestration and prioritization of work.

Why This Is Important

Supply chain technology leaders, especially in high-volume, high-velocity environments like e-commerce, retail and direct-to-consumer, are under pressure to drive increased throughput at lower costs per order, which is pushing the need for high-velocity automated fulfillment. WESs are a potentially good fit for automated order-picking strategies, and companies will look to WESs to help support increased volume and velocity.

Business Impact

WESs can extend the reach of traditional WMS solutions by adding more robust and flexible work management and orchestration capabilities, which will be needed in high-volume and high-velocity warehouse environments. The complex picking needs of warehouses with high order-line volumes were not fully addressed with traditional WMSs, which drove the need for WESs.

Drivers

- Historically, WMSs controlled all people-centric warehouse transaction logic, such as receiving, “put away,” counting, picking, packing and shipping. WESs are specifically suited to high-velocity warehouse processes, adding capabilities like waveless picking that seamlessly integrate with the WCSs, which, in turn, talk (in real time) to the automation layer.
- Early WES vendors had strong domain expertise in automation and built their logic to better exploit automation. WESs are a very specialized use case of the Internet of Things (IoT) in the warehouse.
- If a company’s order-line volume, velocity and variability growth is twice or more than its current levels, then WESs will be a key to future productivity gains.
- Tools are evolving, disparate across various types of solutions and not completely packaged, but the cost and risk of WES solutions are significantly less than that of automation.
- WESs are primarily an operational effectiveness opportunity with minimal impact on the overall strategy. As the amount of automation increases, companies will have to transition management practices from a focus on people to a focus on automation design, which will drive the need for WESs.
- As material handling automation assumes more responsibility for process execution, the changes can be dramatic, and processes like picking will have to be completely redesigned.

Obstacles

- WES is an evolving application category and there is no consensus on the definition of, what capabilities comprise a WES, or what capabilities might be better suited to a WMS, WCS or something else altogether.
- WES will evolve in two conflicting directions. WES vendors that come from the automation world, will continue to add business logic approaching some of the capabilities of a WMS. In parallel, some thought-leading WMS vendors have or are adding WES logic to their WMS to reach further into the automation layer. This bifurcation will threaten traditional WMS vendors' ability to sell into automated facilities if they fail to address this trend.
- WES initially emerged to augment capabilities to support large-scale conventional automation but with the rapid growth in robotics multiagent orchestration platforms will both compete with, or subsume, WES into these platforms.
- Adoption and evolution of specialist WES offerings were stalled because of mergers and acquisitions by hardware providers, and due to vendor and buyer confusion.

User Recommendations

- Investigate WESs as a potentially good fit for automated, order-picking strategies when considering warehouse redesigns to address the need for high-velocity fulfillment.
- Assess future demand to determine the degree of productivity improvement needed to support order volume and velocity increases, which may be needed as part of the redesign.
- Evaluate whether WES can serve as more of an incremental approach in existing warehouses, supplementing areas such as order picking.
- Analyze offerings thoroughly before adopting emerging technology that still has gaps. This is true in organizations with well-functioning capabilities, but also important during redesign.

Sample Vendors

Bastian Solutions; FORTNA; KPI Solutions; Manhattan Associates; Matthews Automation Solutions; Softeon; Tech King Operations (TKO); VARGO

Gartner Recommended Reading

Predicts 2023: Supply Chain Technology

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 1, Improving Upgrades

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 2, Handling Volatility and Complexity

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 3, Labor and Resource Challenges

Top Trends in Strategic Supply Chain Technology 2023

Mobile Sortation Robots

Analysis By: Dwight Klappich

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Mobile robotic sortation systems use various types of flexible, mobile robots to identify and transport goods from an induction point and then divert them to the correct destination within the warehouse. There are various types of mobile sortation robots such as table or suspended robots with tilt trays, roll-on-roll-off, ride on top and automated put walls. Most robotic sortation systems have robust, often AI-enabled, software that optimizes the operation of fleets of sortation robots.

Why This Is Important

E-commerce and direct to consumer fulfillment are increasing the need for solutions to help customers sort and coordinate the processing of up to hundreds of thousands of line-items per day. While conventional automated sortation systems have been around for decades, they were expensive, time-consuming to deploy and inflexible. New mobile robot sortation systems are lower cost, adaptive and scalable.

Business Impact

Mobile sortation robots address the challenges of item sortation which is a labor-intensive, low-value-adding and error-prone activity. Conventional sortation systems often tied up large amounts of capital for underutilized capacity for most of the year. The flexible nature of sortation robots addresses the needs of high-volume, high-velocity environments where the demand is not level and dramatic cyclical differences can exist between peaks and valleys, negatively impacting labor even more.

Drivers

- As e-commerce and D2C fulfillment volume and velocity grow, the need for sortation grows as well. Flexible mobile sortation robots open the market for automated sortation to organizations that would not have been able to afford or justify conventional automated sorting systems that were typically based around some form of powered conveyor.
- Different mobile robotic sortation mechanisms can support different form factors, dimensions and payloads. Some can operate independently while others are part of more integrated, yet still flexible, systems. Payload is a notable factor; some robots can only carry very light payloads of several pounds, whereas others can carry much larger and heavier loads.
- A subtype of sortation — singulation/induction — can also support complex needs of customers. It takes random, misaligned or grouped products and distributes them into an organized single-file line of items. Singulation can be manual (i.e., human picking and placing) or automated where robotic arms pick, identify and place items on another robot. Some robotic sortation systems use robotic arms to singulate, but still use conveyors or other automation to sort. Several vendors will also sort to put/pick walls where singulation is either manual or automated.

Obstacles

- While the value of sortation robots is evident, prospects will be challenged by having to evaluate and decide between many different varieties of sortation solutions, including conventional conveyor sortation and robotics.
- Conventional conveyor sortation is a very mature and proven market, so companies will have to weigh the value and importance of flexibility, adaptability and scalability against solutions' maturity and risk.
- Prospects will need to align these solutions appropriately with their company's specific wants, needs and constraints. Prospects will also have to consider use cases for individual item sorting, order sorting and parcel sorting.

User Recommendations

- Identify all possible sortation use cases within your processes, such as in-bound, out-bound, cross-docking, and returns.
- Investigate emerging mobile robotic sortation systems as more flexible and cost-effective alternatives to conventional conveyor sortation systems.
- Assess the maturity of your sortation processes and document your requirements, considering both conventional and robotic sortation capabilities as well as other factors like scalability risk.
- Evaluate more flexible, adaptive and scalable robotic sortation solutions' value to your organization, even if they provide fewer overall capabilities than conventional conveyor-based systems.

Sample Vendors

Addverb Technologies; Berkshire Grey; Geek+; GreyOrange; Kindred; Tompkins Robotics; Unbox Robotics; Zhejiang Libiao Robotics

Gartner Recommended Reading

Market Guide for Intralogistics Smart Robotics

Predicts 2023: Supply Chain Technology

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 1, Improving Upgrades

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 2, Handling Volatility and Complexity

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 3, Labor and Resource Challenges

Warehouse Picking Robots

Analysis By: Dwight Klappich

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Warehouse picking robots can identify, pick up, handle, move and place goods using some form of reticulated robotic arm and end effector/gripper. These systems employ advanced AI and vision systems to recognize and pick up items that are not in consistent places and orientations, and are not the same sizes and shapes.

Why This Is Important

Picking is a repetitive and labor-intensive task ripe for automation. Warehouse picking robots will continue to evolve over the next several years to better address the needs of single-item picking, offering better cost, flexibility, adaptability, scalability, utility and intelligence.

Business Impact

Warehouse picking robots will transform warehouse operations over the coming decades, as labor shortages and costs continue to rise while robot costs and complexities come down, which will open up the market to more companies. Labor availability and labor costs are the main drivers, but improvements in overall throughput and productivity will be the primary value, regardless of whether labor is reduced.

Drivers

- Picking is a labor-intensive and a low-value-adding capability ripe for robotic automation to free up people from mundane, highly repeatable tasks.
- Picking robot form factors are evolving rapidly and capabilities are improving, but they are not yet appropriate or effective for all use cases.
- These robots combine multiple technologies (such as AI-enabled vision systems, reticulated arms that can move in multiple planes and various forms of gripping technology) to enable the robot to identify, locate, pick up and handle goods.
- Replacing people with robots places significant emphasis on getting technology right. Shifting from people-centric organizations to robotics-driven environments has a significant impact on an organization's strategy and culture at all levels.
- When moving from people-driven to automated activities, processes must be redesigned to benefit from robotic advantages. Primary competitive value comes from achieving best-in-class operational performance.

Obstacles

- While industrial robotic arms are mainstream in manufacturing, they remain nascent in warehousing except for some very specific applications, such as palletizing.
- Industrial robots are normally large, immobile and fit for one task. Given the varying types of work required in warehouses, this architecture is too limiting. Warehouse picking robots must address repeatable tasks with minimal variance from activity to activity and item to item, across dimensions and weights.
- Variability makes creating universal picking solutions technically difficult, and it will be years before picking solutions match the flexibility, dexterity and speed of humans. Consequently, initial growth will come in operations with less variable picking requirements.
- Picking accuracy and performance will be key to driving adoption, and will need to be in the mid 90% range or higher for broader adoption. Again, variability can affect picking performance, so use cases will remain narrow for the foreseeable future.

User Recommendations

- Evaluate stationary robotic picking arms for very specific use cases where the product size, weight and shape are consistent, where the location of product is consistent, and where the operation to be performed is consistent (e.g., palletizing robotic arms for picking cases). If companies have these conditions, then exploring robotic arms is worthwhile.
- Proceed with caution and pilot extensively if you operate in less structured and consistent environments, to ensure the picking robot can support your specific operational requirements.
- Evaluate the realistic speed of robotic picking systems for your environment and use cases. Today, humans can often outperform robotic arms, especially where weights and dimensions vary.
- Evolve your management techniques and organizational design principles with robots in mind. Cultural changes must be kept in mind because some employees will feel threatened by robots, which could negatively impact projects.

Sample Vendors

Berkshire Grey; Boston Dynamics; Covariant; Dexterity; Exotec; Kindred Group; Rapid Robotics; RightHand Robotics

Gartner Recommended Reading

Predicts 2023: Supply Chain Technology

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 3, Labor and Resource Challenges

Quick Answer: What Supply Chains Considering Intelligent Flexible Automation Need to Address

Market Guide for Intralogistics Smart Robotics

Sliding into the Trough

Immersive Experience

Analysis By: Christian Titze

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Immersive experience reimagines the user experience by enabling users to perceive the virtual world using virtual, augmented and mixed reality. It enables users to interact with the virtual world by not only using conversational systems, chatbots and virtual assistants, but by leveraging hardware and software tools that give them the perception of being present in a digital environment or integrate digital content into a real-world physical experience.

Why This Is Important

Interactions are becoming more mobile, virtual and distributed as the user experience undergoes a shift in perception and transitions to a rich, multidimensional and personalized experience. The evolution of continuous, immersive and conversational user experiences will have a profound impact on supply chains' ability to reimagine, improve and enhance the user experience.

Business Impact

Immersive experience technologies have the potential to radically influence the trajectory of the technology supporting supply chain processes. It presents new interaction models through the product life cycle, not only with humans, but with other processes, machines and applications, such as in manufacturing, quality, customer relationship and warehouse management. The new interaction models will augment human capabilities and the nature of standard work.

Drivers

- Immersive on-the-job training can be provided for onboarding new workers in a safe, realistic, virtual environment (e.g., for manufacturing, maintenance, warehouse operations or services). Critical step-by-step instructions can also be given to remote workers through an immersive experience.

- The use of augmented reality headsets in warehousing has garnered interest, and deployments indicate some improvements in worker efficiency versus using existing methods. However, uptake is very slow.
- In transportation, there is the potential for solutions targeted at productivity, such as augmented reality, that support a driver's journey, navigation and safety. Wearable solutions could, for example, monitor driver fatigue.
- In supplier management, remote supplier audits can be enabled with immersive experience technologies, maintaining supplier quality when travel is not possible or desirable.

Obstacles

- Cost, complexity, integration and scaling challenges remain the biggest obstacles to wider adoption of immersive-experience technologies.
- An unclear value proposition makes building a business case hard, which is slowing adoption.
- The degree of maturity of advanced technologies is a barrier to wider immersive experience adoption, but the technologies will become more stable and mature over time.
- The lack of good user experience (UX) design is another barrier (after technology sophistication) to the wider adoption of immersive technologies.
- Development costs or production volumes must be overcome before mass market adoption can be achieved.

User Recommendations

- Strive to create effortless experiences for users by driving an experience-driven agenda for technology investments. Hereby connect and improve digital initiatives that drive user confidence, satisfaction, loyalty and advocacy.
- Start by identifying specific use cases, such as field service, logistics, warehousing, manufacturing, maintenance or design, that can benefit from immersive experience technologies.
- Prioritize the value of immersive experiences and newly emerging applications to provide safer, secure and more transparent working, training, onboarding and processing environments.

- Set the business goals, requirements and measurements for your implementation before choosing a provider or solution. Rich and robust offerings can bring value, but only with a clear intention.
- Identify critical gaps in customer and user interactions, such as a remote workforce being exposed by the pandemic. Determine new targeted business outcomes to address using immersive experience capabilities.

Gartner Recommended Reading

Maverick* Research: Augmented Reality — Stuck Between Virtual and Physical Worlds, and Stressed Out

Emerging Tech: Top Use Cases of the Metaverse

Top Trends in Strategic Supply Chain Technology 2023

Quick Answer: How Do I Get Started With Total Experience?

Warehouse Resource Planning and Optimization

Analysis By: Dwight Klappich

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Warehouse resource planning and optimization applies the concepts of forward-looking, constraint-based planning and optimization to work activities within a warehouse, distribution center or warehouse campus, leveraging advanced analytics, artificial intelligence (AI) or machine learning technologies.

Why This Is Important

Warehousing trails manufacturing by decades in adopting sophisticated constraint-based planning capabilities. As warehouse operations become more complex, the need for new sources of productivity gains will drive the demand for constraint-based planning concepts within warehouse management. Because of the maturity of warehouse management systems (WMSs) and functional parity across vendors, warehouse productivity gains have stalled, which is driving the need for new decision support capabilities.

Business Impact

Warehouse resource planning and optimization will help drive higher degrees of warehouse labor and equipment productivity, and help reduce warehouse labor costs. This will come by optimizing work allocation while respecting warehouse physical and human constraints.

Drivers

- Constraint-based planning and optimization techniques have been used in manufacturing plants for more than 30 years, but these techniques are just emerging in warehousing. Warehouses largely still rely on relatively rudimentary work optimization or allocation methodologies (such as task interleaving and wave planning) to assign warehouse work activities.
- Some WMS vendors are building some forward-planning capabilities (such as labor or equipment planning) into their WMSs, but these are nascent.
- Given user demands for continuous productivity improvements and pressures around labor availability, we anticipate that these solutions will evolve quickly to include more resource, constraint and planning sophistication.
- Today, this market is limited to early adopter customers who are willing to invest in early stage technologies. As the solutions become more mature and robust, we anticipate more users looking to invest in these types of capabilities.
- Labor planning is evolving and improving to help plan and allocate known work by resource, group work area and others. Warehouse execution systems (WESs) focus on orchestrating the release of work in highly automated warehouses. Neither labor planning nor WES leverages advanced constraint-based optimization capabilities, so work planning remains relatively unsophisticated.
- A small number of vendors are now using AI and machine learning algorithms in warehousing. These nascent solutions seek to ensure that work released, in real time, into the warehouse is done in a manner to optimize the flow and minimize bottlenecks by routing to a hybrid of automated and nonautomated work areas.

Obstacles

- The biggest barriers to warehouse resource planning and optimization adoption are end-customer low maturity and lack of sophisticated resources within warehousing that have operations research expertise. Because of this, demand for these types of solutions is constrained and many vendors suffer from never-ending proofs of concept trying to convince customers to move forward. The good news is those that do are realizing the benefits.
- While the concept of constraint-based planning is pervasive in manufacturing, this is new to warehousing, and only the most advanced customers have adopted these concepts.
- A part of the challenge has been how to effectively model processes and subprocesses, and interdependencies in the warehouse.

User Recommendations

- Evaluate warehouse resource planning if you are risk-tolerant, are willing to adopt emerging technologies, and desire improved planning and optimization in your warehouse.
- Segment your warehouse operations by using the Gartner warehouse stratification model and focus your resource planning efforts on your higher-complexity Levels 3, 4 or 5 warehouses.
- Identify potential use cases for resource planning, and work with vendors to conduct a focused proof of concept. The market is nascent, with some specialist vendors and a few WMS vendors now offering solutions.
- If you have an advanced WMS, study what your vendor offers or what capabilities it is working on. If your vendor offers nothing and has nothing on its roadmap, then focus on stand-alone applications that address forward planning.

Sample Vendors

AutoScheduler.AI; Blue Yonder; CognitOps; KNAPP; Manhattan Associates; redPILOT

Gartner Recommended Reading

Apply an Architectural Framework to Stratifying Warehouse Management Systems

Critical Capabilities for Warehouse Management Systems

Returns Management

Analysis By: Simon Tunstall, Dwight Klappich

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Returns management is a class of software solutions that helps manage the end-to-end returns process and activities. This includes connecting with consumers and customers through returns transport to processing and managing the return, evaluation, value recovery, managing returns to vendors and ultimately executing settlements such as refunds, replacements and credits.

Why This Is Important

Returns volumes are growing (partly driven by e-commerce growth) amid varied returns policy expectations. Returns can be a significant and costly problem for companies, making returns a growing area of importance for retailers of all sizes as well as other industries. However, market penetration remains relatively modest because, until recently, returns was a secondary consideration for most organizations, and little IT spending has focused on optimizing multiple factors in the returns process.

Business Impact

By redefining the returns supply chain and implementing advanced returns management solutions, companies can create significant opportunities to improve customer experience, improve value recovery and strengthen brand presence while reducing costs and improving efficiency.

Drivers

- Returns management solutions help automate and manage the end-to-end returns process. This starts by providing consumers and customers self-service connectivity to the returns platform to request a return. The platform then manages authorization, dispositioning, shipping, consolidating returns where possible, providing returns visibility while keeping customers informed, tracking updates and, finally, processing the refund.

- Leveraging business applications to support the returns management process is not new. In fact, over 15 years ago there were numerous first-generation vendors that built robust solutions to support the end-to-end returns process. However, it was too early then, and e-commerce needed to grow dramatically before the market for specialized returns management became sustainable. Virtually all the first-generation vendors ceased operations. It is only recently that a new wave of specialist vendors is beginning to emerge to cover significant and enhanced aspects of returns management requirements.

Obstacles

- Most organizations continue to live with labor-intensive, manual, often undisciplined and inefficient returns management (RM) processes. This is because many organizations prioritized supply-chain-related IT investments on outbound projects (e.g., order management and fulfillment). However, this is changing as the challenges of supporting the growing volume of returns forces companies to automate returns management, organize more efficient returns processing and transportation operations and ease decision making in areas such as dispositioning.

User Recommendations

- Determine which activities to prioritize for improvement by directing your team to conduct a detailed review of returns processing, returns management and reverse logistics operations. This includes contact centers, stores, drop point and carrier networks, distribution/returns processing and repair centers.
- Gauge the current state of the company's returns strategy, capabilities and technology needs. Also map which elements of returns management are covered by existing systems (such as WMS, multicarrier, order management, finance, customer relationship management (CRM), and ERP applications).
- Improve the maturity of the reverse supply chain by identifying areas of disconnect between reverse logistics operations, returns strategy and adjacent initiatives within the business.

Sample Vendors

Easycom; G2 Reverse Logistics; Inmar Intelligence; Newmine; nShift; Optoro; ReBOUND; ReverseLogix; shipcloud (12return); Tech Mahindra

Gartner Recommended Reading

Gartner's Framework for Developing Your Reverse Logistics and Returns Management Program

Market Guide for Multicarrier Parcel Management Solutions

The Contemporary Guide to Retail Supply Chain Excellence: Part 3 - Returns and Recommerce

Light-Cargo Delivery Drones

Analysis By: Bill Ray

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Light-cargo delivery drones are flying, autonomous things used to deliver small packages. Autonomy may be supplemented by remote operation when needed and landing may require special facilities. Deployment use cases are limited by local and national legislation, which may restrict beyond visual line of sight (BVLOS) to specific areas, require safety features and/or limit cargo capacity.

Why This Is Important

High-profile companies, including Amazon, Google and JD.com, have invested in drone delivery services. However, in most cases legislation has yet to catch up with technical capabilities. Consumer deliveries are the ultimate aim to create scale and reduce costs. However, for at least the next five years, we expect use cases to be focused on public services (e.g., medical and relief deliveries) and B2B services, where small-scale deployments can be profitable and legislation is less restrictive.

Business Impact

The initial impact of light-cargo delivery drones will be on courier services. However, delivering products anywhere, at low cost, will have a more significant impact:

- Enterprise deliveries can reduce duplication of resources, such as laboratories used for medical testing.
- Just-in-time delivery to remote sites, such as oil rigs, reduces the need for local stockpiling and accelerates breakdown repair.
- Delivering to a person, rather than to an address, creates new business opportunities in just-in-time products and services.

Drivers

- Delivering directly to a smartphone creates mobile customers who can order (and receive) goods from anywhere. Emergency equipment, such as a defibrillator, can be delivered directly to the point of demand, while businesses will be interested in delivering food into the hands of mobile consumers.
- Drones offer (largely) consistent delivery times, bypassing traffic and other impediments to ground transportation. While this is generally faster, it is also (perhaps more importantly) predictable and forecastable.
- Delivery drones running between hospitals can reduce the need for replicated laboratory services (as samples can be quickly and reliably transported), negating the need for local stocks of rarely used medication (such as obscure anti-venoms, which aren't often used but might be needed urgently).
- Light-cargo delivery drones can be highly valuable in delivering products to locations, or across terrains, that lack traditional infrastructures such as tarmacked roads. Fixed-wing drones can travel hundreds of kilometers, delivering products (such as medical supplies or emergency communications equipment) through a parachute drop or landing (where a short runway is available), reducing the need for local stockpiling "just in case."
- The use of "gig economy" workers to deliver goods is already attracting regulatory attention in many countries, resulting in increased cost of service as operating companies are required to treat delivery drivers as employees.

Obstacles

- Concerns over physical safety, citizen privacy and noise represent further legislative and regulatory hurdles, especially in urban environments.
- Legislation permitting the use of BVLOS drones is still being developed in the biggest markets, such as the U.S. and EU. This legislation is not expected until the tail end of 2023.
- Consumer delivery services still suffer from a lack of infrastructure as drones need somewhere to drop their cargo. Solutions exist where customers have large gardens or driveways, or the drones can hook onto window ledges, but no standards exist.
- Drone flight times and lift capacity are still limited. Fixed-wing drones offer greater range and speed, but require landing facilities unless vertical takeoff and landing are (also) supported.
- Autonomous flight still, often, requires remote monitoring and support, which in turn requires connectivity.

User Recommendations

- Create an expert group within the organization that can advise on the legal restrictions locally, including regional and national legislation, and which will take priority.
- Leverage local “flight test zones” where BVLOS may be permitted for companies or government groups that wish to test technologies and services. These zones may cover wide areas and will often serve as a core from which operations can be expanded over the coming years.
- Identify opportunities for deliveries across private campuses, government sites or in regions where BVLOS is permitted.

Sample Vendors

Amazon; Flytrex; JD.com; Manna; Matternet; Wing; Zipline

Gartner Recommended Reading

Market Trends: 4 Technologies That Will Revolutionize Drones and Robots

Forecast Analysis: Retail and Wholesale Trade IoT Endpoint Electronics and Communications Revenue, Worldwide

Warehouse Simulation and Modeling

Analysis By: Dwight Klappich

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Warehouse simulation and modeling tools use advanced mathematical methods, visualization, simulation and various software technologies to analyze and solve complex logistics problems to improve warehouse processes and decision making.

Why This Is Important

Warehouse management systems (WMSs), while mature, focus on execution best practices, but have little capability to help companies model and evaluate alternative future states. When warehouse operations were stable, and changed little over time, modeling was unnecessary. However, given the recent volatile and high-velocity environments companies face, they need better tools to test their abilities to respond to rapid change.

Business Impact

Work volatility in warehouses is motivating companies to seek better tools to help them understand the impact of changes on their operations. Warehouse simulation and modeling will provide companies more advanced decision support capabilities that go beyond the more rudimentary tools that are common today in WMSs, such as task interleaving, wave planning and basic business intelligence (BI).

Drivers

- Historically, warehouse environments were quite stable and changed little year over year, so demand and market penetration of warehouse simulation and modeling in end-user companies were minimal. While the tools that apply mathematics and simulation to decision support problems within a warehouse are not new, it has taken the volatility of e-commerce and accelerated adoption of warehouse automations to drive increased demand.
- Historically, these tools were either used by consulting companies or system integration firms to help them model their customers' current and future warehouse environments. However, this is changing, and growth is anticipated in end-user supply chain organizations.
- Vendors are refining the user interfaces of their offerings to make them more intuitive and easier to work with, and building low-code/no-code capabilities.
- They are packaging some of the algorithmic power in their solutions, so companies don't have to start from scratch to build initial models.
- Finally, because of the dynamic market that supply chain organizations are faced with today, some companies are developing internal expertise in solutions like these. Third-party logistics (3PL) companies are the most likely to adopt these solutions because they operate in many markets and can benefit from using these tools to model changing business conditions.
- The most comprehensive solutions offered advanced decision support techniques to improve warehouse operations such as 3D visualization, warehouse design, material handling automation design, seasonal reorganization of a warehouse, optimization of warehouse workflows, workforce planning and bottleneck analysis. These solutions combine elements of a warehouse digital twin with advanced simulation and modeling.
- Simulation and modeling can exist without true digital twins, where the algorithms run on data sources generated from applications like WMS, warehouse control system (WCS) and warehouse labor management (WLM).

Obstacles

- The power and sophistication of early generations of these systems required knowledgeable and skilled users, and were often too complex for end-user supply chain organizations. This is why initial use was limited to dedicated experts at boutique consultancies.
- Simulation fits best in complex Levels 4 or 5 warehouse operations. However, these were historically too complex and sophisticated to offer much value for less demanding warehouse operations. This is changing as the solutions are simplified.
- While there are generic simulation and modeling tools, most of these have historically been geared toward manufacturing and not warehousing.

User Recommendations

- Study the capabilities and value proposition of warehouse simulation and modeling tools, especially if operating Levels 4 or 5 warehouse operations. Most complex warehouse operations will benefit from modeling, so it should become a core competency.
- Assess the talent needed to pursue, select, implement, use and fully exploit these advanced decision support tools before starting. Determine whether you have the internal capabilities to pursue these technologies or if you should seek outside help.
- Engage with a consultant or systems integrator to build models initially, with the intent to learn the tools and how to employ the insights developed with the tools. Then, eventually, you may choose to bring these in-house so that the company can own and adapt its models, and run them at will.

Sample Vendors

The AnyLogic Company; FORTNA; Körber; Logivations; Mecalux, NVIDIA; Rockwell Automation (Emulate3D); Slot3D

Gartner Recommended Reading

Predicts 2023: Supply Chain Technology

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 1, Improving Upgrades

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 2, Handling Volatility and Complexity

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 3, Labor and Resource Challenges

Cool Vendors in Supply Chain Management Technology

Collaborative In-Aisle Picking Robots

Analysis By: Dwight Klappich

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Definition:

Collaborative in-aisle picking robots coexist and work with humans to support picking operations, leveraging the existing warehouse physical infrastructure, such as racking and shelving. Robots move to and from aisles where the humans perform picking and other functions.

Why This Is Important

While companies want the benefits of automation, many lack the financial resources to invest large sums of money to deploy large-scale automation. Unpredictability of the future of businesses forces companies to choose more flexible solutions than large-scale, bolt-in automation. In-aisle picking robots allow companies to keep their existing aisles and racks, using mobile robots to collaborate with their workers to partially automate the picking process.

Business Impact

Collaborative in-aisle picking robots are a lower-cost and lower-risk approach to partially automating the picking process. These solutions have low upfront costs and can be operational quickly, within weeks or months, so they have rapid time to value. Also, because they generally operate with minimal, if any, changes to a company's warehouse infrastructure, they are good alternatives for adding some automation to the existing facilities.

Drivers

- Small or individual item picking, which is common in e-commerce and other direct-to-consumer businesses, is labor-intensive and historically has been expensive to automate and required large capital expenditures for very specialized material-handling systems. If companies were building brand-new facilities, the capital outlay for material handling could be buried in the cost of the new facility. However, if a company was looking to add automation to the existing facilities, the time, effort and cost to rip out all the existing infrastructure and replace it with conventional automation was prohibitive. In-aisle picking robots emerged to address these issues.
- Collaborative in-aisle picking robots bring robots and humans together within the existing warehouse infrastructure, taking advantage of the strengths of both. The robots autonomously move around, freeing the humans to handle complex picking tasks.
- The physical robots are complemented with advanced software that helps manage and optimize work across a fleet of robots, which then allocates and assigns the work to humans and individual robots.
- A majority of the traditional picking process consists of walking rather than picking. Collaborative robots can make the picking process much more efficient by doing the walking for pickers.

Obstacles

- Collaborative in-aisle picking robots compete with various other robotic and conventional automation solutions that can perform many of the same activities though in different ways, and with different risk and value propositions. Many customers struggle to choose from all the competitive alternatives they are presented with.
- Many of the boutique consultancies that companies would turn to for assistance have deep experience with conventional material-handling automation systems but less so with robotics, and this adds to the challenges for companies making decisions.
- Because of the need to coordinate the work generated in a warehouse management system (WMS) and the robots, more process and technical integration is required, adding to the cost and time to deploy.
- Because picking heights are limited to what a human can reach, companies cannot take full advantage or ceiling height without adding mezzanines.

User Recommendations

- Pilot in-aisle picking robots for specific use cases by starting small, because a key advantage of collaborative robots is the low upfront costs and reduced risks.
- Develop evaluation methodologies to help quickly identify reasonable use cases for intelligent flexible automation and robotics.
- Create a narrowly focused center of excellence (COE), as it will help to effectively manage flexible intelligent automation in the long term by engaging domain experts across engineering/operations technology (OT), IT and supply chain functions.
- Explore more adaptive funding models that are not constrained by burdensome payback and ROI expectations, using methods similar to how startups leverage venture capital, early in the investigative process.

Sample Vendors

6 River Systems; Geek+; Hai Robotics; inVia Robotics; Locus Robotics; Zebra Technologies (Fetch Robotics)

Gartner Recommended Reading

Market Guide for Intralogistics Smart Robotics

Predicts 2023: Supply Chain Technology

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 1, Improving Upgrades

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 2, Handling Volatility and Complexity

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 3, Labor and Resource Challenges

Supply Chain Convergence

Analysis By: Dwight Klappich

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Supply chain convergence is where supply chain functional silos are broken down and end-to-end (E2E) business processes span, synchronize and optimize across traditional functional domains.

Why This Is Important

To get beyond Stage 3 maturity, supply chain organizations must embrace convergence as both a business and an IT vision and strategy. Companies continue struggling to systematically integrate E2E business processes in the fragmented supply chain functional and IT environments prevalent in most organizations. Coordinating, let alone optimizing, E2E processes across application silos remains elusive, but with the emergence of composable application architectures, this is becoming more attainable.

Business Impact

Supply chain maturity and supply chain convergence attainment are closely aligned, wherein higher-maturity organizations are more likely to address the cultural and operational issues necessary to reach higher levels of convergence. Breaking down the functional silos by leveraging technology to assemble composite processes across domains addresses the urgency to pursue convergence as companies seek higher maturity, and as new business models (like digital) drive transformational change.

Drivers

- E2E processes are horizontal and often span multiple functional organizations and systems, and increasingly span enterprises. Most organizations are organized by functional silos, but once a company makes the commitment to think horizontally, aligning processes will become a necessity.
- New process improvement will require organizations to adapt their cultures and operational environments to coordinate and synchronize E2E processes, such as selling, buying or making. This will require supply chain capabilities and systems to converge across and between traditional supply chain management functional silos. However, until recently, technology was a barrier, but with the emergence of composable application platforms, this is potentially technically feasible.
- While for years companies have recognized the need to better orchestrate E2E processes, it is only recently that technology, notably microservice-based API-centric architectures, is making this possible.
- With the emergence of composable microservice-based technical architectures, in some cases, companies can soon assemble packaged business capabilities (PBCs), irrespective of the functional domain the services typically belong to, which will lay the foundation for Stage 3 and beyond convergence.
- Convergence is needed to support the next wave of business value, because it's better at orchestrating E2E processes. But as they mature, companies will increasingly apply optimization capabilities to these E2E processes to allow them to perform better.
- Initially, convergence strategies will be focused inside-out within the enterprise, but to mature further, companies must shift their focus to an outside-in perspective. Companies must consider the role of multienterprise business networks and how these can enable integrated ecosystems and synchronized cross-enterprise processes.

Obstacles

- Because the technology was not available to effectively progress to E2E process orchestration convergence most organizations have been stuck at lower maturity analytical or transactional integration convergence. Now with composable microservice-based API centric applications, the technology is catching up to the need, making achieving Stage 3 convergence maturity more achievable.
- Technical debt, where companies have large scale investments in existing systems, is a barrier to achieving convergence, as the time, effort and cost to renovate a company's entire application portfolio is prohibitive.
- Organizational culture is a barrier to achieving convergence, as too many operations cling to rigid functional silos with processes optimized vertically within a function, but suboptimally across functional silos.
- Rapid adoption of SaaS-based siloed applications and decentralized technology investment models create obstacles for technical leaders to build a true E2E convergent supply chain.

User Recommendations

- Evaluate how fundamental operational processes are linked with and affected by processes that are controlled by other functional groups and systems within and outside their organizations.
- Adapt your organizational cultures and operational environments to enable coordination and synchronization of E2E processes by shifting your paradigms from a vertical (functional) view of the world to a horizontal (E2E process) view of the world.
- Break down functional silos by creating composite business processes that bring together subprocesses and activities across specific domains.
- Evaluate how fundamental operational processes are linked with and affected by processes that are controlled by other functional groups and systems within and outside their organizations.
- Leverage Gartner research to develop a composability purity test to evaluate the realities and roadmaps of technology vendors you are considering.

Gartner Recommended Reading

Understand the Need for Supply Chain Execution and Manufacturing Operations Management Convergence

Becoming Composable: A Gartner Trend Insight Report

Top Trends in Strategic Supply Chain Technology 2023

Autonomous Mobile Robots (Transport)

Analysis By: Dwight Klappich

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Definition:

Autonomous mobile robots (AMRs) for basic transport add intelligence, guidance and sensory awareness to conventional automated guided vehicle (AGV) platforms, allowing them to operate independently and around humans. These robots focus primarily on autonomously moving (transporting) goods within plants and warehouses.

Why This Is Important

Labor is one of the most sporadic and largest cost elements in warehouses and plants. Employee time dedicated to moving goods from one place to another is unproductive, costly and easily automatable. Transport robots can perform many movement tasks, more efficiently and, often, more flexibly than humans within warehouses and plants. This can free up the employees to focus on more value-added activities, where uniquely human capabilities like problem solving or dealing with ambiguity are needed.

Business Impact

Improvements in overall throughput, adaptability, safety and productivity will be the primary value, regardless of whether labor is reduced or not. Warehouse operations with a high volume of bulk (i.e., pallet) product moves should consider some of the current generations of AMRs as an alternative to, or for supplementing, existing automation, such as conveyors or guided vehicles. Companies looking to build new automated facilities should also explore the potential value of these smart machines.

Drivers

- AMRs will continue to gain traction in warehouses, distribution centers and plants, as AMRs increasingly take over functions historically performed by humans on lift trucks.
- AMRs are the natural evolution of AGVs that have been in use for nearly 50 years.
- AGVs are proven but suffer from inflexibility and lack of adaptability because they have to follow a fixed path (i.e., rails, wires, tags or magnets) on the floor.
- Modern AMRs are significantly more adaptable and can be retrained to perform new or different tasks, and in some cases, simply by the push of a button.
- As computing power has multiplied and the cost of sensors has declined, the power, flexibility and use cases for AMRs have grown while prices have come down, leading to significant AMR market demand growth.
- While there are similarities across AMRs, there are also differences, such as the payload the AMR can move, the height it can reach, and how it picks up and moves goods.

Obstacles

- Market penetration is low overall, with under 25,000 AMRs deployed commercially today, which when contrasted to well over a million lift trucks operational, is a small market so far.
- Payload is a significant determinant of the type of vehicle, and the heavier the payload the higher the cost. The total cost of ownership is a barrier to growth at this end of the market.
- Organizations that have previously used AGVs find the adoption of AMRs seamless, while companies new to mobile robots in general have more to learn. Additionally, many struggle to identify the best near-term use cases, and based on these, the best AMR platform to choose. Building a business case for heavy-payload transport AMRs is proving more difficult for some customers due to the high cost of the vehicles and a lack of experience with the technology.
- Technical issues still plague the viability of fully autonomous lift trucks that can lift loads higher than ten feet, but progress continues in this area.

User Recommendations

- Review your operations and identify areas with wasted travel time to complement the basic transport AMRs' ability to automate the movement of goods.
- Review what you are moving and its characteristics, how you're moving it, and what tasks you hope to automate. This can help define good use cases and determine the core requirements for evaluation.
- Leverage the flexibility of AMRs by approaching the evaluation through concepts of the scientific method, which is where you develop hypotheses for use cases, design experiments to test them and then conduct pilots testing the same.

Sample Vendors

AGILOX; BALYO; Clearpath Robotics (OTTO Motors); MiR; OMRON; Seegrid; Third Wave Automation; Vecna Robotics; Zebra Technologies (Fetch Robotics)

Gartner Recommended Reading

Market Guide for Intralogistics Smart Robotics

Predicts 2023: Supply Chain Technology

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 1, Improving Upgrades

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Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 3, Labor and Resource Challenges

Digitized Freight Networks (Road)

Analysis By: Nathan Lease, Dwight Klappich, Carly West

Benefit Rating: Low

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Definition:

Digitized freight networks have come into the market by offering new approaches to accessing and acquiring road freight capacity. A digitized freight network (DFN) is an open, fully connected freight marketplace that uses machine learning, automation and other software services to efficiently connect shippers and domestic carriers. DFNs for road freight provide an alternative to traditional brokers and load board approaches to the spot market, as well as contracted freight.

Why This Is Important

A growing number of DFNs for domestic road transportation are entering markets, such as North America, Latin America, Europe and Asia. These platforms are becoming more important to shippers to optimize cost, service and efficiency. A typical transport broker would simply accept loads from shippers and find available capacity with carriers. Digitized platforms match capacity available from carriers in real time. Digital brokers are a mix of the platform and legacy transport broker model.

Business Impact

Most shippers use contracted common carriers and private fleets for the biggest part of their business. However, inconsistent capacity constraints, tender rejections and selective carriers will continue to drive demand for ad hoc capacity. These platforms provide shippers with available capacity while decreasing deadhead and empty miles. Some platforms help with contracted freight with annual rates or strategic pricing that fluctuates up and down with the market based on agreed parameters.

Drivers

- Customer demand is typically driven by changes in the transportation market and need for access to real-time freight capacity to drive cost avoidance or savings.
- Many shippers seek for better visibility and DFNs provide much better visibility compared to traditional load assignment through brokers.
- Lack of capacity forces shippers to seek other sources outside their traditional contracted carriers, brokers and spot markets.
- DFNs help shippers and carriers to save time by connecting them digitally. This allows them to eliminate the process and match loads more efficiently.
- Company's existing transportation systems might be directly connected to a small number of preselected carriers; the current business climate necessitates the need to create and communicate with a far larger ecosystem of partners.
- DFNs offer a win-win for carriers, as it fills empty miles and can increase the utilization of the carrier's fleet. Many of these platforms have partnered with existing transportation management system (TMS) vendors to provide integration for loads where contracted rates cannot be honored.
- Traditional road transportation RFPs and annual contracts are typically managed in a manual fashion by shippers using spreadsheets. Many are looking for ways to optimize this process.
- RFPs and annual contracts have stabilized recently. However, some regional markets and operational reasons are driving the need for spot market solutions. With the momentum of leveraging these tools during the recent capacity constrained market, these dynamic and fluid contracts between shippers and carriers are now leveraged to optimize between cost and service. Some of the digital freight vendors are helping solve these longer-term or contract freight opportunities for shippers in addition to their spot needs.

Obstacles

- Although DFNs are growing and increasing their customer base, most shippers use DFNs for a small percentage of their freight.
- For the digitized road freight networks to fully leverage the collaborative opportunities between shippers and carriers, they must grow the volume of transactions.
- During periods of stable markets, high available capacity and low tender rejections DFNs struggle to grow the number of transactions.
- RFPs and annual contracts are stabilizing recently. Some regional markets and operational reasons are driving the need for spot market solutions. With the momentum of leveraging these tools during the recent capacity-constrained market, these dynamic and fluid contracts between shippers and carriers are now leveraged to optimize between cost and service. Some of the digital freight vendors are helping solve these longer-term or contract freight opportunities for shippers, in addition to their spot needs.

User Recommendations

- Source your transportation needs via these networks to increase delivery options when it comes to transportation partners, efficiency and capacity.
- Leverage DFNs to optimize costs for shippers that are challenged with reducing transportation costs.
- Leverage DFNs to increase capacity and drive competition on rates for shippers that have a dependency on the spot market.
- Explore the opportunity to enhance and optimize your manual RFP processes by leveraging a DFN's contract solution offering.
- Leverage DFNs as a strategy to drive down emissions outputs for the organization

Sample Vendors

Convoy; Emerge; InstaFreight; Leaf Logistics; Loadsmart; NEXT Trucking; sennder Technologies; Saloodo!; Transfix; Uber Freight

Gartner Recommended Reading

Market Guide for Digital Freight Models for Road Transportation

Latin America Context: 'Market Guide for Digital Freight Models for Road Transportation'

Asia/Pacific Context: 'Market Guide for Digital Freight Models for Road Transportation'

Mobile Robotic Goods-to-Person Systems

Analysis By: Dwight Klappich

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Mobile robotic goods-to-person (G2P) systems keep a human in one place and let robots move goods to and from the human. G2P systems are not typically autonomous robots, and as such, require less sensory technology onboard the robot and have minimal impact on customer infrastructure.

Why This Is Important

Labor availability constraints, rising operational and labor costs, and the need to improve efficiency are motivating companies to seek solutions that leverage mobile robots. G2P robotic solutions keep people in one place, increasing their efficiency and protecting workers with enforced social distancing. G2P systems are a low-cost, rapid way to add automation into existing facilities with minimal, if any, large-scale infrastructure changes, which aids adoption.

Business Impact

Robotic G2P systems reduce travel, and improve picker efficiency by keeping a human in one place and letting the robots do all of the goods movements. Robotic G2P systems reduce worker fatigue and improve worker satisfaction by significantly reducing walking time and distance per day.

Drivers

- Labor availability constraints coupled with rising labor costs are forcing companies to consider various forms of material handling automation including, but not limited to, G2P systems. G2P solutions are well-suited to e-commerce, and now in some cases, microfulfillment. This is because robots move the goods on portable shelving units, where typically multiple items are stored on the incoming unit, and the picker selects multiple orders on an outgoing shelving unit. Robust software orchestrates the robots' movements to and from the pickers based on orders and inventory flow.
- G2P systems are typically significantly less costly than conventional material handling systems and are more agile, flexible and adaptable. G2P systems have added benefits over other forms of material handling that are increasingly in demand given the ease and speed to be adopted within an environment.
- There are two broad categories of G2P systems — those built around mobile robots (covered here) that move on the floor delivering goods to the human, and robotic cube storage "G2P" systems where robots operate independently on specially designed three-dimensional grids. The former requires minimal infrastructure, other than specially designed shelving units the robots use to move the goods and can be deployed quickly but can require more floor space.

Obstacles

- G2P systems are just one form of automation that might solve a customer's specific fulfillment needs. Choosing between the various options is difficult because systems have differing values, risks, complexities and costs. G2P systems fit a specific use case and companies might have other use cases for mobile robots that require a different type of robot.
- As companies deploy heterogeneous fleets of robots, building an orchestration capability across robot platforms will become more important.
- Mobile G2P systems can take more square footage for the same inventory and order profiles. This is due to the use of mobile shelving units that require floor space for the shelving units to be moved around, and because inventory can only be stored roughly five feet high. However, this can also be a benefit to some customers wishing to implement the system in a nonconventional warehouse environment, like in an office building or store.

User Recommendations

- Map out your current fulfillment processes, order and pick volumes, growth projections and current labor efficiencies before looking at G2P solutions to understand the potential value to your business.
- Ensure your fulfillment profile fits the characteristics best suited to a G2P system, such as high volume, high-mix single-item picking common to e-commerce and related businesses.
- Work with the vendor to size the solutions properly in line with peak daily, weekly and annual demand fluctuations.

Sample Vendors

Geek+; Grenzebach Group; GreyOrange; inVia Robotics

Gartner Recommended Reading

Market Guide for Intralogistics Smart Robotics

Predicts 2023: Supply Chain Technology

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Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 2, Handling Volatility and Complexity

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 3, Labor and Resource Challenges

Web-Based Logistics Portals

Analysis By: Oscar Sanchez Duran

Benefit Rating: Low

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Web-based logistics portals allow the booking and tracking of ocean, air and inland transportation, and do not require the installation of an enterprise transportation management system.

Why This Is Important

Web-based logistics portals offer a consumer-like interaction experience where shippers can visit the website of their choice to enter simple information such as commodity, origin, destination and weight, and instantly receive several shipping quotes and tracking shipment information. These solutions typically offer self-service options and are user-friendly when compared to the traditional process of going through a freight forwarder or carrier.

Business Impact

With a low barrier to entry, web-based logistics portals can be used nearly instantly. These portals will, however, not replace transportation management systems or the contract-based logistics procurement processes that most enterprises use today. Also, they're not meant to replace robust supply chain visibility platforms. Rather, the portals are front-end applications that increase collaboration and end-user experience by digitizing communications while connecting to back-end solutions.

Drivers

- Most web-based logistics portals only focus on a subsegment of the market, whether it is a specific geography, lane, industry, mode or combination thereof, and are not meant to replace multimodal, global transportation systems.
- Web-based logistics portals offer the ability to fill urgent shipping and/or spot procurement strategies that complement an enterprise's contracted transportation services. They offer shippers the access to the global shipping market in a more efficient manner since the access to quotes is much faster and simpler.
- These portals mimic e-commerce services such as Amazon's subsidizing of parcel shipments for small sellers on their platform. Currently, most of the platforms have an emphasis on ocean freight, but services for air and truck also exist.
- Additionally, many portals offer freight forwarders and logistics providers the ability to reach small and midsize businesses (SMBs) in a profitable manner. This is not always possible otherwise, because of the costs associated with the sale and maintenance of a low-volume shipper.

Obstacles

- Most web-based logistics portals focus on a subsegment of the market, making it harder for transportation end users to adopt them across their enterprise and to get large amounts of value.
- Larger enterprise companies typically prefer connecting their transportation management system (TMS) and other applications, such as multienterprise supply chain business networks (MESCBNs), directly to those carriers and freight forwarders with whom they have long-term contracts.

User Recommendations

- Complement your current booking processes rather than replacing them. Web-based logistics portals offer a quick-response solution to fill urgent last-minute requests and spot needs. SMBs, however, may use these portals on a more frequent basis.
- Use these portals to better scrutinize the spot market for rate deals when freight capacity is tight with your preferred carriers.
- Web-based logistics portals offer much more than a simple quotation service. Explore other capabilities like booking, tracking, exception management and collaboration options to improve your logistics operations.

Sample Vendors

BoxC; Cargoplot; Freightos Group; Freightos (WebCargo); iContainers; Maersk (Twill); SeaRates; Transporteca

Gartner Recommended Reading

Market Guide for Global Trade Management

Optimize Ocean Freight by Leveraging Digital Collaborative Transportation Systems

International Context: 'Magic Quadrant for Transportation Management Systems'

3 Ways to Improve Efficiency in Ocean Freight Operations

How to Optimize an Ocean Freight Procurement Strategy

Climbing the Slope

Indoor Location for People Tracking

Analysis By: Tim Zimmerman, Annette Zimmermann

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Indoor location for people tracking is an umbrella of technologies dedicated to 2D and 3D tracking the location of human beings in an indoor context. The precision of these technologies can vary from a few meters to a few centimeters.

Why This Is Important

Tracking people is important in a wide range of industrial, healthcare and personal security or safety situations. It poses different technical challenges depending on the position of the human body or the proximity of the tracking tag to the body. In addition, the energy used for communication may be absorbed or blocked, leading the application to "lose track" of a person if the right technology is not selected.

Business Impact

Over 70% of enterprises looking to track assets also wanted to track people as part of a cohesive solution. From a safety standpoint, not being able to track people in dangerous situations or environments results in not only avoidable injuries but also loss of life. In certain geographies and industries, tracking people for safety reasons can be mandated by law.

Drivers

- Safety and compliance for industrial environments including factories or plants where fumes, chemicals or temperatures create a safety risk, and construction sites for employee safety and anti-collision purposes (with equipment such as forklift trucks).
- Safety in healthcare pertaining to infants or the elderly, or hospitality workers who may not be aware when they are in a dangerous situation.

- Process optimization when employees are performing identified tasks such as tracking patients in hospital care workflows either in real time or geofenced for safety concerns. This can also apply to time and motion standards in manufacturing or other industries.

Obstacles

- The biggest issue in people tracking continues to be privacy. People don't want to be arbitrarily tracked and want visibility on how the tracking data is used. In some countries, government councils may have to approve of such a solution and again in other situations, it may be illegal.
- Organizations must choose the right technology for the desired outcome. Some technologies cannot guarantee the location of the person being tracked 100% of the time.
- Cost, which may manifest itself as the cost of the tag (ranging between a few dollar cents for an RFID wristband to an over 100-dollar badge) or the cost of the infrastructure necessary to capture the information.

User Recommendations

- Define the use case to ensure that the frequency of data collection and accuracy of the location meet the documented requirements. Vertical market solutions such as healthcare or construction may have industry-specific requirements or certifications.
- Consider additional use cases including data analytics or geofencing.
- Implement a center of excellence that reviews the limitations of differing radio frequencies, infrastructure implementation issues, form factor of tags, wristbands or lanyards that are needed to achieve the desired location, and battery life as well as competitive solutions.
- Deploy the correct technology because vendors may try to sell a solution that is applicable for assets but not for people tracking.
- Construct an ROI for any people tracking location investment since the cost of tags varies widely.
- Address pushback from workers' councils and unions by communicating a people-tracking project very openly and transparently, helping to loop in all stakeholders.

Sample Vendors

AiRISTA Flow; CenTrak; HID Global; Litum Technologies; Midmark; Quuppa; Sonitor Technologies; Zebra Technologies

Gartner Recommended Reading

Magic Quadrant for Indoor Location Services

Critical Capabilities for Indoor Location Services

Market Guide for Indoor Location Application Platforms

Competitive Landscape: Indoor Mapping

Last-Mile Delivery Solutions

Analysis By: Oscar Sanchez Duran, Carly West

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Last-mile delivery (LMD) solutions are specialized, customer-centric transportation management solutions that provide capabilities for routing deliveries to consumer homes. With some solutions extending the delivery service capabilities offered support options like store, curbside and locker box collections as well as return options. These solutions are the next generation of delivery solutions, adding additional capabilities, such as customer experience management.

Why This Is Important

Last-mile delivery solutions have grown due to the huge increase in digital commerce deliveries (including B2B e-commerce, direct-to-consumer, drop-ship, and digital marketplaces). Whereas VRS focused primarily on over-the-road fleets and movements for first mile, middle mile and last mile to businesses. These new LMD solutions mainly focus on deliveries to end consumers using either a company's own fleet, or outsourcing transportation with courier carriers and third-party logistics (3PLs).

Business Impact

LMD solutions provide benefits to e-commerce companies and other shippers focused on the last mile. They add incremental benefits to mature users of routing and scheduling, reducing costs and improving customer service in dynamic environments, and provide other options like sourcing transportation from third-party fleets. Additionally, LMD solutions can improve sustainability service levels, providing capabilities to allow end customers to choose more sustainable transportation options.

Drivers

- LMD solutions can dynamically recalculate and communicate a new route to drivers in real time. These solutions can automatically and proactively adapt to unforeseen events like traffic congestion notifications that will delay drivers and may warrant rerouting.
- As customer choice increases, LMD solutions provide ways to maximize fleet capacity, provide options to outsource transportation and consider multiple shipping from-to scenarios. Connection to courier carriers, and local and hyperlocal delivery carriers, including riders or crowdsourced delivery services are becoming increasingly important. The same applies to the delivery services supporting ship-from-store, curbside delivery and access to pick-up and drop-off networks.
- LMD solutions enhance the delivery experience by improving communication with the customer, considering changes throughout the day as variables of change continue to increase and click-to-door times continue to decrease.
- Meeting on-time appointment windows for delivery to home or office is important and a challenge. Consumers are seeking flexibility in delivery slots and are increasingly prone to changing the date and time of delivery according to their changing needs. Missed appointments require more dynamic updating of both routes and notification to customers of changed appointments.
- Sustainability capabilities are starting to be an intrinsic part of LMD solutions. Vendors are adding not only reporting and analytics on carbon emission, but also providing options to the users to add new services based on sustainable choices like moving the freight with electric vehicles.
- There is a higher demand for customer experience management during the pre- and postpurchase processes that connect to the cargo delivery. Providing a branded experience and capabilities to increase the range of customer choice while overpromising and impacting delivery operations are features considered in these applications.

Obstacles

- Not all users will need LMD solutions. Traditional VRS solutions will suffice for those users who are more first- and middle-mile-focused or who do not require to cover B2C use cases with focus on customer experience.
- Some companies operating with courier carriers and having very large volumes of parcel shipping might use multicarrier parcel management solutions instead.
- Many of these solutions have not yet developed capabilities for all segments of transportation (first, middle and last mile). So, we see end users struggling to figure out their entire transportation network with a common organization, process and technology. Many end users will continue to use multiple solutions, like transportation management systems, along with more traditional vehicle routing and last-mile solutions.

User Recommendations

- Determine if your organization might be a good candidate for LMD solution by mapping internal processes for high levels of change over the course of a delivery, or large focus and volume on last-mile delivery to consumers.
- Implement the drivers to define specific use cases above before investigating solutions to ensure the right fit for your operations.
- Understand the limitations of last-mile applications. While they can provide customer experience management and delivery orchestration capabilities, they might feel short in some use cases.
- Companies need to balance the trade offs between optimal and feasible routes as businesses have become more dynamic and customers more demanding.

Sample Vendors

Bringg; DispatchTrack; FarEye; Locus; LogiNext; OneRail; Onfleet; Tiramizoo; Urbantz; WOOP

Gartner Recommended Reading

Market Guide for Last-Mile Delivery Technology Solutions

How Retail's Last Mile Must Evolve to Become a Two-Way Street

Beyond the Amazon Effect: Why B2B Needs to Evolve Its Last-Mile Strategy

Real-Time Transportation Visibility Platforms

Analysis By: Carly West, Dwight Klappich, Nathan Lease, Oscar Sanchez Duran

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Real-time transportation visibility platforms (RTTVPs) complement the planning and execution capabilities of transportation management systems (TMSs) by providing real-time order and shipment visibility. These platforms are a core part of logistics technology and perform functions that support transportation management, warehouse management, yard management and fleet management.

Why This Is Important

Transportation visibility is a “must have” for organizations, and spans a multitude of vertical industries, use-case segments, modes and geographies. When it comes to transportation visibility, customers are demanding more real-time visibility into in-transit shipments. For-hire transportation has struggled with a lack of proper in-transit visibility for loads once they leave the supplier, the shipper, third-party logistics (3PL) providers’ warehouses or other facilities.

Business Impact

RTTVPs can provide shippers, 3PLs, brokers, carriers, customers and other supply chain parties with a multitude of benefits in the transportation processes, as well as warehouse and yard efficiencies. They can also increase customer satisfaction and delivery experience through proactive action when deviations occur from the plan (e.g., the ability to update dock appointments and estimated times of arrival [ETAs] to customers), allowing them to assess whether changes are needed.

Drivers

- Adoption and centralization of RTTVPs from end users has increased. This is done by leveraging RTTVPs that specialize in providing real-time carrier location and status information to the shipper and the 3PL community.
- RTTVPs provide real-time information on shipments from the carriers based on integrations within-cab telematics systems, interaction via the carriers' or freight forwarders' back-end systems, satellite systems or automatic identification system (AIS) data, port information, or a driver smartphone app. These vendors have expanded their solutions to cover more modes of transportation as well as more geographic regions.
- Many Gartner clients have an increasing focus on implementing visibility, with North America and Europe leading the way, and a focus on expansion into Asia/Pacific and Latin American regions as well. There has also been a focused push on expansion into all modes, such as road, ocean, air, parcel, rail and others.
- Shippers and 3PL providers can reduce costs by shortening detention and waiting times, and/or reducing fines for missing dock appointments, and improve utilization of labor, warehouse and yard resources.
- Shippers and 3PLs can provide real-time visibility provisioning to customers online, rather than needing customer service representatives. This can reduce inventory through a reduction in safety stock based on greater trust in reliability of deliveries and creating backhauls through improved alignment of load timing.
- Shippers and 3PL transportation teams can gain productivity to focus on value-added activities for the business, instead of status calls, tracking and carrier communication activities to provide status updates.
- Carriers can increase driving time and reduce detention times due to dynamic and more-accurate dock scheduling (tighter windows), and avoid costs, because services are mainly free for carriers versus electronic data interchange (EDI) setup costs and ongoing charges.

Obstacles

- Adoption of these RTTVP solutions is rising, but many companies struggle with carrier compliance, and data quality and accuracy.
- Organizations lack a thorough understanding of the insights they get from these solutions and then converting these insights into actions.
- Turning the insights into action is a struggle for some companies. When they see an issue occurring, they aren't sure what action to take to resolve.
- Transparency into metrics and the accuracy of ETA predictions is not yet standard in this market, causing end-user frustration and concern related to value delivered from the RTTVPs.
- There is still some confusion among the end-user community about visibility that TMS provides vs. the enhanced real-time visibility from RTTVP.
- Creating visibility for inbound shipments is more challenging than many companies realize. It requires collaboration and participation between suppliers, carriers, other data providers and the vendor in order to achieve success in most cases.

User Recommendations

- Evaluate RTTVPs for creating internal efficiencies, especially given the increasing frequency of supply chain disruption.
- Establish real-time transportation visibility for your internal and external customers by identifying the best RTTVP for connecting to your carriers, data providers, modes and operational regions.
- Select vendors and solutions based on the modes of transportation, regional coverage and size of the carrier network, as capabilities and vendors are different.
- Discuss SLAs and metrics for deliverables like ETA accuracy, shipment tracking success, carrier onboarding and data quality root cause, and resolution with RTTVP vendors to help determine the right partner.

Sample Vendors

Blume Global; Descartes; FourKites; IntelliTrans; Overhaul; project44; Shippeo; Transporeon

Gartner Recommended Reading

Magic Quadrant for Real-Time Transportation Visibility Platforms

Critical Capabilities for Real-Time Transportation Visibility Platforms

Key Insights to Navigating the Transportation Visibility Market

How to Assess the Benefits and Return on Investment of a Real-Time Transportation Visibility Platform

Build the Business Case for Investment in a Real-Time Transportation Visibility Platform

Robotic Cube Storage Systems

Analysis By: Dwight Klappich

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Definition:

Robotic cube storage systems are robotized storage and order-picking solutions that are delivered as an integrated system consisting of unified cyber-physical systems and software. These typically consist of some form of storage bins or totes, a storage cube/grid/hive, flexible mobile robots that operate on, below or around the grid, goods-to-person/robot user ports, and software that controls the robots.

Why This Is Important

Robotic cube storage systems leverage advanced technologies like AI, pattern recognition, sensors and specialized optimization software to provide integrated and holistic robotic automation solutions. These solutions blend the system integration benefits of conventional material handling automation (MHA) systems while also providing the agility, scalability, space efficiency, safety, shorter time to value and ROI benefits of flexible robotics.

Business Impact

Robotic cube storage systems open the market to companies that could not historically justify the high cost and rigidity of conventional MHA and offer highly effective alternatives built on advanced technology for larger companies seeking contemporary, leading-edge alternatives. While these solutions typically deploy quicker at less total cost than a conventional MHA system, they also offer more cutting-edge capabilities derived from their use of AI and machine learning.

Drivers

- Conventional MHA systems, such as storage retrieval, shuttle or conveyor sortation systems, were valuable, but they were often quite expensive and had a long time-to-value and long payback times. The automation market was constrained by the high costs and complexities of these traditional systems, which were largely relegated to large sophisticated companies with deep pockets.
- Engineered robotic MHA systems sit between the mobile robot market and the conventional MHA market, combining elements from both worlds.
- Most robotic cube storage (RCS) systems take advantage of specialized mobile and traditional industrial robots combined with other forms of automation delivered as an integrated system. For example, in an RCS system, robots operate on top of a specialized grid moving products stored in totes to picking stations, which are designed based on ergonomics principles. Humans at the stations pick items into other order totes that can be routed to packing stations or a put-wall using a powered conveyor.
- The benefit of this architecture is that a company gets the flexibility, scalability, space efficiency, safety and no single point of failure from the robots, but also the added efficiency of the other pieces of automation.
- These systems are typically designed to address the needs of a specific customer and are delivered as an integrated system.

Obstacles

- For many customers, the biggest challenge will be sorting through all the various types of automation available to identify the options that best fit the company's needs and constraints.
- Most companies will lack the internal expertise to pursue this on their own so they will need to find good systems integrators to facilitate their projects.
- RCS systems are still expensive sitting somewhere in the middle between flexible mobile robots collaborative picking solutions and conventional large-scale MHA. Consequently developing even a preliminary business case early in the process will be critical to moving projects forward.

User Recommendations

- Engage with a specialist consultant or a systems integrator to design these systems, unless they have deep internal expertise.
- Seek specialized consultancies that know and have experience with warehousing and these types of engineered robotic MHA systems.
- Collaborate with these organizations to model various alternatives, from simple and minimal automation to higher levels of automation considering value, risk, cost, time to value and adaptability.
- Model/simulate your requirements for throughput speed and capacity to ensure you rightsize the solutions. Also, model this out for 10 years or more to factor in growth.

Sample Vendors

Attabotics; AutoStore; Exotec Solutions; fabric; Jungheinrich; Ocado Group

Gartner Recommended Reading

Market Guide for Intralogistics Smart Robotics

Predicts 2023: Supply Chain Technology

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 1, Improving Upgrades

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 2, Handling Volatility and Complexity

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 3, Labor and Resource Challenges

Warehouse Control Systems

Analysis By: Dwight Klappich

Benefit Rating: Moderate

Market Penetration: More than 50% of target audience

Maturity: Mature mainstream

Definition:

Warehouse control systems (WCSs) are software that manages the near-real-time activities of storage and retrieval in the warehouse, translating business transactional information coming out of a warehouse management system (WMS) (or ERP) into real-time instructions for the automation. It monitors output and workstations, increases the efficiency of subsystems (including material flow control [MFC] and programmable logic controllers [PLCs]), and typically interfaces with a WMS or ERP.

Why This Is Important

Use of advanced material handling systems requires standardized warehouse control systems to simplify and reduce the time, effort and cost of integrating business systems with automation down to the programmable logic controller (PLC) level. Furthermore, in some environments, the WCS coordinates the flow of product as it moves between and across various types of automation like conveyors, storage retrieval or sortation systems.

Business Impact

At a minimum, a WCS eases the maintenance burden of integrating a WMS with automation. As WCSs continue to evolve, additional business benefits will emerge from the analytics and event management capabilities embedded in the WCS.

Drivers

- WCSs primarily translate business-oriented instructions into forms that are meaningful to material handling equipment (MHE). Furthermore, the WCSs coordinate material handling subsystems, such as conveyor belts, carousels, scales, sorters, shuttle systems, and storage and retrieval systems.
- WCSs are undergoing an evolution, moving away from a middleware focus to where some solutions now offer more comprehensive business process logic often called WCS+. The role of WCSs has expanded to include such additional capabilities (other than just automation control) as descriptive and predictive analytics, event management, diagnostics, and increasingly, business-like logic, such as picking.
- Adoption of traditional MHE-centric WCSs is high; adoption of newer, more ubiquitous and broader WCSs now offered by leading vendors is minimal, but growing.
- WCSs will evolve along three paths: First, equipment manufacturers and MHE systems integrators will continue to offer WCSs as operational technology (OT) embedded within their automated systems. For users who use only a particular manufacturer's MHE, this will remain a preferred approach. Second, some WMS or warehouse execution systems (WES) vendors will or have embedded WCSs within their systems. This would be an option for customers that will likely use MHE from multiple providers. Third, stand-alone WCS vendors will offer holistic and independent WCSs that can integrate with multiple WMSs and multiple MHE solutions. This last option will be most applicable to companies whose WMS does not have an embedded WCS, and that have multiple vendors providing MHE.

Obstacles

- WCSs are not new; there have been narrowly focused and often heavily customized solutions for years. These were proprietary solutions designed to exclusively work with a specific vendor's MHE.
- WCSs are becoming more generic and some vendors now offer WCSs that can communicate with a variety of MHE products.
- Companies with automation in multiple facilities might like to standardize on a single WCS, but this proves difficult because the switching cost of a WCS is viewed as risky and companies are reluctant to do so until absolutely necessary. Additionally, the WCS is often delivered as part of a large-scale, automated system project, and many companies expect and desire the systems integrator to provide the WCS. If they only have one MHE provider, this is acceptable; the problem happens when they have multiple types of equipment built by different integrators.
- There are now few stand-alone WCS offerings due to acquisitions largely by material handling system integration firms.

User Recommendations

- Familiarize yourself with best-of-breed WCS solutions (including ones that might be provided by your WMS vendor) when building new automated facilities, as well as those that might be offered by your chosen MHE or material handling system integration provider.
- Evaluate and calculate the value of a stand-alone WCS to ease the integration burden for existing automation in warehouses struggling to maintain automation integrations — or those that have added or changed MHE over the years.

Sample Vendors

Dematic; enVista; FORTNA; Hy-Tek, Körber; KPI Solutions; Matthews International (Matthews Automation Solutions); Toyota Advanced Logistics (Bastian Solutions)

Gartner Recommended Reading

Select From the 8 Software Deployment Options to Support Warehouse Automation and Robotics

Revolutionize Automated Warehouse Operations With Rapidly Evolving Warehouse Execution Systems

Entering the Plateau

Indoor Location for Assets

Analysis By: Tim Zimmerman, Dwight Klappich, Annette Zimmermann

Benefit Rating: High

Market Penetration: More than 50% of target audience

Maturity: Mature mainstream

Definition:

Indoor location for assets provides information about the physical, interior location of fixed or mobile devices, wearables or other objects. This information is derived from different algorithms that use different technologies depending on the type of object and the granularity needed. These technologies include Wi-Fi, Bluetooth, very high frequency (VHF), ultrahigh frequency (UHF), ultrawideband (UWB) or lidar.

Why This Is Important

Indoor location for assets addresses the need to locate or track fixed or mobile assets within an office, warehouse, manufacturing facility or distribution center. These assets can be static, can be moved within a defined zone (zonal) or require to be monitored all the time (real-time location system [RTLS]) for increased productivity, process optimization or lower costs.

Business Impact

Misplaced, lost or “ghost” assets cost businesses millions of dollars each year in write-offs and lost productivity either by looking for assets or waiting for replacement materials. While the best practice is annually taking an inventory of assets, over 20% of surveyed end users note that they had not looked for their assets in the last five years. Knowing where assets are located, can help enterprises make better business decisions and eliminate the waste and cost of duplicate items.

Drivers

- Productivity gets reduced looking for assets when they are misplaced or stolen.
- An indoor location for assets provides process optimization when assets such as tools or raw materials are tracked or inventoried in real time.

- Knowing when critical assets have left specific zones, floors, work sites or buildings allows proactive action.

Obstacles

- Depending on the object or the required granularity, the cost of tags or the necessary infrastructure can seem expensive.
- Organizations must choose the right technology for the desired outcome. Some technologies cannot guarantee the location of a critical asset being tracked 100% of the time.
- Multiple different technologies may be needed depending on the assets, which may add infrastructure to capture information.

User Recommendations

- Define the use case to assure that the frequency of data collection and accuracy/granularity of the location meet the documented requirements. Vertical market solutions, such as healthcare and construction, may have industry-specific requirements or certifications.
- Implement a center of excellence that reviews the limitations of differing radio frequencies, the form factor of tags that are needed to achieve the desired location, and battery life (if applicable).
- Construct an ROI for any asset tracking location investment since the cost of tags varies widely depending on the asset being tracked.

Sample Vendors

AiRISTA Flow; CenTrak; Litum Technologies; Midmark; Quuppa; Zebra Technologies

Gartner Recommended Reading

Market Guide for Indoor Location Application Platforms

Magic Quadrant for Indoor Location Services

Critical Capabilities for Indoor Location Services

Appendixes

See the previous Hype Cycle: Hype Cycle for Supply Chain Execution Technologies, 2022

Hype Cycle Phases, Benefit Ratings and Maturity Levels

Table 2: Hype Cycle Phases

(Enlarged table in Appendix)

Phase ↓	Definition ↓
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant media and industry interest.
Peak of Inflated Expectations	During this phase of overenthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leaders results in some successes, but more failures, as the innovation is pushed to its limits. The only enterprises making money are conference organizers and content publishers.
Trough of Disillusionment	Because the innovation does not live up to its overinflated expectations, it rapidly becomes unfashionable. Media interest wanes, except for a few cautionary tales.
Slope of Enlightenment	Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the innovation's applicability, risks and benefits. Commercial off-the-shelf methodologies and tools ease the development process.
Plateau of Productivity	The real-world benefits of the innovation are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generations. Growing numbers of organizations feel comfortable with the reduced level of risk; the rapid growth phase of adoption begins. Approximately 20% of the technology's target audience has adopted or is adopting the technology as it enters this phase.
Years to Mainstream Adoption	The time required for the innovation to reach the Plateau of Productivity.

Source: Gartner (July 2023)

Table 3: Benefit Ratings

Benefit Rating ↓	*Definition* ↓
Transformational	Enables new ways of doing business across industries that will result in major shifts in industry dynamics
High	Enables new ways of performing horizontal or vertical processes that will result in significantly increased revenue or cost savings for an enterprise
Moderate	Provides incremental improvements to established processes that will result in increased revenue or cost savings for an enterprise
Low	Slightly improves processes (for example, improved user experience) that will be difficult to translate into increased revenue or cost savings

Source: Gartner (July 2023)

Table 4: Maturity Levels

(Enlarged table in Appendix)

Maturity Levels ↓	*Status* ↓	*Products/Vendors* ↓
Embryonic	In labs	None
Emerging	Commercialization by vendors Pilots and deployments by industry leaders	First generation High price Much customization
Adolescent	Maturing technology capabilities and process understanding Uptake beyond early adopters	Second generation Less customization
Early mainstream	Proven technology Vendors, technology and adoption rapidly evolving	Third generation More out-of-box methodologies
Mature mainstream	Robust technology Not much evolution in vendors or technology	Several dominant vendors
Legacy	Not appropriate for new developments Cost of migration constrains replacement	Maintenance revenue focus
Obsolete	Rarely used	Used/resale market only

Source: Gartner (July 2023)

Evidence

[1] **2022 Gartner Supply Chain Technology User Wants and Needs Survey:** This survey was conducted to explore the roles digital and technology play in supply chain. It also supports supply chain technology leaders in their efforts to modernize legacy application landscape and generate a trustworthy business case for their digital journey. The research was conducted online during 26 October to 14 December 2022 among 499 respondents from North America, LATAM, Western Europe and the Asia/Pacific region. Respondents were from organizations with $250 million or more in 2020 enterprisewide annual revenue. Industries surveyed included manufacturing (consumer products, industrial, high tech, healthcare products and life sciences), retail, wholesale trade, healthcare providers, natural resources, transportation and logistics. Respondents who had job roles tied to supply chain function and were involved in decision making regarding supply chain management processes/operations for more than two years qualified for the survey. *Disclaimer: Results of this survey do not represent global findings or the market as a whole, but reflect the sentiment of the respondents and companies surveyed.*

Document Revision History

Hype Cycle for Supply Chain Execution Technologies, 2022 - 27 June 2022

Hype Cycle for Supply Chain Execution Technologies, 2021 - 6 July 2021

Hype Cycle for Supply Chain Execution Technologies, 2020 - 7 July 2020

Hype Cycle for Supply Chain Execution Technologies, 2019 - 9 July 2019

Hype Cycle for Supply Chain Execution Technologies, 2018 - 17 July 2018

Hype Cycle for Supply Chain Execution Technologies, 2017 - 20 July 2017

Hype Cycle for Supply Chain Execution Technologies, 2016 - 11 July 2016

Hype Cycle for Supply Chain Execution Technologies, 2015 - 21 July 2015

Hype Cycle for Supply Chain Execution Technologies, 2014 - 15 July 2014

Hype Cycle for Supply Chain Execution, 2013 - 31 July 2013

Hype Cycle for Transportation, 2012 - 26 July 2012

Hype Cycle for Transportation, 2011 - 26 July 2011

Hype Cycle for Transportation, 2010 - 30 July 2010

Hype Cycle for Transportation, 2009 - 24 July 2009

Hype Cycle for Transportation, 2008 - 9 July 2008

Hype Cycle for Transportation, 2007 - 13 July 2007

Recommended by the Author

Some documents may not be available as part of your current Gartner subscription.

Understanding Gartner's Hype Cycles

Tool: Create Your Own Hype Cycle With Gartner's Hype Cycle Builder

Market Guide for Intralogistics Smart Robotics

Predicts 2023: Supply Chain Technology

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 1, Improving Upgrades

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 2, Handling Volatility and Complexity

Top Technology Trends Transforming Warehousing Over the Next 5 Years: Part 3, Labor and Resource Challenges

Innovation Insight: How Specialized Tech Can Enable Sustainability Goals in Partnership With Mainstream Logistics Apps

Use-Case Prism: Artificial Intelligence for Transportation and Warehousing

Use-Case Prism: Artificial Intelligence for Transportation

Table 1: Priority Matrix for Supply Chain Execution Technologies, 2023

Benefit ↓	*Years to Mainstream Adoption*			
	Less Than 2 Years ↓	***2 - 5 Years*** ↓	***5 - 10 Years*** ↓	***More Than 10 Years*** ↓
Transformational			Supply Chain Convergence Transportation Forecasting Warehouse Picking Robots	Autonomous Trucks
High	Indoor Location for Assets Indoor Location for People Tracking Last-Mile Delivery Solutions	Autonomous Mobile Robots (Transport) Collaborative In-Aisle Picking Robots GHG Emissions Calculation Applications Light-Cargo Delivery Drones Mobile Robotic Goods-to-Person Systems Real-Time Transportation Visibility Platforms Robotic Cube Storage Systems	Digital Twins in Warehousing Multiagent Orchestration Platforms Returns Management Warehouse Labor Forecasting Warehouse Resource Planning and Optimization Warehouse Simulation and Modeling	RTLS-Based WMS

Benefit	*Years to Mainstream Adoption*			
↓	***Less Than 2 Years*** ↓	***2 - 5 Years*** ↓	***5 - 10 Years*** ↓	***More Than 10 Years*** ↓
Moderate		Warehouse Control Systems	Immersive Experience Indoor Flying Drones Mobile Sortation Robots Warehouse Execution Systems	
Low		Web-Based Logistics Portals	Digitized Freight Networks (Road)	

Source: Gartner (July 2023)

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Phase ↓	Definition ↓

Source: Gartner (July 2023)

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Source: Gartner (July 2023)

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Source: Gartner (July 2023)