JOBS AND SKILLS IN INDUSTRY 4.0 IMPLEMENTATION

- Singapore is ranked second globally in terms of robot density in manufacturing, with 605 robots per 10,000 workers. This number is expected to increase as more sectors adopt Industry 4.0 (I4.0), as a response to Singapore's ageing workforce demographics and manpower shortages
- Under I4.0, companies across a wide range of sectors exploit technological advancements, particularly in the digital space, to make transformational improvements in process efficiency, sustainability, and product or service quality
- I4.0 will require work processes and functions to change. Job tasks will in turn be impacted. Companies need to upskill the workforce in a bundle of I4.0, digital and green skills to support job roles that are emerging and in demand

Businesses are increasingly turning to **I4.0**, such as using robots and automation to plug workforce gaps. This move accelerated during the COVID-19 pandemic, where many industries faced workforce shortages. A 2021 report by the International Federation of Robotics showed that Singapore has 605 robots installed per 10,000 employees in the manufacturing industry[1].

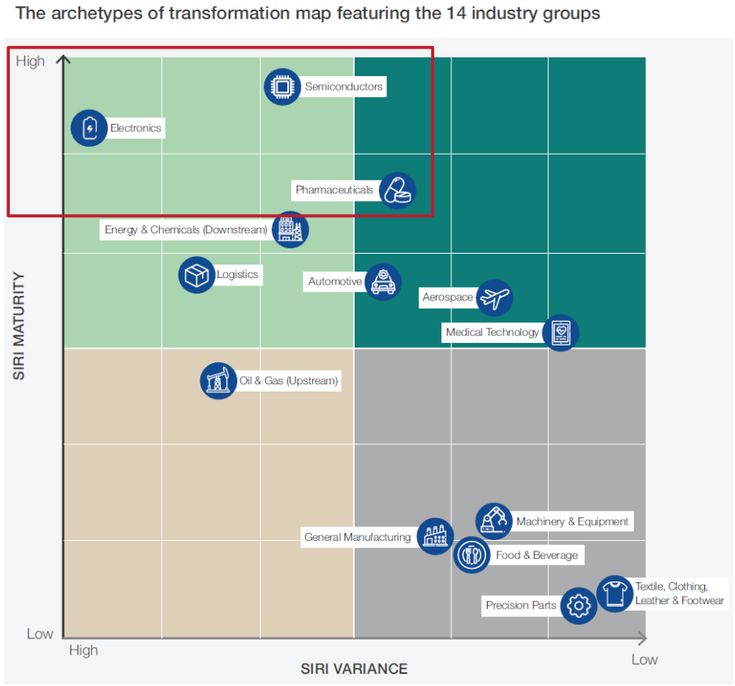
This is the second-highest globally, after South Korea's 932. The use of robotics and automation will continue rising as I4.0 adoption is part of the solution to Singapore's ageing workforce demographic and manpower shortages. A Lightcast report shows that by 2040, growth in the working population will slow down for nine in ten countries around the world, and those populations will decline for three in ten countries.[2] This demographic drought is a global phenomenon. To reduce the impact of manpower shortages, many employers are turning to I4.0 as a solution.

For instance, in Singapore, I4.0 adoption can be seen in the newly launched fully automated Tuas Port. Besides using unmanned vehicles to transport containers around the facility, it has also incorporated the use of artificial intelligence (AI) and machine learning to handle more complex operations[3]. In the area of food production, SATS, which is Asia's largest food solutions and gateway service, is also establishing a network of Internet-of-Things (IoT) technology at its new food hub that will aid in planning, raise asset utilisation, and cut food waste. It is also automating the production of meals, while manual processes such as meal assembly will be carried out by robotic finger grippers and auto dispensing units for efficiency[4].

[1] International Federation of Robotics, 2022
[2] Lightcast, 2022
[3] The Straits Times, 2022
[4] Asian Aviation, 2022

In manufacturing, many leading companies have chosen Singapore as their strategic manufacturing and trade hub. To support these companies in implementing I4.0, the Economic Development Board, together with a network of technology and industry experts, developed the Smart Industry Readiness Index (SIRI)[5], the world's first independent digital maturity assessment for manufacturers. It comprises a suite of frameworks and tools to help companies start, scale, and sustain their manufacturing transformation journeys. Insights from the SIRI initiative showed that companies across 14 industry groups are adopting I4.0 at different rates, with semiconductors, pharmaceuticals and electronics companies being the most mature (see Figure i1). I4.0 is also a critical enabler to Singapore's Manufacturing 2030[6] plan, where its target is to grow the manufacturing sector by 50% before 2030. I4.0 implementation can help manufacturing companies increase productivity by reducing downtime and maintenance costs, increase energy and resource efficiency, and drive innovation. To do so, the workforce will need to be equipped with skills to implement I4.0.

Figure i1: Insights from SIRI initiative showing the industries adopting I4.0 and transforming at different rates and the top 3 most mature industries[7]



A higher ranking in SIRI maturity indicates that the industry is likely to be further ahead and more mature in its industrial transformation journey.

The lower the SIRI variance, the more uniform the pace of industrial transformation in the sector.

[5] SIRI, retrieved 2022
[6] Singapore Economic Development Board, 2021
[7] World Economic Forum, 2022

Key jobs and skills trends in I4.0 implementation

Along with I4.0 implementation, sustainable manufacturing and circular economy skills are also prioritised as consumers gravitate towards more sustainable products and manufacturers respond by finding ways to bring resources back into the economy to be used more efficiently and sustainably (see Figure i2). The end-to-end manufacturing process, enabled by I4.0, is increasingly digitalised, connected and sustainable.

Figure i2: Key trends affecting manufacturers implementing I4.0[8]

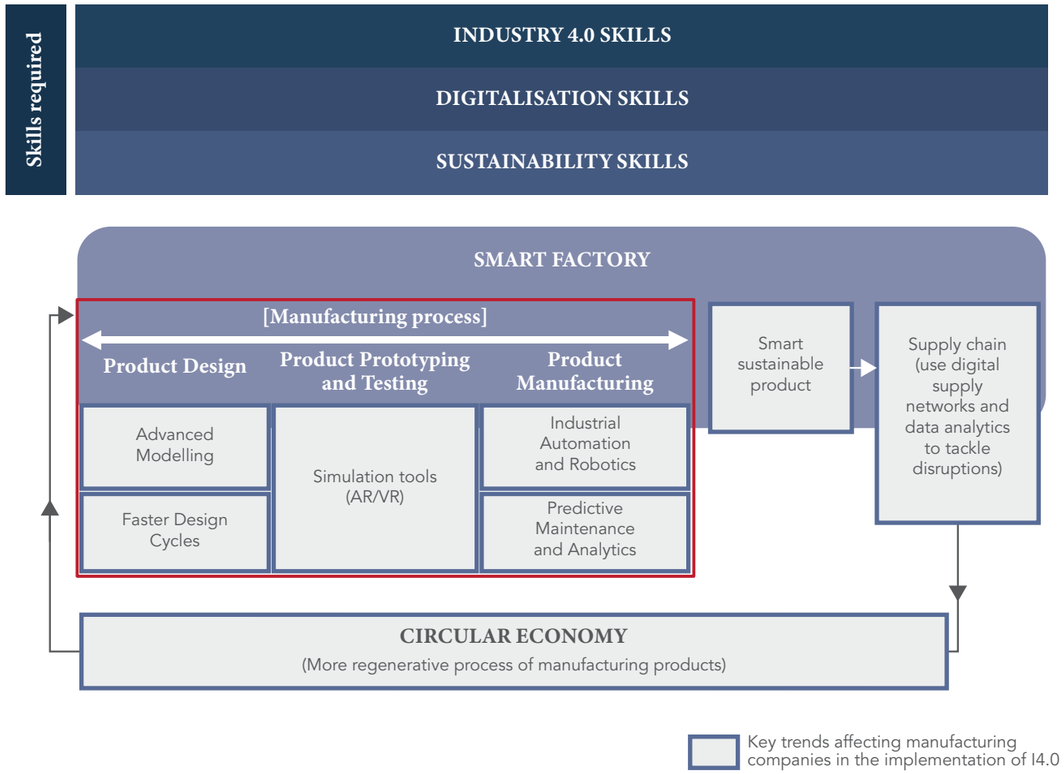


Figure i3 shows a snapshot of the different I4.0, digital and green skills demanded by companies embarking on the industrial transformation journey. The subsequent three key findings are based on the trends and data-driven analysis of some of these skills and jobs in demand that require them.

[8] SkillsFuture Singapore, 2022

INDUSTRY VOICE

The Institution of Engineers, Singapore (IES)

DALSON CHUNG
President, IES

CHANG SAU SHEONG
Chairman, Infocomm Technology Technical Committee, IES

PROFESSOR SEERAM RAMAKRISHNA
Chairman, Climate Change Technical Committee, IES

Singapore is leveraging major global trends to emerge stronger from the COVID-19 pandemic and Ukraine war. Besides notching up our climate ambitions to achieve net-zero emissions by mid-century, a progressive carbon tax is also used to encourage decarbonisation and accelerate our transition to a low-carbon economy. The Resource Sustainability Act, aimed at building a resource-efficient circular economy in Singapore, requires quality and reliable information transfer among diverse stakeholders across value chains.

IES is drawing up an IES Green Plan 2030 to support Singapore's sustainability agenda. IES identifies, develops and conducts skills development courses for practicing engineers.

As I4.0 transforms the way companies manufacture and supply their products and services, it requires the workforce to possess skills in managing technologies such as, *Big Data Analytics, Cloud Computing Application, Machine Learning, Artificial Intelligence Application, Additive Manufacturing, Cyber Security,* and *Robotic and Automation Technology Application*. Related technologies include, Industrial Internet-of-Things (IIoT), smart sensors and embedded software, materials informatics, digital twinning, and modelling and simulation. Such digital technologies and their relevant skills enable preventive maintenance, optimise process improvements, and facilitate tagging and labelling to segregate waste for resource recovery, remanufacturing and upcycling. I4.0 technologies can also enhance green solutions by improving the nutrients and water delivery in urban farming to enhance yield, monitor carbon offsets, and improve efficiency of energy systems. These require digital, green and I4.0-related skills such as *Data Collection and Analysis, Automation Design*, and *Sustainability Reporting.*

There is a wide spectrum of digitalisation opportunities across our industries. For example, in renewables and reducing carbon emissions, or energy efficiency in the energy industry. In other industries, it could be about sustainable use of building materials or reducing food waste or recycling. Just as our engineers and technicians have innovated and facilitated our nation to realise water circularity and water security over the past five decades, Singapore's net zero and circular economy commitments now provide impetus for our engineers and technicians to strive and innovate in the coming years and decades.

> **"As I4.0 transforms the way companies manufacture and supply their products and services, it requires the workforce to possess skills in managing technologies."**

Figure i3: Priority skills required for I4.0 implementation

Priority skills refer to skills that citizens can prioritise to gain access and thrive in Advanced Manufacturing (AM)-related sectors. These skills were derived from SSG's National Jobs-Skills Intelligence engine and validated via expert input from industry, academia, and sector agencies. **Demand growth** (y-axis) refers to the **compound annual growth rate** of job postings (2018 to 2021) that mentioned a given priority skill. **Transferability** (x-axis) refers to the total number of unique job roles from job postings (2018 to 2021) that requires a given priority skill[9]. Refer to the Methodology chapter for further details.

HIGH DEMAND GROWTH
MODERATE TRANSFERABILITY

No. of skills:
55

These skills are critical to support I4.0 implementation and tend to be required in specific roles or relatively new functional areas

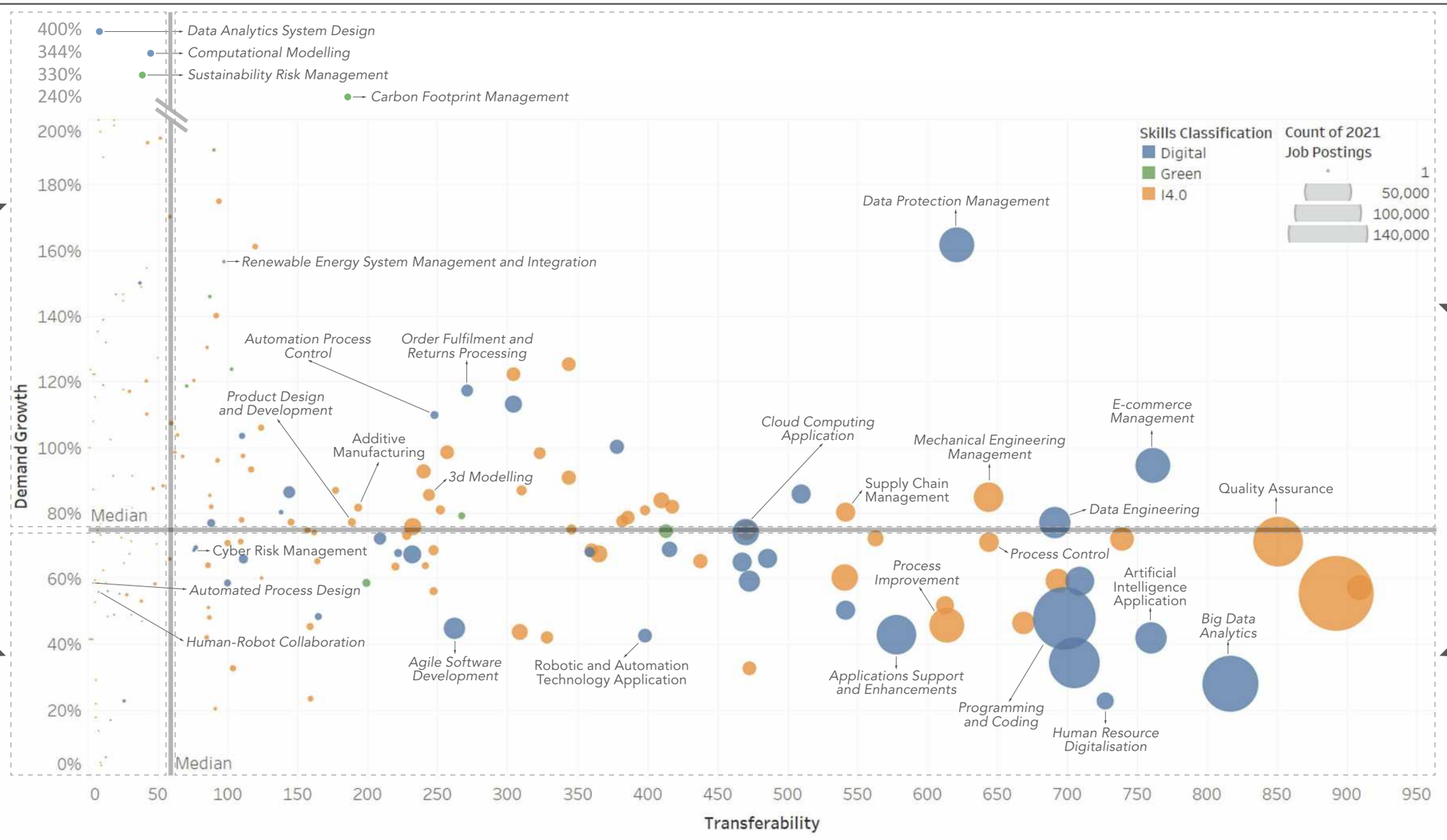
Examples of skills:
Computational Modelling
Data Analytics System Design

MODERATE DEMAND GROWTH
MODERATE TRANSFERABILITY

No. of skills:
36

These skills are still demanded by employers but may have plateaued in demand and consolidated within several job roles

Examples of skills:
Automated Process Design
Human-robot Collaboration



HIGH DEMAND GROWTH
HIGH TRANSFERABILITY

No. of skills:
60

These skills see relatively high demand growth and are required across many job roles

Examples of skills:
Data Protection Management
Carbon Footprint Management

MODERATE DEMAND GROWTH
HIGH TRANSFERABILITY

No. of skills:
63

These skills are still demanded by employers but may have plateaued in demand and are required across many job roles

Examples of skills:
Big Data Analytics
Process Improvement

Skill Title	*Automated Process Design*	*Big Data Analytics*	*Carbon Footprint Management*	*Computational Modelling*	*Data Analytics System Design*	*Data Protection Management*	*Human-Robot Collaboration*	*Process Improvement*
Description	Design processes that utilise automated manufacturing equipment and control systems	Analyse and validate significant volumes of data to discover and quantify patterns and trends to improve business operations	Quantify and reduce the organisational carbon footprint	Develop, select and apply algorithms and advanced computational methods to enable systems or software agents to learn, improve, adapt and produce desired outcomes or tasks	Integrate the use of data analytics in the production environment for the identification of bottlenecks and system improvements	Formulate the organisation's data protection strategy and ensure effectiveness of Data Protection Management Programme (DPMP)	Implement Human-Robot Collaboration (HRC) applications to enhance the efficiency and effectiveness of work processes	Evaluate strategic and longer-term impacts of change and improvement processes, as well as communicate to employees improvement plans, goals and changes to operational procedures

[9] Only data points with positive demand growth are shown. Outlier data points not discussed in this chapter are excluded.

A. To implement I4.0, companies need to invest in a bundle of I4.0, digital and green skills to support in-demand roles across the manufacturing value chain

As the end-to-end manufacturing process becomes more digitalised, connected, efficient, and sustainable, there is a mix of I4.0, digital, and green skills that are fast-growing and highly transferable across job roles. For instance, besides I4.0 skills like *Quality Assurance*, *Mechanical Engineering Management*, and *3D Modelling*, digital skills such as *Big Data Analytics*, *Data Engineering*, and *Data Protection Management* are highly transferable and required by more than 600 job roles. Green skills are amongst the fastest-growing skills, especially skills such as *Sustainability Risk Management*, *Carbon Footprint Management*, and *Renewable Energy System Management and Integration* (see Table i1).

These skills are also increasingly needed to support job roles in demand across the manufacturing value chain. For instance, besides *Big Data Analytics*, a logistics solutions manager also requires green skills such as *Carbon Footprint Management* and I4.0 skills such as *Process Improvement* when performing work tasks to enhance supply chain processes and end-to-end logistics solutions to meet customers' needs, while ensuring cost, efficiency, and carbon footprint reduction priorities are met (see Figure i4).

Similarly, a product designer requires fast-growing digital skills such as *Programming and Coding*, *Big Data Analytics* and *Applications Support and Enhancement*, as well as transferable I4.0 skills such as *Additive Manufacturing* and *3D Modelling* to support the strong growth in electronics, pharmaceuticals and semiconductor sectors.

Figure i4: Examples of skills in demand for a logistics solutions manager

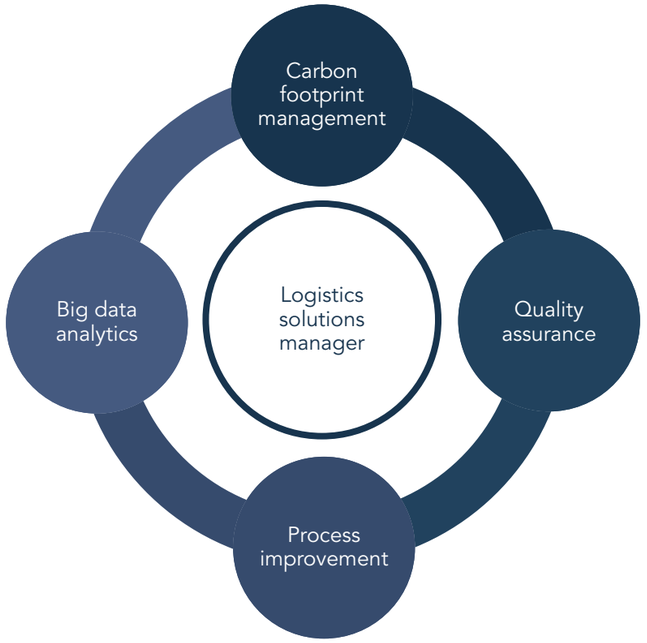


Table i1: List of skills with their associated statistics on demand growth and transferability categorised by the type of skill

TYPE OF SKILL	SKILL	DEMAND GROWTH	TRANSFERABILITY	EXAMPLE OF JOB ROLE
Digital	*Big Data Analytics*	28%	817	• Data engineer • Data scientist • Machine learning engineer
	Data Engineering	77%	691	• Data engineer • Data analyst • QA and QC manager
	Data Protection Management	162%	621	• Data protection executive • Senior technician (manufacturing) • Production engineer
	Programming and Coding	48%	698	• Software engineer • Machine learning engineer • Embedded systems engineer
I4.0	*3D Modelling*	86%	244	• Senior 3D artist • Product engineer • Design engineer
	Additive Manufacturing	82%	193	• Product engineer • Designer (engineering design) • Research technologist
	Mechanical Engineering Management	85%	644	• Senior technician (mechanical) • Senior electrical engineer • Design engineer
	Quality Assurance	71%	851	• Quality control engineer • Quality assurance manager • Quality control assistant
Green	*Carbon Footprint Management*	236%	181	• Logistics solutions manager • Health, safety and environmental officer • Energy trading manager
	Sustainability Risk Management	330%	29	• Health, safety and environmental officer • Health, safety and environmental manager
	Renewable Energy System Management and Integration	157%	97	• Solar photovoltaic project development engineer • Engineer (power) • Health, safety and environmental manager

INDUSTRY VOICE

National Additive Manufacturing Innovation Cluster (NAMIC)

HO CHAW SING

Chief Executive Officer, NAMIC Singapore

Singapore's strong foundation in manufacturing began over 50 years ago. Today, Singapore is one of the largest global exporters of high-tech goods and ranks highly in the Global Talent Competitiveness Index. With manufacturing contributing 21% of Singapore's gross domestic product, it is imperative that Singapore continues to invest and develop our workforce to keep up with our industry needs.

Under Singapore's Manufacturing 2030 plan, Singapore aims to grow the manufacturing sector by 50%, by helping our enterprises transform towards innovation and high value-added manufacturing. NAMIC was founded in late 2015, and is tasked to accelerate the adoption of hybrid and digital additive manufacturing technologies to support the plan, while standardising additive manufacturing training and certification for industry professionals.

As a digital technology, additive manufacturing allows parts to be produced from digital design without going through intermediary steps such as injection moulding and tooling, resulting in faster design iterations and more efficient production workflows. With increased precision and customisation over traditional manufacturing, additive manufacturing can achieve enhanced performance in wide-ranging products, from personalised implants with tissue regenerative properties to more reliable and efficient rocket engines.

Enterprises without the resources to invest in such technologies and human capital can tap on initiatives such as the SkillsFuture Series in Advanced Manufacturing (AM) to equip their workers with the relevant skills, especially in *Additive Manufacturing*, *3D Modelling*, *Robotic and Automation Technology Application*, as well as *Big Data Analytics*. Based on the hundreds of AM projects orchestrated by NAMIC and additive manufacturing job postings, these skills are commonly demanded by roles in design, product development, and R&D.

The diverse verticals that additive manufacturing serves also underscore the need to integrate expertise from other domains such as biomedicine, material science, and even design thinking. With access to the right training and development opportunities, the additive manufacturing sector will benefit from a highly-skilled workforce developing high-value products and intellectual property. Deployed at scale, additive manufacturing can serve as the engine to transform industries to overcome sustainability and supply chain challenges, bolstering our economy while delivering societal impact.

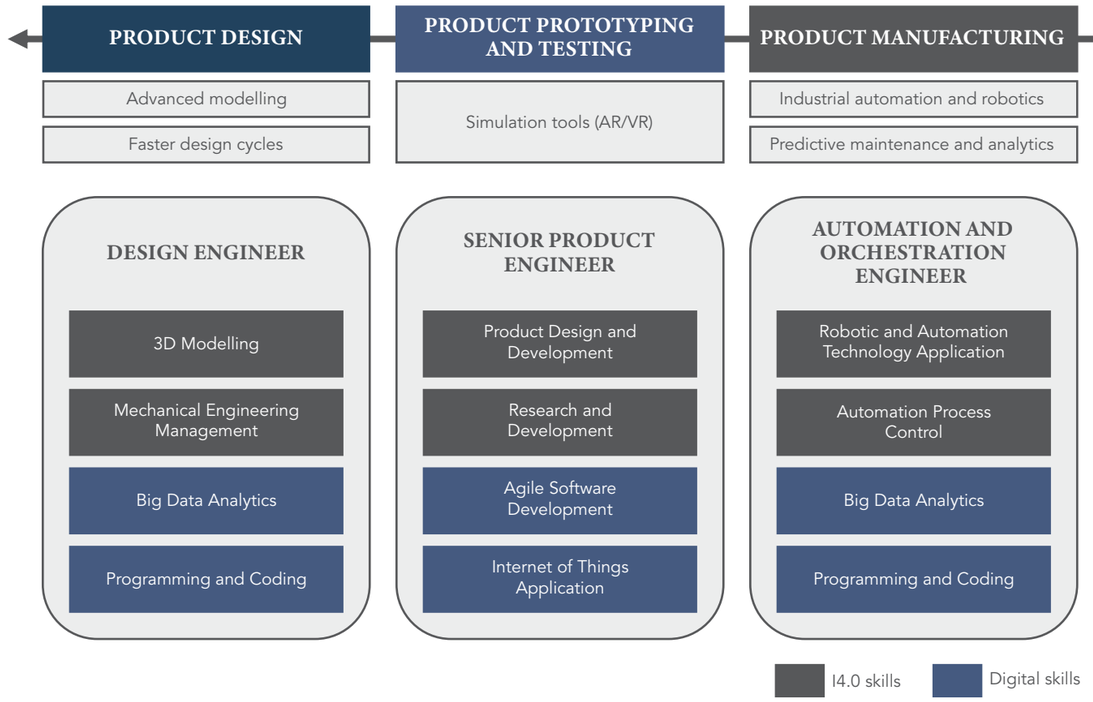
> **"The diverse verticals that additive manufacturing serves also underscore the need to integrate expertise from other domains such as biomedicine, material science, and even design thinking."**

B. As companies transform through I4.0, the work functions and skills demands of engineers are also changing to incorporate fast-growing digital, I4.0 and green skills

Today, some of the common engineer job roles involved in I4.0 implementation are design engineer, product engineer, and automation and orchestration engineer. Based on hiring demand data, the fastest-growing skills in demand are a mix of digital and I4.0 skills. This includes skills such as *3D Modelling*, *Additive Manufacturing*, *Mechanical Engineering Management*, *Big Data Analytics*, *Data Protection Management*, and *Programming and Coding* (see Table i1).

Specifically, these three engineer job roles are also amongst the fastest-growing job roles in the top three manufacturing sectors, including semiconductors, electronics and pharmaceuticals[10], which are the most mature in their I4.0 transformation. Job content of these roles have changed as companies redesign the work processes because of I4.0 implementation, making the end-to-end process from product design to prototyping and manufacturing more connected, automated and accurate. Figure i5 shows the set of fastest-growing skills demanded by these job roles at different stages of the manufacturing process.

Figure i5: Fastest-growing digital and I4.0 skills demanded by engineer job roles[11]



[10] World Economic Forum, 2022

[11] Figure i5 is based on information from CB Insights, retrieved 2022 and SkillsFuture Singapore

FEATURED COMPANY CASE STUDY:

United Test and Assembly Center (UTAC)

UTAC, headquartered in Singapore, is a leading independent provider of assembly, test and bumping services for diverse semiconductor devices. Due to the highly competitive nature of the outsourced assembly and test business, UTAC operates with a highly cost-sensitive business model, especially in Singapore where labour cost is on the rise. Hence, UTAC embarked on an I4.0 transformation to shift from a labour-intensive model to a highly productive and sustainable smart manufacturing plant to maintain its competitiveness.

UTAC focused its I4.0 transformation on process and system automation and has built up world-class overall equipment effectiveness and process control systems to simplify processes, reduce error and mistakes, and improve productivity and product quality. In November 2020, UTAC participated in the Industry 4.0 Human Capital Initiative programme and completed its first SIRI assessment. With the insights gained, UTAC Singapore formulated a new five-year I4.0 Transformation Roadmap focusing on five key pillars – Hands-Free, Remote Control, Data Mining, Artificial Intelligence, and Process/Factory Automation.

UTAC also recognises human capital development as an equally important pillar to I4.0 implementation. With I4.0 transformation, repetitive and manual work will gradually be replaced by automation. Operators and technicians in UTAC will see their job scope redesigned to focus on automation monitoring and maintenance, while engineers and supervisors will take up new functions in robotics programming, data analytics and visualisation, and sustainable operations management.

To enable its employees to take up higher-value tasks, UTAC worked with the Advanced Manufacturing Training Academy to reskill its workforce by performing a skills and training needs analysis, to identify the priority skills required for its workforce and develop holistic training programmes to reskill and upskill them. For example, one of UTAC's project teams is taking up training on autonomous mobile robots to automate manual processes in the cleanroom.

UTAC will also progressively equip its workforce with I4.0 skills in digitisation, data science, artificial intelligence, robotics, and robotic process automation in the near future to operate, maintain, enhance and manage its transformed smart manufacturing plants. Skills such as *Learning Agility* and *Change Management* are also on UTAC's radar to upgrade their workforce to the next level. With I4.0 implementation, UTAC can remain competitive through transforming its manufacturing plant into a smart and sustainable one.

INDUSTRY VOICE

Advanced Manufacturing Training Academy (AMTA)

DR ZENG XIAN TING

Programme Director, AMTA

The manufacturing industry is transforming rapidly with the adoption of I4.0 through convergence of advanced technologies. With an increasingly tightening labour market for the manufacturing industry, the adoption of IoT and industrial automation is no longer an option but a necessity for Singapore's manufacturing companies to survive and progress into the next decade.

Industrial automation technologies will liberate the human from time-consuming, repetitive operations to focus on higher value-added activities, such as product innovation, process improvement and problem solving. Industrial IoT, on the other hand, enables real-time visibility, predictive production planning, and AI-powered resource optimisation for the connected enterprise. The implementation of I4.0 will not only enhance the productivity, capability, and competitiveness of companies, but also transform the image of manufacturing and make it more attractive for young talents to join.

We are delighted to see that many local companies have taken the leap of faith in piloting smart factories with the implementation of IoT and industrial automation technologies. They have robotics lines, Automated Guided Vehicles and Autonomous Mobile Robots implemented to carry out almost all the functions of operators, and an entire shopfloor with equipment of different origins and generations connected into one unified manufacturing execution system. Productivity gains, as much as 80%, have been reported from the pilot smart factories, and the companies are eager to further expand their roll-out of I4.0 technologies.

As a result, we have seen an increasing demand for skills in *Internet of Things Application*, *Robotic and Automation Technology Application*, *Automated Process and System Design*, *Automation System Maintenance*, and *Cyber Risk Management* to facilitate the adoption of I4.0 by companies. With limited supply of such skills and talent in the ecosystem, companies are starting to develop talent in-house and upskill their current workforce with such skills to optimise smart factory operation and reduce reliance on external system integrators.

Looking five years and beyond down the road, the talent in the manufacturing industry will need to be multi-skilled in both AM processes and I4.0 technologies to perform their job functions. We have a narrowing window to close the skills gaps in IoT, robotics and automation for the manufacturing workforce of future.

> **"Looking five years and beyond down the road, the talent in the manufacturing industry will need to be multi-skilled in both AM processes and I4.0 technologies to perform their job functions."**

PROFILE STORY:

SIMON WONG, trainer and welding engineer at a manufacturing company

A former construction project manager, Simon now conducts training for a manufacturing company while pursuing certification as a lead instructor in fields related to manufacturing.

What motivated you to advance your skills?

I have been working in the construction sector for 15 years, specialising in structural steel work. That was also when I first learnt about welding and protective coating. When the COVID-19 pandemic came, I felt the impact on the construction sector. However, that also gave me time to acquire new skills and knowledge to further develop as a trainer, which I have also been doing for over 10 years.

What was your learning journey like?

I enrolled in SIMTech's Graduate Diploma in Precision Engineering Advanced Welding Technologies, where I was exposed to various I4.0 advancements, like using digital tools, robotic welding, additive manufacturing, and other uses of automation. Although many of these technologies are not immediately applicable to the construction sector today, I believe we need to stay updated on the emerging technologies and continuously evaluate how we can improve our productivity. For instance, while *Non-Destructive Testing* skills are already very established in manufacturing, we are also seeing more advanced equipment today that incorporate data collection and analysis to make the testing process more effective. Other skills such as *Equipment and Systems Testing* and *Inspection Engineering Management* are also becoming relevant and applicable across different manufacturing sectors.

Today, I am working towards earning a leading instructor position by pursuing course certifications. I am thankful that my company provides me with the flexibility I need for this.

How important is the ability to learn and adapt?

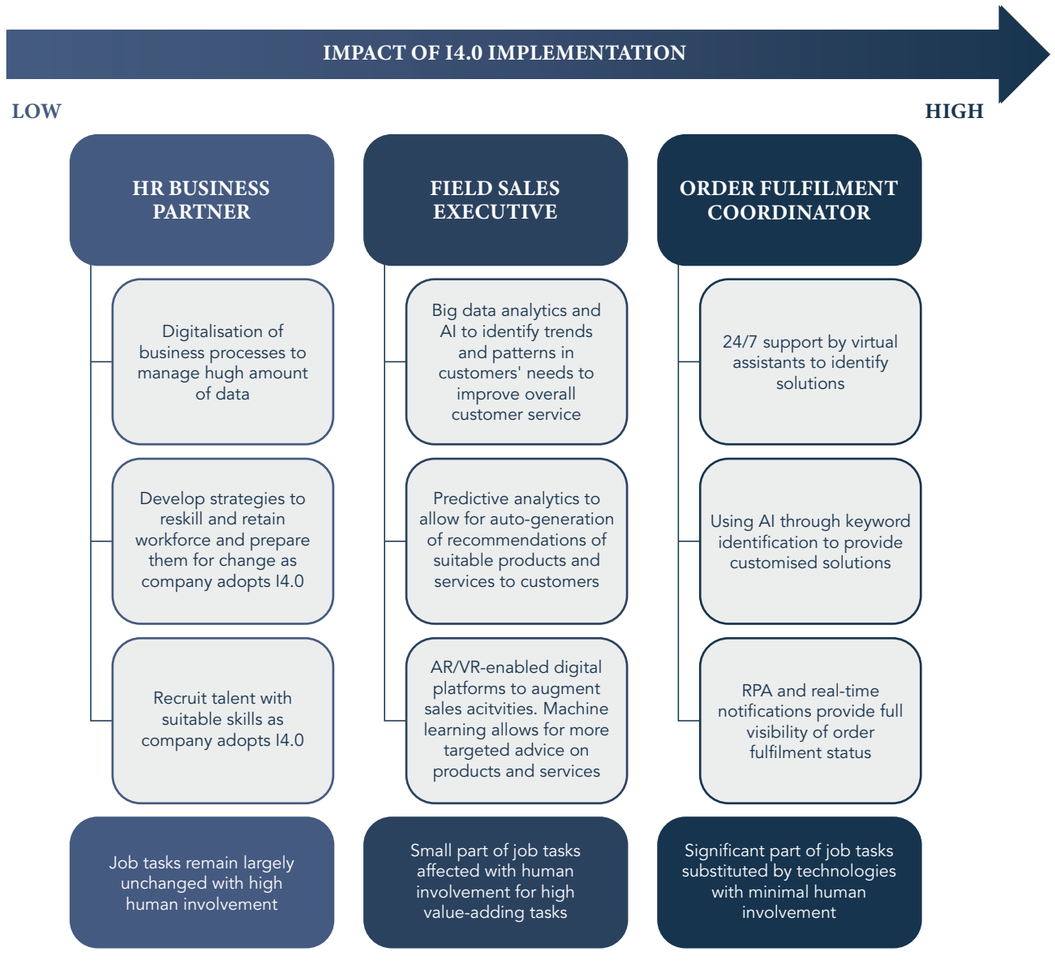
I believe technology can help us do our work more effectively, but it cannot replace humans. For example, as the use of data becomes more prevalent, qualified inspectors need to learn what data is valuable and how to collect it with their equipment. Otherwise, they will just generate 'rubbish' data that is not useful for further analysis.

C. I4.0 implementation has caused non-tech job roles such as those in customer service, sales, and HR to evolve, as processes are affected across the value chain. The degree of change in job scope and skills varies across work functions and job roles

As I4.0 implementation affects business processes across the manufacturing value chain, the work functions and skills required of non-tech roles are also changing, such as those in customer service, sales, and HR. Examples of these roles include field sales executive, order fulfilment coordinator, business development manager, and HR business partner. As more of the manual and repetitive tasks are substituted by I4.0 technologies, such as Robotic Process Automation (RPA), to provide full visibility and real-time notifications of order fulfilment status, I4.0 implementation has enabled workforce in these job roles to focus on more high value-added areas. For instance, they can use behavioural and data analytics to categorise customers, develop data-driven leads generation and customer retention strategies, and use AI and simulation modelling to identify and test different prototypes to customise solutions for customers' needs.

To meet these changes in work functions, new I4.0 and digital skills are required. Figure i6 shows the varying impact of I4.0 implementation across these non-tech roles.

Figure i6: Degree of I4.0 implementation and impact across non-tech job roles[12]



[12] Figure draws I4.0 implementation information from Workforce Singapore, 2020, and job role information from SHS Web of Conferences, 2020

Figure i7 summarises some of the priority I4.0 and digital skills that non-tech job roles will require as part of I4.0 implementation, while Table i2 provides more detail on the growth and the transferability of these skills.

Figure i7: Important skills that non-tech job roles will require with I4.0 implementation

HR BUSINESS PARTNER	FIELD SALES EXECUTIVE	ORDER FULFILMENT COORDINATOR
• *Human Resource Digitalisation* • *Big Data Analytics* • *Process Control* • *Data Protection Management*	• *E-commerce Management* • *Artificial Intelligence Application* • *Cloud Computing Application* • *Supply Chain Management*	• *Order Fulfilment and Returns Processing* • *E-commerce Management* • *Applications Support and Enhancement* • *Mechanical Engineering Management*

Table i2: List of skills with their associated statistics on demand growth and transferability categorised by job role

NON-TECH JOB ROLE	SKILL	TYPE OF SKILL	DEMAND GROWTH	TRANSFERABILITY	EXAMPLE OF JOB ROLE THAT ALSO REQUIRES THIS SKILL
HR business partner	***Big Data Analytics***	Digital	28%	817	• Manager - analytics and customer insights • Internal auditor • Business analyst
	Data Protection Management	Digital	162%	621	• Business-to-customer sales manager • Head of compliance • Manager, talent management
	Human Resource Digitalisation	Digital	23%	727	• Manager, talent management • Business-to-customer sales manager • Manager, employee experience and relations
	Process Control	I4.0	71%	644	• Quality assurance senior specialist • Business process improvement executive • HR manager
Field sales executive	***Artificial Intelligence Application***	Digital	42%	760	• Head of quality • Customer success manager • Analyst - analytics and customer insights
	Cloud Computing Application	Digital	74%	470	• Customer success manager • Sales account manager • Business development manager
	E-commerce Management	Digital	95%	761	• E-commerce manager • Marketing assistant • Customer experience manager
	Supply Chain Management	I4.0	80%	542	• Logistics contracts manager • Procurement manager • Logistics solutions manager
Order fulfilment coordinator	***Applications Support and Enhancement***	Digital	43%	578	• Client support service manager • Customer success manager • Assistant customer support executive
	E-commerce Management	Digital	95%	761	• E-commerce manager • Marketing assistant • Customer experience manager
	Mechanical Engineering Management	I4.0	85%	644	• Senior procurement executive • Claims manager • Quality manager (manufacturing)
	Order Fulfilment and Returns Processing	Digital	117%	271	• Order management executive • E-commerce manager • Supply chain manager

FEATURED COMPANY CASE STUDY:

Universal Aquaculture

A Singapore start-up founded in 2020 by a team of aquaculture enthusiasts whose aim is to produce seafood using sustainable methods, coupled with cutting-edge technology. The company wanted to develop high-tech zero-disruption seafood farming systems that are highly exportable and places Singapore on the map of sustainable seafood production.

To achieve its aim, it implemented I4.0 in its production end-to-end. Together with R&D and collaboration with partners, Universal Aquaculture developed a multi-phased automation roadmap comprising a few phases – (i) installation of sensors and data acquisition equipment to monitor vital water parameters 24/7 and collect real-time data on key behaviour such as feeding habits, growth and mortality; (ii) implementation of AI-assisted auto feeder to enable auto dosing of minerals and supplements based on real-time water conditions monitoring, which in turn minimises feed wastages and improves water quality; and (iii) incorporation of automated harvesting and shrimp transfer technologies such as computer vision AI for auto sorting of shrimp sizes to reduce stress on shrimps during the transfer, and cut harvesting manpower and time by 30%.

Its team of aquaculture specialists and engineers also designed and built their proprietary hybrid biological recirculation system, which is a next-generation water treatment system that saves up to 80%-90% of water and energy, and sustains pH and bacteria levels to ensure optimal water quality.

To manage these technologies, its team must be equipped with skills in digital, I4.0 and sustainability. To build some of this critical expertise, especially in domain aquaculture management skills, it recruited and trained mid-career workers from Workforce Singapore's Career Conversion Programme for Professional Executives.

It also had to collaborate with other partners for complementary skills and capabilities to achieve automated and sustainable food production. These partners complemented its team with skills such as *Sustainable Food Production Design*, especially in the area of feed production (joint research with Grobest), *R&D* skills which is integral to the innovation-led start-up, digital skills such as *Artificial Intelligence Application*, and *Data Collection and Analysis*, and I4.0 skills such as *Robotic and Automation Technology Application* (with partners like SESTO). As a result, the company can produce quality seafood that are healthy and free of chemicals and pesticides, at competitive prices.

PROFILE STORY:

CHRISTIAN NUGRAHA, senior full-stack developer in I4.0 technology

Having started his career as a manufacturing test engineer, Christian transited into a new role as a full-stack developer for his company.

What motivated you to make this career transition?

Back in 2017, I was fortunate to be able to participate in a company-sponsored 'Career Conversion Programme (CCP) for Tech Professionals - Full Stack Web Developer', offered by National University of Singapore's Institute of Systems Science. This course focused mainly on software development, which was something I found missing in my role before.

At that time, we saw our industry shifting towards AI and IoT, and the company that I was placed with saw the need to have these skills.

What was your learning journey like?

The programme comprised full-time training that lasts two months. After that, I had four months of project work, which I did as part of on-the-job training. Beyond basic programming, I learnt how the whole software development process works, and how to use codes to interact with hardware. This is a concept that I find very helpful to understanding the communication between software and hardware.

After completing the course, I continued to learn a lot of new technologies along the way. Most of this came from client engagement, through their use cases and pain points. I applied many skills in serving both internal and external clients. For instance, *Data Engineering* skills helped me better capture and analyse user behaviour information, while *Supply Chain Solutioning* skills enabled me to develop models to optimise supply chain operating models based on data, leading to improved inventory levels, delivery times, and cost savings.

With external clients, I also had to help them integrate the hardware with software. Skills such as *Internet of Things Application*, *Robotic and Automation Technology Application*, and *Automated System Design* helped me understand and work with different hardware, such as robots, Automated Guided Vehicles and IoT sensors.

How important is the ability to learn and adapt?

I think it is very important to have an open mind and understand that our jobs are never static. Technology is changing and so is our society at large. At some point, the skills that we have might become obsolete. Hence, it is important to look at the industries and see what skills are in demand and be open to pick up these skills. In addition, the past learning that we gained from previous jobs are often not wasted and can be applied in new settings.

Skills featured in this chapter

SKILL TITLE	SKILL DESCRIPTION
3D Modelling	Generate 3D models using a variety of modelling software to represent characteristics of a real-world system
Additive Manufacturing	Design and apply additive manufacturing workflows to create three-dimensional objects
Agile Software Development	Plan and implement Agile methodology and the use of adaptive and iterative methods and techniques in the software development lifecycle
Applications Support and Enhancement	Provide ongoing technical support and improvements to users of applications
Artificial Intelligence Application	Apply algorithmic, statistical and engineering knowledge to integrate artificial intelligence into engineering processes
Automated Process Design	Design processes that utilise automated manufacturing equipment and control systems
Automated System Design	Design and commission automated systems as well as evaluate the system design specification against functional requirements
Automation Process Control	Apply automation process control to monitor performance metrics and quality of manufacturing outputs to determine the optimal settings as well as productivity improvement strategies
Automation Design	Manage control systems and information technology to reduce the need for human work in the production of goods and services in order to streamline operations
Automation System Maintenance	Maintain automation systems to meet operation requirements as well as propose strategies for improvement of automation systems' performance
Big Data Analytics	Analyse and validate significant volumes of data to discover and quantify patterns and trends to improve business operations
Carbon Footprint Management	Quantify and reduce the organisational carbon footprint
Change Management	Manage organisational change management systems to drive organisational success and outcomes by preparing, equipping and supporting adoption of change
Cloud Computing Application	Manage cloud computing technologies in order to offer a collaborative framework with centralised storage and contact points, fewer visibility barriers, and opportunities to enact simplified, standardised processes
Computational Modelling	Develop, select and apply algorithms and advanced computational methods to enable systems or software agents to learn, improve, adapt and produce desired outcomes or tasks
Cyber Risk Management	Develop cyber risk assessment and treatment techniques that can effectively pre-empt and identify significant security loopholes and weaknesses and provide risk treatment and prioritisation strategies
Cyber Security	Develop awareness of cyber security threats
Data Analytics System Design	Integrate the use of data analytics in the production environment for the identification of bottlenecks and system improvements
Data Collection and Analysis	Collect, extract and interpret data according to defined requirements to obtain project insights
Data Engineering	Develop and implement efficient and stable processes to collect, store, extract, transform, load and integrate data at various stages in the data pipeline.
Data Protection Management	Formulate the organisation's data protection strategy and ensure effectiveness of Data Protection Management Programme (DPMP)
E-commerce Management	Develop, manage and execute e-commerce strategies and activities according to organisational objectives
Equipment and Systems Testing	Execute equipment and systems testing procedures to ensure continuity of operations and meet standards of performance
Human Resource Digitalisation	Innovate human resource (HR) processes and practices through digitalisation
Human-Robot Collaboration	Implement Human-Robot Collaboration (HRC) applications to enhance the efficiency and effectiveness of work processes
Inspection Engineering Management	Manage fixed equipment and piping inspection schemes, materials selection, construction, corrosion control, condition and fitness-for-service through on-stream, risk-based monitoring programmes and downtime inspections
Internet of Things Application	Implement Internet of Things (IoT) technologies to drive efficiency and effectiveness of operations
Machine Learning	Apply machine learning knowledge and algorithms, optimise the models learnt into project execution and maintenance processes
Mechanical Engineering Management	Manage the design, technical specification, selection, modification and troubleshooting of mechanical equipment, structures and systems
Non-Destructive Testing	Execute non-destructive tests to ensure structural integrity, insulation resistance, continuity and satisfactory performance of electrical equipment and installations
Order Fulfilment and Returns Processing	Develop order fulfilment guidelines and execute order fulfilment activities
Process Control	Apply process control to monitor and optimise process plant performance and quality of production output
Process Improvement	Evaluate strategic and longer-term impacts of change and improvement processes, as well as communicate to employees improvement plans, goals and changes to operational procedures

Product Design and Development	Manage new product design and development from Research and Development (R&D), including initial product design concepts, small batch piloting, market testing and evaluation
Programming and Coding	Develop technical capabilities to understand, design and write instructions to be processed by computers as software programmes to achieve desired outcomes
Quality Assurance	Develop, implement and monitor practice of clear quality expectations and standards aligned to the organisation's values and business objectives
Research and Development	Optimising manufacturing processes, material developments and development of new product lines
Renewable Energy System Management and Integration	Analyse impact of renewable energy system integration on energy grid in steady state and during dynamic operation.
Robotic and Automation Technology Application	Integrate robotic and automation technologies in manufacturing workflows, to enhance productivity, precision and reduce reliance on manual tasks
Supply Chain Management	Develop and maintain supply chain processes, comprising feedstock, production, storage, and export, to ensure supply and demand are managed in an integrated manner
Supply Chain Solutioning	Develop new operating models and solutions for customers to manage their supply chain needs as well as improve inventory levels, delivery time and cost saving
Sustainable Food Production Design	Design and implement sustainable food production policies, processes and initiatives within the organisation
Sustainability Reporting	Lead development of organisation's sustainability reporting and accounting policies and processes in line with regulatory requirements and international best practices
Sustainability Risk Management	Develop frameworks, strategies and policies for managing sustainability risks for the organisation to minimise and mitigate risks and impact to the organisation

The skills featured in this chapter are non-exhaustive.
To see the full list of priority skills, please visit this link:

https://go.gov.sg/2022skills-i40

Please visit this link for information on suggested courses for I4.0:

https://go.gov.sg/i40-econ-courses