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**Using autonomous robots to drive
supply chain innovation**

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Do you need autonomous robots in your supply chain?

Autonomous robots can be used to improve the speed and accuracy of routine operations, particularly in warehousing and manufacturing spaces; work side-by-side with humans for added efficiency; and reduce the risk of employee injury in dangerous environments.

Of interest because: As the hardware and software in autonomous robots continues to improve, they could provide a competitive advantage to employers within the next 10 years. Through improvements in sensors, dexterity, artificial intelligence, and trainability, they are becoming faster and more sophisticated, and they now include safety provisions that allow them to work collaboratively with humans.

Could improve your supply chain by: decreasing long-term costs; providing labor and utilization stability; increasing worker productivity; reducing error rate; reducing frequency of inventory checks; optimizing picking, sorting, and storing times; increasing access to difficult or dangerous locations.

Why not? Requires an upfront feasibility assessment based on financial return, additional skillsets, and training, as well as balancing public perception when replacing traditionally manual labor with capitalized assets.

Deloitte recommends: Continue to monitor advancements in autonomous robots for applicability to supply chain. Autonomous robotics have the potential to improve operations, and they offer new opportunities to increase productivity, reduce risk, decrease cost, and improve data collection, particularly as customer expectations and volumes of packages, shipments, and orders reach unsustainable levels for traditional approaches.

What are autonomous robots?

Overview

Autonomous robots are devices that are programmed to perform tasks with little to no human intervention or interaction. They can vary significantly in size, functionality, mobility, dexterity, intelligence, and cost—from robotic process automation to flying vehicles with artificial intelligence. Autonomous robots can recognize and learn from their surroundings and make decisions independently.

Recent developments and outlook

Autonomous robots are expected to see strong growth over the next five years, particularly within supply chain operations that include lower-value, potentially dangerous or high-risk tasks. Manufacturing, final assembly, and warehousing, for example, are areas where robots already have a presence; continued growth of autonomous robots could allow people currently performing these tasks to shift to more strategic, less dangerous, and higher value work.

Autonomous robots will become more ubiquitous with advancements that make them operate with more human-like abilities. For example, improvements in haptic sensors—those relating to the sense of touch—will allow robots to grasp objects ranging from fragile eggshells to multi-surfaced metal assembly parts without changes in programming or robotic components.

As artificial intelligence continues to advance, problem solving and learning analytics will enable robots to be responsive with minimal human feedback. Facial recognition software is making leaps in detecting movements in eyebrows, eyelids, and lips; through these sensors, combined with audio recognition software that recognizes changes in tone, pitch, and volume, autonomous robots can detect frustration, urgency, or approval, and in turn, adjust actions to modify behavior based on live interactions.

Overview

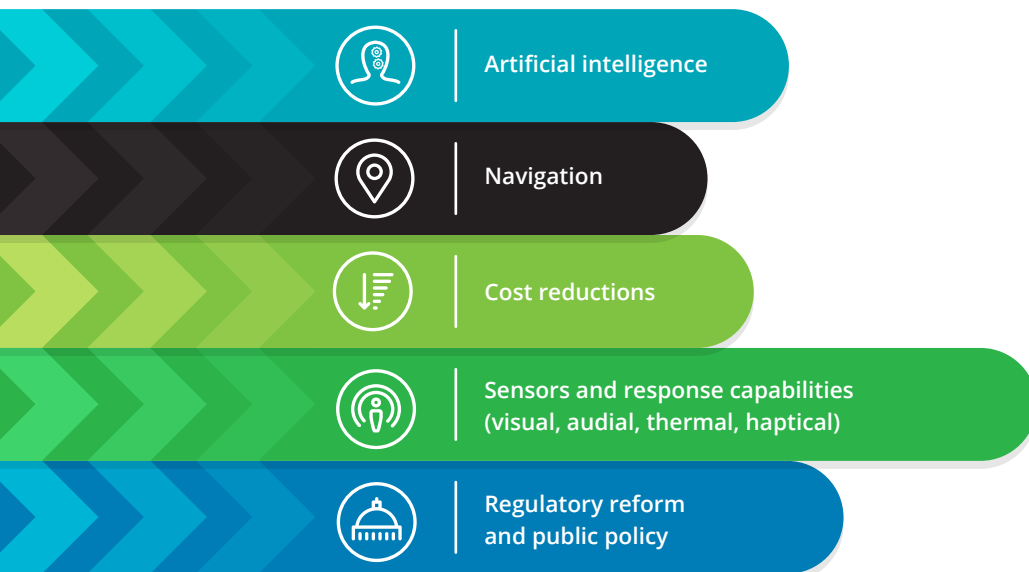
Value drivers	<ul style="list-style-type: none"> • Increased efficiency • Reduced error and return rates • Improved safety in high-risk environments • Collaboration with humans • Faster delivery or product movement rates • Ability to operate in environments inaccessible to humans
Scope	More efficient operations within all segments of the supply chain
Technology substitutes	<ul style="list-style-type: none"> • Advanced software • Simple machines or tools • Human workforce

Autonomous robots in the supply chain

Traditionally, robots have been deployed for executing routine and repetitive tasks, requiring complex programming for setup and implementation, while lacking the agility to easily adjust operations. As autonomous robots become more sophisticated, set up times are decreasing, they require less supervision, and they are able to work side by side with their human counterparts. The benefits are expanding as autonomous robots become capable of working around the clock with more consistent levels of quality and productivity, performing tasks that humans cannot, should not, or do not want to do.

As the market for autonomous robots grows, the end-to-end supply chain operations alignment will become more fluid. Currently, many companies that use autonomous robots have implemented them for targeted functions within their supply chain, piloting various robots to verify expected efficiency gains. As innovative companies grow and expand operations, robots that build robots could be the norm for economically and efficiently optimizing manufacturing operations.

Five key developments in autonomous robots



Benefits of autonomous robots in the supply chain

Primary potential benefits



Value drivers for autonomous robots

The implementation of autonomous robots could primarily drive value by reducing direct and indirect operating costs and increasing revenue potential.

Autonomous robots can reduce labor costs and increase productivity by continuously working around the clock without fatigue. Employee safety can be improved in highly hazardous environments, and insurance and injury leave costs can be reduced significantly.

With the introduction of collaborative robots, the days of fenced-off machines that interact independently are slowly fading away. As designs for safety and human interaction evolve, autonomous robots in assembly lines, factories, and warehouses are less obtrusive.

Humans can work directly with collaborative robots, easily training them with programmable movements and then handling material and sorting packages side by side with them. In material transportation environments, robots can seamlessly zip past each other, humans, or other moving objects thanks to advanced collision avoidance capabilities, which are processed as quickly as any human can react to potential accidental run-ins.¹

Autonomous robots can test, pick, pack, sort, build, inspect, or transport materials of various sizes and weights faster and more efficiently than ever. Drones are already used to monitor hazardous areas, including

control towers, agricultural fields, and mines, and for general security and surveillance.

As technologies have advanced, robot setup and implementation is getting faster and easier than ever before. Learning models are becoming more intuitive, allowing any technician or employee to "train" an autonomous robot in a matter of minutes or hours. Additionally, these learning models allow robots to respond to sudden changes, adapt to stimuli, and improve manufacturing methods based on build results.²

Autonomous robots give growing companies more options for meeting capacity demands. Available labor, particularly during peak holiday months, cannot always meet seasonal demands but companies can turn

Secondary potential benefits (intangibles) of autonomous robots

- Enhanced employee value through focus on strategic work instead of mundane tasks
- Focus on personal safety by minimizing work in hazardous areas for employees
- Boosted corporate brand by signaling leading-edge practices and implementation of innovative technology
- Exponential learning by collecting and analyzing machine data

to robots to improve operations and meet labor demands; during the 2016 holiday season, some warehouses even used robots to quickly train temp workers so that they could add value in as little as two days of training.³

Ultimately, in material handling or process-centric scenarios, error reduction and cycle time improvement can help increase customer loyalty and drive sales growth for companies in any industry. For businesses that rely on excellent client service, such as banks, robotic process automation can allow personnel to spend significantly less time on managing customer information and instead focus their attention on individually serving clients.⁴ As supply chain operations continue to shift focus to direct customer needs, autonomous robots can serve the end consumer with better service and faster response times.

As employees learn to collaborate with autonomous robots in manually intensive roles, there are potential intangible benefits to the workplace environment. Shifting risky roles to autonomous robots can improve employee safety, and removing people from hazardous situations where they could fall or hurt themselves can help reduce stress and anxiety.

Using autonomous robots to perform repetitive, mundane manual tasks can also improve employee satisfaction as they shift to more strategic and mentally stimulating work.

From a company's perspective, in addition to boosting employee safety and morale, there are additional potential benefits, such as reducing liability and, potentially, insurance premiums.

In 2015, the state of Nevada licensed two freight trucks to operate autonomously on public roads.⁵ Via multiple advanced sensors, the truck could detect traffic lanes, immobile objects, and other vehicles

Case study: Drones

Drones are aircraft that do not have a human pilot on board. The aircraft is either remotely controlled by a pilot on the ground or autonomously controlled by computer systems on the aircraft.

Drone technology has evolved from a proprietary military-only technology to a household name, evoking interest from hobbyists to businesses. By 2021, the overall drone aircraft industry is poised to grow to \$10 billion.⁶

This massive growth is due in part to improved technology and widespread innovation—established firms and start-ups have introduced new products with diverse performance metrics to develop new business use cases.



to maintain appropriate driving speeds and distances. With full autonomy, the truck safely maneuvered through the route, demonstrating the potential for drivers to spend long hours on the road focused on other tasks, such as planning routes, organizing documentation, or completing training.

Current applications for drone aircraft:

- Drones can be used in various warehouse operations, from inbound logistics in time-critical situations; carrying materials from storage to factory; transporting directly from receiving to shipping; or efficiently scanning inventory and significantly reducing labor costs.
- In the telecom industry, drones are used to conduct high-quality site audits in a single pass, offering detailed panoramic and top-down views of lattice towers; they can also be used to perform radio planning and line-of-sight inspections.
- In media and photography, drones are expanding customized offerings to include aerial views and camera angles for real estate and high-end event productions.
- For emergency relief operations, drones can replace expensive helicopters and arrive at difficult-to-reach rural areas to send supplies and provide support.
- In agricultural applications, drones provide data for smarter irrigation and more targeted application of chemicals, while removing pilots from potentially hazardous flying in tight-maneuvering spaces.

These workforce-related, intangible benefits may be difficult to quantify but are nonetheless valuable benefits for companies to consider while strategizing on the use of autonomous robots and communicating benefits with employees and shareholders.

Criteria for evaluation and adoption

Operational considerations

To use autonomous robots across your supply chain, start by developing a productivity and asset procurement strategy based on your company's profile and specific needs. The following five attributes can help shape your decisions and determine the potential overall return on your company's investments in autonomous robots.

Company and facility profile

- Autonomous robot procurement options and constraints vary according to company size and facility profile. Key questions in this category may include:
 - What types of facilities (manufacturing or testing facility, distribution center, office) do you operate?
 - Which functional areas are the most critical to the success of your supply chain operations?
 - How many IT systems are used and could they be automated?
 - What are your current bottlenecks throughout the end-to-end supply chain that currently prevent improvements in throughput?
 - What is your asset management strategy (i.e., maintenance, servicing and disposition) in your facilities and do you have the processes, training, and tools to appropriately manage additional capital equipment?

Functional efforts and expertise

Functional areas that require a high level of expertise may indicate the most time-critical areas of your supply chain. Automating redundant tasks and reducing time-critical

efforts can improve time to market, reduce supply chain bottlenecks, and improve overall business strategy. Key considerations in this category:

- Which tasks do your employees find the most repetitive, redundant, low value, hazardous to their safety, or time intensive?
- What higher value, strategic roles will employees take on as they become more available and less focused on mundane tasks?
- What training is available to upskill your employees to more strategic tasks?

Regulations

Labor regulations for operating machinery vary among and within countries. What is viable in one country may not be in another; in the United States, for example, the FAA currently limits commercial drone operations to under 400 feet, during the day, within line of sight, and at or below 100 mph.⁷

Additional considerations include:

- What countries do you operate in?
- How will regulations and business model options in each location impact your use of autonomous robots?

Investment

Procurement of autonomous robots should focus on an overall investment strategy. For companies that currently invest in capital equipment, the acquisition of autonomous robots can follow similar investment criteria or strategies that currently exist. Key questions may include:

- What investment considerations must be taken into account?

- What is the cost of capital?
- What are the projected interest and labor rates in the foreseeable future?
- How long will the robots be used?
- How will the depreciation and disposition of assets be handled?
- What additional infrastructure, if any, will need to be set up to have a seamless implementation?

Operating environments and perception

Autonomous robots in certain functions of the supply chain (for example, build and package) have become more commonplace but their use in the operating environment will continue to be an adjustment.

Employers should try to mitigate negative perceptions of safety or labor outsourcing among individuals who interact with the robots. It will take time to train employees and training must be updated with each technology improvement in the robot. Key questions to consider:

- How do you expect the current workforce to respond to working with autonomous robots?
- Will you need to create a communication strategy with labor unions or current employees?

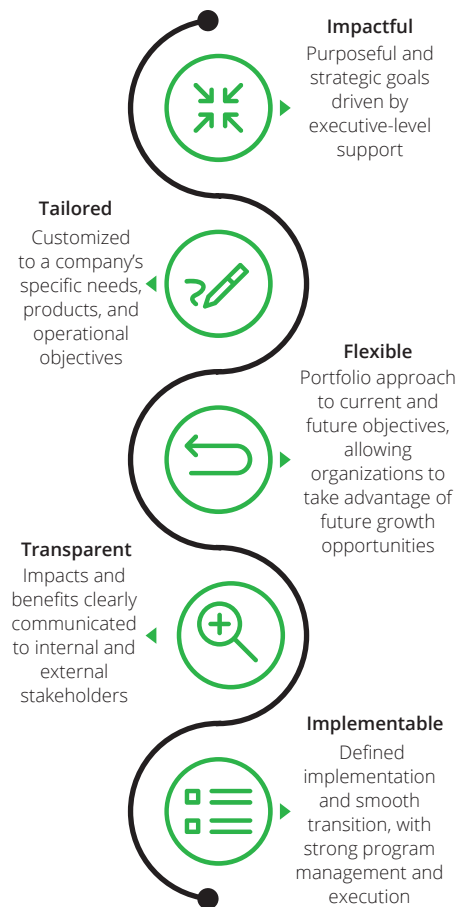
Framework for decision making

Autonomous robot success factors

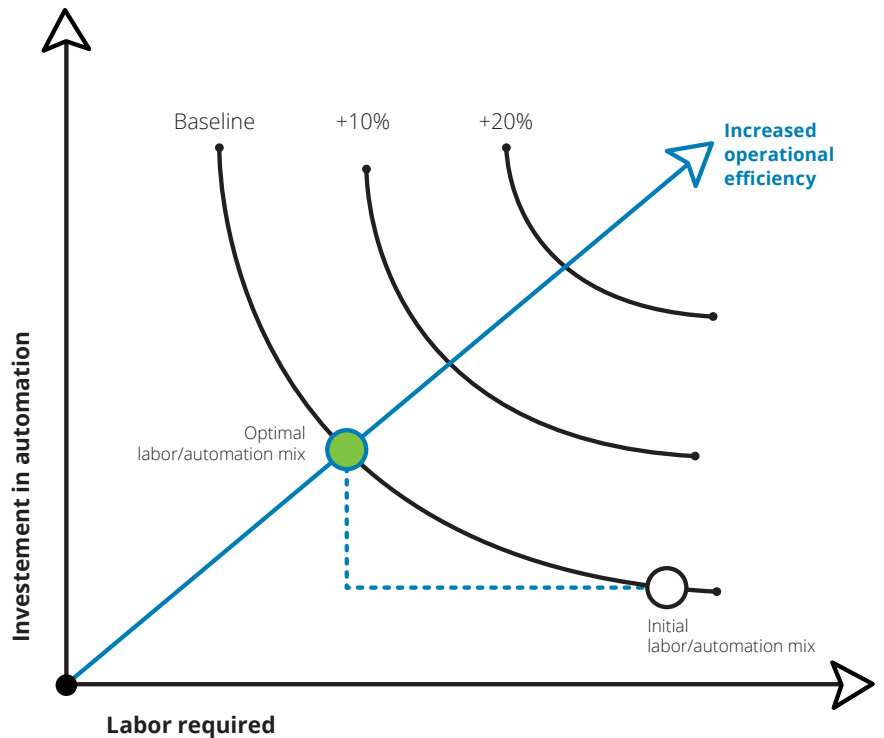
Leveraging industry-leading practices can help you define an implementation strategy for autonomous robots in your organization. As with any new strategy, your goals for incorporating autonomous robots and automation into your supply chain should match your organization’s overall vision, goals, and strategy.

Investment impact on operational efficiency

Investments in autonomous robots should be prioritized to achieve end-to-end efficiency, productivity, and risk reduction. When considering the level of automation to bring to your organization, it is important to define the optimal labor-to-automation mix to achieve desired benefits.



A balance of labor and automation optimizes levels of efficiency



Autonomous robot procurement options

Services versus direct purchase

Depending on the application, autonomous robots can be deployed either as a service provided by manufacturers or third parties, or as a direct product for companies to implement in their operations.

Offerings and applications of autonomous robots are growing as companies look for innovative ways to reduce costs and place employees in roles that maximize value-added work.

Flexible leasing options could provide a service model appealing to growing companies with limited funds for initial acquisition. Autonomous robots as a service may also be a good option for organizations with minimal operator experience in their user base. Drones, for example, require operators to have piloting and navigation skills in addition to passing an aeronautical test at an FAA-approved testing center (as of August 2016).⁷ Services that offer certified pilots to navigate drone aircraft and are familiar with the robot's data collection capabilities offer significant value and immediacy: They are ready upon hire to perform the flight operations, facilitate

data collection and processing, and present actionable insights of immediate business value to companies.

Organizations that invest in owning autonomous robots could see a return on investment through the efficiency and productivity gains from accurate and around-the-clock tasks. The time horizon on these investments will depend on the company's return on invested capital requirements. As operations expand, companies can continue to strategically add autonomous robots to complement business growth and support evolving customer needs.

Pricing factors

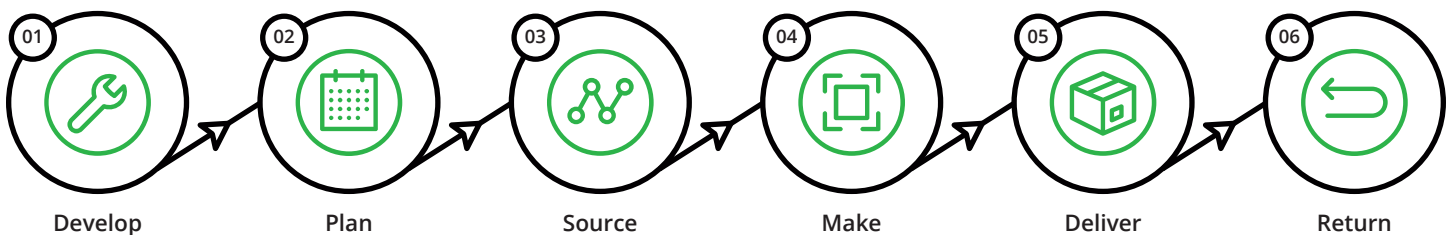
Price ranges for both consumer-facing and industrial robots vary greatly, depending on the technology, level of artificial intelligence, and functional capabilities. However, as the cost of materials such as lasers, cameras, processors, and force-torque sensors continues to decrease, robots are becoming increasingly affordable.

Production costs are also decreasing, bringing autonomous robots within an affordable range for hobbyists as well as large organizations, allowing for the proliferation of use cases and reducing cost barriers to autonomous robot implementation.

Key levers for autonomous robots in your supply chain

Supply chain applications

Significant opportunities exist for implementation of autonomous robots in each stage of the supply chain.



Examples

1. Develop: Product design will benefit from robotic process automation in product lifecycle management data entry activities; product development and prototyping activities can benefit from around-the-clock testing for fatigue, damage tolerance, and quality as autonomous robots are set up to perform continuous, repetitive tasks.
2. Plan: Inventory management and cycle counting done by drones can support more accurate supply-demand reconciliation and replenishment needs, ultimately reducing on-hand inventory. Robotic process automation can benefit data entry tasks performed in demand and supply planning.
3. Source: Robotic process automation in standard sourcing processes can reduce effort and time requirements and improve the accuracy of mundane tasks. Autonomous robots are able to perform inspections on inbound goods and provide real-time data to suppliers.
4. Make: Collaborative robots working side by side with humans can improve

efficiency, reduce mistakes, and allow humans to focus on more strategic and mentally stimulating work.

5. Deliver: Autonomous vehicles with self-guiding abilities can reduce cross-docking times; improve accuracy and rates of picking, packing, sorting, and labeling of items; increase perfect order rates; and potentially drive higher customer satisfaction.

6. Return: Advanced scanning abilities through improved cameras and lasers can allow for quicker receiving and put-away of customer returns, enabling faster redeployment of products.

These examples are just a few of the many opportunities to improve supply chain performance with autonomous robots. Opportunities exist throughout the end-to-end supply chain for cost reduction and value creation.

Motivation for action

The time for companies to assess their supply chains for piloting autonomous robots is now. Depending on needs and existing capabilities within the supply chain, implementing autonomous robots—from

robotic process automation to self-guiding, vehicles with artificial intelligence—can provide significant improvements in productivity and efficiency, while reducing labor costs and improving customer satisfaction.

As technology and autonomy continues to improve and prices decrease, the question is no longer whether autonomous robots will find a way into the supply chain, but where and how soon.

Autonomous robots have the potential to improve supply chains end-to-end:

- Increased efficiency
- Reduced error and return rates
- Improved safety in high-risk environments
- Improved collaboration with humans
- Faster delivery and product movement

Key Deloitte contacts in autonomous robots and supply chain management



Joseph Fitzgerald
Principal, Supply Chain &
Manufacturing Operations
Supply Chain Innovation
Deloitte Consulting LLP
+1.415.519.2115
josit Fitzgerald@deloitte.com



Evan Quasney
Senior Manager, Supply Chain &
Manufacturing Operations
Deloitte Consulting LLP
+1.415.205.6128
equasney@deloitte.com

The authors of this paper would like to thank the following contributors:

Adam Volini, Manager, Deloitte Consulting LLP; Erika Berg, Senior Consultant, Deloitte Consulting LLP; Sophia Moradian, Business Analyst, Deloitte Consulting LLP.

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