RMIT UNIVERSITY

Insight Series

Demystifying Industry 4.0

Helping SMEs lay the tracks for Australia's digitalisation express train

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Terms and abbreviations

AI	artificial intelligence
AR	augmented reality
Big data	extremely large and complex data sets, especially from new data sources, that are so varied and voluminous they cannot be managed using traditional data processing software
Digital twin model	a digital replica of a physical machine or process
I4.0	Industry 4.0, the fourth industrial revolution, uses technologies to provide up-to-date information for better decision making.
IoT	Internet of Things, the concept of connecting any device (for e.g. mobile phones, wearable devices, washing machines, kettles, lights) to the Internet and/or to each other. (IIoT – Industrial Internet of Things)
PLC	programmable logic controller, a ruggedised computer that has been adapted for industrial digital automation
MES	manufacturing execution system. An information system that monitors and coordinates manufacturing processes, with the aim of ensuring effective operations and improving production output
The cloud	cloud computing refers to storing, accessing and processing data over computer clusters located remotely rather than on the local machine
VR	virtual reality

Overview

Industry 4.0 (I4.0) is also known as the fourth industrial revolution. Its impact will be felt by individual companies and industry sectors in every country across the globe. As the revolution progresses, businesses that fully embrace the transformation will be in the best position to thrive, while those that have lagged behind their more agile competitors may struggle to survive.

Despite the rapidly approaching wave of industrial change, most Australian businesses are still grappling with how to implement or progress beyond entry-level I4.0 technologies and practices. Many company owners are still sceptical about the potential returns on investment. Others are uncertain about where and how to begin their I4.0 journey. There are also misconceptions among many small and medium enterprises (SMEs), in particular, that the new technologies are too costly and beyond their reach.

During 2019, RMIT researchers interviewed executives from SMEs and larger companies across Australia about their views on digital operations and I4.0. This paper draws on those interviews, and experience gained from RMIT's ongoing engagement with its partners in the advanced manufacturing sector, to examine the specific benefits, challenges and opportunities I4.0 presents for SMEs.

Our in-depth interviews identified four common I4.0 issues facing each company:

- acquiring the most relevant data
- integrating systems for better-aggregated data
- visualising the data, and
- extracting more value from the data.

Other issues and barriers identified through RMIT's research include:

- lack of understanding of I4.0
- low buy-in from top management
- limited solutions tailored to the needs of SMEs, and
- data security concerns.

We highlight three key requisites for success: the commitment of top management; a deep understanding of one's own business, and the potential and desired level of transformation; and having a clear implementation strategy.

We also offer and expand on the following insights to support industries on their I4.0 implementation journey:

- get crystal clear on what data you actually need
- start now and move forward incrementally
- develop an I4.0-savvy workforce, and
- involve key stakeholders in the journey early.

Case studies based on RMIT's collaboration with three Australian manufacturers: Asahi Beverages, Sutton Tools and New Touch Industries, provide further insights into how cost-effective I4.0 solutions can be applied to improve the bottom line of already lean SME operations.

Our aim is that this paper will help to demystify I4.0 for Australian SMEs. The intention is to increase awareness of the implications for local manufacturers and offer practical insights to help companies overcome barriers, implement low-cost solutions and thrive in what will soon be a vastly different business environment.

> **Industry 4.0 revolves around applying systems theory to expedite the timely flow of useful information. It's about extracting the most valuable information from the enormous volumes of available data, and getting it to the right people at the right time in a user-friendly format."**
>
> - Neil Wilson, Chairman, Romar Engineering

A tidal wave of industrial change is coming

I4.0 is bringing rapid and far-reaching change for industries and consumers across the globe. The forecast impact on industry will significantly outstrip the change wrought by the traditional technologies introduced during the third industrial revolution (Industry 3.0).

Companies that fail to ride the wave of this radical transformation will struggle to survive. And yet, relatively few are currently well-positioned to leverage the benefits of I4.0. Many business leaders do not yet fully appreciate the gravity and rapid pace of this latest industrial revolution.[1, 2] Some are still sceptical about the forecast benefits and return on investment (ROI). There is still a widespread lack of in-depth understanding about what I4.0 entails and a misconception that its implementation is inherently costly and therefore only within reach of large, cashed-up corporations.

As a result, most businesses are not yet prepared to meet the inevitable challenges of I4.0 or to exploit the vast opportunities it represents. According to the 2017 digital transformation study conducted by SAP and Oxford Economics,[3] a large majority of the company leaders surveyed believed digital transformation would be a crucial factor for a business to survive in the next five years. However, only 3% had finalised digital transformation projects across their organisations (Figure 1). Leaders of the 100 companies at the forefront of this transformation reported stronger revenue growth and profitability and expected that advantage to continue. They were also seeing increased customer satisfaction and engagement among their employees.

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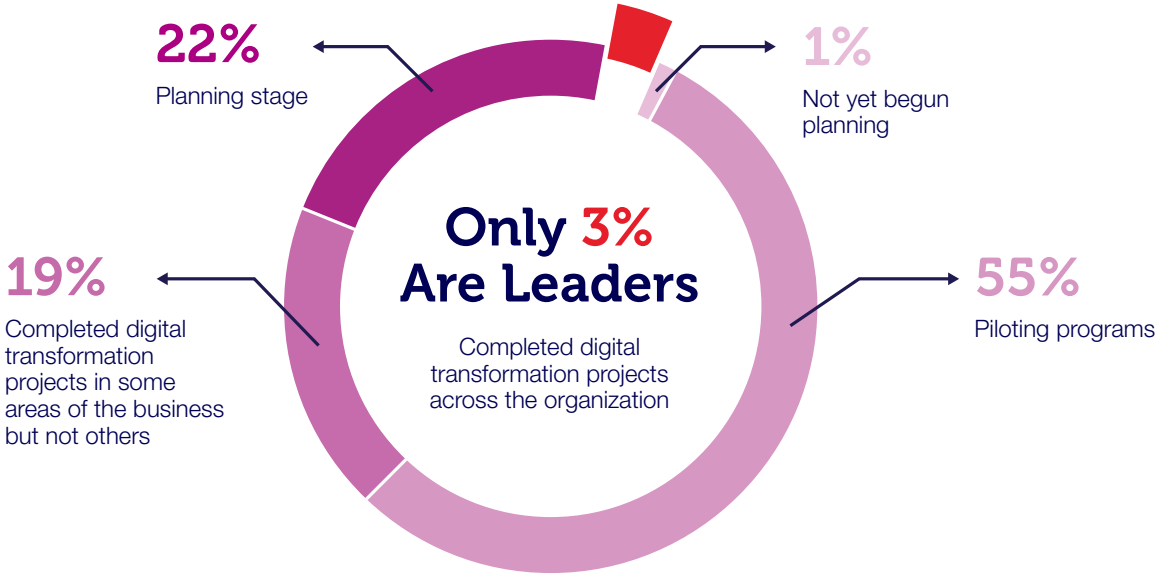

Figure 1. Digital transformation progress among companies in various sectors, including manufacturing, retail, healthcare and public services
Source: SAP, 2017. https://www.sap.com/dmc/exp/4-ways-leaders-set-themselves-apart/index.html

We aim to demystify I4.0 in this paper and demonstrate that keeping up with technological advances doesn't necessarily require major investment. In particular, many effective solutions are well within reach of Australia's many innovative and agile small- to medium-sized manufacturing enterprises.

Two years on from the SAP international study, a relatively low level of data maturity and lack of in-depth understanding of I4.0 continues to persist within Australia's manufacturing sector. Research by RMIT University's School of Engineering during 2019 yielded similar findings to the SAP study. Interviews conducted with more than a dozen executives from 7 Australian-based SMEs revealed that many are still uncertain about how to position their companies to capitalise on I4.0's promised benefits. Those businesses that had already implemented some form of I4.0 technology were mostly engaged in entry-level activities that only begin to scratch the surface of what these nascent technologies can offer.

The fundamental industrial transformation I4.0 is bringing will mean that only the digitally fittest and most connected businesses will be agile enough to remain competitive in an increasingly dynamic global business environment.

This white paper draws on interviews conducted with company executives and senior managers across a range of industries to ascertain their views about digitalisation and I4.0. We also draw on knowledge gained through RMIT's ongoing field-based collaborations with local industries. The insights and case studies provided examine the unique challenges and characteristics of the impending changes specific to Australian SMEs in the manufacturing sector. Our goal is to dispel misconceptions about I4.0 for SMEs and offer guidance to help them prepare to outpace their competitors and unlock the full potential of their organisations.

The nature and origin of Industry 4.0

I4.0 uses transformative technologies to make data and information accessible to business operators promptly. It brings together emerging technologies such as advanced manufacturing and automation, sensors, robotics, data analytics, cloud computing, artificial intelligence and big data to drive a paradigm shift in how businesses operate and perform, from energy and agribusiness to manufacturing and the health sector (Fig. 2). No industry sector or business will escape the impact of I4.0. The disruptive changes are already happening and are escalating rapidly.

The I4.0 concept grew out of a 2011 German government initiative aimed at integrating information and communication technology in industrial production. It was soon being adopted by industries in other countries. The Industrial Internet Consortium was established in the United States (US) in 2014, and in Australia the Prime Minister's Industry 4.0 taskforce (now known as the Industry 4.0 Advanced Manufacturing Forum) was established in 2016 to share information and facilitate collaboration between Australia and Germany. Australia is one of only five countries to have signed a cooperative agreement with Germany's Plattform Industrie 4.0.[4]

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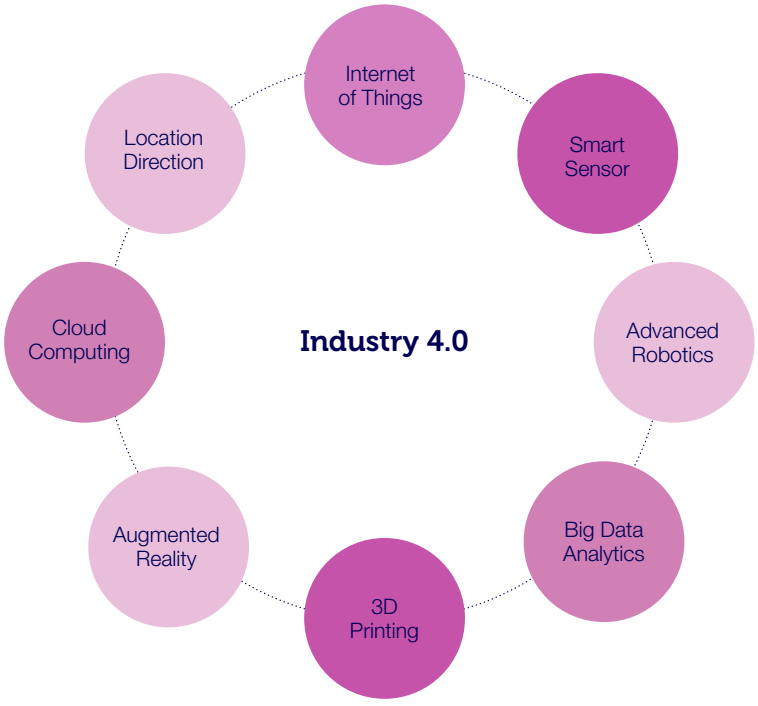

Figure 2. Key elements of Industry 4.0

Key enablers of the revolution

The digitalisation of the manufacturing sector and the associated production supply chain is largely being driven and enabled by:

- high demands for transparent systems providing real-time data
- the increasing availability of low-cost computational power and network connectivity
- a reduction in the barriers to adopting advanced analytics and business intelligence in recent years
- recent advances in human-machine interfaces such as wearable devices, virtual reality (VR) systems and cobots, and
- the availability of cyber-physical translators such as advanced robotics, 3D printers and augmented reality (AR) technology.

Transforming the 'What' and 'How' of business operations

While the automation of standalone machines and processes is well understood and utilised by industry, I4.0 involves end-to-end interaction and data integration of the entire value chain (Figure 3). This generates many unprecedented challenges and opens up new digital products and services. The convergence of these new technologies is stimulating conceptual leaps in thinking around:

- new ways of operating connected physical and virtual resources
- how to transform and integrate all operations and internal activities
- rethinking and forming strategic partnerships, and
- optimising sales and customer-management activities.

The broadest transformation in the manufacturing industry, regardless of the type or scale of an operation, is coming from the Internet of Things (IoT), the cloud and big data analytics. These technologies impact product and plant design, operations, maintenance, supply chain management and consumption. They differ fundamentally from traditional technologies. For example:

From an IoT perspective – despite the wide use of network-connected industrial devices since the early 2000s, many industrial components (particularly field devices) are commonly used in an isolated mode, or simply have one-way communication. However, the IoT requires two-way communication. In addition to data needing to be fed up to the controller and to the cloud, feedback also needs to be sent back to the device. An example is when a sensor's parameters change, triggering a change in the corresponding production run.

From a cloud perspective – clouds are being used occasionally for data storage and processing at an enterprise level, but they are rarely used at the factory floor level for conveying decisions or reporting. Using the cloud can make the data available and accessible to workers at different levels of the organisation and thus lead to faster and better decision making.

The digitalisation process in I4.0 allows data along the value chain to be accessible in real-time. Such added transparency allows for faster and more decentralised decision-making, which in turn contributes to more agile business operations. Cloud-based software solutions such as manufacturing execution systems (MES) are being developed that will offer the necessary controls via the cloud.

From a big data perspective – the enormously rapid growth in the data being collected and stored is overwhelming manufacturers. The real challenge, and opportunity, for production-oriented businesses lies in big data analytics.[5] This is due to the large number of connections between the components and devices (e.g. new sensors). Also, industries are becoming more aware of the potential for the captured data to help improve their competitiveness and processes.

Additional business investments are needed to accommodate big data storage and security, and to upgrade and replace traditional data processing software in order to properly handle the additional complexity and scale of the data being generated.[6]

Also, the need to collect larger amounts of relevant data means industries have to develop more complex algorithms in artificial intelligence (AI) and machine learning (ML).[7] This is essential for achieving a wide range of improvements, including boosting the effectiveness of equipment, refining predictive maintenance, reducing waste and managing energy consumption. Embedding greater intelligence in system components will enable subsystems to make decentralised analyses and even make autonomous decisions.[8]

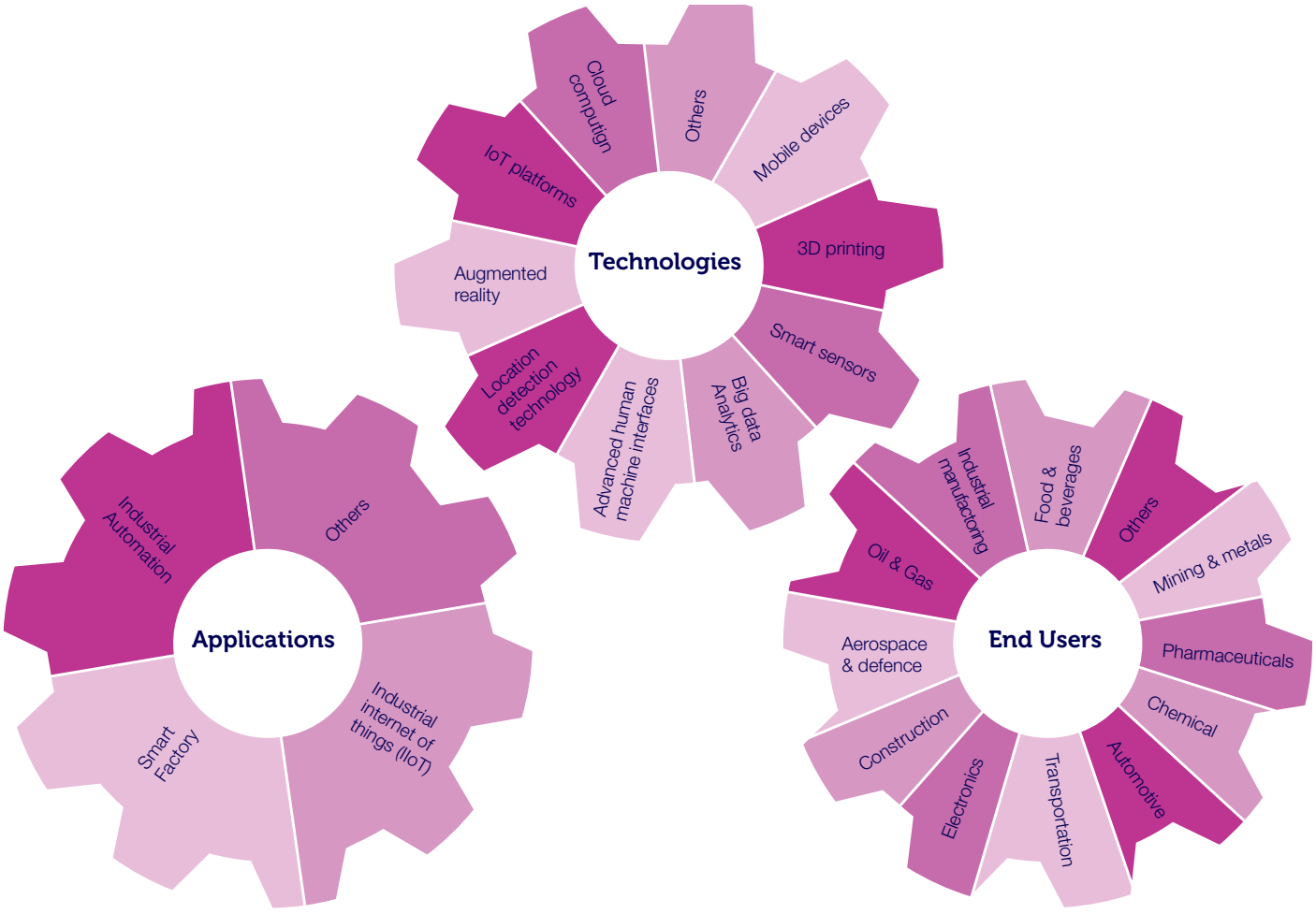

Figure 3. Essential components of Industry 4.0

Australia's 'high potential' as a future producer

Most manufacturers in Australia have the potential to adopt and develop advanced technologies. Currently, 54% of the research and development expenditure of the manufacturing sector has been driven by just 5% of the firms.[9] However, the latent potential for this country's industries to leverage emerging technologies to advance and grow their operations has been identified and reported in the international arena.

The World Economic Forum's (WEF) Readiness for the Future of Production Report 2018 [10] does not include Australia among the 25 'Leading countries' that have both a strong existing production base and exhibit a high level of readiness for the future. Leading countries include the United States (US), the United Kingdom, China, Japan, Germany, France and Korea. Australia is, however, named in the report as being among several 'High-Potential countries' – those nations with a limited production base today that score well for having the necessary 'drivers of production'.

Australia has the weakest 'Structure of Production' among G20 countries and ranks 61st globally. Our manufacturing sector contributes less than 7% to national gross domestic product (GDP). However, the WEF report states that Australia is in a strong position to potentially improve its production base in future and cites our signed I4.0 agreement with Germany and the Australian Government's forward-thinking strategies as positive signs.

High-volume manufacturing is increasingly becoming the domain of countries such as China, the US and Japan. The opportunity for Australian companies lies in focussing on low-volume but highly customised products delivered using advanced manufacturing techniques. This high-quality, smart and agile manufacturing is where Australia's highest potential lies.[10]

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As the vast majority of Australian manufacturers are SMEs, these companies are well placed to leverage this potential, with the assistance of I4.0 technologies. According to a study conducted by the Australian Industry Group (Ai Group),[11] small- and medium-sized manufacturing companies account for 87% and 12% (by number) of employing manufacturers in Australia. Only 1% of hiring companies in this country are considered to be large enterprises.[11] SMEs therefore have a vital role to play in Australia's economic growth and their market competitiveness and future prosperity must be safe-guarded by the timely development of I4.0 capabilities.

Federal government incentives and programs designed to help Australian industry realise this potential are opening up many opportunities for local SMEs to join the revolution.

Benefits for SMEs of transitioning to I4.0

Advanced business and manufacturing technologies are becoming more accessible and inexpensive. Taking advantage of them now, even at an entry level, can yield direct bottom-line benefits and pave the way for higher returns as a business's level of data maturity grows (Fig. 4).

For low profit margin manufacturing operations in particular, staying agile and with or ahead of 'the game' is crucial. The potential impacts of incrementally increasing the efficiency of mechanical and human resources, cutting costs and reducing waste cannot be understated. The scope for transformation within an individual business's operations poses significant challenges and opportunities for value creation across four critical, linked areas shown in Table 1 together with examples of the potential benefits of I4.0 technologies. These four areas represent several sub-areas, including stakeholders, product and service providers, third-party consultants, employees, and customers.

Business Area	Benefits from I4.0 technologies
Customer solutions	• Improved customer information, communication, tracking and reporting. • More transparent and resilient customer relationships. • Predictive and pre-emptive customer service and market development practices. • Capacity for sharing real-time order status updates with customers. • Greater agility to react quickly and precisely to dynamic market requirements, e.g. developing new, responsive products and bringing them to market much faster. • Cost-savings passed on to customers can increase market share. • Improved lead generation, quoting and conversion rates.
Operations	• Real-time monitoring and reporting on operation of production lines and machines. • Less need for human intervention in production line. • Less production stoppages and downtime. • Increased machine operator efficiency (MOE). • Less wastage of materials, time and money across the entire value chain. • Better timed and targeted predictive maintenance. • Accelerated adaptation capacity, e.g. able to quickly introduce new products and production modalities. • Increased overall profit margin. • The ability to accomplish more with less.
Technology	• Improved connectivity and consistency in data sourced from a mix of 2.0–4.0 production equipment. • Agile, flexible, responsive systems. • Securely storing large volumes of data to the cloud for aggregation, visualisation and dissemination. • Real-time, interactive visual dashboards to support informed and faster decision-making. • Vastly improved transparency across the entire value chain. • Revealing and addressing 'hidden' issues and costs from out-dated legacy technology and practices.
People	• Real-time monitoring and reporting on critical organisational and management performance indicators. • Decentralised and faster decision-making processes. • Automating routine, time- and labour-intensive tasks. • Meaningful employee performance metrics and dashboards. • Increased staff efficiency and productivity (including MOE). • Little or no need for manually compiled internal reports and updates.

Table 1: Potential benefits of I4.0 across four critical areas within a business

As Figure 4 indicates, the further along the I4.0 journey a business travels, the greater the value generated. Thus, it follows that the faster a business moves along an implementation path, the sooner the higher returns on the capital investment will start to flow. Continuing to steadily increase connectivity, visibility, transparency, predictive capability and adaptability within the business is therefore essential. The level of innovation doesn't need to be radical. A business can develop a strategic, flexible plan and make incremental changes over time.

"... the further along the I4.0 journey a business travels, the greater the value generated."

"The chief economic potential of Industrie 4.0 lies in its ability to accelerate corporate decision-making and adaptation processes."

– Industrie 4.0 Maturity Index, Acatech Study, 2017 [12]

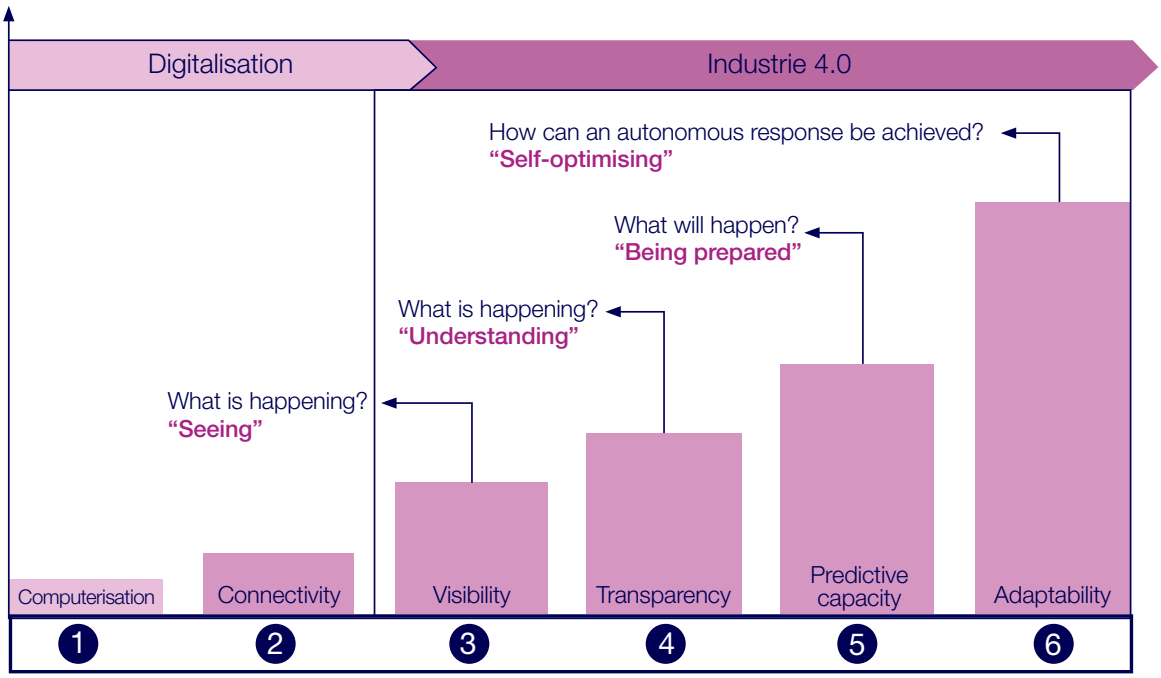
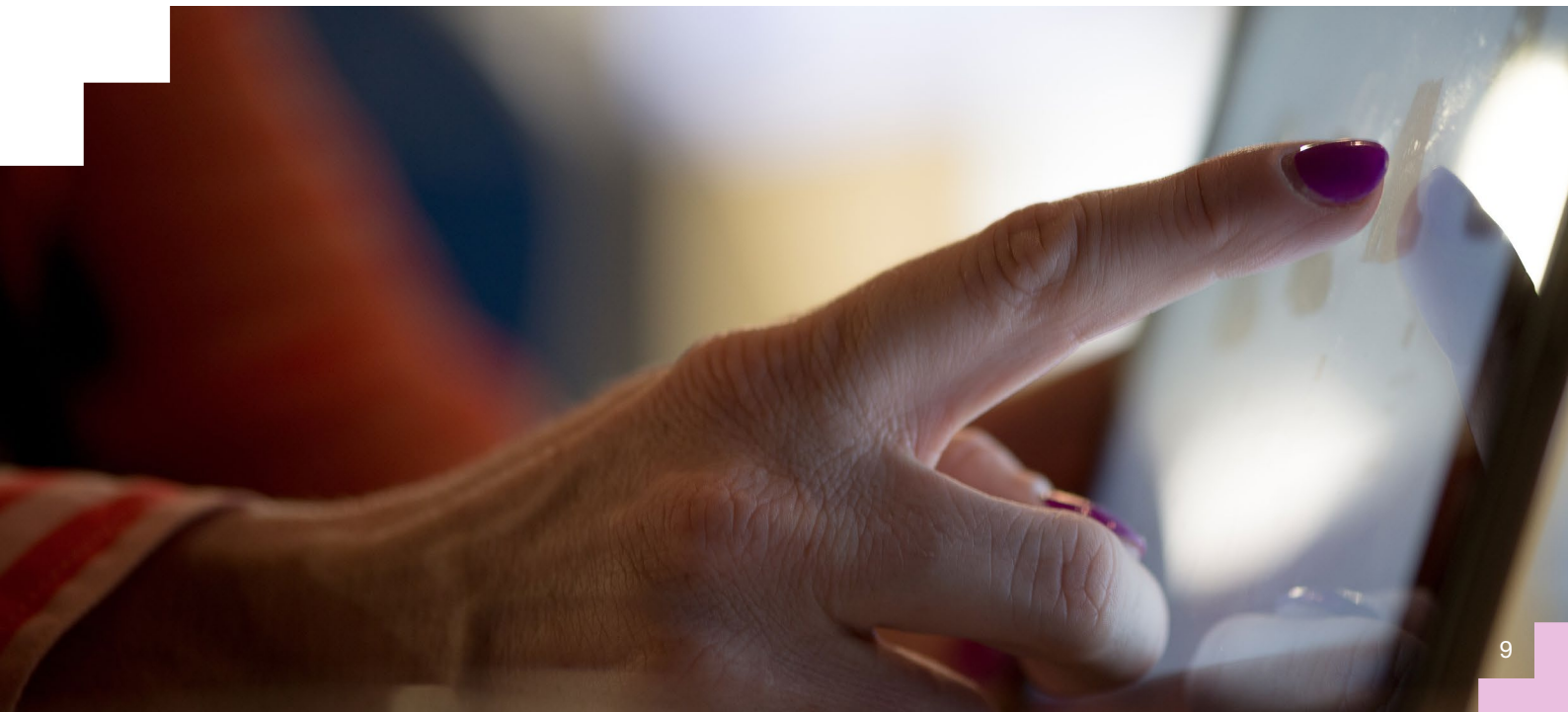


Figure 4. Stages in the I4.0 development path. Source: Industrie 4.0 Maturity Index, Acatech Study (2017)[12]

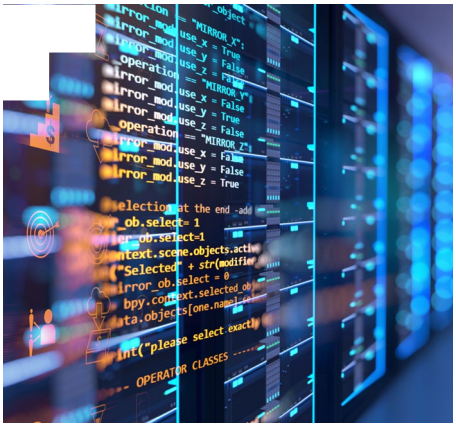


Issues and barriers slowing adoption of I4.0

Four common issues for Australian SMEs

RMIT's in-depth interviews and engagement with senior representatives from several Australian advanced manufacturing companies identified four common issues that their companies have encountered while endeavouring to implement I4.0 solutions.

Issue 1: Acquiring the most relevant data



A common issue for each business embarking on its I4.0 journey is knowing exactly what data they need to capture and why, and then working out how to obtain and transfer that data from the physical world into the virtual world.

Given the overwhelming volume of potential data available, the first critical step is to decide exactly what information to target with smart systems and then develop solutions for 'cherry picking' only that information. This means deciding which data will be the most useful for developing strategic operational transparency and, ultimately, positively impacting the company's bottom line. A system engineer therefore requires a deep understanding of the specific business they work in or with, its strategic objectives and the key performance indicators for each member of the management team in order to design the most beneficial and cost-effective data acquisition system.

Representatives from Bosch mentioned that when they customise an I4.0 system for a client, they invite representatives from all departments of the business, including sales, to be involved in identifying their priority KPIs, so Bosch's team can consider the most direct mechanisms for obtaining the most relevant data.

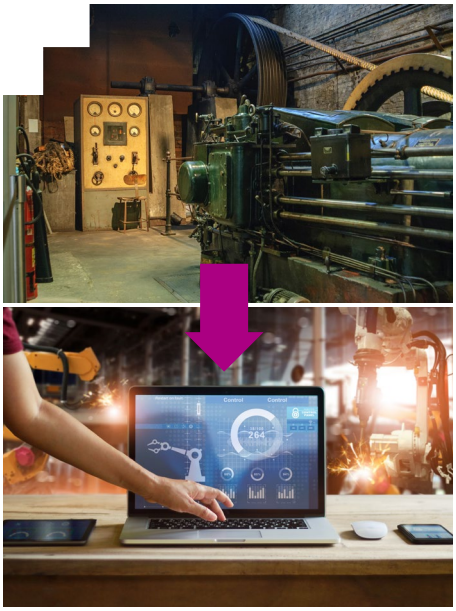
Once the specific data requirements have been determined, the next challenge is usually how to extract it from the factory floor. This can be a major headache for industries running a combination of legacy machinery from Industry 2.0 and 3.0, as well as 4.0 technology. Problems include difficulties tapping data out from machines or processes that have no connection ability, and managing signal conversions and translations.

All the interviewees agreed that achieving the "last-mile" connectivity is often the most challenging aspect of implementing and integrating I4.0 systems. To help address this issue, instrument manufacturers, Bosch and Romar are proactively developing cost-effective connectivity modules for their previous and current models.

All the interviewees agreed that achieving the "last-mile" connectivity is often the most challenging aspect of implementing and integrating I4.0 systems.

Once data have been retrieved from the physical world, they can be collected via different wired or wireless communication systems. Apart from integrated solutions provided by major I4.0 infrastructure providers, data acquisition systems can be developed in-house with open-source hardware and software. At Sutton Tools, a cost-effective data acquisition solution based on XBee wireless modules (~AUD $30 per node) was developed to digitalise their I2.0 machines (pictured opposite, top left). Their system demonstrates that the development cost and time can be largely reduced by utilising existing sensors in the machines. For an average SME, the major barriers could involve signal conversion (mechanical/electrical) and translations (formats/standards).

Issue 2: Integrating systems for better-aggregated data



All the advanced manufacturing SMEs interviewed during RMIT's research had multiple factories and/or warehouses. As mentioned under Issue 1, some were experiencing challenges associated with extracting consistent and comparable data from a mix of legacy and state-of-the art production machinery.

Inconsistencies in the language used and data generated by different generations and types of equipment can lead to costly misinterpretations and missed opportunities for improving efficiency. Enabling different generations of machines to communicate effectively with each other and generate data able to be quickly and easily aggregated is essential.

The selection of appropriate communication technologies is heavily dependent on the application scenarios, including communication ranges, noise and interference levels, energy consumption, data throughput and cost. Some commonly adopted standards are:

- BLE/Zigbee – low power, low cost, small form factor
- WiFi – high throughput, easy to manage
- LoRa/Sigfox – mid-range coverage, noise immunity, low cost
- NB-IoT – long-range coverage
- MQTT and OPC UA - data protocols

Compatibility issues often arise when systems with different protocols and data representations are integrated together. The issue becomes more complicated when proprietary systems or formats are involved. A lot of companies or system integrators try to alleviate the issue by acquiring systems from the same supplier. However, such an approach can lock them in to using a single supplier. The trouble-shooting process often does not involve advanced technologies, however it is time-consuming and requires cross-disciplinary knowledge. It can be difficult to find engineers who have all the necessary skillsets.

I4.0 technologies can add value to products by encouraging information exchanges among parties along the value chain. For example, Hofmann Engineering has installed cameras in its facilities to stream live videos to selected customers so they can monitor progress on the production floor (pictured below). Another company is rolling out a fully integrated online system that enables its customers to monitor the progress of their orders. However, the market still lacks other innovative business cases for industries to make good use of the exchanged data.

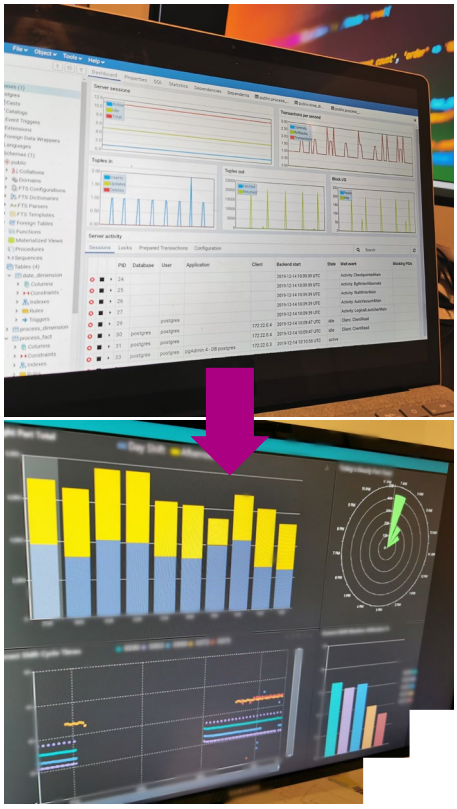
Source: Photo provided by Hofmann Engineering

Issue 3: Visualising the data

The digitalisation process in I4.0 can generate massive volumes of high dimensional structured (tabular) and unstructured (text/voice/video) data. Another common challenge therefore facing businesses is how to present this data visually in ways that provide the most pertinent and useful information to different people depending on their needs.

Providing meaningful visual data in real time increases operational transparency and enables faster, decentralised decision making and adaptation. The greatest benefits come when data and data analyses are made visible across the whole enterprise, from the sales team to the operations team to top management.

Most of the industries interviewed are aware of the need for efficient tools to process such vast and complex data in real-time. While most of them use interactive visual dashboards to present all their figures and graphs regularly, they are looking for more intuitive data visualisation techniques to represent the data in more meaningful ways. For example, instead of showing the downtime of a machine in terms of time, it is more useful to represent the loss in terms of money.



Examples of a database (top) and a visual dashboard (bottom) customised for Australian advanced manufacturing firms by RMIT students using open-sourced software packages.

At the moment, I4.0 studies lack business cases for industries that are not machine intensive, and visualisation tools for businesses that do not use CAD/CAM drawings. And although AR and VR often appear as buzzwords in I4.0 pamphlets, surprisingly, none of the participating industries is using them in their day-to-day business. (Apparently, compelling AR and VR applications for the business world are yet to be developed or utilised.)

Issue 4: Extracting more value from the data

Many businesses in the early stages of implementing I4.0 systems are analysing the data generated at relatively superficial levels. Machine learning (ML) is one way deeper insights can be extracted from data collected from the factory floor. Data are often correlated with product quality, productivity, utilisation and the health of the machines. However, the issues and interrelationships are often hidden and highly nonlinear, and best revealed via ML.

Many businesses in the early stages of implementing I4.0 systems are analysing the data generated at relatively superficial levels.

Defects in production processes can be identified in their early stages using ML methods, thereby increasing yield rates. Predictive maintenance can be carried out to reduce machine downtime. Among the interviewed industries, Bosch is one organisation that is actively developing ML-based methods for its machines and I4.0 solutions. Other participating companies are investigating applicable ML scenarios.

The Sutton Tools case study in this paper is a practical example of how sophisticated analysis of raw production data can identify hidden issues and inconsistencies and reveal new applications for the data. During one university semester, more than 100 RMIT Master of Business Information Technology students were tasked with analysing the company's production data. They identified a number of opportunities for improvement, including the predictive maintenance of specific machines.

Other barriers to implementing I4.0

Lack of understanding of I4.0

The expectations for what I4.0 can eventually deliver are significant, however a lack of real understanding of the concepts and potential benefits involved is a key barrier to adoption. A recent report from by PwC (Australia) indicates that many companies are expecting to have revenue increases and higher operational efficiency with the adoption of I4.0 technologies, however, 37% of respondents said they still don't have a strong understanding of I4.0.[2]

A company should have a good understanding of the capabilities,limitations and drawbacks of a technology before introducing it into its day-to-day operations.[14] A lack of understanding also contributes to personnel generating too many ideas and options for getting involved in I4.0, rather than taking time to fully investigate the company's specific needs and develop a strategic implementation plan.

Low buy-in from top management

Many company owners and executives remain unconvinced of the benefits of I4.0 and instead view it as a costly undertaking for a low and/or slow return on investment (ROI). As a result, they are not prioritising it in their businesses.

Limited solutions tailored to the needs of SMEs

Decision makers in Australian SMEs are becoming increasingly hungry for strategic guidance around the 'what' and 'how' of getting on board the I4.0 movement and who to turn to for help. Existing I4.0 solutions are mainly designed for global or national businesses, which are more likely to have the capital to invest in the necessary infrastructure. Many academic studies focus on large enterprises and technologies that may not be able to bring a short-term ROI. The options available for SMEs to fully embrace I4.0 and its corresponding benefits are still relatively unclear.

Data security concerns

All the companies interviewed are highly aware of and prioritising data security and integrity in their systems. For companies involved in defence projects, military-grade security measures have been adopted. As one of the business owners interviewed explained, his intellectual property and the associated data are the livelihood of his business.

This means they are naturally wary of potential risks associated with the integrity of cloud-based storage options. These concerns are exacerbated by the lack of in-house IT professionals in some SMEs. Lack of internal IT and research and development capability can also constrain a business's ability to plan and implement cost-effective solutions.

All the companies interviewed are highly aware of and prioritising data security and integrity in their systems.

Further insights for Australian SMEs

Key requisites for success

The most essential ingredients for mastering I4.0 include:

- the commitment of top management
- a deep understanding of one's own business, and the potential and desired level of transformation, and
- having a clear implementation strategy.[15]

Get crystal clear on what data you actually need

Before investing in I4.0 solutions, a business needs to develop a specific understanding of which data is most essential to capture, who within their organisation will use it, and how that data can be presented to these people in meaningful ways that meet their needs.

It is often difficult for end-users of data within a business to easily provide a list of data most relevant to their tasks. A more practical way is to first gather data that have been already digitalised and stored in the database, process them, and present them to the employees. The data can be presented via interactive dashboards, which are ordinary monitors hooked up with embedded computers. Both can be acquired and set up at low-cost.

The real-time data will provide individuals and teams with rapid insights into how their performance can impact on the overall productivity of the organisation. More importantly, dashboard systems allow employees to realise what data and information are crucial for them to be more efficient. Their feedback after being exposed to the available data will allow system integrators to pinpoint the types of sensors to be installed and design their installation locations in a sensible way.

For example, to monitor the productivity of a machine, it will be more cost-effective to count the number of parts it produces over time rather than measuring its vibration. It can be done with low-cost proximity sensors and inexpensive controller boards like Arduino and Raspberry Pi. The latter option can be configured with OpenPLC such that the whole setup can be easily ported to PLC modules when needed.

As the above internal process is continually repeated, new data will keep enriching the digital twin model of the specific business's manufacturing process and make the model more accurate. At the same time, the model allows operators to have a better understanding of the system and identify new relevant data to be included and generate new business cases out of them. Continuing from the previous example, instead of measuring productivity, vibration information can be useful for predictive maintenance. Prediction can be done with conventional statistical computer programs or via artificial intelligence (AI) software toolboxes. Both commercial and open-source options are available.

Before investing in I4.0 solutions, a business needs to develop a specific understanding of which data is most essential to capture, who within their organisation will use it, and how that data can be presented to these people in meaningful ways that meet their needs.

Start now and move forward incrementally

Some companies reported that, although they are interested in digitalisation and adopting the I4.0 framework into their business, they are still exploring the most effective ways to capture, present and use the data collected, and at this point in time are uncertain about how to proceed. Some have put their implementation plans on hold until there is greater clarity around these questions.

Taking a business from I3.0 to I4.0 doesn't have to happen overnight; think of it as a journey rather than a sprint. However, there is still a need for timely action, particularly if competitors are already gearing up and introducing I4.0 technologies. The I4.0 express train is leaving the platform and playing catch up if left behind could be costly. It is important to be on that train and to keep moving forward as quickly and strategically as possible.

Develop an I4.0-savvy workforce

Investing in technology and infrastructure is only one component of the I4.0 equation. The other component is developing the right internal capability by hiring people with up-to-date I4.0 knowledge and skills, as well as upskilling the existing workforce. Recent university graduates, who are likely to be well-versed in the latest technological advancements, can be valuable assets in this respect. Partnering with a reputable research and training organisation that has a strong track-record in the cross-disciplinary fields contributing to I4.0 technologies, will also give a business access to the latest skills development opportunities.

> **We've taken on a lot of graduates – it's one way we can stay ahead of the game.**
>
> **When it comes to maintaining a competitive advantage, it's important to keep up to date and track the right competencies into the business by being an employer of choice for the next generation.**
>
> **The best way to do that is to partner with universities so we can work with the next generation of engineers, mechatronics specialists and so on.**
>
> – Rodney O'Brien, Manufacturing Operations Manager, Asahi Beverages

Involve key stakeholders in the journey early

Important internal stakeholders, such as a senior IT professional (if there is one), need to be engaged and involved in production-related I4.0 projects earlier than they may have been required in an I3.0 environment. Involving IT expertise from the outset will minimise the risk of making unnecessary mistakes that cost time and money.

Similarly, engaging with the sales and distribution teams, external suppliers and other stakeholders along the entire value chain will mitigate risks and increase the likelihood of making sound planning and investment decisions.

Asahi Beverages: A low-cost, smart-tech solution to existing equipment

> For us, Industry 4.0 is about how we use our control network and our systems to access the Internet of Things and expedite value. It's all about extracting value, and there's no value in having an operator standing there observing a machine.
>
> – Rodney O'Brien, Asahi Beverages

Asahi Beverages is a leading beverage company employing more than 2,300 people across operations in Australia and New Zealand. The company is part of the Japanese-owned Asahi Group and produces an extensive range of alcohol and non-alcohol drinks, including iconic brands such as Asahi Super Dry, Schweppes, Pepsi, Solo, Peroni, Gatorade, Cottee's and Cool Ridge.

Managers in Asahi's Melbourne production plant acknowledge that Industry 4.0 poses both challenges and opportunities for the business and have been exploring ways to not only survive but to thrive, by embracing the benefits digitalisation can offer. With a lean mindset, they are continually making incremental changes as well as achieving breakthrough improvements to their existing systems and equipment.

The improvement opportunity

Asahi's business involves high-paced, fast-volume manufacturing, with the resulting need to extract the greatest possible efficiency from their production lines. To increase the efficiency of their equipment they need to avoid or reduce the impact of unplanned stoppages.

The integrated production line runs on one belt, and thus any interruption will stop the whole production unit from running. The risks of stoppages are increased when line operators have to feed raw material to the machinery, which can be quite common in a system relying on a combination of legacy and I4.0 machines.

Four undergraduate students from RMIT's Bachelor of Engineering (Honours) program visited the Asahi production plant in 2019 as part of their final-year capstone project. They studied the plant's operation to identify opportunities for improving efficiency through strategic, low-cost I4.0 solutions. They observed that, although the production line uses advanced automation, some sections still require human intervention to feed in raw materials. For example:

- the packaging conveyor requires a new stack of cardboard sheets to be fed into the process at frequent intervals
- an adhesive container regularly needs to be refilled with glue granulates, and
- a label sticker roll needs to be replaced once each roll has been exhausted.

The lack of real-time digital monitoring meant that Asahi's line operators had to constantly stay close to the conveyor to check the changing levels of each raw component and feed them into the line when necessary. This was taking up a large proportion of the operators' time and preventing them from performing tasks elsewhere.

A low-cost Industry 4.0 solution

The RMIT team visited Asahi on three more occasions to discuss and work out potential solutions with senior members of the company's manufacturing team. Working collaboratively, they designed a low-cost solution that provides Asahi with a long-term Industry 4.0 system using proximity sensors and programmable logic controllers to continually monitor the remaining levels of consumables and alert the machine operators when each element needs to be replenished.

Once integrated with Asahi's existing production line, the system will provide real-time information that allows the operators to plan, prioritise and coordinate their time between different workstations and decrease unnecessary walking and manual monitoring time. The production line will ultimately benefit from lesser machine downtime and a higher level of machine operator efficiency.

Asahi Beverage's Melbourne production line. RMIT students identified smart opportunities to improve machine operator efficiency by reducing the need to constantly monitor levels of raw materials being fed into the line.

Sutton Tools: Leveraging Industry 4.0 to create business value

Sutton Tools is a traditional manufacturer of drills, taps and endmills for the consumer, trade and industry markets. The business has always invested in the latest technologies and aims to use best practice where practicable, not only in manufacturing but in all its processes. To that end, in recent years Sutton Tools has piloted low cost digitalisation systems for factory visualisation in its plants in Australia and New Zealand.

The improvement opportunity

Sutton Tools wanted to better understand the potential return to the business of adopting more advanced Industry 4.0 systems and to investigate how to maximise that return. Accelerated corporate decision making and adaptation are among the widely reported benefits of I4.0, however Sutton Tools management wanted to know what those outcomes would look like in an Australian context and how the business could realise that potential.

The company partnered with RMIT during 2019 to draw on the collective knowledge and ideas of more than 100 Master of Business Information Technology students. The aim of the project was to explore how Sutton Tools could scale up the company's existing Industry 4.0 pilot systems and generate greater value that impacts the company's bottom line.

The students observed operations at Sutton Tools' Melbourne manufacturing plant, consulted with the company's Technology Manager Dr Steve Dowey (who is an RMIT Industry Research Fellow), and were given six month's worth of data to analyse. The project gave the students an opportunity to relate the broad and complex concepts of I4.0 to a real manufacturing environment.

A suite of solutions to choose from

The students explored a variety of options for increasing Sutton Tools' I4.0 capability and delivering tangible business improvements. At the end of the project, they presented their proposals to company representatives as business cases, making recommendations that could potentially help to enhance decision making, improve on the existing I4.0 system, and create and capture business value. Sutton Tools is investigating the feasibility of implementing the recommendations most aligned with the company's strategic business vision.

> Having access to the collective knowledge and analytical power of such a large group of RMIT students gave us the capacity to generate and evaluate multiple business options simultaneously.

– Dr Steve Dowey, Technology Manager, Sutton Tools

RMIT Master's students inspect Sutton Tool's Melbourne production plant.

Sutton Tools' Technology Manager, Dr Steve Dowey, discusses data visualisation options with colleague, Matthew Holst.

New Touch Industries: Visualising the benefits of Industry 4.0

New Touch Industries (NTi) is a manufacturing company providing advanced laser cutting, folding and fabrication services from two Melbourne locations. With approximately 65 staff, NTi aims to deliver high-quality and timely services to its customers.

To maintain and improve the quality of that service, NTi has been progressively implementing a series of strategic business improvement measures, including introducing highly automated I4.0 machinery. NTi is also exploring state-of-the-art information communication technologies and ways to transform the organisation by expanding its I4.0 capabilities.

The improvement opportunity

In collaboration with RMIT, NTi launched a pilot project in the second half of 2019 to develop a dashboarding system, which would allow transparent and aggregated data to be visualised instantly within the organisation. Displaying data on monitor screens within the warehouse and the back office, meant it could be viewed by the production, management and sales teams in real time. Eventually, the company wants to have a paperless system that allows targeted and integrated real-time data to be provided to each department.

The existing practice is for a staff member to manually prepare information on an Excel spreadsheet and display the document in various locations within the building. The dashboarding system will fully automate this time-consuming activity, providing a direct time efficiency improvement to the business as well as providing timely data to support faster decision making and increase internal agility.

A customised solution

Two master's students from RMIT's Data Science stream interned at NTi for eight weeks in the second half of 2019, as part of a Social Media and Networks Analytics project. The duo worked closely with NTi personnel to understand the business's operating context and the most pressing day-to-day information needs of respective departments. The students proposed a customised dashboarding system that feeds interpreted data to employees related to their interests. The pilot has successfully laid the foundations for the dashboard facility to be implemented and built upon within NTi in future.

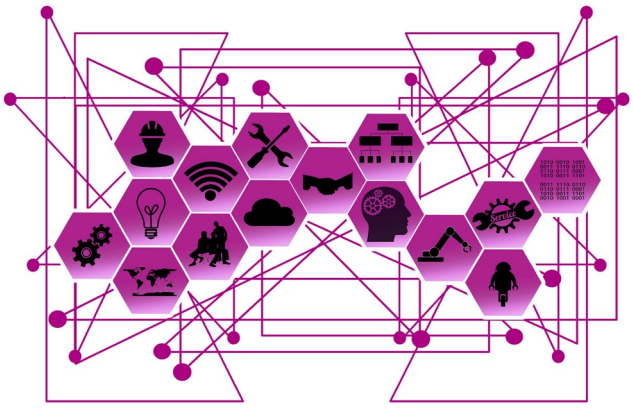
Designing a common digital strategy for SMEs

RMIT's cross-disciplinary expertise gives our people a clear understanding of the digital roadmap to implementing I4.0 and unlocking its potential. RMIT shares this knowledge with our industry partners, as demonstrated in the three case studies provided. Our aim is to help our industry partners to develop and implement cost-effective and efficient solutions.

Using a tailored approach and methodologies, RMIT assisted these businesses to shine a light on the next stages of their respective I4.0 journeys. Implementing the recommended improvements will return many potential benefits, including:

- an automated workflow to increase staff productivity and efficiency
- a reduction in human intervention and labour intensity
- exploring the potential business use cases of I4.0
- improved connectivity and data transparency, and
- faster decision-making processes.

The experience and lessons learnt from RMIT's collaborations with a wide range of industries can be formulated and developed into a common digital strategy, and the transferable knowledge can be easily retained and applied to other businesses in the future.



Conclusion

As RMIT's research findings and continuing field experience indicate, Australian SMEs are well placed to realise their 'high-potential' by riding the global wave of I4.0 transformation rather than being left in its wake. While time, capital and human resources can be extremely tight within many SMEs, these businesses often have the advantage of less decision-making hierarchies and red tape. This makes them nimbler and more capable of responding quickly to new opportunities.

Contrary to existing perceptions, transitioning to I4.0 technologies does not necessarily require major investment. Sure, advanced automation, cognitive computing and robotics are I4.0 technologies, however there are more affordable technologies, such as data analytics, that can return significant value when expertly deployed within a manufacturing enterprise.

Contrary to existing perceptions, transitioning to I4.0 technologies does not necessarily require major investment ... there are more affordable technologies, such as data analytics, that can return significant value when expertly deployed within a manufacturing enterprise.

I4.0 is not a one-off technological solution that can simply be bought off the shelf; it is a journey of continuous, incremental learning and improvement. Provided each business develops a clear and strategic plan to follow, the shift to I4.0 technologies can be implemented progressively; it does not have to be an 'all or nothing' approach. There are many low-cost options and smart solutions available that can deliver immediate benefits and set an SME up to progressively evolve onto a full I4.0 operational platform. The further down the path a business progresses, the more transparent its business operations will become, leading to greater agility, competitiveness and profitability.

Ultimately, it will come down to a case of survival of the fittest. Exactly how far a business travels along the I4.0 implementation path will determine its relative level of fitness.

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Why partner with RMIT university?

Access to cross-disciplinary expertise

In producing this paper, our goal is to offer support to Australian industries by helping them better understand how to introduce the new technologies and practices that will enable them to thrive once the I4.0 revolution is in full force. I4.0 is not a clearly defined set of physical products or services that can be purchased off the shelf. It is a broad and complex topic that requires cross-disciplinary expertise capable of customising solutions that suit the needs of each business.

RMIT has significant applied research and development and educational capability in Advanced Manufacturing, Systems Engineering, Business Information Technology and other fields relevant to developing I4.0 capabilities. RMIT is therefore a major resource for Australian SMEs looking to access cross-disciplinary expertise and state-of-the-art research facilities to help them move confidently into I4.0 territory.

Enabling Capability Platforms

RMIT's cross-disciplinary capacity in I4.0 technologies is harnessed and amplified within our Enabling Capability Platforms (ECPs). Unlike conventional discipline-based research structures, our ECPs connect researchers from multiple disciplines and across RMIT's Schools and Colleges under eight thematic umbrellas. RMIT's I4.0 capability is mainly shared across three ECPs: Advanced Manufacturing and Fabrication, Information and Systems (Engineering), and Global Business Innovation. Expertise from other ECPs is available to contribute to projects as required.

I4.0 is not a clearly defined set of physical products or services that can be purchased off the shelf. It is a broad and complex topic that requires cross-disciplinary expertise capable of customising solutions that suit the needs of each business.

RMIT Enabling Capability Platforms' contribution to Industry 4.0 research activities.

Contribution	Advanced Manufacturing and Fabrication	Advanced Materials	Biomedical and Health Innovation	Design and Creative Practice	Global Business Innovation	Information and Systems (Engineering)	Social Change	Urban Futures
Core	✓				✓	✓		
Strategically Aligned			✓	✓				✓
Contributing as needed		✓					✓	

Low-cost collaboration and solutions

The three case studies in this publication demonstrate some of the ways RMIT is working with individual SMEs and larger companies to investigate areas for improvement, diagnose problems and develop appropriate, cost-effective I4.0 solutions.

RMIT can provide a wide range of support and partnership options depending on the complexity and nature of the industrial issue needing to be addressed. This can include supplying a digitally savvy 'army' of students to brainstorm solutions for businesses, as the Sutton Tools case study illustrates.

Our collaborations with businesses can take the form of:

- short-term projects involving undergraduate students or Master's/PhD researchers
- work integrated learning activities, such as student internships and professional projects
- year-long capstone projects undertaken by final-year undergraduates
- fully or partially sponsored research projects spanning 2–8 years, in which a business co-supervises a master's or PhD researcher.

These longer-term projects may be eligible for government funding and rebates.

Our collective resources can be tapped to help a business:

- identify exactly which data they need and how to extract it
- access no-cost diagnostic support and ingenious low-cost business solutions
- scope and install the appropriate smart sensors and systems onto their machines
- visualise their data by developing interactive dashboards and other ingenious ways of aggregating and representing data
- find ways to make different internal systems talk to each other, and
- access the next generation of engineers, technicians and data analysts to build internal I4.0 capability.

In addition to field-based research, RMIT is also continually improving and expanding our undergraduate and postgraduate courses on I4.0-enabling technologies, particularly in regard to applying them within business contexts.

Tips for effective business-tertiary student research collaborations

RMIT's experience working with many different manufacturers has instilled a practical working knowledge of the key ingredients for successful collaborations. They include:

- Agree and document clear expectations of the project at its commencement, both from the business and from the university/students' perspective.
- Establish clear project parameters with specific deliverables for students to work within while engaged in the project.
- Agree on the communication protocols and code of conduct in relation to how the students and their supervisors will interface with people in the business to obtain information, monitor progress and discuss issues that arise.
- Ensure that the business is in a position and/or willing to share the raw and aggregated data students will need to deliver meaningful outcomes (and that the necessary non-disclosure agreements are in place).
- Ensure there is an agreed issue-resolution procedure.
- Hold regular check-in meetings between student supervisors, students and nominated company representative/s.
- Where possible, involve participating businesses in the selection of students for their projects.

Contact RMIT to partner for a better future

Reach our Research Partnerships and Translation Team on:
research.partnerships@rmit.edu.au

Find further information and examples of our success stories at:
https://www.rmit.edu.au/research/research-expertise/our-focus/enabling-capability-platforms

Insight Series

Demystifying Industry 4.0

Helping SMEs lay the tracks for Australia's digitalisation express train

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