



SINGAPORE

YOUR GLOBAL PARTNER IN MANUFACTURING



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Foreword

Situated off the southern coast of Singapore is one of the world's leading chemical manufacturing sites — Jurong Island. Over 100 global petroleum, petrochemical, and specialty chemical companies are housed on 32 sq. km of land, most of which was reclaimed from the ocean in the 1990s as part of an ambitious move by the government to make Singapore the premier destination in Asia for multinational chemical companies.

It was a bold plan for a country that does not produce a single drop of oil. Today, Singapore is the world's fifth largest refinery export hub¹ and among the top ten global chemical hubs by export volume.²

Innovating to stay ahead of the pack has always been in Singapore's DNA. The small citystate has for a long time embraced challenges and developed innovative solutions to overcome constraints in natural resources, land, and talent.

¹BP World Statistical Review 2017
²World Trade Statistical Review 2017

The Pursuit of Industry 4.0

Anticipating shifts in the evolution of manufacturing, Singapore has embarked on a series of initiatives to ensure that the economy is prepared for the future, such as driving the adoption of advanced manufacturing, or Industry 4.0.

First, Singapore has focused on grooming a deep pool of technical expertise and solutions together with industry-leading companies. Some of the biggest names in the industry — from ABB's Regional Robotics Packaging Application Hub to Siemens' first fully integrated Digitalisation Hub.

Second, the fast-growing startup scene in Singapore provides subject matter expertise to larger companies, offering opportunities for co-innovation. For instance, when German semiconductor giant Infineon was exploring solutions to transport materials across the production floor, it turned to local small and medium-sized enterprise (SME) HOPE Technik, which developed Automated Guided Vehicles (AGVs) for the latter. The partnership was awarded as the most disruptive collaboration between an SME and an MNC at the 2017 Singapore International Chamber of Commerce Awards.

Third, a model factory built by Singapore's research institutes provides companies with a collaborative environment to research and trial technologies before deploying them. Feinmetall, for instance, increased their productivity levels by 10 to 15 per cent through this initiative.

Singapore also recognises the importance of talent development and has developed a series of modular courses in consultation with the industry to help workers acquire skills in

areas such as Internet-of-Things management and robotics coordination, enabling them to assume related roles.

Kickstarting the Journey

The pursuit of advanced manufacturing is not about achieving a one-off boost in productivity but about equipping companies with the right tools and mindset to meet challenges of the future.

In this regard, Singapore has developed the world-first diagnostic tool — The Smart Industry Readiness Index[®] — that allows companies evaluate the current state of their facilities and provides step-by-step guidance to help them transform. The Index aims to catalyse the creation of new businesses and enables Singapore to not only become a champion of Industry 4.0, but also an exporter of innovative ideas and solutions.

Beyond tools such as the Index, Singapore helps companies kickstart their advanced manufacturing journeys by bringing together best practices and facilitating opportunities for co-innovation with technology suppliers. In April 2018, Singapore participated in the world's leading industrial trade fair, Hannover Messe, and will be hosting its Asia-Pacific version this October.

In the following pages, you will read about Singapore's manufacturing story, how several industry players have grown with us, and understand why Singapore is your best partner for Industry 4.0 success.

Join us in shaping the future of manufacturing!

Mr Lim Kok Kiang
Assistant Managing Director
Singapore Economic Development Board

Making a World-Class Impression at Hannover Messe 2018



In April 2018, Singapore showcased its manufacturing story at the world's leading industrial trade show, Hannover Messe.

This year's event, which took place in Germany in April, attracted more than 250,000 visitors from all over the world. About 6,500 exhibitors showcased their latest advanced manufacturing products and solutions.

The country booth told the story of Singapore's long-standing relationship with manufacturing, its strong commitment to research and development, and its focus on developing a strong talent pool – factors that have catalysed the Industry 4.0 journeys of manufacturers based in the country.



On display: Singapore as a world-class manufacturing hub

“Our significant presence at Hannover Messe of Singapore demonstrates our companies’ interest and commitment to forge deeper partnerships with their German counterparts.”

A key highlight at the booth was also The Smart Industry Readiness Index®. The Index, a world-first Industry 4.0 diagnostic tool, was pioneered by the Singapore Government to aid companies in better understanding Industry 4.0 concepts, evaluate their current state of facilities, and architect a comprehensive transformation plan for sustainable growth.

Alongside these factors, Singapore's vibrant ecosystem of technology suppliers and adopters makes it the hub of choice for companies seeking manufacturing solutions for the rapidly growing Asian markets.

Mr Bernd Gienger, Head of Market Management in South-East Asia for Festo, a German automation technology firm that also exhibited at the event, said, “Singaporeans are very open to new technologies. And in that sense, we find a lot of people who are well educated, in science, in mathematics, and that is brilliant.”

Besides Singapore's country booth, some 19 local companies, ranging from larger corporations such as Singapore Technologies Kinetics to small and medium-sized enterprises (SMEs) like Onn Wah Precision Manufacturing, also exhibited their advanced manufacturing products and services. For these

exhibitors, the event was a platform to observe and learn best practices from top names in the business.

The Germany–Singapore Connection

Singapore and Germany share exceptionally strong bilateral trade links. Germany is Singapore's largest trading partner in Europe while Singapore is Germany's biggest trading partner in the Association of South-East Asia Nations (ASEAN). There are currently more than 1,700 German companies in Singapore.

Speaking at the Germany-Singapore Business Forum (GSBF) held at Hannover Messe, Minister for Trade and Industry, Mr S Iswaran, said, “Our significant presence at Hannover Messe of Singapore demonstrates our companies’ interest and commitment to forge deeper partnerships with their German counterparts.”

The GSBF also saw the signing of three new Memorandums of Understanding (MOU) between Singapore and Germany, aimed at strengthening economic ties and partnerships between the two countries.



New agreements were inked during the Germany-Singapore Business Forum (GSBF), to enhance cross-country partnerships and co-innovation between German and Singapore companies

One of the key MOUs signed was between Enterprise Singapore and German Accelerator programmes, which uses accelerator programmes to help high potential German startups enter the South-East Asia (SEA) market. The new MOU will enable improved market access for startups from both countries, and boost Singapore as an ideal regional launchpad to SEA for global startups. Importantly, this new partnership will allow greater collaboration between Singapore and Germany on innovation, knowledge exchange, and sharing of business best practices.

“Like Germany, Singapore places great emphasis on innovation. Our complementary strengths make it meaningful for German and Singaporean enterprises to be innovation partners and build deeper technical capabilities,” added Minister Iswaran.

Hosting the Inaugural Asia-Pacific Version of Hannover Messe

In October 2018, Hannover Messe landed in Asia. Called the Industrial Transformation Asia-Pacific (ITAP), the trade show will be held in Singapore for three years, starting from 2018.

A testament of Singapore being the region's premier location for Industry 4.0 success, ITAP provides a platform for leading manufacturers and technology suppliers to converge and showcase best practices in Asia for global adoption, and presents opportunities for co-innovation.

According to Mr Lim Kok Kiang, Assistant Managing Director, Singapore Economic Development Board, “Industrial Transformation ASIA-PACIFIC (ITAP) reinforces Singapore's position as a leading manufacturing hub as well as a gateway to Asia, where there is growing interest in the adoption of the latest technologies and solutions to enhance competitiveness.”

Singapore's Manufacturing Story



Singapore's manufacturing story begins with a shift towards export-led industrialisation in 1965. To grow a manufacturing sector, the government developed industrial land, built infrastructure, reformed labour laws, and invested in technical education.

1965



Singapore embarks on large-scale industrialisation, with factories producing items such as matches, fish hooks, mosquito coils, and televisions.

1969

Texas Instruments opens its first plant in Singapore, marking the rise of a robust electronics manufacturing industry.



1972



Beecham Pharmaceuticals' (now part of GlaxoSmithKline) amoxicillin production plant is Singapore's first foray into pharmaceutical manufacturing.

1973

Hewlett-Packard produces the first pocket calculator in Singapore.

1974

Sundstrand (now Hamilton Sundstrand) commits to building a 6,968m² aircraft equipment parts plant – Singapore's first major investment in aerospace.



1982

GlaxoSmithKline produces its first anti-ulcer drug in Singapore, a billion-dollar-a-year product.

Seagate anchors its disk drive manufacturing in Singapore.

Did you know?

In the 1990s, Singapore was the world's leading producer of hard disk drives, accounting for about 35% of global output.

1988



Apple Computer establishes a S\$25 million (US\$12 million) facility to manufacture Mac computers in Singapore.

The first petrochemicals complex in Southeast Asia is established, comprising Petrochemical Corporation of Singapore, Phillips Petroleum Singapore Chemicals, Polyolefin Company, Denka Singapore, and Ethylene Glycols. The S\$2 billion (US\$940 million) complex marks the rise of the chemicals industry in Singapore.

1984



1996



"[T]he fundamental strategy of tripartism will remain constant. This synergistic relationship between labour, business, and government has served Singapore well. It will help us to adapt and re-adapt ourselves year after year" – then-DPM Brigadier General Lee Hsien Loong on tripartism's longstanding contribution to Singapore's progress through policies and initiatives that benefit both the economy and the workforce.

1995

To further develop the energy and chemicals industry, land is reclaimed to form Jurong Island, expanding its size from 10km² to 32km².

Did you know?

By the end of 2010, almost 100 chemical and petrochemical companies had invested over S\$30 billion (US\$21 billion) in fixed assets on Jurong Island.



2006

Edward Lifesciences opens its Asia-Pacific headquarters and the first Asian heart valve therapy manufacturing plant.

2010

Rolls-Royce builds a facility to house a Trent aero engine assembly and test facility, a Wide Chord Fan Blade manufacturing facility, and an advanced technology centre.

2016



Micron Technology opens its new, expanded NAND flash memory fabrication facility in Singapore. The S\$5.4 billion (US\$4 billion) investment makes Singapore the location for Micron's worldwide manufacturing base and NAND Center of Excellence, driving the production of cutting-edge 3D NAND.

Manufacturing has been the engine of Singapore's economy since the country's independence in 1965. Today, it accounts for around 20% of the nation's Gross Domestic Product (GDP).

Over the years, Singapore has built a diverse base of industries, occupying leadership positions in the aerospace, semiconductor, chemicals, and biomedical sciences sectors. Today, Singapore's world-class manufacturing ecosystem makes it one of the best places globally for manufacturers to design and execute their global manufacturing strategies.



Ranked 2nd globally in the 2018 World Economic Forum's *Readiness for the Future of Production Report*.¹

2ND



The world's 4th largest exporter of high-tech products.²

4TH



Ranked 5th globally in the *Bloomberg 2018 Innovation Index* for manufacturing value-added.³

5TH

LEADERSHIP IN HIGH-VALUE MANUFACTURING

5TH

ENERGY AND CHEMICALS

Jurong Island is the world's fifth-largest producer of refined oil and ranks among the top 10 globally in terms of chemicals exports by volume.

60%

BIOMEDICAL SCIENCE

60% of the world's micro-arrays and one-third of the world's thermal cyclers and mass spectrometers are manufactured in Singapore. Four out of the top 10 drugs by global revenue are also manufactured in the country.

10%

AEROSPACE

Singapore accounts for about 10% of the global maintenance, repair, and overhaul output.



AHEAD OF THE GAME

A conducive advanced manufacturing ecosystem has given rise to various new innovations and solutions that ensure Singapore continues to strengthen its manufacturing footprint and punch above its weight.



Infineon is embarking on a five-year "Smart Enterprise Program", linking production in Singapore to other sites in real time and automating the assembly line to boost productivity.



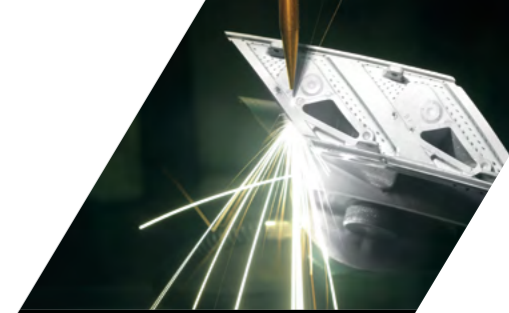
MTQ raises worker productivity by using Automated Welding Machines, which require minimal supervision, instead of the traditional hand-welding process. The company leveraged the Inclusive Growth Programme by NTUC's Employment and Employability Institute to help with this transition in 2012.



To enhance the safety of its operations, Chevron Oronite collaborates with US engineering and technology firm Emerson to install a wireless plant network with mobile tracking devices for employees, saving the company 30,000 man-hours a year.



GE spearheads technology development and advanced research in automation and robotics in its repair facility.



Pepperl+Fuchs' Global Distribution Center in Singapore features an intelligent warehouse management system, and is the world's first facility with an automated storage and retrieval system built above a pallet warehouse.



Dyson makes 13 million motors a year at its Advanced Manufacturing Centre in Singapore. The precision and tolerances required for ultrasonic motors mean that they can only be assembled on robotic lines. The equipment is so precise that it is classified as weapons-grade and requires special export permissions.



¹The World Economic Forum, *Readiness for the Future of Production Report 2018*
²The World Bank Open Data, High-Technology Exports
³Bloomberg 2018 Innovation Index



ENABLING GROWTH WITH SINGAPORE'S MANUFACTURING ECOSYSTEM

By leveraging Singapore's nationwide focus in driving Industry 4.0 adoption, companies based in the country are able to design and execute their strategies to lead this new era in manufacturing where mass customisation — not mass production — is key.

HP Inc. SMARC, a Playground for Engineering and Analytics



Traditional manufacturing systems face a constant dilemma. They excel in either one of two things: efficiency or flexibility.

A factory can produce the same thing repeatedly and find the most resource-efficient way to do it. Or it can produce a highly-customised product using a flexible manufacturing process, but at significantly lower efficiencies.

But the world is changing. According to *Manufacturing Ecosystems*, a 2017 report by Accenture Strategy, consumers of the 21st century have increasingly demanding expectations, desiring “more frequent product launches” and “extreme personalisation” from businesses. In other words, they are no longer willing to choose between efficiency and flexibility. Companies at the forefront of manufacturing innovation must develop smart processes that transition from mass production to mass customisation in order to respond to the needs of this new generation.

HP's manufacturing solutions are leading this new era in manufacturing. Its *Jet Fusion 3D* printer gives precise control — from the production of parts, to the voxel level (3D pixel) — and allows users to quickly create cost-efficient prototypes, or samples, of designs in small quantities.

According to HP's internal tests, customisable physical parts that are of superior quality can be produced at up to 10 times the speed and at half the cost. Global titans like Nike, BMW, Jabil, and Johnson & Johnson are just some of the companies that are already users of this platform.

Doing SMARC Manufacturing with Data Analytics

In the smart manufacturing landscape, 3D printing is just the tip of the iceberg. In December 2017, HP Singapore opened the Smart Manufacturing Applications and Research Centre (SMARC), an “engineering playground” for HP's technical staff to “experience, trial, and prototype” solutions, according to Ms Jamie Neo, HP's Director of Operations for Supplies, whose initiative led to the creation of SMARC.

Elements of this playfulness are scattered throughout the 550 sq.m facility. The labs have single-word verbs for names, such as “Think”, “Build” and “Sense”. In the Move Lab, which explores the potential of cyber-physical integration, a sleek white single-armed collaborative robot (cobot) brews a cup of coffee, as an autonomous intelligent vehicle (AIV), a rectangular-shaped tray on wheels, roams the room inquisitively, careful to stop in front of obstacles — such as the feet of visitors — that were in its path. Nearby, a live map of the room represented how the AIV “saw” its surroundings, with symbols for feet shifting in accordance with the movements of visitors.

HP Inc.'s mission centres around the drive to “keep reinventing”, and to “engineer experiences that amaze”. And it was this creative freedom

“In recent years, with volumes of data outstripping the capacity of manual analysis, computers becoming more powerful, networking ubiquitous and algorithms developed that can connect data-sets to enable broader and deeper analysis — we can make the data work harder”

that motivated Ms Neo's idea for SMARC. “I realised that we could use Big Data in manufacturing too”, she said, “[and] started the journey within the business to use data analytics in manufacturing and Industrial IoT to derive meaningful algorithms and insights for manufacturing”.

In Singapore since 1970, HP's strength has always been in the fundamentals of engineering. But what Ms Neo realised was that these fundamentals can be augmented and improved by data-driven analyses and smart processes. “In recent years, with volumes of data outstripping the capacity of manual analysis, computers becoming more powerful, networking ubiquitous and algorithms developed that can connect data-sets to enable broader and deeper analysis — we can make the data work harder”.

One example of this is in the domain of quality control. Most companies use Statistical Process Control, a means of monitoring the output of processes to ensure that they fall within certain statistical boundaries. While traditionally this is done with only one variable at a time, such as the weight of a component or speed of a process, HP has derived algorithms that can meas-

ure and monitor multiple parameters at one go. If the analysis of any of these variables reveals a significant anomaly, HP's system will trigger early warnings and drive corrective action.

Bringing together more than 3,000 innovators and problem solvers from over 35 nations in a single location, HP aims to increase such efficiencies in the entire supplies manufacturing process by adopting Industry 4.0 technologies, with the overall aim of improving productivity by 20 per cent. Apart from the “Move” Lab with the cobots and AIVs, the “Think” Lab focuses on developing tools for data analytics and the “Sense” Lab applies these developments to industrial applications. 3D-related experiments and prototyping happen in the “Build” Lab, with its focus on converging flexibility with efficiency.

An Ecosystem View of Industry 4.0 in Singapore

The decision to open SMARC in Singapore also leverages on the Industry 4.0 transition that the country is undergoing. The transition takes into

account both employers and employees, aiming to equip the workforce with the capability to engage in smart manufacturing processes and enable companies to integrate smart processes into their systems.

For instance, in October 2017, a new set of adult training programmes, under the nation's SkillsFuture series, was launched, offering more than 400 courses across eight areas developed by the Singapore government in collaboration with industry partners. Data Analytics, Tech-Enabled Services, Cybersecurity, and Advanced Manufacturing are just four of the areas that train the Singaporean workforce in skills that are integral to smart factories. These government programmes parallel similar initiatives in the private sector.

HP Singapore has also invested in its local workforce through a range of training initiatives, including the company's "Brain Candy" learning platform and graduate programmes. These training initiatives have enabled their employees to learn new skills relevant to their jobs, in emerging fields such as data analytics and additive manufacturing.

In support of the SkillsFuture movement, HP launched an in-house initiative to certify employees as SkillsFuture Growth Mindset Ambassadors. These Ambassadors will be tasked with promoting lifelong learning throughout the organisation.

In 2017, HP set up a multimillion-dollar Graphics Solutions Service Learning Academy in Sin-

gapore, providing professional development courses in digital printing technologies to over a thousand customers, managers, engineers, and operators across the Asia Pacific and Japan.

On the side of corporations, the Singapore government is pouring S\$450 million (US\$335 million) into the National Robotics Programme, which helps companies adopt robotics to make their work more efficient. Another initiative, the National Additive Manufacturing Innovation Cluster (NAMIC), supports collaboration between leading universities and industry partners with the aim of translating 3D printing techniques into practice.

Transitioning to Industry 4.0 — Not a Lone Endeavour

Such a holistic focus on equipping both corporations and the workforce is crucial to a successful Industry 4.0 transition. As a founding member of Singapore's first Additive Manufacturing Coalition in partnership with NAMIC, HP is acutely aware that an organisation's transition to Industry 4.0 cannot be managed in isolation.

For example, in HP Singapore's case, supplies manufacturing is just one part of the whole production ecosystem, which also includes materials suppliers, equipment vendors, automation and tooling vendors, contract man-

ufacturers, and logistics firms. The full benefits of smart manufacturing and big data are only attainable if the entire ecosystem is on board.

"To transform into a data-driven decision-making organisation, we [need] to digitise the whole value chain, [and] connect the data sets to enable broader and deeper analysis within the ecosystem", Ms Neo said. "The reinvention of our supplies manufacturing processes impacts not just us, but also the wider ecosystem we work with."

With their new engineering playground in place and an ecosystem view in mind, HP is leveraging on the synergies of Singapore's comprehensive transition to Industry 4.0, involving both employers and employees alike, to drive sustainable growth of its whole value chain for years to come.

"By creating better, more efficient ways of working with data analytics, automation, robotics and 3D printing while helping our wider ecosystem participants digitise their business, we are using technology to deliver better experiences and accelerated performance for the future", she said.

STRONG COMMITMENT TO RESEARCH & DEVELOPMENT

Investments in Research and Development are critical to ensure that Singapore remains at the forefront of global innovation. To this end, the Singapore Government has committed S\$3.2 billion (US\$2.4 billion) to foster industry-focused research in Advanced Manufacturing and Engineering. National initiatives such as the National Robotics Programme help partners translate their research into reality. The Model Factory setup within Singapore's research institutes and universities simulate real-life production environments for the testbedding of new manufacturing technologies.

Innovation at Infineon, and Beyond



In about five years, Infineon's backend manufacturing plant in Singapore will be transformed for the information age.

Building on the back of the Industry 4.0 blueprint, the German chipmaker will progressively introduce the latest trends in manufacturing — from a real-time global production network, end-to-end digital integration, manufacturing automation, to smart solutions — in its Singapore facility.

Currently, the company uses autonomous guided vehicles to transport products around the facility and digital factory simulation for new manufacturing concepts analysis. By 2020, robots will be manning the loading, and unloading of the products to/from machines, and data mining will enable the predictive maintenance to be performed.

The smart factory will also digitally integrate the production process, generating precious data that can help boost performance levels further. "Singapore is our choice location as a pilot site as we already have the foundation and cross functional competence in smart manufacturing. We can leverage on a conducive Research and Development (R&D) ecosystem and supportive policies for high value-added manufacturing in Singapore," said Mr Chua Chee Seong, President and Managing Director of Infineon Technologies Asia Pacific.

The pilot is another sign of commitment that marked the company's 48 year-old relationship with Singapore, one which has seen the continual investments that the German company has made in its Singapore operations over the years.

Indeed, when it comes to innovation work, Singapore, which also functions as Infineon's Asia Pacific regional headquarters, is the company's preferred location to carry out innovation activities.

The company has two tracks of innovation. One is endogenous, focused on the continual improvement of processes and operations by using new ideas, tools, and technology. This includes building smart factories and newer, faster, and better semiconductor chips. The numerous patents it has filed is testament to this process.

For the second track, the company actively monitors innovation trends and opportunities in the market, in order to safeguard and harness disruptive forces to their advantage. The company is working with startups engaged in innovation activities.

Smarter Way to Manufacture

Infineon's R&D teams across its global offices follow the same philosophy: Innovation is about everything that creates positive business value.

"It can start as an invention, an alternative or better process, a new product; a new technology, a new business model," said Mr Jerome Tjia, the Senior Director and Head of Development Centre at Infineon Technologies Asia Pacific.

The Singapore Development Centre, a R&D hub for Infineon in the Asia Pacific, looks at several key areas in the chip manufacturing process. For instance, one of the areas is in microelectronics, which focuses on its architecture, design, product,

and test development, among others, said Mr Tjia.

The centre also develops cutting edge and highly complex microcontrollers for the automotive industry. The range of applications includes combustion powertrain, hybrid and electric drives, advanced driver assistance systems (ADAS), and networked cars of the future.

These innovations resulted in numerous patents for the company, some of which are proudly displayed at the company's office lobby.

But more than pride, these innovations bring important incremental improvements to their products.

"In product development, innovation focuses on finding solutions to customer requirements and pain points on the system level. As a result, the innovation should make the customers more successful," said Mr Tjia.

"In product development, innovation focuses on understanding weaknesses, for example, in a customer's system and deriving different means to overcome those weaknesses. As a result, the innovation should help to make the customers more successful"

Looking Out, Innovating Within

While the company's R&D has produced strong results, Infineon is also paying close attention to what is happening on the outside.

According to Mr Rohit Girdhar, Vice President for Strategy, Merger and Acquisition at Infineon Technologies Asia Pacific, the company monitors and deals with potentially disruptive forces in three ways: scan the environment for potential threats, fix the pain points early, and work with startups to develop new solutions that benefit the company.

First, the company wants to keep its focus on trends or issues that are just beyond the horizon or around the corner, to add an additional layer of protection against disruption. It does this by talking to its partners, clients, and customers, said Mr Girdhar.

"We are also looking at innovation which is coming from the markets and customers, from the inputs of external environments, what is needed

tomorrow, what other technology trends, what kind of disruptions are happening", he said.

Second, Infineon ensures that their customers are satisfied by taking a "build-to-order" approach.

"We sit down with our customers and understand where they want to use our products. What matters to them most? What kind of external environment do they want to use our products in? If so, are the products even the best ones for the customer or should we maybe design something else for them? If you think like that, from that angle, then chances of getting disrupted is lower", he said.

"Third, we work with external parties such as research institutions, universities, partners, and startups to create solutions together. This ensures that we continually have access to some of the best ideas that are being generated outside Infineon", Mr Girdhar added.

To facilitate its innovation endeavours, the company had to look for a location in Asia that comes with a thriving ecosystem of top-tier research institutions, large industry players of its kind, and startups that are able to partner them in innovation activities.

The answer was a no-brainer: Singapore.

Singapore: Strong Government Support, IP Regime, and Talent Pool

There are many big advantages that Singapore has over other Asian sites.

Mr Girdhar noticed that the government was open to sandbox experiments, where new technology can be tested in virtual or physical spaces.

Singapore's robust intellectual property (IP) protection is also a key advantage, where its strong policies imbue companies with the confidence to experiment and innovate.

Talent, which is crucial for any kind of innovation research, is also plentiful in the country.

"We are able to get talent from any part of the world and certainly, the best Asian talent."

Lastly, the most commonly cited advantage — Singapore's location — is also one of the most important considerations when it comes to Infineon's innovation activities.

This is because much of their externally-driven innovation relies on partnership and collaborations. And to be able to put a team — comprising an engineer, a researcher, and a startup — togeth-

er quickly is critical, especially in a fast-changing business environment.

"All the different areas we look at are important: Innovation, production, technology, product development, application, customer, and market. Singapore is so well connected; we are really close to the customers and markets in the region. So all this, we are able to drive out of Singapore very effectively", he added.

To facilitate its innovation endeavours, the company had to look for a location in Asia that comes with a thriving ecosystem of top-tier research institutions, large industry players of its kind, and startups that are able to partner them in innovation activities.

The answer was a no-brainer: Singapore.

Attracted by the dense network of manufacturers and robust research, leading technology and solutions providers have established global or regional centres in Singapore. In partnership with lead customers, these centres develop new products, solutions and business models that are exported to the rest of the world.

Accenture and ABB: Propelling Customers into Industry X.0



What if the machinery in your factory can speak? What would it tell you?

It sounds like a chapter out of science fiction, but indeed, assets can actually tell you about their condition and performance.

Working with the industrial manufacturer ABB, Accenture helped build an innovative Industrial Internet of Things solution that generates tangible value for ABB and its customers.

The Rationale

ABB was keen to help customers use the power of the Industrial Internet of Things (IIoT) to translate machinery asset data into actionable insights and needed an interface that could connect the sensor to its customers, helping them better analyse and consume the data.

ABB collaborated with Accenture to develop this innovative solution quickly – just in time for its unveiling at Hannover Messe in 2018.

The Solution

In just a span of six weeks, ABB and Accenture developed the customer journey and mobile application demonstration, all out of the latter's facility in Singapore. The solution has now become a central part of ABB Ability, the company's unified, cross-industry digital capability, and the solution includes the following key components:

“ABB and Accenture developed the customer journey and mobile application demonstration, all out of the latter's facility in Singapore. The solution has now become a central part of ABB Ability, the company's unified, cross-industry digital capability”

Mobile app: Design thinking was applied to maximise the overall user experience. The mobile app serves as an offline-capable IIoT gateway and allows service personnel to commission the sensors and monitor the motors on the shop floor to react quickly in emergencies.

Portal: The portal collects asset data to help ABB customers manage plants, teams, relationships between teams, assets, and organisations. Application Programming Interface (APIs) integrate customers and their service providers into the Smart Sensor portal and cloud ecosystem.

Common sensor platform: Built on Microsoft .NET technology, the common sensor platform integrates three types of sensors with ABB's systems that can continue to scale.

ABB Ability Digital Powertrain platform and dashboard: The platform helps customers monitor large parts of their shop floor and group assets using different sensors. This allows customers to monitor the whole turbine, not just parts of it.

The Result

With its new capabilities, ABB can better compete in a digital world. Improving time to market, differentiating its products, creating new opportunities to provide services, and generating value for customers with actionable insights and a state-of-the-art customer experience, are just some of the benefits:

ABB can gather data from its sensors to benchmark its motors, improving product lines, and saving on manufacturing costs without reducing quality.

By retrofitting sensors onto ABB competitor motors, data that reveal strengths and weaknesses in the equipment can help ABB gain insights into new industry verticals.

Powertrain monitoring encourages customers to use sensors across different types of equipment.

The new tools offer insights to help service providers do their jobs better – an extra benefit that enhances ABB's relationships with their ecosystem partners.

Looking to the Future

The new IIoT capabilities are only the beginning. ABB now has the foundation to apply more advanced analytics that deepen its knowledge about its motors' performance, competitor assets, and customer needs.

Not only can the assets communicate, they can speak volumes. With these data insights, factory managers can monitor their motors' health, status, history, and other details within, across factories, and remotely.

Over time, the insights can help them decide whether to work motors harder to improve production bandwidth, or hold off on routine replacements for motors that still function well. In both cases, these insights help to extend a motor's lifecycle while not disrupting production. ABB's customers benefit as well – service contracts are made more affordable since technicians will only need to be engaged on an as-needed basis.

With the Powertrain dashboard, customers can monitor the condition of whole fleets of assets – not just motors – including bearings, drives, and pumps. This allows management to gain insights into the interdependencies of their assets and how these relationships affect breakdowns. With the condition of their essential equipment at their fingertips, they can focus their attention on decision making and achieving their business goals.

A strong workforce will accelerate the transformation and growth of the manufacturing base. With the advent of Industry 4.0, skillsets must evolve. To help its people remain relevant and to groom a ready supply of talent for the industry, the Singapore Government partnered companies to identify new skills needed across job archetypes, launched nationwide training programmes such as the SkillsFuture Series for Advanced Manufacturing, and leveraged strong tripartite partnerships with unions and the private sector to continually upskill and reskill its workforce.

Singapore's World-Class Talent Powers Dyson's Global Ambitions



British technology firm Dyson makes almost all its digital motors in Singapore and is expanding its presence in the citystate. Mr Scott Maguire, Vice President, Engineering and Operations, Research and Development (R&D), explains why the firm remains bullish about Singapore after more than a decade in the country.

Q: Why did Dyson choose Singapore as its RHQ?

Maguire: It is just over 10 years since we began in Singapore with a small, focused, engineering team. Our task was to develop, and make, the world's first high-speed, digital, electric motor. Today, Dyson has more than 1,000 people working in [our] Technology and Advanced Manufacturing Centres. In 2017, we announced that we would be investing a further S\$587 million (US\$427 million) into our future here. That shows the scale of [our] ambitions in Singapore.

Singapore offers a ready access to world-class engineering and supply chain talent. At our Technology Centre, we have the world's brightest minds working on artificial intelligence, machine learning, robotics, fluid dynamics, vision systems to bring hardware, electronics, and software together. The talent base allows us to develop our digital motor, connected machine, Supersonic hairdryer, and vision system robotics products – all in Singapore. It is critical that we have the right people who understand the data, [are able to] leverage it, and apply the benefits to our supply chain.

Like Singapore, Dyson takes a long-term approach to success. We are continuing a S\$4.5 billion (US\$3.3 billion) investment programme in long-term technology. The government has a Smart Nation agenda and is open to using the citystate as a testbed to experiment and innovate. This iterative approach is "very Dyson" and we think that it makes sense to deepen our commitments in Singapore as we continue to expand our engineering and operations footprint worldwide.

Q: What can you find in Singapore which is difficult to obtain in other territories?

M: As a technology company, Dyson needs access to engineering and supply chain talent as well as a strong infrastructure that supports R&D and manufacturing. Singapore is one of the few places where you can find this combination.

Revolutionary technology starts with research, which requires long-term thinking and investment into future technology in our R&D spaces. Singapore makes sense for us [when choosing a location] to manufacture the digital motor because it's one of the few nations with the skills, and supply chain, to make such a complex motor, before final assembly takes place in Malaysia and the Philippines.

Take our latest motor, the Dyson digital motor V10. It spins at 125,000 RPM and is the fastest and most advanced Dyson digital motor, giving [our] new vacuum the most powerful suction in the use of any cord-free stick machine. To manufacture such an intelligent and precise motor, Dyson engineers have developed brand new and fully automated manufacturing processes in Singapore which now have more than 300 autonomous robots with the capacity to produce up to 13 million motors a year.

Q: What is your strategy for Singapore as your Asian base? How are you looking to use it as a launchpad for your growth in the region?

M: As a dynamic city in Asia, Singapore provides a close link to the rest of the region and allows us to create technology for an urbanising world. Last year, 73 per cent of Dyson's growth came from Asia. We see tremendous growth opportunity here and value being in the region. Working on a similar time zone has undoubtedly made our development cycle more efficient.

Singapore understands the value of technology and advanced manufacturing and is willing to make the necessary investment. That is our approach too. It is where we will continue to launch future generations of motor technology before transferring them to other locations.

Q: You have spent more than a decade in Singapore. What lessons have Dyson picked up during this period about investing and developing here?

M: You have to remain focused on the long term and partner with the right stakeholders. Like Dyson, Singapore takes a long-term view to investing in technology. It is no coincidence that, to realise our technology ambitions, we are deepening our commitment to Singapore. Dyson has in-house expertise in fluid, mechanical, electronics, EMC, thermal, chemical, acoustic, as well as software engineering. We are committed globally to developing future technology, of which [our] Singapore Technology and Advanced Manufacturing Centres are a part of. At our Advanced Manufacturing Centre, we have just invested another S\$54 million (US\$39 million) for the V10 motor production. We believe that by working together, we can make real technological breakthroughs.

Q: James Dyson said last year that Singapore has "some of the brightest minds"? Would you be able to elaborate on the kind of talent which your firm has found and groomed here?

M: In a recent speech to university students, [the Prime Minister of Singapore] called for the development of a visionary plan that takes the country from SG50 to SG100 and beyond as we reimagine and rebuild Singapore. And you need engineers for this. Our job is therefore to create exciting new opportunities for young people here, igniting a passion in them to make some new technology that solve a problem, to engineer an original product, and design it well.

We are deepening our investment in Singapore to achieve our technology ambitions. Our plan is to develop core technologies, around which we could then engineer products. We need people who can create better versions of existing technologies [for use in] the motor, purification, and filtration. At the same time, as we venture into new areas, we need skills to develop other core technologies in areas such as vision interpretation, energy storage, and robotics . . . Every 2 to 3 years, these components, and the product in which they are assembled, are obsolete and we start all over. And that's just the hardware. We need the agile brains, and determined characters, to make this complex operation happen. And for that, we need the best brains to do so.

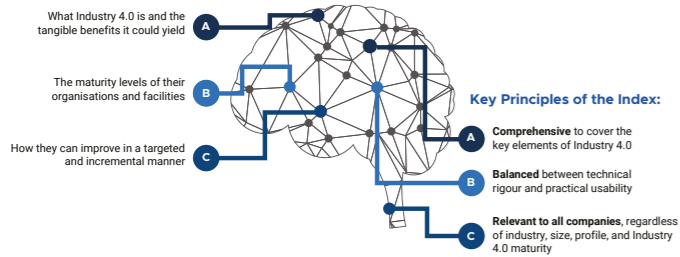


Start, scale, and sustain Industry 4.0 transformation:

The Smart Industry Readiness Index[®]

The Index is the world's first Industry 4.0 tool developed for nationwide transformation of industries and companies.

To help companies start, scale, and sustain their Industry 4.0 transformation initiatives, Singapore has developed The Smart Industry Readiness Index[®]. The Index allows companies to evaluate the readiness of their facilities and design their transformation roadmaps in a more systematic manner.



“The Smart Industry Readiness Index[®] is a framework that strikes a good balance by offering practical applicability while maintaining both conceptual and technical rigour.”

— Prof. Dr.-Ing. Siegfried Russwurm, University Erlangen-Nürnberg

Created in partnership with TÜV SÜD, and validated by an advisory panel of academic and industry experts, the Index is a comprehensive and easy-to-use tool for all companies, regardless of industry or size. The Index draws on the Reference Architectural Model for Industry 4.0 (RAMI 4.0).



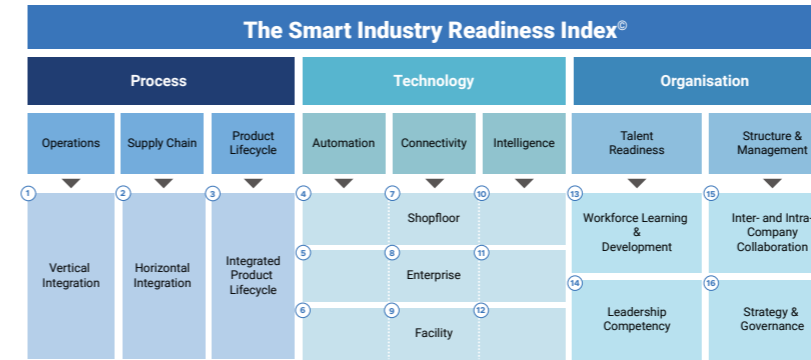
The Smart Industry Readiness Index[®] Framework

“Like us, many companies have already started their transformation journey. Beyond addressing the operational concerns today, this Index is a useful framework to also guide our future decisions to deliver sustained impact. It also ensures that we’re always moving in the right direction and focusing on the things that matter.”

— Mr Goh Koon Eng, General Manager, Chevron Oronite

The 3 Layers of the Index

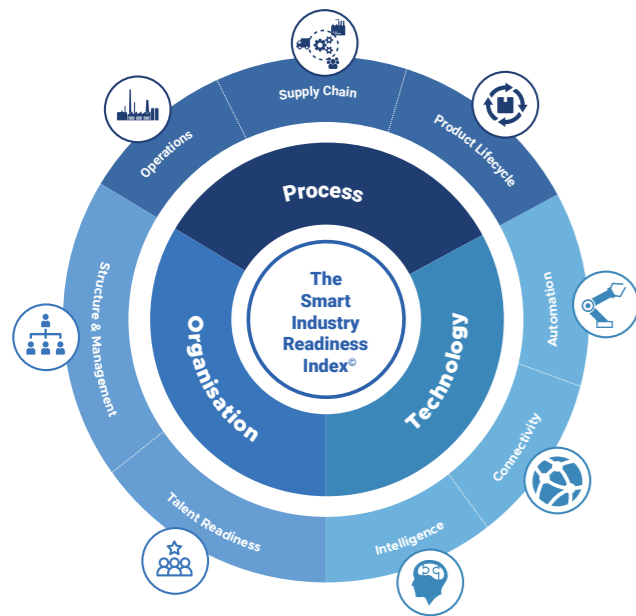
The Index comprises 3 layers. The topmost layer is made up of the 3 building blocks of Industry 4.0: *Process*, *Technology*, and *Organisation*. Underpinning these building blocks are 8 pillars of focus. The pillars then map onto 16 dimensions of assessment, which companies can use to evaluate their facilities.



Translating Concepts into Business Value

The Index outlines four steps for companies — to learn, evaluate, architect, and deliver their Industry 4.0 transformation roadmap.





The Technology Building Block

Industry 4.0 is characterised by the convergence of the digital and physical worlds, where digital technologies meet automation systems. To build a smart factory, companies need Automation (the muscle), Connectivity (the nervous system), and Intelligence (the brain).

The Process Building Block

Technology must always be applied to effective, well-designed processes. Under Industry 4.0, the concept of process improvements has expanded to focus on the integration of processes within a firm's Operations, Supply Chain, and Product Lifecycle.

The Organisation Building Block

With the advent of Industry 4.0, companies must adapt their organisational structures and processes to allow their workforce to keep pace. Industry 4.0 calls for a greater focus on two key components: the people who make up the organisation and the institutional systems that govern how the company functions.

“The Index gives clear orientation to manufacturers on what Industry 4.0 means and how they can initiate their transformation journey. It is a world’s first Industry 4.0 tool that is developed by the government for nationwide transformation of industrial sectors. Strongly aligned with Industry 4.0 and other global manufacturing initiatives, it has the potential to be the global standard for the future of manufacturing.”

— Prof. Dr.-Ing. Axel Stepken, Chairman of the Board of Management, TÜV SÜD

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