Predicts 2025: Supply Chain Operational Technology

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Technology is considered a critical enabler of competitive advantage and leaders often cite improving their position as a key driver for investing in operational technology. Supply chain technology leaders can use this research to discover where future risks and opportunities lie.

Overview

Key Findings

- Supply chain organizations are actively investing in operational technologies, with 82% of respondents to the 2023 Gartner Supply Chain Technology User Wants and Needs Survey reportedly increasing their IT spending. Of those respondents, 24% intend to significantly increase their spending over the next two years.
- Robotics has been identified as an important investment area to help companies address labor cost and availability challenges. Ninety-two percent of respondents reported they have or plan to invest in robotics over the next two years, and 20% say robotics is one of their top three funded initiatives.
- AI (in varying forms) is seen as an important technology to support companies in improving and accelerating their decision-making processes. Thirty-one percent of respondents cite AI as one of their top three funded initiatives. Similarly, AI, machine learning (ML) and

generative AI (GenAI) have been identified as some of the most disruptive, yet important, emerging technologies.

- Application modernization for transportation technology was identified as a key area of supply chain investment, with a significant number of respondents saying upgrading applications (24%) and deploying new applications (23%) were among their top three funded initiatives.

Recommendations

- Lay the groundwork for rapidly growing and evolving robotics portfolios by developing an organizational structure to support the evaluation, adoption, prototyping, deployment, management and support of robotics across the organization.
- Identify processes in need of high degrees of flexibility and adaptability, and focus on learning how your human workforce performs these tasks to understand what capabilities a humanoid robot will need in order to effectively offer support.
- Embrace application modernization with an ecosystem approach to transportation technology strategy by focusing on solutions that meet specific functional and technical requirements.
- Evolve to adopt composite AI by combining multiple existing and new algorithmic techniques to overcome the limitations of current single-technique AI approaches.
- Experiment with a number of low-risk and low-cost autonomous data collection alternatives because, for the foreseeable future, there will not be one vendor or one solution that fits all possible use cases.

Strategic Planning Assumptions

- By 2030, one in 20 managers will manage robots rather than humans, forcing companies to develop new management methods.
- By 2027, some humanoid robots will verbally receive and respond to human-prompted work instructions via AI agents.

- Through 2027, 75% of large shippers will struggle to juggle their fragmented transportation application portfolios, despite strategies to support a single solution.
- By 2027, 25% of high-performing organizations will adopt composite AI and employ multiple AI techniques to address growing operational complexities.
- By 2027, 40% of yard and warehouse management deployments will employ vision-AI-enabled autonomous data collection, instead of RFID.

Analysis

What You Need to Know

In the 2023 Gartner Supply Chain Technology User Wants and Needs (UWaN) Survey, customers were asked various questions about their technology investment strategies, goals, obstacles and opportunities. [1] This study focused on supply chain professionals, rather than IT professionals, as we wanted to understand the business users' perspectives on supply chain technologies.

Supply chain leaders often view technology as an important way to improve their competitive position. To highlight this commitment to investing in technology, we asked respondents what their top goals were for investing in new technologies over the next two years. Thirty-eight percent said improving their competitive position was one of their top three goals, and 13% said it was their top goal. [1]

To explore if respondents were serious about investing in technology for the future, we sought insight into their investment plans. We also asked, "How do you anticipate your organization's overall investment in supply chain technology will change over the next two years?" Eighty-two percent of respondents said they were increasing their IT spending and, of those respondents, 24% said they were going to significantly increase their spending over the next two years. [1]

Additionally, we wanted to better understand if there were any barriers to respondents making these investments. Therefore, we asked, "Thinking about the next two years compared to the previous two, how easy or hard do you anticipate it will be for your supply chain organization to

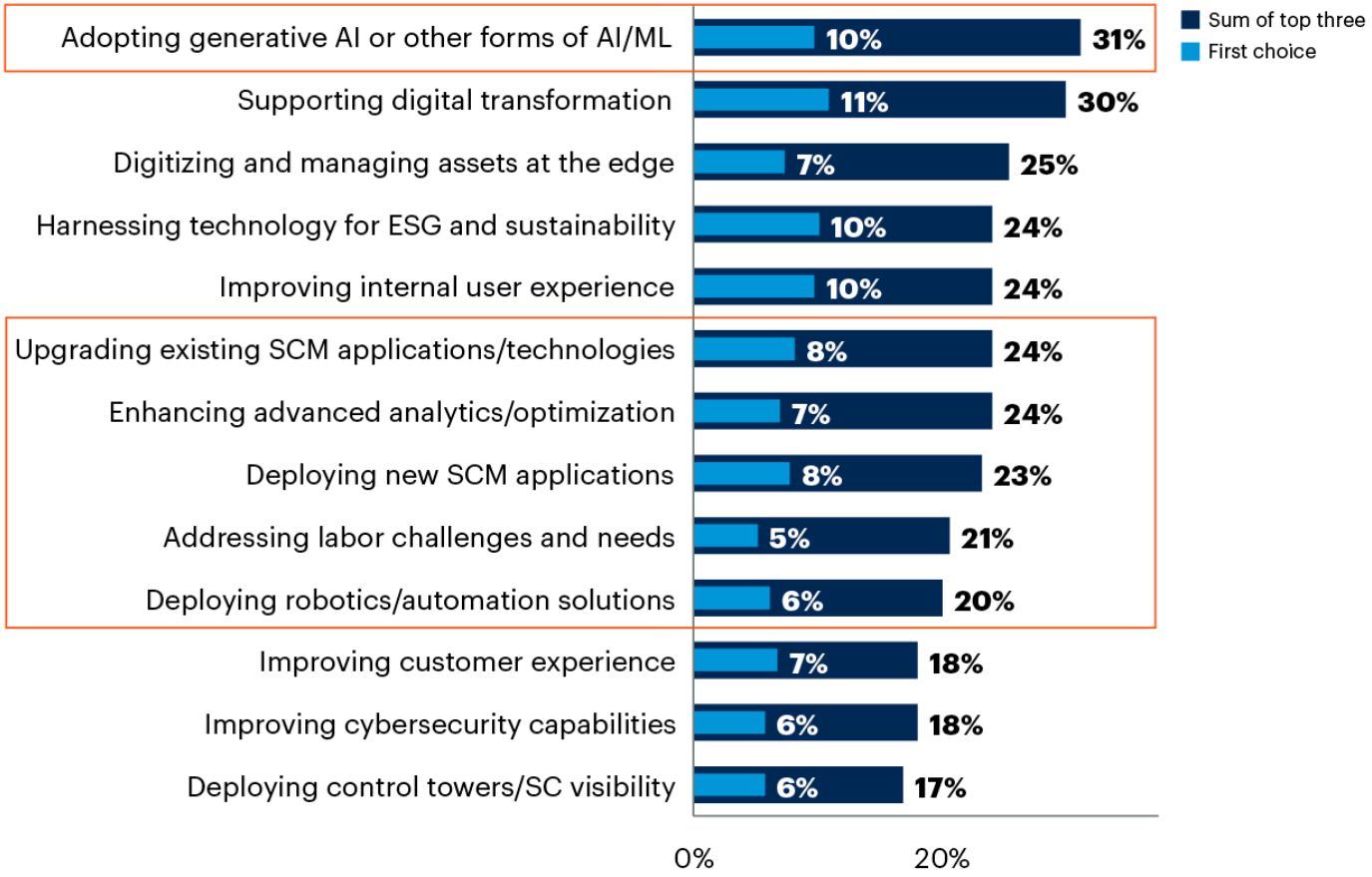
justify and fund new supply chain technology investments?" Seventy percent of respondents said supply chain IT projects will be easier to justify and get funding. [1]

Finally, we wanted to investigate what IT projects were actively being funded. So, we asked, "Which of these are your organization's top three supply chain technology funded initiatives for 2024?" Highlighted in Figure 1 are some of the initiatives that align with this research. [1] Key examples are:

- Exploiting various forms of artificial intelligence in novel ways to solve previously difficult problems
- Addressing labor challenges with robotics and automation
- Modernizing applications portfolios

Figure 1: Supply Chain Technology Funded Initiatives

Supply Chain Technology Funded Initiatives



n = 505, all respondents excluding don't know

Q. Which of these are your organization's top three supply chain technology funded initiatives for 2024?

ML = machine learning; ESG = environmental, social and governance; SCM = supply chain management; SC = supply chain

Source: 2023 Gartner Supply Chain Technology User Wants and Needs Survey

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Combined, these initiatives indicate companies have the motivation, wherewithal and intentions to invest in technology to improve their businesses. Logistics and operations leaders are particularly focused on exploring new technologies to help address their specific obstacles to success.

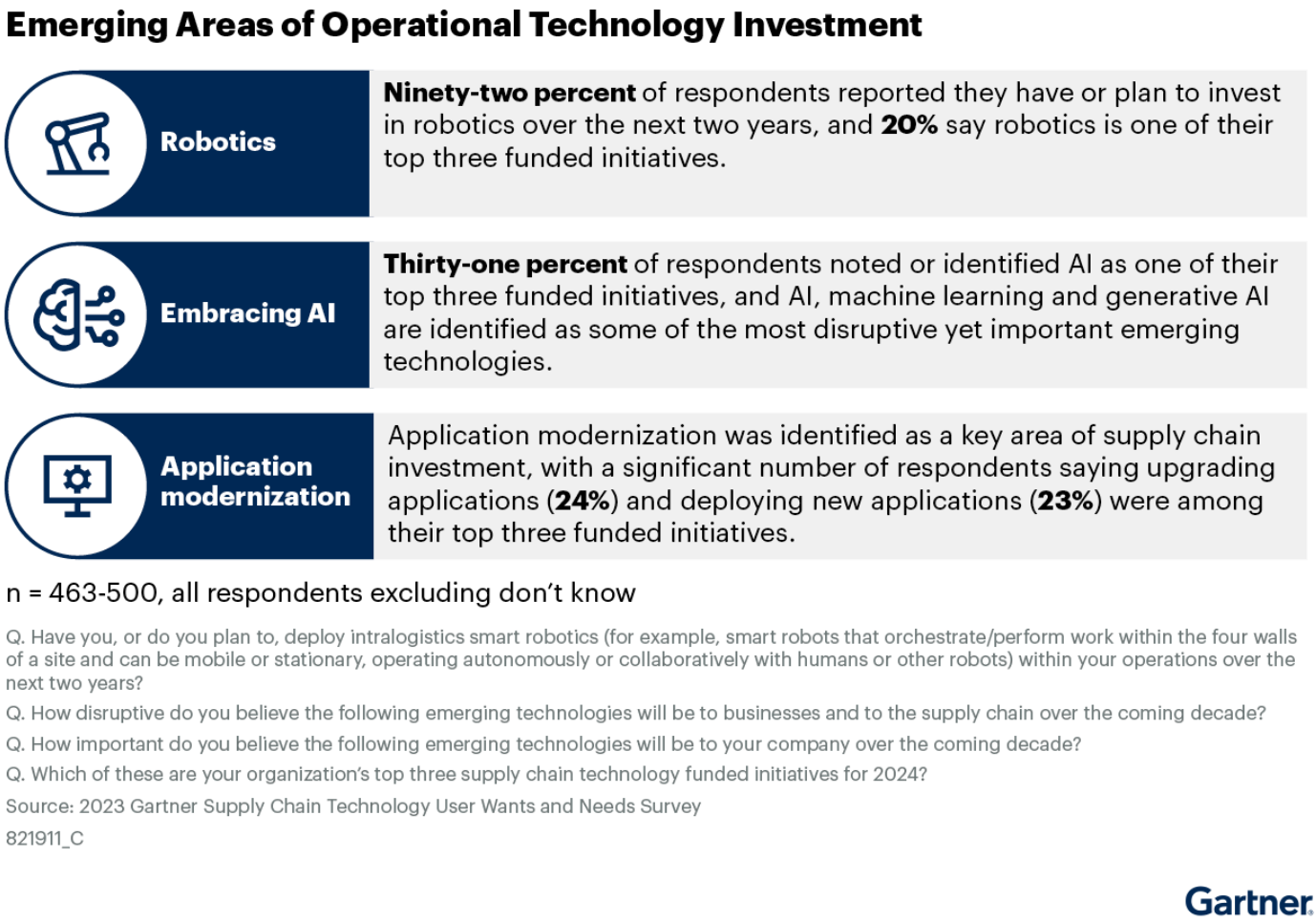
Cost management — notably, the mitigation and control of volatile or uncontrollable supply chain costs — was identified overall as the top internal obstacle to achieve supply chain goals and objectives. Thirty-eight percent of respondents cited this as one of their top three obstacles, and 13% stated it was their main challenge. [1] This is not unexpected, given global economic and inflationary conditions putting pressure on labor, energy and material costs.

Another obstacle cited by 24% of respondents was their feeling that, even with previous investments in technology, they suffered from having inadequate and/or obsolete supply chain applications or technology. The commonality among the technologies covered in this research is their ability to help address these challenges.

We identified three major areas of emerging technology investment that are behind these supply chain technology predictions (see Figure 2). These are:

- **Robotics:** Address rising labor costs and labor shortages by supplementing, enhancing or replacing humans with technology and automation that can perform tasks independently.
- **Embrace AI:** Harness AI in novel ways to help solve wicked problems and make better, faster and more enlightened decisions.
- **Application modernization:** Look at technology architectures that blend the value of applications in the cloud with the responsiveness and performance of technologies sitting at the edge.

Figure 2: Emerging Areas of Operational Technology Investment



These macro trends align well with the operational technology predictions for 2025.

Robotics

Finding, hiring, developing and retaining frontline labor is a continuous challenge for supply chain organizations. In the 2023 Gartner Supply Chain Technology User Want and Needs Survey, 26% of respondents said labor constraints were among the top three internal obstacles to achieving their supply chain goals and objectives. [1] Furthermore, 93% of participants said they are currently using or plan to use cyber-physical automation (for example, robotics) in their plants and/or warehouses over the next two years. Finally, when asked about the impact of labor issues on their cyber-physical automation purchase decisions, 48% of respondents said labor availability issues was their primary motivation for investments in this area. Similarly, 52% said it was due to rising labor costs.

When combined, these issues drive an increased focus on workforce issues, which is the impetus behind two of this year's predictions:

- To improve collaboration between humans and robots, some humanoid robots will be able to verbally interact with humans via intelligent chatbots.
- As robot fleet sizes grow, and the variety of robot types expands, it is expected that one in 20 managers will manage robots rather than humans by 2030.

Embracing AI

Currently AI is one of the most talked-about emerging technologies. The perceived potential of AI can be seen in responses to the aforementioned 2023 Gartner Supply Chain Technology User Wants and Needs Survey. We asked respondents to rate how important they currently saw certain emerging technologies (such as GenAI) as being and how transformative they felt these technologies were going to be over the next decade. Adopting GenAI or other forms of AI/ML was the highest-rated funded initiative, with 31% of respondents saying AI was one of their top three funded initiatives for 2024. [1]

In addition to the focus on GenAI, various other forms or uses of AI (such as advanced analytics, ML and the embedded use of AI in things like vision AI and robots) are seen as important and disruptive technologies. This supports several predictions in this research, including:

- Organizations will embrace composite AI concepts by employing multiple AI techniques to address their supply chain function's execution needs.
- Vision-AI-enabled technologies will replace manual processes to support autonomous data collection and improve areas like yard and warehouse operations.
- GenAI-enabled intelligent chatbots will allow some humanoid robots to verbally interact with humans.

Application Modernization

Application modernization refers to updating an organization's existing supply chain software portfolio to better support the needs of the business.

Gartner's research finds improving their application portfolio is a focal point for many supply chain organizations. For example, nearly a quarter of respondents said one of the top three

internal obstacles to achieving their supply chain goals and objectives was having inadequate or obsolete supply chain applications or technology. [1]

To address this, a similar percentage (24%) said one of their top three funded initiatives was aimed at upgrading their existing supply chain management (SCM) application and technology portfolios. [1] Finally, a majority (78%) of respondents have or are planning some significant investment in business applications over the next two years.

While application modernization is a current journey for many companies, this is not always a smooth process. As we see with transportation management systems (TMS), for example, many shippers will still have fragmented transportation application portfolios despite having strategies to support a single solution.

Strategic Planning Assumptions

Strategic Planning Assumption: By 2030, one in 20 managers will manage robots rather than humans, forcing companies to develop new management methods.

Analysis by: Dwight Klappich

Key Findings:

Gartner has observed significant and growing interest in flexible automation and adoption of mobile and intelligent robots for use in warehousing and fulfillment operations. Many factors are driving this demand for greater automation — from consumer and competitive pressures, to the need to supplement frontline labor where there are growing constraints, to rising costs and challenges hiring and retaining people.

The 2023 Gartner Supply Chain Technology User Wants and Needs Survey (Gartner's 16th annual study of supply chain technology) explored the roles technology plays in supply chain. [1] Consistently throughout the study, labor was identified as a growing challenge for supply chain organizations, and automation was identified as an area for current and planned investment. In this study:

- Ninety-two percent of respondents said they were already investing, or planned to invest, in robotics over the next two years.

- Fifty-two percent of those respondents said that between labor cost reduction and labor availability constraints, the primary reason they were planning to invest in robotics was because of rising labor costs. Alternatively, 48% said they were doing so because of labor constraints.
- Hiring, retaining and managing supply chain labor/talent was identified as one of the top three internal challenges for 26% of study participants.

Bottom-line pressures from rising labor costs and growing labor availability constraints, combined with the many other difficulties logistics organizations face, are driving the growing demand for robotics. This will lead to more robots, which will then require more people to manage those growing fleets of robots.

Near-Term Flag: The need for organizations to explicitly manage larger fleets of robots will depend on the continued growth in deployments. Over the next five years, continued compound annual growth rates (CAGR) of 20% or more (year over year) in numbers of robots sold, not revenue, will be a leading indicator for the need for robot managers.

Market Implications:

Finding, hiring, developing and retaining frontline labor is a growing challenge for supply chain organizations. Combined, these matters are driving an increased focus on addressing workforce issues with robotics.

However, the road to robotics adoption is not smooth, and supply chain leaders need to start now to build the organizational structure needed to support their robotics journey. Gartner's study found that 32% of companies that have already pursued intralogistics smart robots (ISRs) identified "lack of internal robotics expertise" as one of the top three obstacles they faced when considering robotics adoption. [1] This indicates that addressing this issue is essential for the industry's continued growth.

While most companies have well-established human capital management methodologies, they have few for managing robots. Furthermore this is a gap across industry. For example a quick search on Amazon found around 6,000 books on general management and leadership, with almost all focused on managing people. A similar search asking about managing robots found less than 100 and almost none have anything to do with managing fleets of robots. With

millions of robots already deployed and annual growth rates of 20% or more, this will have to change.

As fleets of robots grow at anticipated rates, more companies will increase their adoption of and pursue numerous use cases for robots. When robot fleets are small and narrowly focused, a technical professional or an engineer might be responsible for ensuring the robots do what they are supposed to within the narrow confines of the robot's function. However, as robot fleets grow, and as companies adopt a variety of robot use cases, the need for a management structure emerges.

Companies at the forefront of robotics adoption are addressing the above challenges by creating robotics competency and collaboration centers (competency centers). Companies can use competency centers to formalize their processes and make them focal points for driving successful robotics adoption across their organization. These competency centers will be the foundation for developing an organizational and management structure that evolves the role of a manager. Instead of simply managing people, the role will become one where frontline managers will be supporting fleets of robots as if they are humans.

Robot management today appears to be analogous to the information technology function in the late 1970s and early 1980s. Back then, IT was a separate technical function that owned the data center, and business users used rudimentary IT tools to perform functions like accounting. Today, most job functions feature an IT element, and IT departments have become a large and influential part of organizations. We believe that, over the next decade, robotics competency centers will progress in a similar way to the evolution of the IT function, as companies deploy more robots across their organizations.

Recommendations:

- Develop a robotics competency center, typically within the operations function, that can establish the organizational structure for managing the robotics journey. This should encompass all steps in the journey, from knowledge gathering to deployment, as well as support and maintenance.
- Create multiple solution frameworks that can codify different scenarios to support various robotics use cases.

- Build internal robotics expertise with an emphasis on business value, rather than technical design.
- Implement strong governance and control to address:
  - Formalizing the robotics selection process
  - Outlining expected contract service-level agreements
  - Understanding various pricing mechanisms
  - Defining cyber-security standards

Related Research:

Infographic: Intralogistics Smart Robots: Which Ones Should You Choose?
Quick Answer: IT's Role in Selecting and Supporting Intralogistics Smart Robots
Hype Cycle for Mobile Robots and Drones, 2024
Hype Cycle for Supply Chain Execution Technologies, 2024
Top Supply Chain Technology Trends for Warehousing and Fulfillment Leaders 2024

Strategic Planning Assumption: By 2027, some humanoid robots will verbally receive and respond to human-prompted work instructions via AI agents.

Analysis by: Dwight Klappich

Key Findings:

Supply chain demand for robots remains high. In the 2023 Gartner Supply Chain User Wants and Needs Survey, 51% of respondents said they believe robots are highly disruptive technologies, and nearly 60% said they believe these are highly important to their businesses. [1]

There are many vendors with strong examples of highly productive mobile robots that use wheels or tracks (see **Hype Cycle for Mobile Robots and Drones**). However, there have been few successful examples of robots that offer human-like mobile manipulation (for example, moving around, picking up and carrying things), or that can handle varied or unpredictable terrain.

Humanoid robots are designed and built to look like, and mimic, the human body in shape, function and locomotion. The next generation of humanoid working robots will combine sensory awareness with mobile manipulation and dynamic locomotion to perform productive work that was previously relegated to humans.

What is lacking today is the ability to interact with the robot as if it were a human, providing instructions and getting responses verbally.

While still nascent, over the next three to five years, next generation humanoid working robots will approach the level of adaptability that humans now have. This will allow humanoid robots to be used and repurposed for many different activities without programming, enabling the fluidity of work assignment expected of a company's human workforce.

This generation of humanoid robots will approach the physical adaptability of humans, where they can flexibly support the needs of the business by dynamically moving from process to process and taking on new activities without special programming. However, one of the notable gaps between current generations of robots and humans is the ability to allow verbal and bidirectional interaction between human and robotic agents.

By achieving this, humans could provide verbal instructions like "go to location A21-06 and pick three cases," and the robot would respond back with verbal replies to instructions or completed actions. While not currently commercially viable, we have seen some experimentation of intelligent agents using GenAI that is moving toward bidirectional robot-human verbal communication.

Market Implications:

Conversational humanoid robot interaction is not currently commercially available, but we believe there are already technologies that will be repurposed to make this a reality over the next three to five years:

- **Transactional voice:** What Gartner refers to as "transactional" voice technology are systems that provide verbal instructions to human users and then humans provide verbal feedback, like confirmations, back to the systems. The key is the voice system follows the flow of the application logic, replacing screen and keyboard commands with voice. Transactional voice is very mature and there are hundreds of thousands of daily worldwide users. As the name

implies, transactional voice supports multistep transactional workflows common in a warehouse operation and solutions from vendors — such as Ehrhardt Partner Group (EPG) and Honeywell — are proven and mature.

- **Conversational voice:** While nascent in warehousing and manufacturing, use of conversation chatbots (like Apple's Siri) is nearly ubiquitous today. Conversational platforms use natural language to remove complexity from the interface, so users theoretically don't have to learn how to use the technology. Instead, the vision is users would interact in their natural language. Currently, conversational interactions are limited by the system's ability to understand user intent. Conversational platforms can usually understand and respond to simple queries and commands, such as "When will my goods be available?" They are not yet adept at supporting business work-flows.

- **Composite AI/GenAI:** Composite AI is the combined application of multiple AI techniques to solve a variety of business problems that drive supply chain performance improvements. Related terms include hybrid AI, neuro-symbolic AI and causal AI. Today, robots use various types of AI like ML and optimization extensively. However, we are currently unaware of any robotics provider that is live and comprehensively using GenAI in their solutions. Some have small projects underway, such as using GenAI to create synthetic data and train ML models, but we do not yet see conversational interactions.

Transactional voice combined with the power of GenAI-enabled intelligent AI agents will enable voice interaction between humans and humanoid robots over the next three to five years. The reliability and maturity of transactional voice proves that workflows can be created requiring bidirectional verbal interaction between systems and humans across a predetermined workflow. Add the power of GenAI, and we believe this will be the foundation for conversational robot-human interaction.

Recommendations:

- While the potential for conversational humanoid robots is alluring, supply chain operations with high-volume, predictable and consistent processes should not delay investments in robots waiting for this technology to emerge. These organizations should consider some of the current generations of intralogistics smart robots to enhance or supplement their human workforce.

- Before pursuing humanoid robots, companies must first map their functional processes to determine which, if any, of these processes can be addressed with current generations of robots and which will benefit most from human-centric design.
- Companies should identify processes in need of high degrees of flexibility and adaptability, and focus on learning how the human workforce performs these tasks to understand what capabilities a humanoid robot will need to support.
- As these capabilities emerge over the next several years, companies should develop a structured methodology for conducting effective proofs of concept.
- Companies should build a robotics competency and collaboration center (RCCC) to put in place the capabilities and competencies needed to leverage existing types of intralogistics smart robots. In addition, the RCCC will help to build the internal skills necessary to exploit conversational robots when they become available.

Related Research:

Hype Cycle for Supply Chain Execution Technologies, 2024
Hype Cycle for Mobile Robots and Drones, 2023
Top Trends in Supply Chain Technology for 2024
Technology Trends Transforming Warehousing — Part 1: Improving Upgrades
Technology Trends Transforming Warehousing — Part 2: Handling Volatility & Complexity
Technology Trends Transforming Warehousing — Part 3: Labor Challenges

Strategic Planning Assumption: Through 2027, 75% of large shippers will struggle to manage their fragmented transportation application portfolios, despite strategies to support a single solution.

Analysis by: Brock Johns

Key Findings:

- As shippers grow in size and expand globally, the complexity of their transportation operations increases. This increase in complexity requires additional technological capabilities to support operations.

- Most shippers seek software providers offering a TMS, assuming these solutions will support all of the organization's functional requirements.
- Vendors in the TMS market have increased their efforts in recent years to add additional functionality and modal support. Some vendors have added functionality organically via research and development, while others have pursued mergers and acquisitions to bring additional capabilities to their products. Despite these efforts, gaps in capabilities still exist for many shippers.
- Many vendors now promote the idea of a transportation platform or suite to support the expanding requirements of shippers.

Market Implications:

Gartner has seen a strong preference among shippers to select a single, global technology solution to support their transportation operations. Most commonly, shippers start with a narrow focus on TMS solutions. Despite the TMS market's growth and maturing capabilities, for a majority of large shippers, a TMS solution alone will not support all of their functional requirements and needs.

This has driven significant effort by SCM vendors who offer transportation technology, to expand their product portfolio and increase the breadth and depth of functional capabilities to support more complex operations. In addition, some vendors are increasingly positioning their transportation technologies as a platform or suite, with the intent to bring different solutions onto a common technical architecture.

However, the number of vendors that have developed a true platform and transportation suite is very small at this point. In addition, even for a vendor that has achieved this, they often still only support some of the complex transportation needs and requirements for large shippers, such as over-the-road transportation, parcel management or private-fleet management. The transportation technology landscape is highly fragmented, with TMS solutions offering the broadest set of capabilities, but point solutions exist for more specific needs or areas that TMS solutions fail to adequately support. These solutions include:

- Multicarrier parcel management systems
- Real-time transportation visibility platforms

- Vehicle routing and scheduling
- Last-mile delivery solutions
- Global trade management
- Yard management
- Freight audit and payment

This continued fragmentation and vendor specialization will require shippers to continue evolving their transportation technology strategy and employ an ecosystem approach. With a lack of one-size-fits-all applications, platforms or suites, shippers will largely continue the current approach of selecting individual technologies from different vendors.

The 2024 Gartner End-User Buying Behavior Survey found that, among B2B buyers selecting more than one provider to support initiatives involving a technology purchase, 46% did so to leverage specialized expertise. Similarly, 41% did so for diverse geographical or regional requirements, and 38% because a single provider did not offer all the technologies needed.

This fragmentation will continue to impede shippers' ability to bring all transportation information and data together, and subsequently hinder improvements in the level of efficiency and orchestration they are pursuing.

Recommendations:

- Determine the level of transportation complexity — such as modes, lanes or numbers of carriers — by reviewing your transportation operations globally before setting a strategy for transportation technology.
- Assess technology partners' abilities to support broad transportation requirements by conducting proof of concepts and detailed product demos. Consider a vendor's approach to technical architecture and ability to connect to other applications within a vendor's platform or suite.
- Embrace an ecosystem approach to your transportation technology strategy by focusing on solutions that meet your specific functional and technical requirements.

- Prepare for potential disruptions and integration challenges that may be brought on by increasing M&A activity within the transportation technology market.

Related Research:

Top Supply Chain Technology Trends for Transportation Leaders, 2024
Gartner's Model for Holistic Multimodal Transportation Management Systems — Part 1: Core Capabilities
Gartner's Model for Holistic Multimodal Transportation Management Systems — Part 2: Extended Capabilities

Strategic Planning Assumption: By 2027, 25% of high-performing organizations will adopt composite AI, employing multiple AI techniques to address growing operational complexities.

Analysis by: Rishabh Narang

Key Findings:

- While recent attention has focused on GenAI, the greater value for supply chains lies in composite AI. Its predictive and prescriptive capabilities leverage advanced algorithms to tackle critical operational challenges, directly impacting costs, productivity and overall performance.
- Increasingly, composite AI-embedded technological applications are enhancing human decisions, making manual processes redundant and individuals more productive.
- Supply chain technology vendors have significantly enhanced their AI and ML capabilities in recent years, either through organic product development or partnerships with API-based optimization solutions. However, substantial gaps remain in effectively integrating multiple AI/ML tools and techniques cohesively.
- Organizations that narrow AI down to ML struggle in situations where data is scarce, rendering their existing AI efforts ineffective or unfeasible for many potential use cases.
- Combining multiple existing and new techniques in composite AI holds the promise of overcoming the limitations of current single technique AI approaches. This, however, comes

at the price of AI's growing complexity, with ever more capabilities and skills required in both development and operations.

Market Implications:

Functions such as logistics and distribution have relied on data for real-time decision making in areas such as last-mile deliveries for many years. Composite AI in supply chains integrates multiple AI techniques to address complex challenges. Unlike traditional methods that rely on a single approach, composite AI combines various technologies for a more robust solution.

According to the 2023 Gartner Future of Supply Chain Survey, nearly half of respondents said delivering digital capabilities was the most important attribute for supply chains to robustly support new business and operating models. [3] Similarly, 48% of high performers responded that data to automate business processes and augment decision making will be a prime driver for the investments. [3]

Further, these respondents also identified technologies such as AI- and ML-driven optimization, advanced analytics and large language models (LLMs) to reengineer core supply chain tasks to be the prime tools that drive investment.

In the same survey, high performers responded affirmatively to enhancing their use of data by using ML and AI to automate and optimize decision making within supply chain functions and activities. Nearly 40% of high performers responded to currently leveraging AI/ML for demand forecasting, and 27% responded to leveraging AI/ML for logistics and distribution functions. [3]

Key components of composite AI:

- **Machine learning:** Enables predictive analytics, demand forecasting and anomaly detection through historical data analysis.
- **Natural language processing (NLP):** Processes unstructured data, enhancing understanding of customer feedback and supplier communications.
- **Rule-based systems:** Utilizes predefined rules for quick decision making in urgent situations.
- **Simulation and optimization:** Models scenarios to optimize inventory management and logistics.

- **Computer vision:** Analyzes visual data from sensors to monitor operations and maintain quality control.

Gartner has identified few potential improvement areas in the supply chain function that can benefit significantly from composite AI techniques:

- **Enhanced predictive capabilities:** Combining ML algorithms and NLP processing with other AI techniques can provide deeper insight into demand forecasting, inventory optimization and risk management.
- **Real-time decision making:** Computer vision can be used for real-time monitoring of warehouse operations, while ML models can analyze this data instantly to optimize workflows. Natural language processing can facilitate seamless communication between different systems and stakeholders, ensuring decisions are made quickly and accurately.
- **Improved supply chain visibility:** Composite AI can enhance supply chain visibility by integrating data from various sources, including Internet of Things (IoT) devices, RFID tags and GPS systems. This holistic view will provide end-to-end visibility of goods in transit, enabling better tracking and management of shipments. AI-driven analytics will identify potential bottlenecks and inefficiencies, allowing for proactive measures to be taken to mitigate delays and disruptions.
- **Autonomous operations:** Composite AI can support the rise of autonomous operations (for example, autonomous vehicles and drones, guided by computer vision and ML algorithms, to handle tasks such as picking, packing and transportation with minimal human intervention). Additionally, AI-driven robotics enhance manufacturing processes, ensuring precision and consistency in production.
- **Sustainability and efficiency:** Combining AI-driven analytics and things like combinatorial optimization can improve route planning and with ML models can identify opportunities for waste reduction and resource optimization, contributing to more sustainable practices.

Recommendations:

- Identify improvement initiatives in which a fully data-driven, ML-only approach is inefficient or ill-fitted. For example, in cases when enough data is not available or when the pattern cannot be represented through current ML models.

- Extend the skills of data sciences experts, or recruit/upskill additional AI experts, to cover graph analytics, optimization or other techniques for composite AI. For rules and heuristics, consider knowledge engineering skills, as well as emerging skills such as prompt engineering.
- Combine the power of ML, image recognition or NLP with graph analytics to add higher-level, symbolic and relational intelligence into different supply chain functions (such as demand forecasting and inventory optimization).
- Push your existing technology partners — such as warehouse management systems (WMS), demand planning, inventory management and ERP vendors — for their current support, roadmaps and adoption rate of composite AI.

Related Research:

Hype Cycle for Artificial Intelligence, 2024
Supply Chain Executive Report: Future of Supply Chain 2024
Apply AI Engineering to Scale Analytics and AI
Innovation Insight for Composite AI

Strategic Planning Assumption: By 2027, 40% of yard and warehouse management deployments will employ vision-AI-enabled autonomous data collection instead of RFID.

Analysis by: Simon Tunstall

Key Findings:

Since it became common in the 1980s, bar code scanning has been the dominant technology used for automated data collection in manufacturing, logistics and warehouse operations. However, many organizations remain dissatisfied with the level of inventory accuracy they can achieve with bar code scanning alone and, as a result, have sought alternatives. While bar code scanning works as intended, and is now ubiquitous, there is still a large element of human intervention necessary in scanning. What companies want is a way to capture data more autonomously, with as little human intervention as possible.

To address their challenges, some organizations have experimented with technologies like RFID. The focus on RFID peaked around 2004/2005 and, for years after, it went out of favor.

However, we have seen a resurgence in interest in RFID, especially in retail for store-level inventory tracking. Furthermore, companies looked beyond just tracking inventory with RFID and considered it for activities like equipment location monitoring (such as trailers and containers in a yard).

While there have been improvements since the first generation of these technologies, with tags becoming less expensive, there are still limitations. For example, the inability to read tags in certain conditions (like through liquids or metals) or from certain distances, and constraints such as infrastructure and discipline in tag application and compliance. Consequently, use cases typically remain limited to store-level inventory, higher value items or large equipment (such as trucks and trailers).

With growing pressure on operations to continuously improve process performance, traditional automated data collection solutions are no longer good enough. Many companies are seeking novel solutions that can automate historically human-dependent processes and avoid the constraints of other supporting technologies like RFID. Companies are beginning to look at vision AI to address these limitations.

While the use of computer vision systems and AI is not new, the combined use of these in supply chain operations is nascent and often considered "bleeding edge." However, in the 2023 Gartner Supply Chain Technology User Wants and Needs Survey, nearly 20% of respondents said they have already adopted AI-enabled vision systems, and nearly half say these are highly disruptive technologies. [1] This is driving companies to consider the emerging, but maturing, combination of advanced vision systems and AI for things like inventory management or process monitoring.

For example, cycle counting is a people-intensive, costly and important but not value-adding process for most companies. Companies have to do it, but it ties up valuable resources that could be attributed to more valuable tasks. In addition, regardless of the efficacy, some organizations have to conduct a high number of cycle counts to fulfill contractual obligations. This is an area where vision-AI-enabled systems are already demonstrating value by using drones, or robot-mounted cameras, to traverse aisles, counting and locating inventory and identifying discrepancies with no human intervention.

In recent years, the evolution of vision-AI-enabled systems (computer vision and advanced document and image processing [ADP]) has emerged. This in itself is a further evolution from

optical character recognition (OCR), which translates printed or written text into images.

Market Implications:

Vision-AI-enabled systems are novel hyperautomation solutions that combine industrial 3D cameras, computer vision software and advanced AI pattern recognition technologies. These solutions use high resolution vision systems combined with AI's advanced pattern recognition capabilities and ML to radically change how some processes are performed.

These solutions can autonomously capture, interpret and make inferences based on the unstructured images the vision systems see in real time. This information can support many operational processes that historically had to be directly performed by a human keying in data on a keyboard, manually scanning something like a bar code or by using other scanning/sensing technologies such as RFID. The AI models can then interpret this information and run it against a company's operational databases to update the systems and identify inconsistencies.

More recently, these systems are also being used to monitor how processes are being performed in real time to identify problems, safety issues or process execution deviations. This is to determine if these processes are being performed correctly or if ergonomic issues keep them from meeting expectations.

Vision-AI-enabled systems are already being deployed to supplement or replace traditional scanning-based systems. Historically, one barrier to adoption was the high upfront cost for system integration and solution development. However, as packaged solutions become more readily available, the costs of AI-enabled vision systems are decreasing. Consequently, these solutions will propagate quickly, because of the simple value proposition. The costs and performance of cameras are improving constantly, and the pattern-recognition capabilities of AI models are also improving as solutions become more packaged and robust. This combination will make these solutions very appealing to companies where the cost advantages of such vision-AI-enabled systems will surpass traditional approaches to similar activities.

Recommendations:

- Experiment with a number of low-risk and low-cost vision AI alternatives because, for the foreseeable future, there will not be one vendor or one solution that fits all possible use

cases. However, the value proposition of these solutions is potentially quite good, offsetting the challenge of managing multiple solutions and vendors.

- Start with simple processes, like cycle counting or multiscanning with cameras on receiving, that are tailor made for a vision-AI-enabled system. Learn from early initiatives, aiming to better identify additional use cases in the future.
- Push your existing technology partners, such as WMS vendors, for their current support for vision AI or roadmaps in this direction.
- More mature companies with good manual processes (such as labor management) established should start looking at more advanced solutions, like process ergonomic monitoring.

Further Reading:

Top Trends in Supply Chain Technology for 2024
Hype Cycle for Supply Chain Execution Technologies, 2024
Hype Cycle for Mobile Robots and Drones, 2024
Technology Trends Transforming Warehousing — Part 2: Handling Volatility & Complexity

A Look Back

In response to your requests, we are taking a look back at some key predictions from previous years. We have intentionally selected predictions from opposite ends of the scale — one where we were wholly or largely on target, as well as one we missed.

On Target: 2019 Prediction — By 2023, 90% of blockchain-based supply chain initiatives will suffer blockchain fatigue for lack of strong use cases.

At the time of the initial prediction, we saw that success in initial supply chain blockchain projects was very limited, with initiatives failing to match the initial market exuberance. We felt then that this would lead to disillusionment and buyer fatigue, and it did.

This was principally because companies continued to struggle to identify how blockchain would be a better offering and provide higher value over conventional technology like cloud-

based solutions. Companies eventually delayed pursuing blockchain initiatives and reverted to focusing on solutions that were “real” today and exploited well-known existing technologies. While there have been some successful packaged blockchain solutions, these were few and far between and most proof of concepts taking place five years ago never went to scale.

Missed: 2021 Prediction — By 2023, 50% of WMS/supply chain execution (SCE) vendors will have deployed ML capabilities in their software to enhance integration and workflows between autonomous mobile robots (AMRs) and traditional material handling equipment (MHE).

In 2021, we saw a growing need and increasing demand from WMS customers for richer and more sophisticated decision support capabilities. We thought this would force WMS vendors to pursue ML and embed these capabilities within their WMS applications. We expected WMS vendors to embed ML in their applications to enhance integration with AMRs and conventional MHE. While a few vendors have done so, we have not witnessed anything near the 50% number we expected in 2021.

We believe there are several reasons for this. First, having ML in a WMS has not become a mandatory requirement for a WMS selection, so vendors have not felt compelled to add these capabilities purely for competitive reasons. Second, warehousing has proven a very complicated environment to apply these advanced decision support techniques, so even vendors that have played around with AI and ML struggled to commercialize these capabilities. Finally, identifying the most appropriate use cases for AI and ML in warehousing also proved to be problematic and only a few areas gained much traction, such as using ML to calculate labor standards. While we didn’t reach the 50% mark by 2023, there is now momentum in the WMS market to add AI and ML, and we are seeing more realistic solutions emerging.

⊕ Evidence