

**MANNING THE MISSION FOR  
ADVANCED  
MANUFACTURING**

**NEW DEMANDS ON TALENT IN  
SINGAPORE'S ENERGY, CHEMICALS  
AND UTILITIES INDUSTRIES**



# FOREWORD

## Dear Readers,

People are the true authors of the digital story; it is the workforce that lies at the heart of digitalising Singapore's manufacturing sector. With over four decades of collaboration with the local manufacturing sector, Accenture remains committed to working with the sector to realise its digital ambitions. We are privileged to have the support of the Singapore Economic Development Board (EDB) and leading industry stakeholders to explore a subject that is not only timely but pressing, and we thank all participating organisations for their time and valuable input.

Talent and skills are critical to successful digitalisation. The workforce's skills, capabilities and readiness to change underscore its ability to evolve and be digitally ready. Findings from this study prompt an urgent call to action as well as the need for strong and immediate intervention.

The proposed recommendations seek to facilitate interventions across the talent life cycle. Recommendations address the sources of talent, as well as strategies to attract talent to the industry, to build digital capabilities and finally, to retain this talent within the industry. Collectively, the recommended actions aim to ensure the workforce thrives in a digitalised environment and to enhance Singapore's position as a leader in the global manufacturing sector.



**Teo Lay Lim**

Country Managing Director  
Accenture Singapore

### Opening Note

Manufacturing is on the brink of a new age as we enter the Fourth Industrial Revolution. Here, Singapore has already taken early steps to carve out its role as the global beacon for Advanced Manufacturing. Our ambition is to be a top-of-mind location where not only the latest robotics and Internet-of-Things solutions are developed, but also home to a critical mass of highly automated and digitalised manufacturing facilities.

Talent plays a critical role in enabling this vision, as technology can only come to life through a good workforce. As we transform our manufacturing

sector, we need to equip our workforce with the necessary skills for them to take on new or adjacent jobs that Advanced Manufacturing will create.

This paper by Accenture provides insights that Singapore could build upon to prepare our workforce for future growth, as we write the next chapter of our manufacturing story.



**Lim Kok Kiang**

Assistant Managing Director  
Singapore Economic Development Board

This white paper has been written by leading global professional services company, Accenture, and supported by the Singapore Economic Development Board (EDB), Singapore's lead government agency for planning and executing strategies to enhance the nation's position as a global business centre.

# EXECUTIVE SUMMARY

**By 2025, digital transformation could add between US\$310 billion and US\$550 billion of economic value to the global chemicals and advanced materials industry, according to an analysis by the World Economic Forum (WEF) and Accenture.<sup>1</sup>**

Industry 4.0 has arrived, blurring the lines between the digital and physical worlds. As intelligent, interconnected systems seamlessly support activities along the entire value chain, Industry 4.0 is transforming manufacturing industries across the globe. The opportunities for digital transformation today are undeniable, and the time to act upon them is now.

Representing close to 20 percent of Singapore's 2016 GDP,<sup>2</sup> manufacturing is a key pillar of the nation's economy. Today, the city-state is committed to leveraging Industry 4.0 as part of a national push into advanced manufacturing. More critically, Singapore recognises that successful Industry 4.0 adoption is not dependent on technology, but rather on the people who use it. As new technologies transform the workplace, there is an urgent need to take a closer look at the talent agenda. This is especially critical given that 89 percent of C-suite decision makers globally do not believe they have all the skills necessary for digital transformation.<sup>3</sup> With this in mind, this white paper examines how Singapore's manufacturing workforce must evolve to unleash its true potential, enrich its experience and pave the way for a sustainable digital transformation. This paper presents key emerging technical and soft skills and competencies, as well as the underlying changes to organisational culture needed to support their acquisition.

For the purpose of this white paper, key terms are defined as follows:

- 1 Digitalisation** enables organisations to execute business strategy through the implementation of digital technologies. It creates new opportunities and revenue streams.
- 2 Industry 4.0** refers to the digitalisation of manufacturing. It implies heightened connectivity and intelligence in industry operations via the Industrial Internet of Things (IIoT) and cyber-physical systems.
- 3 Advanced Manufacturing** refers to Singapore's ambition to anchor high-value manufacturing in the local industry, and to transform the country's existing base of manufacturers through the use of smart technologies.

**“Digitalisation is not revolutionary, it is evolutionary.”**

**Lim Kok Kiang, Assistant Managing Director, EDB**

This white paper focuses on new demands on talent within Singapore's process and hybrid manufacturing industries, specifically energy, chemicals and utilities. Combined, these industries account for approximately 30 percent of the country's manufacturing output, and tap into the same pool of labour. Our research enabled us to identify and validate future talent needs, and has given rise to an emerging skills map. The map, along with the three key findings highlighted below, inform the recommendations of this paper, and call for concrete actions by stakeholders.

### **Industry 4.0 is expected to be pervasive by 2020.**

Global Industry 4.0 developments have rallied companies to a tipping point in the transition from automated to intelligent plants. The next three years will see an increase in the adoption of solutions that include: robotics, big data analytics, artificial intelligence (AI), information and operational technology (IT/OT) convergence, and cyber and operational security.

### **Workforce and organisational requirements are changing to support this transition.**

To keep pace with technological change, organisations are demanding increased digital literacy and a culture of change-readiness across all levels. They highlight an increasing need for a workforce skilled in both core engineering and the application of digital technologies, as well as soft skills to deploy them effectively.

### **The demand for IIoT-ready talent will grow.**

Organisations will initiate digital transformation by injecting talent and capabilities from solution providers in the short term, while building those capabilities internally over the longer term.

In view of the above findings, this paper provides key stakeholder groups with the following recommendations and actionable agenda:

## **1 A joint industry-government deep dive into identifying the emerging digital skills required.**

The industry should collaborate closely with government agencies to comprehensively map out the technical skills and corresponding knowledge required across job roles to facilitate Industry 4.0 adoption.

## **2 Educational institutions and training providers to develop additional programmes and initiatives to nurture cross-trained industrial engineers and technicians with digital skills.**

As the need for cross-trained engineers with digital skills grows, government agencies, Institutes of Higher Learning (IHLs), Research Institutions (RIs), and solution providers must collaborate and find new ways to deliver cross-functional learning. Examples include assigning research projects with cross-disciplinary requirements, and setting up learning factories outfitted with fully-integrated Industry 4.0-enabled systems.

## **3 Inclusive planning and clear communication by unions, as well as trade associations and chambers (TACs) to prepare the workforce for digital transition.**

Unions and TACs must leverage common platforms for collaboration to understand digital developments and support the continued employability of the workforce.

## **4 Organisations to implement programmatic interventions from shop floor to top floor.**

At the organisational level, the development of a 'digital DNA' conducive to Industry 4.0 adoption depends on initiatives at the leadership, ecosystem, and individual levels. A digital capability development programme by Accenture – 4.0 Applied Now – addresses these perspectives holistically in an applied learning environment.

The following analysis distils learnings that are neither limited to the sector, nor to Singapore alone. These findings may be applied beyond process and hybrid manufacturing and the city-state to inform a global workforce seeking to capitalise on the growing opportunities Industry 4.0 presents.

## METHODOLOGY



A total of 29 key industry stakeholders were interviewed during the research process. On the demand side, C-suite leadership, plant and human resources managers from 20 manufacturing companies were interviewed. These companies represent 64 percent of Singapore’s manufacturing output in the energy, chemicals and utilities industries.<sup>4</sup> On the supply side, interviews were conducted with five major solution providers in Singapore. Institutes of

Higher Learning (IHLs) and government agencies that provide and train talent for the three industries were also consulted. Research by the Committee on the Future Economy (CFE), SkillsFuture Singapore (SSG), and the World Economic Forum (WEF), was leveraged. Finally, a Design Thinking workshop was conducted for the technicians and engineers from the participating organisations to gain an empathetic understanding of motivations, experiences, and needs on the ground.

# INDUSTRY 4.0 IN PERSPECTIVE

**Globally, successful implementations of Industry 4.0 solutions have demonstrated returns on investment and tangible business value. Adoption of these solutions could increase asset utilisation and maintenance productivity by up to 5 percent and 15 percent, respectively, and reduce asset downtime and total maintenance costs by up to 5 percent and 30 percent, respectively.<sup>5</sup>**

For example, Woodside, an Australian oil and gas company with a global presence, is implementing predictive analytics for maintenance and process-control in production operations across its liquefied natural gas (LNG) assets. Digital technologies are helping Woodside create an intelligent, agile and competitive organisation.

The prospect of tangible business benefits has sparked intensified interest in Industry 4.0 solutions in recent years. In a 2016 study on the energy, chemicals, and utilities industries in 19 countries, 82 percent of the senior technology executives interviewed reported increased investment in digital

technologies over the previous two years.<sup>6</sup> As the industry converges on Industry 4.0 solutions, our assessment is that a global tipping point has been reached. While earlier technologies — such as distributed control systems — facilitated the industry's gradual transition to automated and connected plants, they stopped short of intelligent and predictive capabilities. Today, Industry 4.0 solutions are propelling organisations towards intelligence, and compelling them to take bold steps in the direction of a dynamic and ecosystem-driven industrial space.

# SINGAPORE'S GREATER DIGITALISATION JOURNEY

**As an island city-state with limited land and human capital, Singapore's digital journey is borne out of necessity. By improving efficiency and productivity, and promoting new opportunities for value creation, technology offers the city-state the opportunity to expand beyond what its limited natural resources would otherwise afford.**

The Smart Nation vision launched in 2014 crystallised a cohesive national strategy to harness technology across industries and government. To galvanise action, in March this year, the Smart Nation Programme Office (SNPO) was subsumed under the new Smart Nation and Digital Government Office (SNDGO) in the Prime Minister's Office, highlighting the state's commitment to its digital vision. Just prior to that, in February this year, the Committee on the Future Economy (CFE), tasked with developing economic strategies to position Singapore for the future, emphasised building strong digital capabilities as a key strategic thrust.<sup>7</sup>

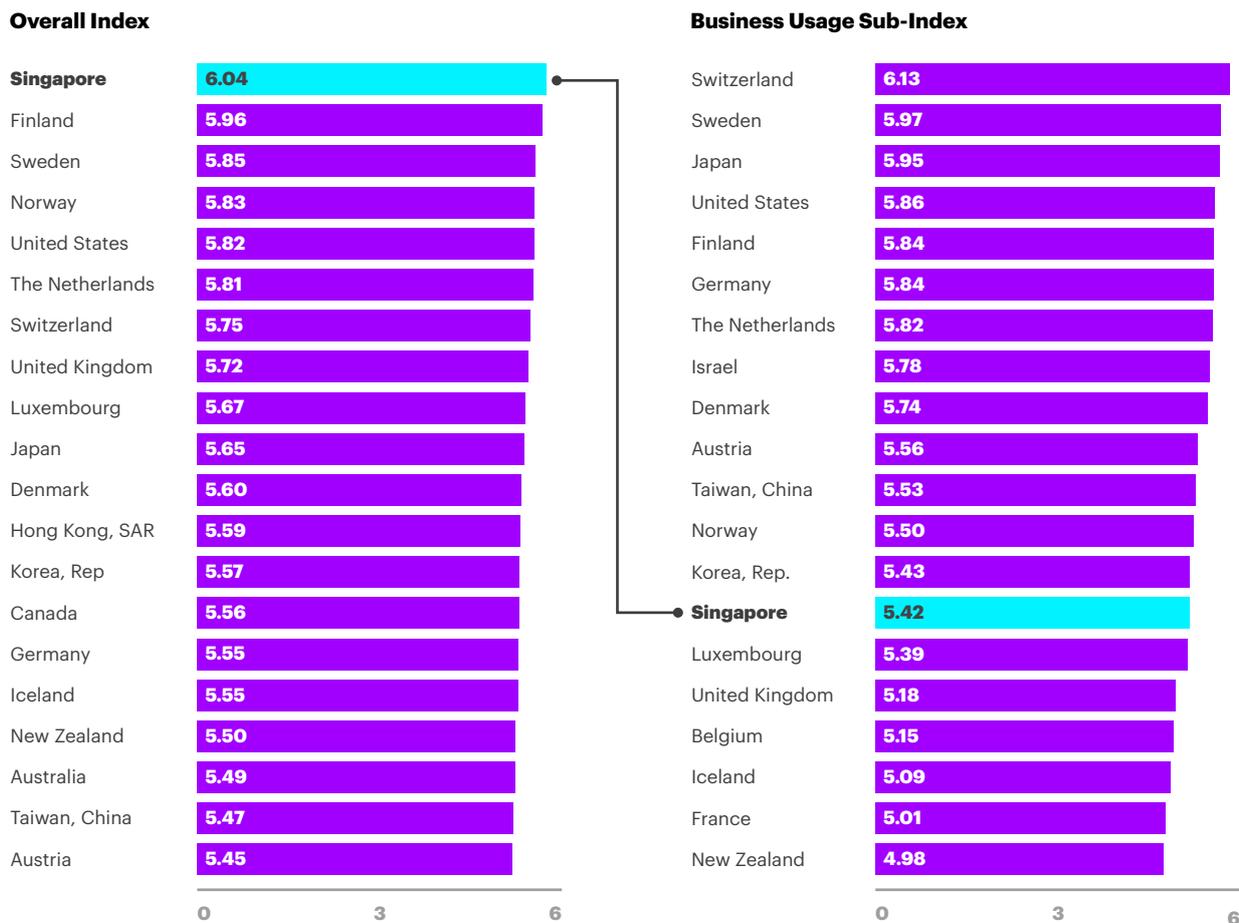
As a driver of Singapore's economy, manufacturing is not exempt from pressures to digitalise. The industry accounted for close to 20 percent of the country's GDP in 2016, and 11 percent of total employment.<sup>8</sup> The Singapore Government remains committed to maintaining a globally competitive manufacturing sector and tapping on growth opportunities arising from advanced manufacturing.

Nevertheless, manufacturing remains a highly competitive and increasingly complex sector. This complexity is expected to increase with new technologies transforming the way products are created, supply chains are managed and operations are optimised. Singapore must adapt to the technology trends of this new age of manufacturing. In 2016, Singapore topped the rankings of the World Economic Forum's (WEF) Networked Readiness Index (NRI), which indicates countries' readiness to boost competitiveness and well-being through digitalisation. The ranking was largely due to the government's strong commitment to a coherent digital strategy. This contrasted with the capacity of its businesses to absorb technology and innovate, where Singapore ranked 14th, indicating a significant opportunity for increased adoption.<sup>9</sup>

**“Digitalisation is not something we can achieve in a day or a week, but rather, it is a journey that we must take with our manufacturing sector in a phased and incremental fashion.”**

**Fong Pin Fen, Director, Cities, Infrastructure & Industrial Solutions, EDB**

**FIGURE 1: SINGAPORE'S NETWORKED READINESS INDEX (NRI) RANKINGS IN 2016**



\*The business usage sub-index measures the private sector's ability to absorb and capitalise on technology, as well as its overall capacity to innovate, in order to generate productivity gains.

Source: World Economic Forum, "Global Information Technology Report", 2016

Industry 4.0 opens up opportunities to Singapore's manufacturing industry, including for the creation of new products, services and business models. At a time when traditional productivity levers such as lean adoption have largely been exhausted, Industry 4.0 offers the means for the next leap forward. It is estimated that the automation of knowledge work, for instance, could increase productivity in technical professions by 45 percent to 55 percent.<sup>10</sup> Industry 4.0 adoption would thus be key to achieving the CFE-recommended productivity-led growth of 2 to 3 percent a year.

However, across nationwide initiatives such as the CFE and Industry Transformation Maps (ITMs), and in Singapore's 2017 Budget, there is clear consensus that successful digital transformation is contingent upon deepening skillsets and digital capabilities within the workforce. Singapore's ability to reap the benefits of Industry 4.0 fundamentally depends on its workforce, but the gap in the understanding of emerging skills to support this transition must be bridged. To that end, SkillsFuture Singapore (SSG) was developed in 2016 to encourage lifelong learning, as well as the reskilling and upskilling of employees.

# KEY FINDINGS

## Industry 4.0 is expected to be pervasive by 2020.

Industry 4.0 adoption is gathering momentum in Singapore's process and hybrid manufacturing industries, and is expected to be pervasive over the next three years. Some 70 percent of local manufacturers interviewed regard Industry 4.0 as a lever to drive competitive advantage and enhance both organisational efficiency and business productivity.

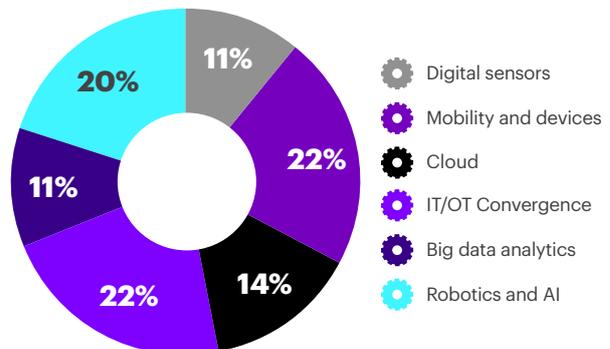
All manufacturers surveyed have already begun adopting Industry 4.0 solutions and show no sign of slowing down. Examples of digitalised practices that local manufacturers have implemented in their day-to-day operations include automating welding for tanks in chemical plants for higher quality outcomes, conducting evacuation drills to test tracking via digital sensors, and implementing real-time 'live' capture of feedback. Seven in 10 manufacturers surveyed intend to increase the deployment of Industry 4.0 solutions by 2020, with mobility and devices, robotics and artificial intelligence (AI), and information and operational technology (IT/OT) convergence reflecting the most significant growth opportunity.

Both manufacturers and solution providers repeatedly emphasised the need for the seamless integration of a digital value chain. Given the asset-intensive nature of process and hybrid manufacturing, digital value chain

integration requires large-scale transformation implemented over multiple phases. One example is Chevron Oronite's Smart Plant initiative, a multi-year effort launched in 2016 with the support of the EDB. The initiative focuses on upgrading field equipment and leveraging data analytics to drive energy efficiency and labour productivity, and to enhance overall site safety. Successful integration required the installation of Pervasive Sensing Infrastructure, which acts as a wireless smart platform on which applications that improve plant operations and maintenance are developed.

**FIGURE 2: INDUSTRY 4.0 SOLUTIONS THAT MANUFACTURERS PLAN TO IMPLEMENT BY 2020**

**Share of Industry 4.0 Growth by Solution**



**70 percent of local manufacturers interviewed regard Industry 4.0 as a lever to drive competitive advantage and enhance both organisational efficiency and business productivity.**

# As Industry 4.0 becomes pervasive, workforce and organisational requirements are changing to support this transition.

People are at the centre of technological change, and their willingness and readiness to support digital transformation is key to success. Emerging technical and soft skills, as well as organisational change will become increasingly important for companies to catalyse Industry 4.0 adoption.

## Technical Skills

Industry 4.0 will alter the way facilities are run, managed and maintained. Industry participants foresee an evolution of existing job roles as well as a need for the workforce to acquire new technical skills. Technicians and engineers will be required to have both an understanding of core engineering-based skills and know-how, as well as some degree of exposure to digital skills. More than three quarters of the companies surveyed said their operators and technicians should be able to read and interpret data that is collected and displayed on performance metric dashboards. Engineers increasingly need to exhibit some degree of familiarity with the management of IoT infrastructure, big data and cybersecurity, in addition to core engineering knowledge. At the managerial level, most executives surveyed cited a need for an appreciation of a wide range of IoT capabilities.

Acquiring emerging digital skills will breed more multi-domain specialists or hybrid talent — people who are not only proficient in their core domain areas, but also equipped with digital skills. Multi-domain specialists who understand Industry 4.0 solutions such as big data, can envision how these solutions can be applied and create value in plant operations.

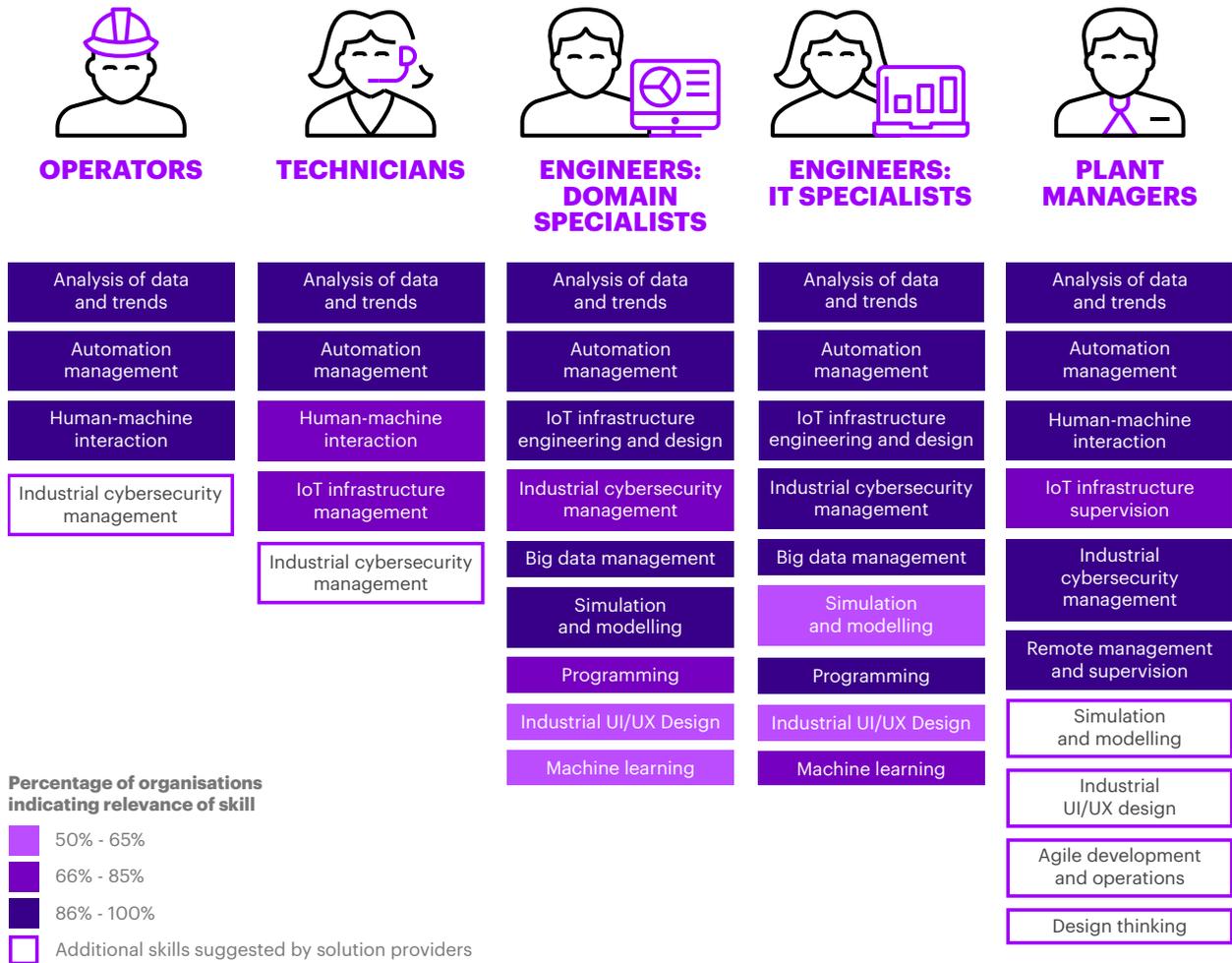
According to **General Manager of Shell Jurong Island, Stephen Fowler**, **“People who can understand the industry and also manipulate data will be a lot more valuable than vanilla-flavoured data analysts who just put data through a machine. They know what the data represents and where the potential value in the data exists.”** At the same time, core engineering expertise is necessary to identify and implement solutions safely and feasibly within the realistic constraints of a plant. Hybrid talent is thus better positioned to implement successful digitalisation initiatives and operate IoT-enabled facilities.

**“As companies on Jurong Island embark on advanced manufacturing initiatives, engineers will need to build up an appreciation of ICT-skillsets such as data analytics, network engineering and cybersecurity. This demand for hybrid talent is expected to increase as digitalisation becomes pervasive across industries.”**

**Damian Chan, Executive Director of Energy and Chemicals, EDB**

This paper identifies five key job role personae and their respective emerging digital skills. The preliminary skills map in Figure 3 is a non-exhaustive selection of digital skills that manufacturers and solution providers believe to be most pertinent to Industry 4.0 adoption. Annex A elaborates on the knowledge that the workforce requires to perform each skill. This industry-validated perspective serves as a first step towards a comprehensive understanding of emerging digital skills such as robotics, agile development and design thinking.

**FIGURE 3: PRELIMINARY SKILLS MAP - EMERGING DIGITAL SKILLS BY JOB ROLE/PERSONA**



(Preliminary skills map based on input from 19 organisations)

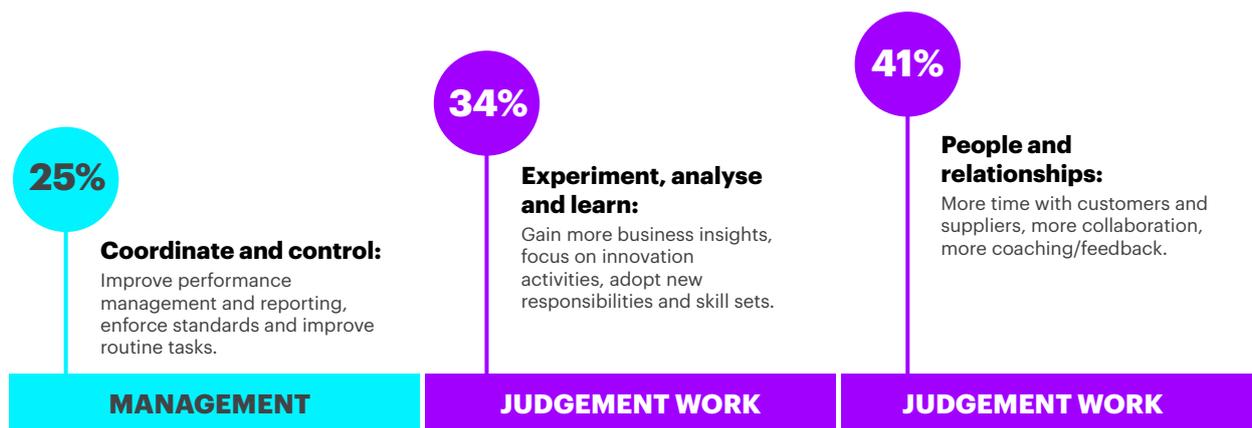
## Soft Skills

While there is a need to bridge the technical skills gap, Industry 4.0 also calls for a substantial change in soft skill requirements. The workforce’s ability to apply technology to their jobs and disciplines will require the acquisition of skills and capabilities such as creative, transdisciplinary and importantly, computational thinking—which is fundamental to problem solving. A global mindset will also be important to enable sense- and decision-making. As machines begin assuming routine tasks, the workforce will evolve from performing ‘knowledge work’ to ‘judgement work.’ In the new digitalised workplace, knowledge is readily available and provided by machines, while people focus their efforts on ‘judgement’. An Accenture study estimates that ‘judgement work’ will comprise 75 percent of an employee’s job. ‘Judgement work’ will not only include having access to the right information at the right time and place, but also taking the most optimal action given the information available.<sup>11</sup> Formal modes of learning or exhibiting skills in just one area

will not be enough to perform ‘judgement work’. As explained by **Liew Kok Oon, Country Manager, AkzoNobel Surface Chemistry**: **“The future worker would be somebody who is always learning, reflecting about himself, understanding what is happening around him, evolving with the environment, and adapting to the new environment. The future worker would understand that change is the only constant, and that he or she has to continue to evolve and learn new skills, and communicate with different stakeholders, not just his boss.”**

Going beyond one’s field of expertise will also necessitate deeper and more regular collaboration, communication and teamwork, calling for enhanced interpersonal skills. **“We must progress towards a collaborative way of working. We cannot just develop a software and push it to the workforce. We work together with them to come up with it,”** said **Tan Swee Thim, Head of Projects at Vopak Terminals Singapore**. Working together is central to the needs of the new workforce, and will inform the leadership of the future.

**FIGURE 4: JUDGEMENT WORK WILL TAKE CENTRE STAGE IN THE WORKPLACE OF THE FUTURE**



Source: “Judgment calls: Preparing leaders to thrive in the age of intelligent machines,” Accenture Strategy, 2016.

## Organisational Changes

People constitute the heart of any change. It is thus essential that they are supported by an environment that is open to change. **“You can teach digital literacy, but nothing will change if people don’t. Most importantly, we need people who have an openness to change and the ability to adapt,”** said Lillian Lee, Senior Vice President of Group Human Resource at Sembcorp. In order for the workforce to realise a state of digital readiness, organisations must foster a digital DNA, enabled by the following critical components:

- Committed leadership that recognises the value of digital, and can communicate a vision to gain buy-in and empower the workforce to adopt Industry 4.0
- Organisations and structures designed to facilitate innovation by eliminating common barriers, that protect traditional ways of working and allow access to external ecosystems
- Cultivation of behaviours and mindsets that promote change, curiosity, experimentation and innovation across all levels of the workforce
- Management of a change journey from its inception

A successful and sustainable digital transformation is contingent upon having an intact digital DNA. Furthermore, when initiating change management to facilitate digitalisation, it is important to recognise that the workforce is not uniform but diversified. While many may find change difficult, there is wide variation across the workforce as to how much of a challenge change brings. At least three generations are at stake in the workplace today: the generation entering the workforce, the one that is on the verge of leaving, and the often-overlooked middle group. Each generation brings unique value to the fore. Organisations surveyed recognised that senior employees tend to have deep industry expertise, but may take longer to adopt digital ways of working; the reverse applies for fresh graduates entering the workforce. It is imperative to digitise the wisdom of the experienced, and those that marry this asymmetry of strengths will find themselves ahead of the pack.

Change must occur at both an organisational as well as at individual employee level for successful digitalisation to take place. It is only after such shifts have taken effect that the adoption of technical skills and practices will follow with conviction.

**FIGURE 5: TECHNICAL SKILLS, SOFT SKILLS, AND ORGANISATIONAL CULTURE TO ENABLE INDUSTRY 4.0**

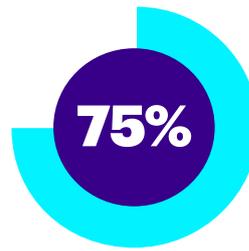
SKILLS		CULTURE
TECHNICAL	SOFT	
<ul style="list-style-type: none"> <li>• Analysis of data and trends</li> <li>• Automation management</li> <li>• Human-machine interaction</li> <li>• IoT infrastructure management</li> <li>• Cybersecurity architecture</li> <li>• Big data analytics</li> <li>• Simulation and modelling</li> <li>• Programming</li> <li>• Industrial UI/UX design</li> <li>• Machine learning</li> <li>• Agile operations</li> <li>• Design thinking</li> </ul>	<p><b>Cognitive</b></p> <ul style="list-style-type: none"> <li>• Cognitive flexibility</li> <li>• Lifelong learning</li> <li>• Problem solving</li> <li>• Computational thinking</li> <li>• Creative thinking</li> <li>• Critical thinking</li> <li>• Sense making</li> <li>• Decision making</li> <li>• Transdisciplinary thinking</li> <li>• Digital literacy</li> <li>• Auditory and visual skills</li> </ul>	<p><b>Interpersonal</b></p> <ul style="list-style-type: none"> <li>• Emotional intelligence</li> <li>• Develop people</li> <li>• Communication</li> <li>• Virtual collaboration</li> <li>• Teamwork</li> <li>• Leadership</li> <li>• Managing diversity</li> <li>• Resource management</li> <li>• Service orientation</li> <li>• Negotiation</li> </ul>
		<ul style="list-style-type: none"> <li>• Willing to take risks</li> <li>• Accepting of failure</li> <li>• Encourages innovation</li> <li>• Encourages learning</li> <li>• Encourages cross-functional collaboration</li> <li>• Ethics/trust/integrity</li> <li>• Responsible corporate behavior</li> </ul>

## The demand for IIoT-ready talent will grow.

The advent of Industry 4.0 also generates new job opportunities. Two-thirds of the organisations surveyed stated their intention to build digital capabilities in-house, and 75 percent of participants spoke of outsourcing or ‘borrowing’ digital expertise. More generally, stakeholders expressed plans to ‘borrow’ digital expertise to serve their short-term talent needs, with the intention to build critical capabilities internally over the longer term in order to be self-sufficient.

**Chief Operating Officer of global environmental solutions company Hyflux, Wong Lup Wai, articulates this sentiment: “There is no point reinventing the wheel because a lot of these capabilities are already out there. But, we still need to have people within the department who are familiar with implementation.”** Regardless of ‘build’ or ‘borrow’ then, the key takeaway is the urgent need for IIoT-ready talent.

Where demand is growing, a concurrent check on supply is necessary. The field of engineering remains a priority in Singapore’s IHLs given a fairly large engineering cohort size graduating each year. However, many engineering graduates entering the workforce choose not to pursue careers in their field. For example, while approximately 1,500 engineers graduate from the National University of Singapore (NUS) each year, only half are estimated to pursue engineering careers. The remaining opt for other roles, in fields such as finance, marketing, and sales.<sup>12</sup>



**discussed borrowing digital capabilities from third party vendors in the short term**



**mentioned their intent to build digital capabilities in-house in the longer term**

# DESIGN THINKING WORKSHOP

## Capturing views on the ground

**“It is critical to consult users of the technology – the operators and technicians – on what they need. Nobody is going to use the technology you give them unless it helps make their job easier, faster, and better.”**

**Bhaskar Venkatraman, Technical Manager, ExxonMobil Singapore Chemical Plant**

### WHY

Accenture, in collaboration with Singapore Polytechnic, conducted a Design Thinking Workshop in March 2017. The objective of this workshop was for participants to experience a digital work environment, share what digital means to them, and understand how to facilitate a seamless transition to Industry 4.0. The participants included 22 engineers and technicians from Jurong Island, who were also representatives of the organisations that participated in this study.

### HOW

Accenture hosted the workshop at its Internet of Things (IoT) Center of Excellence. Leveraging the IoT Center’s plant of the future infrastructure, three zones were designated according to themes that resonated with the participants in their daily work. These included: safety and security concerns in the plant, training using augmented reality and virtual reality (AR/VR), and intelligent plant operations on the shop floor.

As participants rotated between the zones in small groups, they were immersed in a future plant experience. They were prompted to discuss what came to mind with regard to the culture, soft skills and technical skills necessary for digital transformation. Here are some highlights from their discussions.

### WHAT

#### Culture

- Responsible management and transparent access to data is important to develop a culture of employee empowerment and trust vis-à-vis digital usage.
- Management should communicate commitment to a balance between productivity gains from digitalising and the threat to employee privacy associated with digital tracking.

#### Soft skills

- Skills such as sense-making, problem solving and critical thinking would help to optimise human-machine interaction.
- Creative thinking and the appetite for risk were summed up most palpably in one participant’s exclamation of, “Dare to dream!”

#### Technical skills

- Big data analytics, data interpretation and management, machine learning, and automation management would be key skills for the workforce of the future.
- Human-machine interaction is important to leverage the effectiveness of augmented and virtual reality in a training environment.

As the workshop came to a close, participants reinforced the importance of both technical and soft skills to the successful implementation of Industry 4.0. Their inputs contributed to the list of skills in Figure 5.

# RECOMMENDATIONS

**Given the findings, there is an urgent need for a pragmatic roadmap to prepare Singapore's manufacturing workforce for the future.**

**The recommended interventions, moving from strategic to tactical, are framed by the following four objectives:**

- **Source** job-ready talent.
- **Attract** a higher percentage of fresh graduates and mid-career professionals.
- **Build** digital capabilities to enable existing talent.
- **Retain** talent by reducing the loss of engineers to other non-manufacturing industries.

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## **Need for an industry-government deep dive to validate and expand on the emerging skills required**

This study has identified a number of emerging digital skills as workforce requirements change. These are shown on the preliminary skills map (Figure 3). The preliminary skills map is not exhaustive, but rather suggests the direction in which the workforce is headed. More work should be done to build on this preliminary map, and to comprehensively flesh out the knowledge required to execute each skill. Given the escalating pace of technological transformation, skill obsolescence is occurring at a growing rate. For our workforce to remain relevant in an increasingly digitalised manufacturing sector, there needs to be stronger ongoing industry-government collaboration to jointly map out the future skills, competencies, and knowledge required.

Since 2015, Singapore has embarked on a skills-mapping exercise for key job roles within growth industries as part of the nationwide Skills Framework. This is being done by SkillsFuture Singapore (SSG) and other government bodies. The Skills Framework provides key information on sectors and employment, career pathways, occupations/job

roles, as well as on the existing and emerging skills required for specific occupations/job roles. It also provides a list of training programmes for skills upgrading and mastery, and serves as reference for education and training providers to innovate and contextualise curricula design and training programmes that will suit the needs of the industry.

This paper recommends that the industry collaborate more closely with SSG to provide clarity on the emerging digital skills required of its workforce, as well as on the impact digitalisation would have on existing job roles, skills and competencies. In the near term, SSG and the industry can focus on identifying the "lowest common denominator" or set of emerging digital technical skills and competencies (TSCs) that would be useful for its workforce to have across all job roles. Once this set of emerging digital TSCs has been identified, education and training providers can use these industry-validated needs to develop the necessary Pre-Employment Training (PET) and Continuing Education and Training (CET) programmes.

# Educational institutions and training providers to develop additional programmes and initiatives to nurture cross-trained industrial engineers and technicians with digital skills

Industry consultations revealed that, when faced with the multi-faceted and interdisciplinary nature of digitalised work today, organisations are increasingly demanding a cross-trained workforce. Manufacturers shared that a typical IIoT team comprises individuals who have domain-specific industry expertise, data analytics capabilities, and some understanding of the business. As part of its ongoing manpower plan, Singapore has facilitated the training of 2,500 data analytics professionals over the last four years. But while training data analytics professionals with deep skills is important, more can be done to meet the country's and sector's needs for cross-trained digital talent. There is a need to quickly equip the entire engineering workforce — both undergraduates and mid-career professionals — with a variety of broad digital skills and knowledge. To do so, programmes and initiatives to cross-train industrial engineers and technicians with digital skills are required, at both the PET and CET levels.

IHLs can incorporate IoT-related material into their curricula by:

- Adding new content to existing core modules
- Developing electives that provide engineering students with exposure to IoT technologies
- Assigning research projects that require cross-disciplinary skills

Similarly, to aid the delivery of digital knowledge, schools could set up learning factories that emulate integrated Industry 4.0-enabled systems, complete with cloud-connected sensors, devices and control systems. These 'live' manufacturing facilities will provide students with the opportunity to gain practical experience of what will be required of them in the industry. Additionally, Research Institutes (RIs) such as SIMTech and the Advanced Remanufacturing Technology Centre (ARTC), both of which have set up model factories, could open up their facilities to be used for training.

## **Inclusive planning and clear communication by unions and trade associations and chambers (TACs) to prepare the workforce for digital transition**

For the workforce to remain relevant and meaningful, all stakeholders will need to foster a culture of life-long learning and adaptability amongst the existing workforce. As important stakeholders in supporting workforce employability, unions and TACs such as the National Trades Union Congress (NTUC) and Singapore Chemical Industry Council (SCIC), play a pivotal part in the digitalisation journey, and can help ease the transition for the existing workforce.

Singapore enjoys a strong tripartite relationship between unions, employers (through the TACs) and the Government. For instance, tripartite platforms such as the Sectoral Tripartite Committees (STCs) and Council for Skills, Innovation and Productivity (CSIP) have been established in recent years

to create avenues that bring together key stakeholders to plan and formulate inclusive growth strategies for key sectors. This paper urges unions and TACs to better leverage such platforms to communicate opportunities, understand common challenges and form partnerships. The objective is to help the workforce remain relevant and contribute meaningfully, even as Industry 4.0 results in changes to job roles and the operating environment. Additionally, given the strong relationship that unions have with the workforce, employers should leverage unions to bring the workforce on board and foster a culture of life-long learning and adaptability.

# Industry to implement programmatic interventions from shop floor to top floor

FIGURE 6: FIVE PILLARS OF DIGITAL DNA



**“We have conducted interviews with senior executives and plant heads, to obtain a top-down view, in parallel to a design thinking workshop for operators and engineers, to corroborate a bottom-up view. A holistic sampling of inputs helped us craft deliberate and pointed recommendations that are grounded in practical learning experiences.”**

**Senthil Ramani, Global Technology Lead for Chemicals and Natural Resources, Managing Director, IoT Centre of Excellence, Accenture**

It is clear that organisations preparing to reap the benefits of Industry 4.0 must examine the ‘digital DNA’ of their workforce and organisation to move forward. The following recommendations outline actions that organisations can take to embrace Industry 4.0, and to prime their companies for change. To this end, Accenture will launch a targeted digital programme — 4.0 Applied Now, tailored to provide continuous learning opportunities to Singapore’s manufacturing workforce and to help develop its digital capabilities. The following points are critical for any organisation managing change, and preparing their people and company for the future.

## Leadership

C-suite executives, plant managers and their leadership teams, need to convey a clear vision of their company’s or plant’s digitalisation journey and its business objectives, in order to generate buy-in from their people. Leadership also needs to build new capabilities that allow

them to understand how technology can be applied to solve business issues and develop new opportunities, as well as gain the buy-in to make it happen. One way to start this journey is through reverse mentoring, where young and digital-savvy junior employees mentor senior executives, helping them build digital acumen and spur top-down change across the organisation. This fosters a digital mindset among the organisation’s leadership, and sets a company-wide mobilisation into motion.

## Organisation & Ecosystem

The capital-intensive nature of process and hybrid manufacturing makes it difficult for businesses in these industries to innovate, fail, and recover quickly; existing processes do not lend themselves easily to experimentation and innovation. An approach to innovation that works well in a consumer-focused business for instance, may not be suitable in a plant environment. Successful and expeditious digital innovation hence requires the right operating model, which supports agility to develop new solutions in a controlled environment.

Today, operational technology and information technology have converged, demanding a well-defined governance model. For digitalisation to gain momentum, the business requires support from its IT department. Several archetypes are emerging in response, one example being a large petrochemical and oil and gas organisation that is already merging governance around these two functions, and bringing more clarity and effective decision making to enable faster digital adoption.

Plants can also develop specific areas or Centres of Excellence (CoEs) to encourage innovation from within the plant. For example, a large oil and gas organisation has set up a 3D printing CoE to explore alternate materials and identify opportunities for implementation within the business. During interviews, some manufacturers also called for increased intra-industry collaboration to pilot digital projects. Each manufacturer would focus on a unique segment of the value chain, promoting the development of 'live' industry-use cases and increasing the rate of industry-wide adoption.

**Select few and go deep.** Whilst access to ecosystems exist, organisations need to clearly distinguish their own capability gaps and identify a select few, targeted and complementary ecosystem partners that bridge the gap. Organisations ought to be deliberate in partnering with start-ups and companies that are suited to an industrial context, which requires a unique set of capabilities around control, safety and capacity to scale. A deeper and careful understanding is therefore required to evaluate the suitability of ecosystem partners, and start-ups in particular, to determine the right fit.

## Culture

Beyond encouraging innovation at the organisational level, companies also need to foster a culture in which individuals develop mindsets that are open to digital adoption, as well as corresponding behaviours that demonstrate such openness. This mindset does not fear the unknown, and tolerates an ambiguity that digitalisation sometimes brings. While mindset changes are often difficult to achieve, research in cognitive dissonance shows that changes in behaviour – for example doing something new every day – may influence mindset, and subsequently lead to the desired change. In this example, not being afraid of trying something new, over time. One way to affect such behavioural change is through organisational incentive systems. Performance management structures that do not punish failure, but reward experimentation, for instance, can foster the development of a workforce that is excited to challenge the boundaries and explore

the unknown. Both are crucial to facilitating the adoption of new technologies in a digital era. Further to this, effective behaviour change can be accelerated through **gamification**, where the reward and punishment feedback loop is short and linked to frequent and specific individual tasks. An individual performs tasks based on their own initiative to achieve a particular goal in an enjoyable context.

## Human-centred design

Digital technologies not only shape jobs and ways of working, but alter an employee's entire experience in the plant. A compelling digital employee experience that empowers the workforce to make more strategic decisions at a local level, could serve to **attract and retain talent** within an organisation. A positive experience would also likely impact the adoption of digital solutions. In the initial stages of change, utilising a **design thinking methodology** which makes people and their experiences central to the innovation process, can help organisations and their leaders obtain an empathetic understanding of the motivations and needs on the ground. As a result, design solutions around people that will be adopted and used by the very people they have been designed for.

## Skills & Capabilities

Targeted interventions are required to source, attract, build and retain talent for digitalisation. Interventions of a pragmatic, interdisciplinary nature are needed at the source, to equip talent that enters the industry with multi-domain capabilities, as well as an agility and flexibility that has been described above.

Most importantly, an infusion of new skills and capabilities into the workforce is required to take advantage of the opportunities associated with Industry 4.0. The shift from knowledge worker to judgement worker adds a new layer of required technical and soft skills, enabled by targeted capability development and continuous learning. A one-off course or training is not enough to enable digitalisation. In fact, digital calls for a different type of learning, where technical and soft skills can be applied to real business issues by multi-disciplinary teams.

# 4.0 APPLIED NOW

This paper recommends the launch of 4.0 Applied Now. Two fundamental perspectives inform the development of a change-ready organisation: the first is that of the leadership, and the second is a ground-up organisational perspective. 4.0 Applied Now is a digital capability development programme that brings these two perspectives together, allowing the **leadership** and **individuals** to collectively drive Industry 4.0 adoption within a conducive **ecosystem**.

4.0 Applied Now brings a **continuous, targeted** and **applied** approach to capability development. As a continuous programme, 4.0 Applied Now recognises the need to reskill and upskill, and offers progressive stages of capability development according to proficiency level. The targeted programme, will be offered to two primary groups: students from universities and polytechnics, as well as existing members of the manufacturing workforce such as operators, technicians, engineers and managers. Finally, the programme's applied approach ensures that the technical and soft skills discussed above are covered in an industry context. 4.0 Applied Now will encourage actionable learning through methods such as practical use cases, coaching, immersive experiences and internships.

It is consortium-led, bringing together IHLs, government agencies and industry players, among others.

Broadly, 4.0 Applied Now will enable participants to (non-exhaustive):

- Enhance their knowledge and awareness of digital technology, for example, why, how and where data science, AI and robotics are applied
- Identify and prioritise digital opportunities to meet business objectives
- Apply engineering, technical and digital skills to solve pragmatic challenges
- Develop ideas to digitise wisdom and experience
- Manage IoT devices
- Identify where and how to form key ecosystem partnerships
- Build capabilities to define and articulate the business case for digitalisation to gain organisational buy-in and manage change
- Master interpersonal communication and other soft skills in the new working environment
- Develop pilots in an interdisciplinary manner, leveraging design thinking principles and agile methodologies

# **This white paper comes at a critical juncture in Singapore’s digitalisation journey, and calls for an urgent reexamination of talent strategies to propel the adoption of Industry 4.0.**

It is people who ultimately drive digital transformation. Having a future-ready talent pool that is prepared for change and convinced of the direction in which the industry is headed will determine how quickly and successfully this transition can take place.

Our findings stress the pressing need for stakeholders to work in unison and on integrated platforms to collectively develop a future-ready workforce. Collaborative efforts must nurture both the incoming workforce, and promote the upskilling of current employees. This paper also calls for an organisational culture that is supportive of digitalisation and that fosters openness to change and adaptability.

Like digitalisation, talent charts a journey of its own. These recommendations target junctures where actions can be taken, specifically for sourcing, attracting, building, and retaining talent within the sector. It is our belief that the interventions proposed here will be equally relevant to other industries and regions that see digitalisation on their horizon.

## ANNEX A: PRELIMINARY SKILL MAP FOR EMERGING DIGITAL SKILLS WITH CORRESPONDING KNOWLEDGE, AND PROFICIENCY REQUIRED

LEGEND:    Novice Intermediate Expert

JOB ROLE	SKILL CATEGORY	SKILL DESCRIPTION (FOR JOB ROLE)	KNOWLEDGE	PROFICIENCY
Operator	<b>Analysis of data and trends</b>	Access data on mobile devices and computers, identify trends in data and detect problems, and visualise data effectively	Data visualisation on tools such as Tableau, Qlikview, QlikSense, Microsoft Power BI, and Sisense (not exhaustive)	
	<b>Automation management</b>	Monitor and interpret system performance metrics; operate, control, and maintain automated operational technology systems; ensure quality control; troubleshoot; understand and respond according to security exceptions	Process control; advanced process control (APC); regulatory control (PID tuning); historian applications; open platform communications (Data Access, Historical Data Access); plant design and simulation packages	
	<b>Human-machine interaction</b>	Manage and maintain machines including advanced sensor, processing, and communications technology; use wearables to optimise task accuracy and facilitate real-time insights like instant work updates and materials tracking; ensure workplace safety in machine handling	Mobile and ATEX certified devices; management of digital logs; wearable technologies; digital twins; 3D operation simulations; virtual over-the-shoulder coaching; virtual and augmented reality	
	<b>Industrial cybersecurity management</b>	Recognise the potential for cybersecurity risks and threats; working understanding of potential threat vectors and techniques for good cyber hygiene	Policy, communication and response requirements and expectations	
Technician (Domain-Specialist)	<b>Analysis of data and trends</b>	Corroborate from multiple sources, access data on mobile devices and computers, identify trends in data and detect problems, and visualise data effectively	Data visualisation on tools such as Tableau, Qlikview, QlikSense, Microsoft Power BI, and Sisense (not exhaustive)	
	<b>Automation management</b>	Monitor and interpret system performance metrics; understand underlying operational technology systems, and how they can be integrated with greater automation	Process control; advanced process control (APC); regulatory control (PID tuning); historian applications; open platform communications (Data Access, Historical Data Access); plant design and simulation packages	
	<b>Human-machine Interaction</b>	Manage and maintain machines including advanced sensor, processing, and communications technology; use wearables to optimise task accuracy and facilitate real-time insights like instant work updates and materials tracking; ensure workplace safety in machine handling	Mobile and ATEX certified devices; management of digital logs; wearable technologies; digital twins; 3D operation simulations; virtual over-the-shoulder coaching; virtual and augmented reality	
	<b>IoT infrastructure management</b>	Understand network security protocols, communication protocols, wireless infrastructure, on-premises solutions, switches and integration of the IoT ecosystem	Raspberry Pi, ARM, Intel; RS-282/485; Zigbee, Z-Wave, 6LoWPAN; Sigfox, CDMA, GSM, UMTS, 3-5G; TLS/SSL; Internet protocols (TCP, UDP/IP, PPP, HTTP); Modbus, HART-IP, OPC; AMQP; AES; Beacon technology	
	<b>Industrial cybersecurity management</b>	Understand cybersecurity risks and threat vectors; use and interpret installed tools and systems to detect, manage and respond to incidents	Digital identity of 'things'; basics and benefits of data protection; encryption types and security infrastructure; monitoring and incident response triage; policies and communication expectations	

JOB ROLE	SKILL CATEGORY	SKILL DESCRIPTION (FOR JOB ROLE)	KNOWLEDGE	PROFICIENCY
Domain-Specialist Engineer	<b>Analysis of data and trends</b>	Build the vision for impact of analytics for specific domain functions; corroborate data from multiple sources; access data on mobile devices and computers; identify trends in data and detect problems; visualise data effectively	Trends analysis from multiple structured and unstructured data; data visualisation on tools such as Tableau, Qlikview, QlikSense, Microsoft Power BI, and Sisense (not exhaustive)	
	<b>Automation management</b>	Monitor and interpret system performance metrics, understand underlying operational technology systems, and how they can be integrated with greater automation	Process control; advanced process control (APC); regulatory control (PID tuning); historian applications; open platform communications (Data Access, Historical Data Access); plant design and simulation packages	
	<b>IoT infrastructure engineering and design</b>	Understand network security protocols, communication protocols, wireless infrastructure, on-premises solutions, switches and integration of the IoT ecosystem	Raspberry Pi, ARM, Intel; RS-282/485; Zigbee, Z-Wave, 6LoWPAN; Sigfox, CDMA, GSM, UMTS, 3-5G; TLS/SSL; Internet protocols (TCP, UDP/IP, PPP, HTTP); Modbus, HART-IP, OPC; AMQP; AES; Beacon technology	
	<b>Industrial cybersecurity management</b>	Understand cybersecurity vulnerabilities and mitigations for IoT systems; have contemporary knowledge of domain threats, experiences, mitigations and current exposure	Industry best practices, trusted information and support resources, relationships with threat providers and response actors	
	<b>Big data management</b>	Understand how data is synthesised across entire plants for monitoring and process improvement, how data analytics systems are designed, and how processes are integrated with data funnels	Unstructured data, semi-structured and structured data; log files; enterprise systems data; instrumentation and sensor reliability; applications of algorithms and data science	
	<b>Simulation and modelling</b>	Understand temporal statistics, classical statistics, spatial statistics, and analysis of structured and unstructured data	Forecasting, time-series analysis; general linear model, ANOVA; geographic covariates; statistical graphics, mapping	
	<b>Programming</b>	Modify software and application functions; understand digital processes and systems	Java/J2EE 1.8; JavaScript; Python; C, C++, and C#; iOS (Obj. C/Swift); Android (Java); Ajax; Angular.js; Backbone.js; HTML 5, CSS; Struts 2.0; agile and Dev Ops enablers	
	<b>Industrial UI/UX Design</b>	Create wire frames, illustrations, renderings, 3D models, and functional mockups	Adobe Photoshop, Illustrator, and InDesign (non-exhaustive)	
	<b>Machine learning and big data</b>	Complement the use of data along with application of first principles; understand how big and distributed data can be analysed using decision trees, neural nets, support vector machines, clustering, and linear, integer, convex and global optimisation	Python (SciKitLearn), R, Cplex (optimization), AWS Lambda, Spark, Apache MLlib	

JOB ROLE	SKILL CATEGORY	SKILL DESCRIPTION (FOR JOB ROLE)	KNOWLEDGE	PROFICIENCY
IT-Specialist Engineer	<b>Analysis of data and trends</b>	Corroborate from multiple sources; access data on mobile devices and computers; identify trends in data and detect problems; visualise data effectively	Data visualisation on tools such as Tableau, Qlikview, QlikSense, Microsoft Power BI, and Sisense (not exhaustive)	
	<b>Automation Management</b>	Integrate robotics, mobility, blockchain, and greater automation with underlying operational technology systems	Process control; advanced process control (APC); regulatory control (PID tuning); historian applications; open platform communications (Data Access, Historical Data Access); plant design and simulation packages	
	<b>IoT infrastructure engineering and design</b>	Understand network security protocols, communication protocols, wireless infrastructure, on-premises solutions, switches and integration of the IoT ecosystem; create solution blueprints that meet business and technical requirements	Raspberry Pi, ARM, Intel; RS-282/485; Zigbee, Z-Wave, 6LoWPAN Sigfox, CDMA, GSM, UMTS, 3-5G; TLS/SSL; Internet protocols (TCP, UDP/IP, PPP, HTTP); Modbus, HART-IP, OPC; AMQP; AES; Beacon technology; pervasive wireless setup and implications	
	<b>Industrial cybersecurity management</b>	Understand current organisational cybersecurity risks, exposure, and regulations; conduct cyber vulnerability assessments, red team and adversary exercises; monitor and identify security events and mitigate identified risks; design and implement cybersecurity solutions; maintain relationships with the industry for support and assistance; keep abreast of recent events	Encryption and data protection systems (confidentiality, integrity and availability); core IT and OT security principles and implementation; monitoring and analytical tools for the identification of anomalous events; trusted computing platforms and protocols; trusted threat and mitigation sources; nuanced threat vectors	
	<b>Big data management</b>	Synthesise data across entire plants for monitoring and process improvement, implement and design data analytics systems, and integrate processes with data funnels	HDFS; Apache Cassandra, DocumentDB, MongoDB; Hadoop MySQL, MS-SQL, SQLite; Oracle DB; JSON; In-Memory DB & Compute (memsql, Spark, Terracotta)	
	<b>Simulation and modelling</b>	Understand temporal statistics, classical statistics, spatial statistics, and analysis of structured and unstructured data	Forecasting, time-series analysis; general linear model, ANOVA; geographic covariates, GIS; SQL, JSON, XML; noSQL, text mining; statistical graphics, mapping	
	<b>Programming</b>	Modify software and application functions; understand digital processes and systems	Java/J2EE 1.8; JavaScript; Python; C, C++, and C#; iOS (Obj. C/Swift); Android (Java); Ajax; Angular.js; Backbone.js; HTML 5, CSS; Struts 2.0; agile and Dev Ops enablers	
	<b>Industrial UI/UX Design</b>	Create wire frames, illustrations, renderings, 3D models, and functional mockups	Adobe Photoshop, Illustrator, and InDesign (non-exhaustive)	
	<b>Machine learning and big data</b>	Analyse big and distributed data using decision trees, neural nets, support vector machines, clustering, and linear, integer, convex and global optimisation	Python (SciKitLearn), R, Cplex (optimization), AWS Lambda, Spark, Apache Mlib	

JOB ROLE	SKILL CATEGORY	SKILL DESCRIPTION (FOR JOB ROLE)	KNOWLEDGE	PROFICIENCY
<b>Manager or Plant Supervisor</b>	<b>Analysis of data and trends</b>	Strategically lead the use of analytics across the plant; complement the use of data science with business insights; corroborate from multiple sources; produce visuals (dashboards, charts, infographics) and presentations to communicate findings effectively; derive actionable insights from data findings	Lead with design thinking principles; trends analysis from multiple structured and unstructured data; data visualisation on tools such as Tableau, Qlikview, QlikSense, Microsoft Power BI, and Sisense (not exhaustive)	
	<b>Automation management</b>	Understand underlying operational technology systems and how they can be integrated with greater automation; evaluate and procure as-a-service (aaS) and commercial off-the-shelf (COTS) software from vendors	Process control; advanced process control (APC); regulatory control (PID tuning); historian applications; open platform communications (Data Access, Historical Data Access); plant design and simulation packages	
	<b>Human-machine interaction</b>	Understand implication of workplace safety, productivity enhancement	IoT and mobile devices; ATEX certification; degree of artificial intelligence and automation, pervasive wireless, digital operating procedures	
	<b>IoT infrastructure supervision</b>	Understand network security protocols, communication protocols, wireless infrastructure, on-premises solutions, switches and integration of the IoT ecosystem; create solution blueprints that meet business and technical requirements	Beacon technology; pervasive wireless setup and implications	
	<b>Industrial cybersecurity management</b>	Understand cybersecurity risks and regulations; balance the risks to the organisation, investment and resource availability; implement strategies to address system vulnerabilities; maintain relationships with industry for threat advice, technical advice, and response support; develop, communicate and champion security policy and expectations; upward communication of risk and exposure	Security investments; security governance systems; details of contemporary security events and their relation to the organisation	
	<b>Remote management &amp; supervision</b>	Understand anomalies identified by systems; manipulate system control parameters remotely; communicate solutions to operators	Workflow management tools, processes, and exceptions	
	<b>Simulation and modelling</b>	Understand temporal statistics, classical statistics, spatial statistics, and analysis of structured and unstructured data	Forecasting, time-series analysis; general linear model, ANOVA; geographic covariates; statistical graphics, mapping	
	<b>Industrial UI/UX Design</b>	Understand wire frames, illustrations, renderings, 3D models, and functional mockups	Adobe Photoshop, Illustrator, and InDesign (non-exhaustive)	
	<b>Agile development and operations</b>	Understand and leverage agile methods for development and operations	Agile methodologies; dos and don'ts	
	<b>Design Thinking</b>	Design solutions centred around humans; assess feasibility of initiatives according to their impact on people and roles across the plant	Methodology and approach of design thinking	

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Senoko Energy Pte Ltd  
Shell Jurong Island\*  
Siemens Pte Ltd\*  
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