



Your partner  
in progress

# Robotics and Automated Machines Report

Improving operational efficiency  
and competitiveness

# Contents

|    |                                     |    |                                 |
|----|-------------------------------------|----|---------------------------------|
| 3  | Introduction                        | 16 | Case studies                    |
| 5  | Benefits and challenges of robotics | 18 | Latest developments in robotics |
| 10 | Legislation for robotics            | 21 | Conclusion                      |
| 12 | Standards for robotics              |    |                                 |



# Introduction

The successful adoption of robots in manufacturing can improve productivity, product quality, safety, and cost-effectiveness for organizations, making them more competitive.

The main benefit of using robots in industrial and manufacturing settings is to address the 'dull, dirty and dangerous' tasks that are challenging for human workers. For example, robots can take over monotonous and physically demanding jobs like repetitive manual assembly or moving products, freeing up human workers to focus on other healthier and more stimulating activities. Robots can also perform dangerous jobs like inspecting hazardous environments or hard-to-reach areas, reducing the risks to human workers from exposure to hazardous substances and ergonomic issues.







Robots can operate 24/7 without the need for rest, increasing production efficiency and reducing costs. They also offer flexibility in adapting to different tasks and environments. Future advances in Artificial intelligence (AI), sensors, and navigation are enabling robots to tackle more complex and changing environments and will lead to a wider range of applications.

The latest industrial robots report from International Federation of Robotics shows that in 2023 a total of 541,302 robots were installed globally, taking the number of operational industrial robots to over four million. The report states “The five major markets for industrial robots are China, Japan, the United States, the Republic of Korea, and Germany. These countries accounted for 78% of global robot installations”.

The largest sectors in terms of robot installations are automotive, electrical and electronic, and metals/ machinery. However, recent advancements in robotic technology, coupled with evolving economic pressures, have accelerated opportunities for the integration of robots into a wider range of sectors and, increasingly, into small and medium sized companies.

The UK manufacturing landscape is undergoing a significant transformation, driven by the increasing adoption of industrial robots. Last year there was a 51% increase in the number of robots installed in the UK, but, despite this growth, the overall use of robots still lags behind other similar industrial nations. This relatively slow uptake of industrial robots in the UK presents both challenges and opportunities.

On the one hand, it suggests a potential for increased productivity and competitiveness if the barriers to adoption can be overcome. On the other hand, it raises questions about the UK’s ability to keep pace with global trends in automation and the potential impact on employment and skills development for future-proofing UK manufacturing.

### References:

- Implementation of Robot Systems | ScienceDirect
- International Federation of Robotics (ifr.org)
- About BARA | Automate UK (automate-uk.com)



# Benefits and challenges of robotics





# Benefits of robotics

The primary business drivers for implementing robots are usually to reduce operational costs and increase productivity, but, in fact, there are a host of different benefits when robots are deployed in factories, including:

- 1. Increased productivity:** Robots can perform production tasks at greater speeds and with higher repeatability than human operators, bringing more consistency and less variation to the process and outcome.
- 2. Health and safety:** Robots can perform tasks that are difficult or unhealthy for human operators, thereby reducing workforce exposure to harmful processes and workloads.
- 3. Expanded capabilities:** Robots can make the impossible possible, either by performing production tasks that humans simply cannot do or by assisting operators in jobs that they cannot achieve on their own due to ergonomics, human factors, adverse environmental conditions, etc.
- 4. Greater flexibility:** Advanced sensor technologies and software control measures now allow humans and robots to work together more closely and collaboratively on shared tasks in safe conditions, utilizing their different individual skills and capabilities in new and more effective ways, which opens up new technical applications and business benefits.





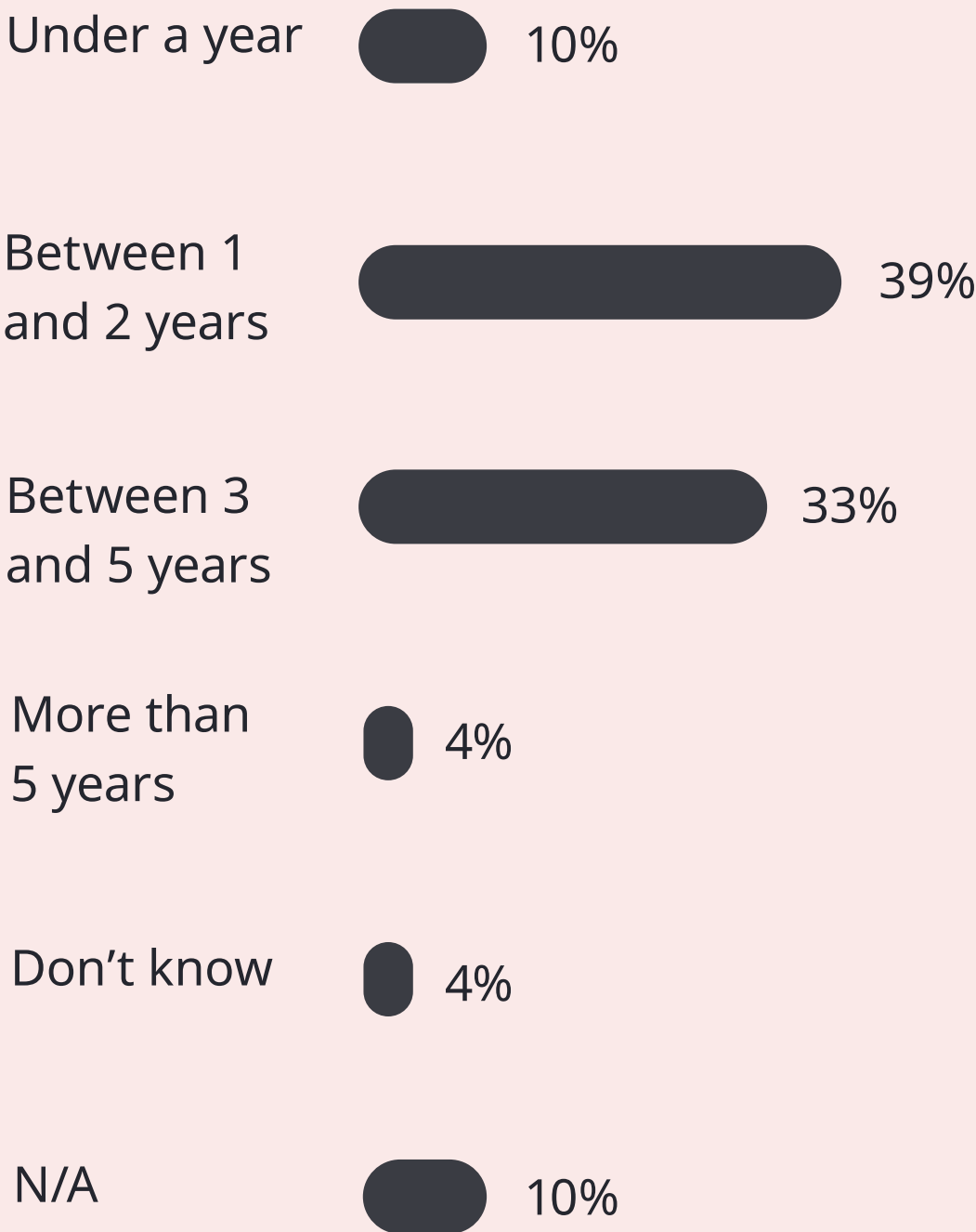


Once the benefits have been identified, the decision to invest in automation will depend on expected returns on investment (ROI) – in other words, whether the future gains are worth the cost of investment. The time periods for returns can vary greatly depending on the type of investment and the cost. Figure 1, taken from a report by MakeUK, shows that a majority (82%) of polled manufacturers expected a positive ROI in less than five years.

Although the ROI is a financial decision, there can be other factors that influence it, such as cost avoidance of possible health and safety issues.

A long-term view is necessary to promote the right types of investment. Policymakers’ strategic vision on support and incentives should consider this when attempting to attract investment and supporting businesses to adopt new automation.

**Figure 1 – Timelines for expected ROI Investment**



Reference: [Make UK/Infor Automation survey 2023](#)



# Challenges of robotics

Challenges which end user manufacturers might experience throughout a project or programme life cycle, or which may deter them from deploying new robots in their factories, are often rooted in a lack of understanding of how to effectively automate an existing manual process and consider all of the various physical and human elements, including:

- 1. Situational awareness:** Adapting to the variation in the incoming state of the components which might be handled, assembled, or joined.

Robots are highly positionally repeatable; however, if there is variation in components size or how the components are presented to the robot, this needs to be accommodated by the robot using additional 2D/3D vision camera sensors. These provide a means for adaptive robot path planning and position algorithms, which could lead to fixtureless pick/place assembly applications, but add another layer of complexity which would add cost to the system.

This type of technology has been available in the marketplace for over 20 years. However, the rapid pace of development of AI vision systems targeting robotics has made this new wave of capabilities more readily available and accessible. This reduces barriers to entry of investment and skills required for these types of robotic applications.

- 2. Design readiness:** When automating an existing process, or designing a completely new product, a critical consideration is designing the product to be processed or assembled with automation in mind. There are a number of reputable approaches to address this, including suitability for Design for Manufacture (DfM), Design for Assembly (DfA), and Design for Automation (DfAuto). Considerations could include the part to be handled, and the robot end-effector, to ensure repeatable process outcome. There is a trade-off between designing repeatability into the process and the required complexity of the robotic application.

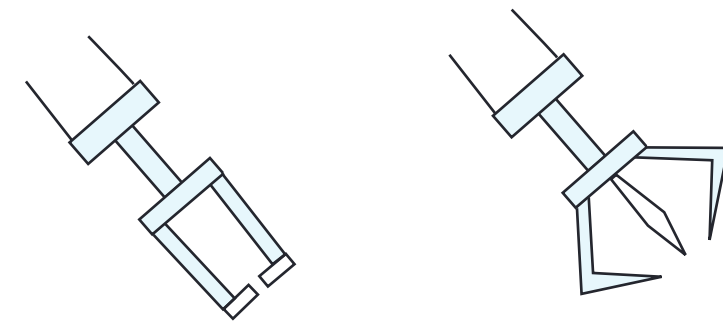
- 3. Human factors:** Designing a system to suit the people who work with it is critical to success. However, human factors can be overlooked and often overshadowed by technical issues, especially when automating existing manual processes. With collaborative and autonomous systems, there is an increasing need to understand and design for human requirements, because they can have a greater effect on people. Such issues need to be identified and considered early in the design process.



# Human-robot collaboration

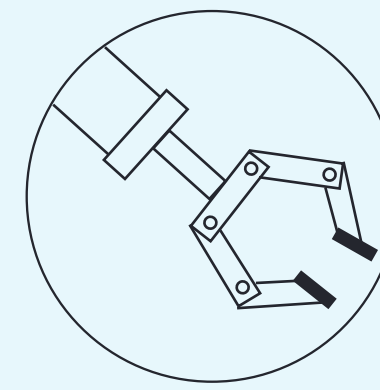
The fundamental design of production tasks and processes should utilize the characteristics and capabilities of both the human and the robot to maximize the safety and performance of each. A good understanding of task, skills and changes required is essential when automating. This can be achieved with the involvement of operators at the design stage to capture their valuable knowledge and experience. This information can also be used to design out sources of variation or excessive manual interventions of the process or product. Operator engagement encourages a sense of ownership which promotes adoption of the new system.

During operation, robot systems need to be continuously monitored and managed to maintain optimal levels of performance and to ensure no detrimental impacts have developed. The closer proximity and interactivity involved in collaborative systems means there is an even greater need for oversight. The continued engagement of operators in training activities can provide a feedback loop for drawing out new knowledge and ensuring continual improvement.

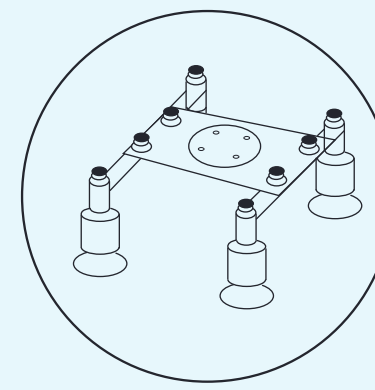


## Anatomy of a Robot

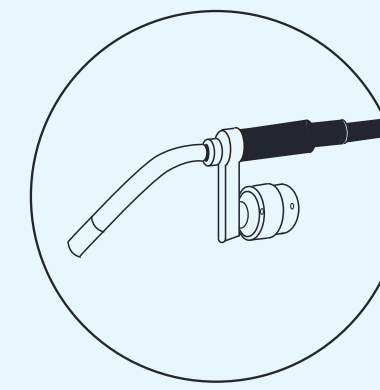
### Example End Effectors



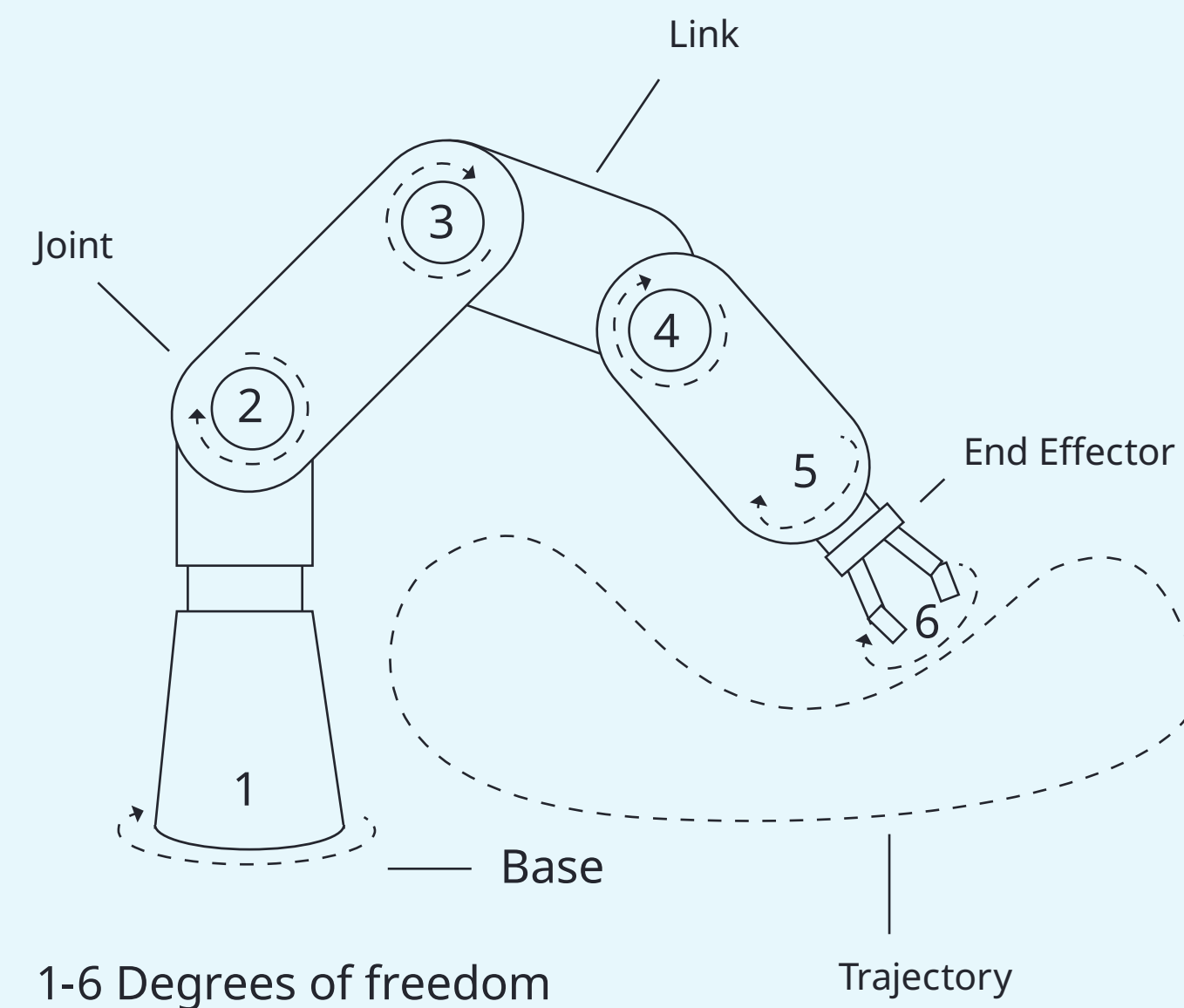
Gripper



Vacuum gripper



Welding tool



1-6 Degrees of freedom

Trajectory





# Legislation for robotics





When supplied from the manufacturer, a robot is normally considered to be a partially completed machine. When someone subsequently programs the robot to complete a specific task, it then becomes a machine, at which point it will need to comply with the relevant local product safety legislation in your region.

For example, in the European Union, it will need to comply with the Machinery Directive (or new Machinery safety regulations from January 2027). This requires ensuring that it complies with all relevant essential health and safety requirements (EHSRs) listed in the legislation; this needs to be documented in a technical file, and the new robot application then needs certifying and marking (e.g. CE or UKCA) to the relevant legislation.

The easiest way to ensure compliance with the EHSRs is by working to ‘designated’ or ‘harmonized’ standards which, provided they cover all relevant hazards in the chosen application, can give a presumption of conformity to the product safety legislation.

Other legislation may be relevant. For example, if the robot is in a work environment, legislation that covers the use of the robot will also apply. This will include how people should interact with the robot, any necessary training and how it should be maintained to ensure safety over the lifetime of the robot application.

When a robot is reprogrammed to complete a new task, an assessment is needed to decide whether the new application is broadly similar to the old one, or whether it introduces new risks and therefore would require recertification as a new machine.

**Harmonized standard:** A standard that has passed an assessment that, if it is followed, will ensure that a machine is designed to be safe and will comply with the SMSR (Supply of Machinery Safety Regulations) or the Machinery Directive respectively and is officially recognized as such by the government (UK, or EU).





# Standards for robotics



# How international standards are supporting robotics adoption

The use of robots in industrial applications can be supported by following the standards widely used for the safety of industrial machinery. Additionally, standards have been created to address safety and integration needs specifically for robots.

These standards cover the hazards created when robots are installed in industrial applications where human operators can also work. They also specify the necessary conditions for safely undertaking collaborative tasks. This enables organizations to take full advantage of the efficient interaction between humans and robotic systems working together.



## General principles

**BS EN ISO 12100** is the starting point for every application, providing the general principles for design and risk assessment and reduction methodology. It is a standard crucial for the safety of any robotic installation, as it helps to define the requirements needed for putting the robot to use.



## Safeguarding

Safeguarding can take the form of physical guards or electronic devices that detect the presence of people. The use of guards to protect people from hazards is described in **BS EN ISO 14120**, while **ISO 14119** describes how to safely deploy interlocking devices. In addition, the application of presence sensing devices is described in **BS EN IEC 62046**.

The position of the safeguard is governed by the following standards. **BS EN ISO 13855** considers the approach of humans towards a machine to safely position safeguards, with **BS EN ISO 13857** considering the reach of upper and lower limbs and **BS EN ISO 13854** considering the sizing of gaps to avoid crushing zones.

Safety-related sensors used for protection of persons are described in the **BS EN IEC 61496 series** series of standards.





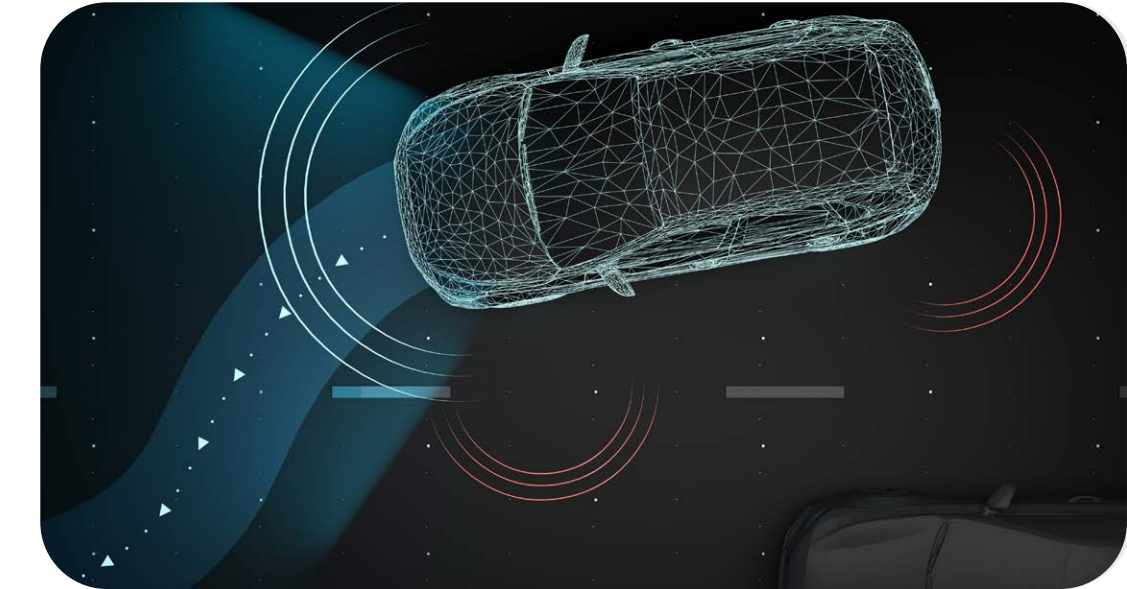
## Control systems

The requirements for safety-related parts of control systems are described in **BS EN ISO 13849-1** or **BS EN IEC 62061**. These standards explain the necessary safety performance each system should achieve based on the risks of the application. To ensure the robot can stop safely in an emergency and to avoid unexpected start-ups, **BS EN ISO 13850** and **BS EN ISO 14118** apply, respectively.



## Industrial applications

The **BS EN ISO 10218 series** specifically help with the installation and use of robots in industrial applications. They do this by bringing together the wide range of machinery and robotics safety-related standards in one place, to ensure their safe and effective installation and use. **BS EN ISO 10218-1** describes the requirements for industrial robots and **BS EN ISO 10218-2** guides the designers, integrators, and end users to their safe application.



## Industrial trucks and autonomous mobile robots

Autonomous trucks and mobile robots can offer an efficiency boost in industrial environments. **BS EN ISO 3691-4** discusses the safety requirements and verification for autonomous industrial trucks. Specific automated functions of industrial trucks are covered in **BS EN ISO 24134** and safety functions from a control system perspective are covered in **BS EN 1175**.





## Collaborative applications

**BS EN ISO 10218-2** considers the use of robots alongside human workers without a physical barrier between them and is of great interest to end-users of industrial robots in collaborative applications. The document guides end-users in defining safe limits to allow robots and people to work together in a safe environment.

Together, these standards provide a framework for the safe use of autonomous trucks and mobile robots to the organizations using them.

### Safe and intelligent automation starts with the right standards

As robotics and automated machines become more autonomous, connected and data-driven, organizations must navigate an increasingly complex standards and safety landscape. BSI Knowledge provides a single digital platform to access and manage the latest robotics, machinery safety and digital standards, helping teams reduce risk and design with confidence.

**Explore how BSI Knowledge supports robotics and automation**





# Case studies





# Progressing the safe use of robotics and automation

The adoption of robots in industrial environments has created opportunities for organizations to become leaders in their fields. The following case studies demonstrate successful adoption of various robotic technologies worldwide.

**Ocado Intelligent Automation** has revolutionized warehouse automation. By using intelligent and adaptable automation they have minimized the costs and increased the efficiency of warehouse operations. This includes the handling of complex objects by expert robot pickers.



**Universal Robots** has been an enabler for organizations of all sizes, from SMEs to multinational manufacturers. The introduction of robotic automation in **SEAT** enabled seamless introduction of robots into the factory floor, increasing efficiency and safety. This resulted in freeing worker time by automating the task of unloading 18,000 gears a day. Repetitive and non-ergonomic tasks were replaced by cobots (collaborative robots) in **Schneider Electric** capable of operating alongside human workers, resulting in a ROI within 2 years.



**The West Japan Railway Company** has procured a humanoid robot to undertake dangerous work in railway maintenance. Removing humans from challenging and dangerous environments, such as operating at heights near high voltage electrical conductors, the application has brought an elevated level of efficiency and safety, as well as worldwide renown for the organization.





# Latest developments in robotics





## Artificial intelligence (AI) and robotics

When paired with robotics, AI can give robots the ability to operate in highly complex environments and provide autonomy in how to achieve the tasks given to them.

Machine vision will lead to cognitive robots that can understand their environment and react to it. Research shows that when coupled with natural language processing, this will create completely new ways of human/robot interaction and has the potential to unlock new tasks and deliver increased autonomy in robotic applications. Robots can also increase their awareness and take advantage of cutting-edge sensing systems, such as 2D or 3D lidar, radar, and ultrasonic sensors which are developing fast to aid with 3D mapping of environments and detection of objects and people.

For now, safety is maintained by traditional methods, but in the future robots may also be capable of making safety decisions. The groundwork for this is already underway. A joint ISO/IEC working group has written ISO/IEC TR 5469, *Artificial intelligence - Functional safety and AI systems*, and the same group is now working to develop technical requirements that could pave the way for a future 'AI and safety' standard that could revolutionize robotics and automation.

## Walking robots

Walking robots are increasingly finding applications in various industries, offering unique capabilities compared to traditional wheeled or tracked robots. Their ability to navigate complex and unstructured terrains makes them suitable for tasks such as inspection, surveillance, and maintenance in challenging environments like construction sites, tunnels and complex industrial facilities. These robots can be equipped with sensors and cameras to collect data, identify potential hazards, and monitor progress, improving safety and efficiency. Boston Dynamics' Spot is a prime example of a walking robot, its agility and modular design allow it to be customized with various payloads and programmed for autonomous operation, making it adaptable to a wide range of industrial applications.<sup>3</sup>

Spot's impact is evident in its adoption across diverse sectors in a variety of different applications which demonstrate the potential of walking robots to revolutionize industrial operations, enhancing productivity, safety, and data-driven decision-making. As technology advances and costs decrease, we can expect to see even wider adoption of walking robots in industry, transforming the future of work.

References:

- [Spot | Boston Dynamics](#)



## Humanoid robots

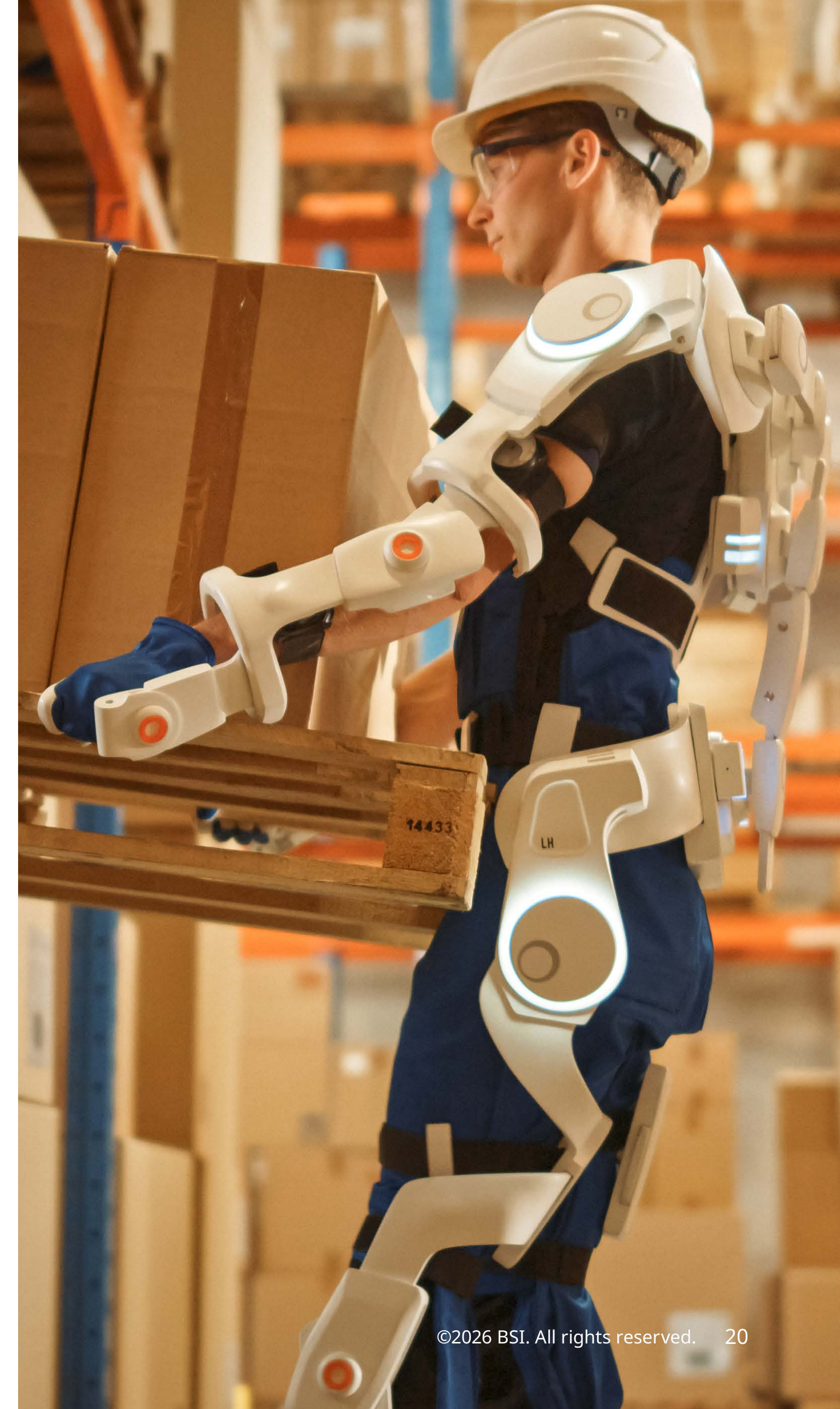
Humanoid robots are undergoing rapid development, led by firms in the United States<sup>4</sup> and China.<sup>5</sup> Recent advances in AI have shown humanoid robots to be capable of autonomously completing complex and dexterous tasks. For now, these examples are prototype applications and there are significant challenges in bringing them into full scale operation in real world facilities where they may be required to work collaboratively with people. Agility Robotics' Digit is one such robot that has been deployed in industry; their aim is that the next generation of this robot will be capable of co-operating with human workers safely.<sup>6</sup>

## Exoskeletons

Powered exoskeleton systems are wearable robotic devices that aim to enhance operator efficiency and reduce injuries. In the industrial setting, exoskeletons are used by car manufacturers, first adopted to combat shoulder and back injuries due to repetitive tasks. In logistic operations, exoskeletons are used to aid with manual lifting tasks. The maturity of exoskeleton technology leading to higher autonomy and longer use is helping their adoption in more varied applications. The increase in robotics within industrial environments could lead to increased benefits due to the cooperations between robots and exoskeleton powered operations.

### References:

- [Atlas | Boston Dynamics](#)
- [Humanoid robot H1 | Unitree Robotics](#)
- [Digit — Agility Robotics](#)





# Conclusion





The successful adoption of robotics and automation in manufacturing is crucial for companies to enhance productivity, product quality, and cost-effectiveness.

Robots excel in addressing 'dull, dirty, and dangerous' tasks, and improving safety and efficiency.

The manufacturing landscape is undergoing a transformation with the increasing adoption of robots, presenting both challenges and opportunities. By understanding the benefits, addressing the challenges, and staying informed about the latest developments, organizations can leverage the power of robotics to enhance productivity, improve safety, and drive innovation.

The primary business drivers for implementing robots are to reduce costs and increase productivity. However, there are many different benefits, including expanded capabilities and greater flexibility. The decision to invest in automation often depends on the expected return on investment (ROI), with many manufacturers expecting a positive ROI in less than five years.

Challenges in implementing robots often stem from a lack of understanding of how to effectively automate processes. Adapting to variations in components, designing products for automation, and addressing human factors are critical considerations.

International examples like Ocado and Universal Robots demonstrate successful implementations of robotics in various industries. Adhering to international standards for the safety of industrial machinery is crucial for the safe integration of robots into the workplace. Standards such as **BS EN ISO 12100** and **BS EN ISO 10218 series** provide a trusted foundation for manufacturers adopting automation, helping organizations achieve compliance, safeguard their people, and realize long-term ROI.



The next phase of industrial transformation depends not only on innovation but on responsible adoption. BSI continues to work with industry, regulators, and innovators to shape the evolving standards landscape for robotics, AI, and automation. By embedding standards at every stage of implementation - from design and risk assessment to integration and maintenance - organizations can ensure that robotics drives productivity and competitiveness while maintaining safety, trust, and resilience.

Looking ahead, the future of robotics and automation is promising. Advancements in AI, machine vision, and natural language processing will lead to even more autonomous and adaptable robots. Walking robots like Boston Dynamics' Spot are finding applications in various industries, offering unique capabilities in navigating complex terrains. The emergence of humanoid robots and advancements in exoskeletons hold further potential for transforming the future of work, and standards will continue to provide the framework to ensure these developments benefit both businesses and society safely and sustainably.



# Next steps

Adopting robotics and automation successfully isn't just about investing in new technology - it's about doing so safely, efficiently, and in compliance with international best practices. To move forward confidently, consider the following steps:

- 1 Assess your current level of automation:**  
Identify processes where robotics could improve productivity, consistency, or worker safety. Look at tasks that are repetitive, hazardous, or hard to staff.
- 2 Evaluate your readiness for automation:**  
Consider factors such as workforce skills, data maturity, safety culture, and system integration. Understanding your organization's readiness helps determine the best path to adoption.
- 3 Apply the right standards from the outset:**  
Use internationally recognized standards such as **BS EN ISO 12100** and **BS EN ISO 10218 series** to guide design, integration, and operation. Working to these standards provides assurance of safety and compliance with relevant legislation.
- 4 Engage your people early:**  
Successful automation depends on workforce involvement. Involve operators and technical staff in planning and design to ensure systems meet both.
- 5 Monitor, learn, and continually improve:**  
Automation is not a one-time investment - it requires ongoing monitoring, maintenance, and updates to maximize performance and safety.
- 6 Explore BSI resources and expert guidance:**  
Access relevant standards, guidance documents, and expert insights on BSI Knowledge, your digital standards library.
  - a. Learn more about the standards mentioned in this guide.
  - b. Explore related modules on manufacturing and automation.
  - c. Book a demo of **BSI Knowledge** to see how easy it is to access, apply, and manage the standards that will guide your automation strategy.

By taking a standards-based approach, your organization can adopt robotics responsibly – improving productivity, enhancing safety, and building long-term resilience in an increasingly automated world.

## Build trust into every automated system

From collaborative robots to fully automated production environments, applying the right standards is critical to safety, compliance and performance. BSI Knowledge helps organizations stay informed and aligned as robotics technologies and regulations continue to evolve.

Book a demo of BSI Knowledge to see how your teams can manage robotics and automated machinery standards across sites and disciplines.



[Get a live demo](#)



# Authors



**Steven Carter Eur Ing  
CEng FMIET**

Steven Carter is a Director in Manufacturing IT/OT Architecture for a global portfolio medical technology company. He has a manufacturing background within the automotive, aerospace and MedTech industrial sectors with technology development and application, with a focus on developing advanced robotic and automation systems for new manufacturing technologies and assembly processes along with designing and delivering new SMART factories with highly integrated digital manufacturing and IT systems. Steven is an externally-recognized specialist within his field, cyber-physical systems, and is a member of several industry level technical panels within BSI, ISO, IEC, and CEN for robotics, automation, industrial data, AI, machine safety systems and cybersecurity. He is also chair of the European CEN/TC 310, 'Advanced automation technologies and their applications' technical committee.



**Dr Sarah Fletcher**

Dr Sarah Fletcher is a Principal Research Fellow in the Centre for Robotics and Assembly at Cranfield University where she leads the industrial psychology and human factors research group. Her research is dedicated to human analysis for enhancing the design and integration of robotics and advanced technologies in industry, particularly by improving workforce trust, acceptance, satisfaction, performance and safety behaviours. Sarah has directed social science in a number of UK and EU research projects and works on a number of national and international standards committees in robotics, robot ethics, and human-system ergonomics.



**Nick Hall**

Nick is a chartered electrical and control systems engineer. He spent 22 years in industry designing and commissioning machinery and process control systems in projects all over the world. Since joining the HSE in 2015 he has investigated many serious and fatal incidents on machinery and represents HSE on British and international standards for machinery safety, cybersecurity, robotics and artificial intelligence. Nick's current focus is on advanced automation, writing standards and guidance for autonomous equipment, and how AI can be used to safely control equipment.





**Dr Ioannis Dimitrios Zoulas**

Dr Ioannis Dimitrios Zoulas is a Principal Control Systems Engineer specializing in cutting-edge telerobotics and haptics systems for complex environments. He has designed complex robotic and digital capability systems at international fusion experiments (JET and ITER). He led the first robotic decommissioning of a fusion reactor, responsible for the robotic integration of the updated JET remote handling system. As a member of the BSI and ISO groups on robotics, he is involved in the production of standards on the safe operation of machinery and robotics. He is committed to advancing safety in human-machine interactions to enable innovative solutions in robotics.

## Technical reviewer

Martin Kidman, Safety Manager  
(Europe S&W), SICK

Disclaimer: The views and opinions expressed in this document are those of the authors. They do not necessarily reflect the official policy or position of BSI Group. This document is not a peer-reviewed work. Although it may be a sponsored publication, it is issued solely for information of the authors' views and opinions only. BSI Group makes no representations as to accuracy, suitability or validity of information. All information is provided on an "as is" basis. BSI accepts no liability for any loss or damage caused, arising directly or indirectly in connection with reliance on its contents except to the extent that such liability may not be excluded in law.





BSI Group  
Seventh and Eighth Floors,  
The Acre, 90 Long Acre,  
London, WC2E 9RA  
United Kingdom  
+44 345 086 9001  
[BSIMarketing@bsigroup.com](mailto:BSIMarketing@bsigroup.com)  
[bsigroup.com](https://bsigroup.com)