

Digitizing Canada's Manufacturing Sector

Exploring the intersection of manufacturing technologies to enhance productivity, innovation, and sustainability.

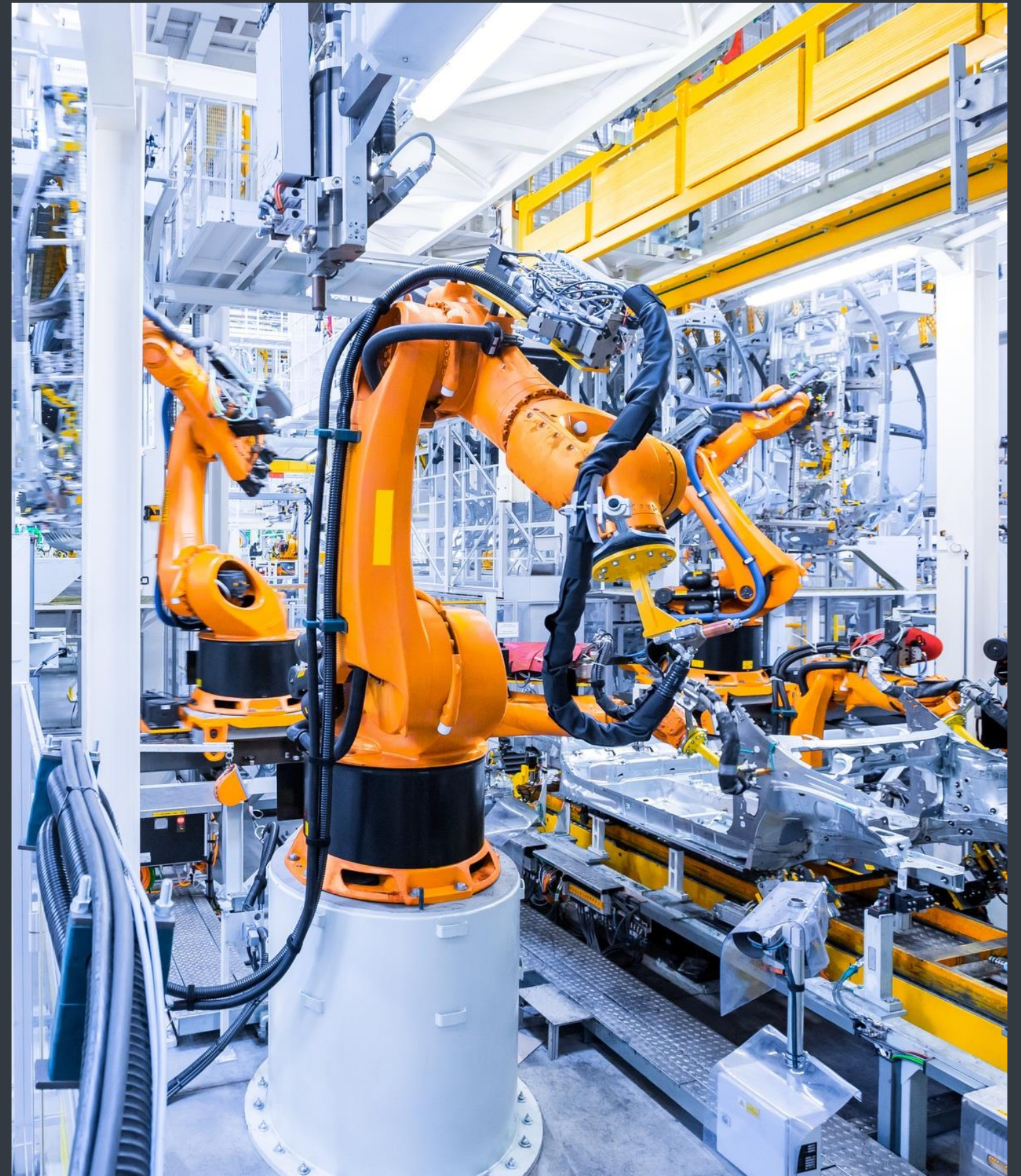


Technologies of Industry 4.0

Areas of Impact

Skills for Industry 4.0

Technologies of Industry 4.0



Technologies of Industry 4.0

Computer-aided manufacturing (CAM) processes create parts or components by adding layers of materials. A common method is 3-D printing, which has advantages in small batch production, as well as prototyping and customized products. As an efficient and cost-effective method, additive manufacturing is being utilized in many industrial contexts.

Additive Manufacturing



Smart Sensors



Smart sensors are advanced electronic components that transform physical data into digital signals, enabling on-site processing and analysis for immediate decision-making. Unlike basic sensors, they integrate digital sensors, processors, and communication tech to relay actionable insights, enhancing supply chain visibility and optimizing production and distribution.

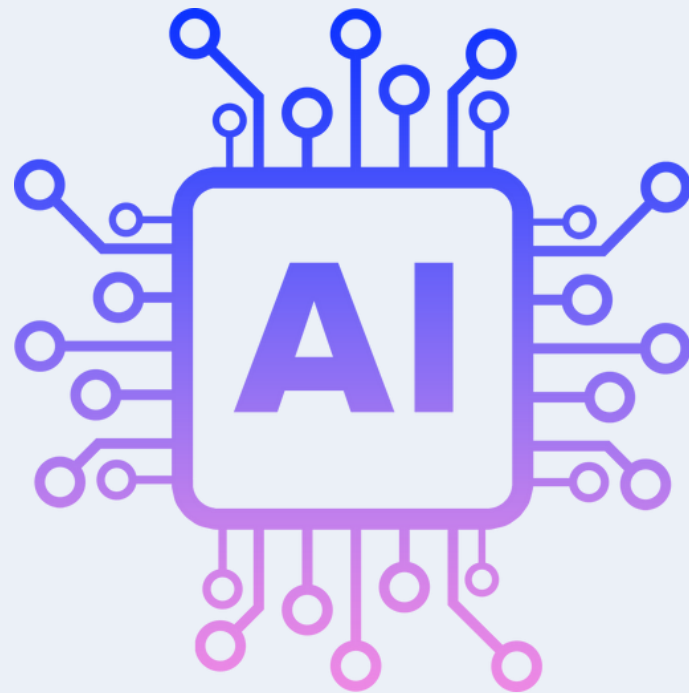
Technologies of Industry 4.0

2D and 3D graphics via AR on devices like tablets and glasses enhance production by providing real-time data and instructions to workers. This technology is key for error-sensitive industries like automotive and aeronautics, boosting productivity, accuracy, and decision-making quality.

Virtual Reality



Artificial Intelligence (AI)

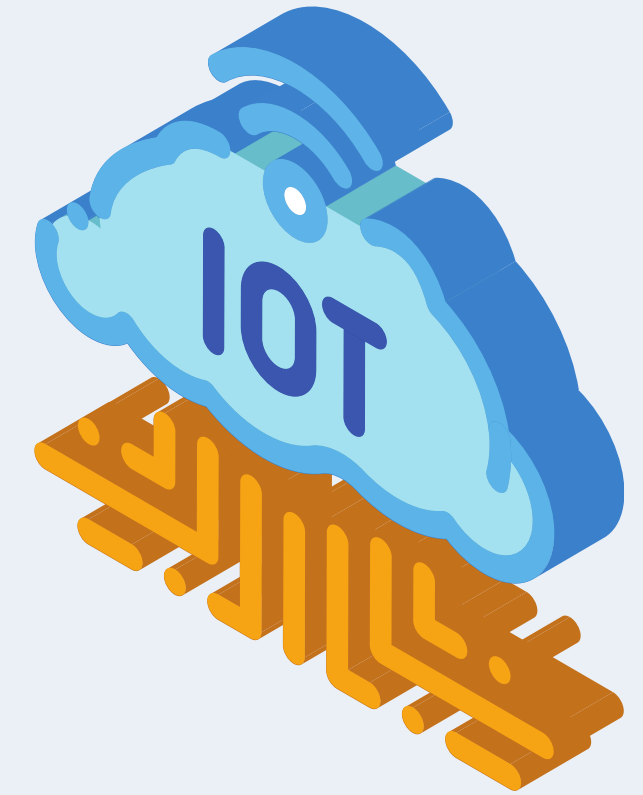


Artificial Intelligence (AI) empowers machines to learn from data and improve over time, enabling them to execute tasks and make decisions akin to human intelligence and reasoning. It's particularly advantageous in manufacturing for its rapid, precise decision-making, which is crucial for forecasting, outlier analysis, and efficiency improvements such as predictive maintenance and inventory management.

Technologies of Industry 4.0

The Internet of Things (IoT) connects diverse devices over the internet, facilitating interaction and decentralized, real-time decision-making through built-in computing. In manufacturing, IoT boosts productivity by harnessing data from production, aiding in predictive maintenance, and integrating customer feedback into design, enhancing the customer experience.

Internet of Things (IoT)



Cyber Security

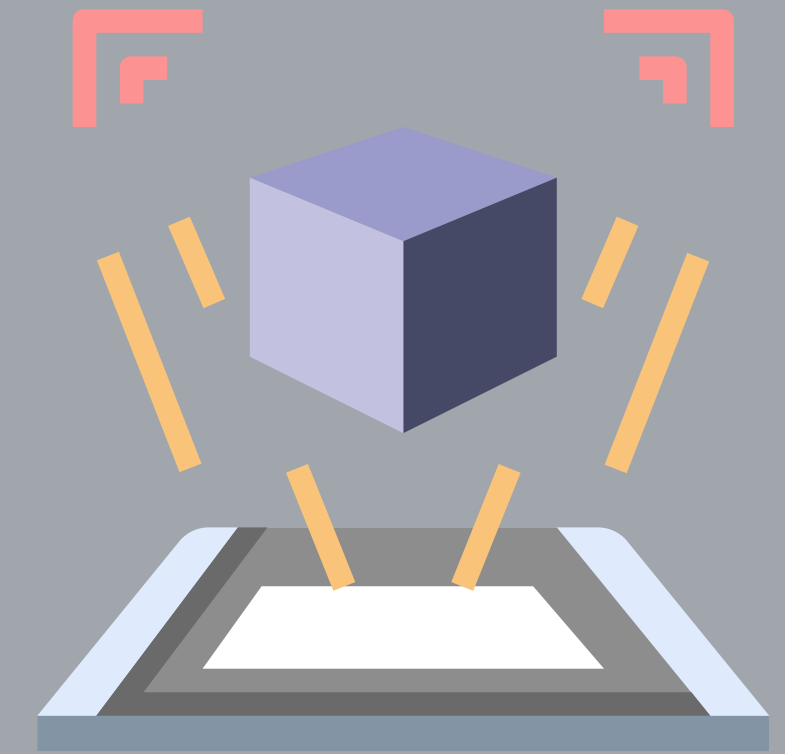


Digital transformation in manufacturing brings the risk of cyber-threats, which can damage systems, products and jeopardize important data. Cybersecurity safeguards systems against these threats. In manufacturing, cybersecurity extends to Operational Technology (OT), which is critical to plant and product security. Increasing threats necessitate real-time intrusion detection and often require external support for incident response.

Technologies of Industry 4.0

Simulation modeling streamlines design and testing, offering cost savings and process optimization in manufacturing. It helps reveal pinpoint bottlenecks and optimize labour input. Despite the challenges of time and expertise needed to develop valid models, simulations significantly boost performance and accelerate new product introduction.

Simulation



Big Data and Analytics



Industry 4.0 digitization enables the accumulation and management of large datasets throughout the supply chain. Big Data and Analytics involve analyzing these vast datasets to uncover patterns and insights, thus enhancing error detection, production quality, and supply chain efficiency. Sharing data across firms further refines AI algorithms and ensures the peak performance of data-driven applications.

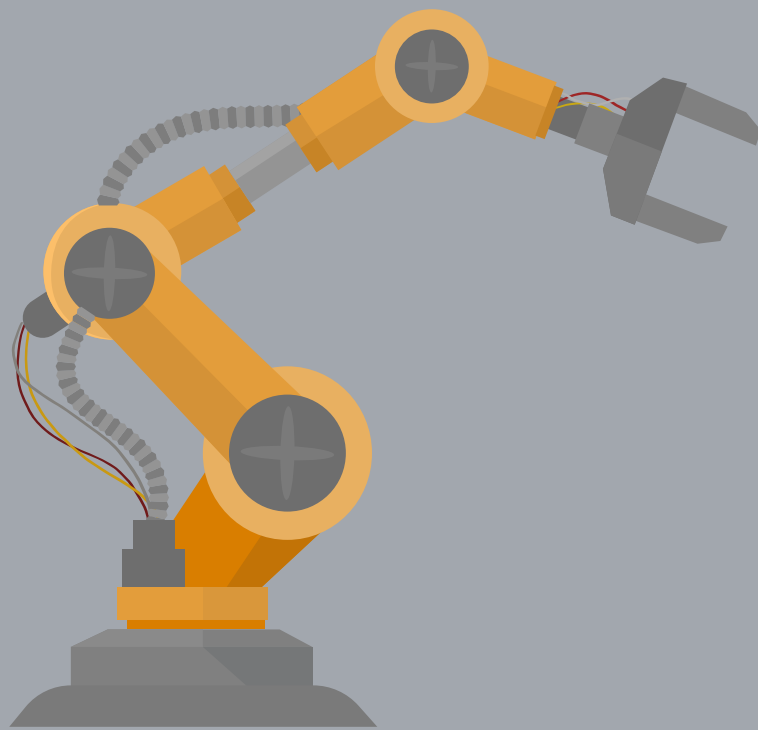
Technologies of Industry 4.0

The cloud centralizes data management and services for manufacturing, streamlining processes and supply chain integration. Its full business potential, beyond just tech and security, remains largely untapped. Cloud adoption facilitates scaling, IoT, and AI-enhanced operations through varied service models.

Cloud Computing



Autonomous Robotics



Robots in manufacturing are becoming increasingly adept and collaborative. Equipped with smart sensors and with access to AI capabilities, these robots are able to make autonomous decisions and learn from their surroundings, thus enhancing efficiency, precision, and safety. By assisting humans, they reduce the need for manual labour and minimize the risk of injuries. In certain scenarios, tasks can be fully automated, leading to increased productivity.

Areas of Impact of Industry 4.0



Areas of Impact of Industry 4.0

Automation

Industry 4.0 advancements streamline manufacturing with autonomous robotics and AI, promoting customization, efficiency, and reduced labor costs. These technologies facilitate flexible automation and strategic decision-making through data analysis, supporting rapid scalability and quality maintenance. The shift towards adaptive automation represents a more dynamic and economically viable production approach.

Supply Chain

Industry 4.0 technologies are revolutionizing supply chains, making them more connected and responsive from procurement to delivery, thus ensuring product quality and demand satisfaction. The integration of advanced technologies enables efficient market demand response, enhancing customer loyalty through personalized experiences. Real-time data and analytics drive predictive planning and production adaptability, fostering a transparent, agile supply chain capable of meeting current and future market needs.

Areas of Impact of Industry 4.0

Decarbonization

Industry 4.0 technologies are key for Canadian manufacturers to meet decarbonization targets by improving efficiency and accuracy. Techniques like additive manufacturing minimize waste, while AI and big data enhance energy use through precise forecasting. IoT and cloud computing streamline operations and quality control, and VR/AR in training enhances energy savings. Together, these innovations drive sustainability and competitiveness crucial for achieving decarbonization goals.

Customer Experience

Industry 4.0 technologies elevate customer service by offering personalized experiences, swift query handling, and predictive analytics. They leverage big data, AI, and IoT for tailored production and stock management. Digital tools process customer feedback for improvement, and VR/AR facilitates virtual product trials, enhancing trust. Early defect detection via IoT ensures product quality and customization, streamlining the consumer journey.

Areas of Impact of Industry 4.0

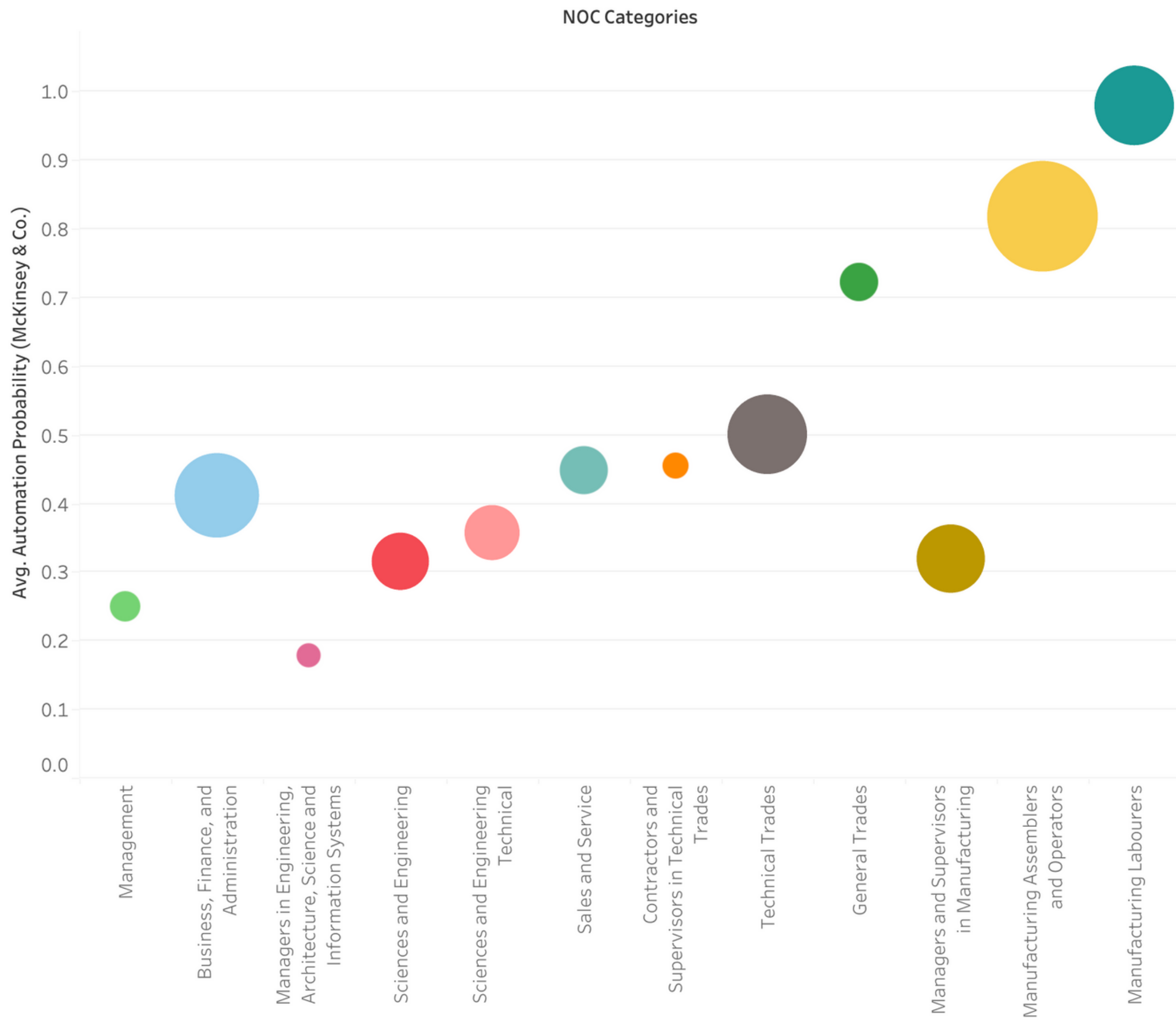
Product Development and Customization

Emerging technologies have the ability to revolutionize product development, catering to the rising demand for personalized products and fast delivery. Additive manufacturing, a key driver, enables custom solutions like bespoke medical implants, blending operational and information technology for more tailored and complex offerings.

Labour

The digitization and automation of manufacturing will transform existing jobs, necessitating new skills as some roles change or disappear. This evolution sparks a demand for highly-skilled workers to support emerging technologies, leading to opportunities for re-skilling and up-skilling. The focus on skilled labor could result in higher wages and make the industry more attractive to a diverse workforce, emphasizing the importance of equitable and inclusive work environments. Additionally, advancements in robotics, AI, and data analytics are set to enhance workplace safety and reduce hazards.

Automation Probability of Industry 4.0



Industry 4.0 Job Skills



Technical Skills for Industry 4.0

Cyber Security

Computational Fluid Dynamics (CFD)

Simulations

Robotics

Automation

Security Engineering

Digital Forensics

Vulnerability

IT Security

Continuous Improvement and Process-Optimization

Computer Science

Ethical Hacking

Software Engineering

Continuous Integration and Deployment

Deep Learning

Artificial Intelligence



Software Skills for Industry 4.0

Software As A Service (SaaS)

MATLAB

Penetration Testing

Simulation Software

Ansys Simulation Software

C (Programming Language)

AWS CloudFormation

Infrastructure as Code (IaC)

DevOps

Python (Programming Language)

PyTorch (Machine Learning Library)

Microsoft Azure

Amazon Web Services

Machine Learning

C++ (Programming Language)



Integrating I4.0 Technologies - Autonomous Robotics

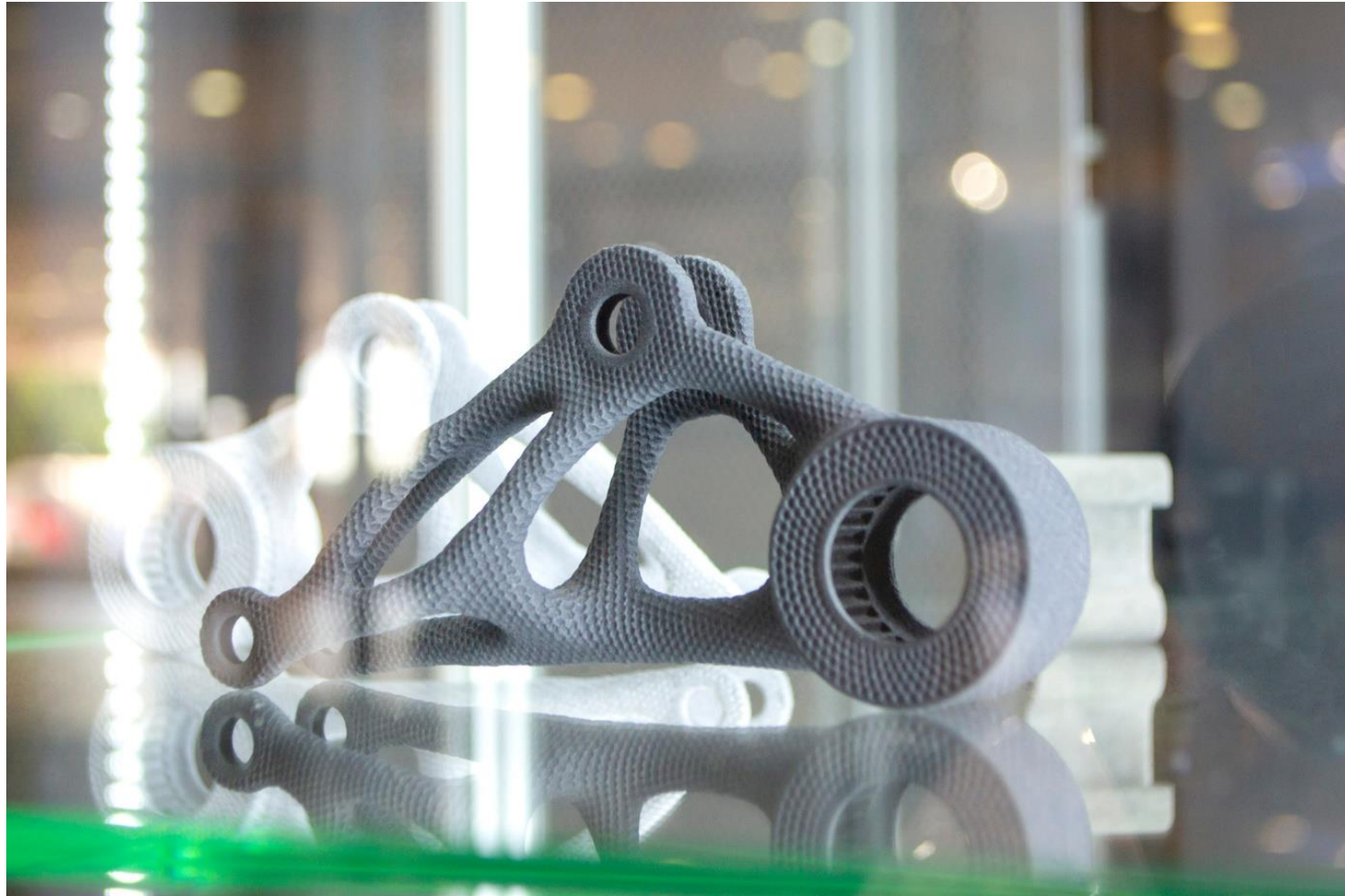


Autonomous Robotics involves the development and integration of robots capable of performing tasks with high degrees of autonomy and accuracy. Skills in this area are crucial for designing, programming, and maintaining robotic systems that can learn from their environment and make decisions with minimal human intervention.

Associated Job Skills

- Robotics: Design, implementation, and maintenance of robotic systems.
- Automation: Developing systems for operating manufacturing equipment autonomously.
- Artificial Intelligence, Machine Learning, Deep Learning: Enabling robots to learn from data, improve over time, and make autonomous decisions.
- Python (Programming Language), C++ (Programming Language): Programming languages used for robotic control systems and AI algorithms.
- PyTorch (Machine Learning Library): An AI library for developing machine learning models, particularly useful in robotic perception and decision-making processes.
- Simulation Software, Ansys Simulation Software: Software for simulating and testing robotic systems and components in virtual environments before deployment.

Integrating I4.0 Technologies - Additive Manufacturing



Additive Manufacturing, or 3D printing, revolutionizes the way complex products are designed, prototyped, and produced, allowing for unique geometries and customizations not possible with traditional manufacturing methods. Skills in this area are critical for operating and innovating in 3D printing technologies.

Associated Job Skills

- Software Engineering, Simulation Software: Developing and using software to design, simulate, and refine 3D printed parts.
- Digital Forensics (applied in a broader context): Understanding material properties and failure modes through detailed analysis.
- Python (Programming Language), C++ (Programming Language): Programming for customizing 3D printing processes and integrating with other manufacturing systems.
- MATLAB: For algorithm development in materials science and engineering analysis related to 3D printing processes.
- Machine Learning, Artificial Intelligence: Optimizing 3D printing processes, predictive maintenance for 3D printers, and material selection algorithms.
- Ansys Simulation Software: Simulating the 3D printing process to predict outcomes and improve product quality.

Integrating I4.0 Technologies - Cyber Security



As manufacturing becomes more digitized and connected, protecting sensitive data and ensuring the integrity and security of manufacturing systems become paramount. This area involves skills related to securing networks, systems, and data against cyber threats.

Associated Job Skills

- Cyber Security, IT Security, Security Engineering: Protecting systems, networks, and data from cyber threats, and ensuring data integrity and confidentiality.
- Digital Forensics: Investigating and analyzing breaches to understand their impact and prevent future incidents.
- Vulnerability, Penetration Testing: Identifying, assessing, and mitigating vulnerabilities in software and networks to prevent unauthorized access.
- Ethical Hacking: Using penetration testing and other techniques to identify vulnerabilities in systems and networks, with the aim of securing them from malicious attacks.
- Infrastructure as Code (IaC): Managing and provisioning computing infrastructure through machine-readable definition files, improving the security and stability of cloud environments.

Integrating I4.0 Technologies - Virtual Reality (VR)/ Augmented Reality (AR)



Virtual Reality (VR) and Augmented Reality (AR) technologies enable manufacturers to simulate complex processes, visualize products in 3D before they are built, and provide real-time assistance, thus reducing errors, saving time, and improving safety on the factory floor.

Associated Job Skills

- **Ansys Simulation Software:** This is crucial for creating accurate and detailed simulations that can be explored and interacted with in VR/AR environments, enhancing understanding and decision-making in design, maintenance, and training scenarios.
- **C and C++ (Programming Languages):** These languages are often used for developing VR and AR applications due to their performance and efficiency, especially in creating real-time interactive systems.
- **Python (Programming Language):** Python can be used for scripting within VR and AR development environments and for creating prototypes, due to its ease of use and wide range of libraries.
- **Microsoft Azure and Amazon Web Services (AWS):** Cloud platforms like Azure and AWS offer services that can host and process the vast amounts of data involved in VR and AR applications, facilitating scalable, accessible, and powerful computing resources.

Integrating I4.0 Technologies - Continuous Improvement & Process Optimization



As Industry 4.0 accelerates the digitization of manufacturing, continuous improvement and process optimization become cornerstones for enhancing operational efficiency and product quality. These methodologies drive waste reduction and streamline processes, paving the way for advanced digital integration and increased productivity.

Associated Job Skills

- Lean Manufacturing: Implementing efficient workflows and minimizing waste to improve overall production processes.
- Six Sigma: Utilizing data-driven analysis to reduce process variation and enhance quality control.
- PDCA Cycles: Applying the Plan-Do-Check-Act framework to facilitate ongoing process refinement and adaptation.
- Value Stream Mapping: Charting the material and information flows to identify bottlenecks and opportunities for streamlining operations.
- Root Cause Analysis: Investigating underlying issues in production inefficiencies to prevent recurrence.
- Kaizen: Encouraging small, continuous changes involving all employees to foster a culture of constant improvement.

Industry 4.0: An Innovative Future

Technological Integration: Industry 4.0 is not just about adopting new technologies; it's about the integration of multiple tools and technologies which directly contribute to efficiency, quality and innovation.

Skills for the Future: To navigate and excel in the Industry 4.0 era, a diverse range of job skills is essential. From software engineering to AI, and from robotics to additive manufacturing, professionals equipped with these skills are crucial for leveraging the opportunities Industry 4.0 presents.

Transformative Impact: These technologies are reshaping labor practices, enhancing automation, optimizing supply chains, driving decarbonization efforts, and redefining efficiency and productivity in the manufacturing sector.



The Future Ready program is a \$19 million program funded in part by Employment and Social Development Canada's Sectoral Workforce Solutions Program to support companies in onboarding new and diverse workers to Canadian manufacturing. The initiative will also aid Canadian manufacturers in identifying their critical skills gaps to support the future profitability and growth of their organization through NGen's highly regarded Transformation Leadership Program. Through these approaches, the program aims to provide demand-driven solutions for the manufacturing sector, one of the sectors hardest hit by the pandemic, and a key to the recovery of the Canadian economy.



**Future
Ready**

Thank You

Hindsight is 20/20, Foresight is Future Ready



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The opinions and interpretations in this publication are those of the author and do not necessarily represent those of the Government of Canada.