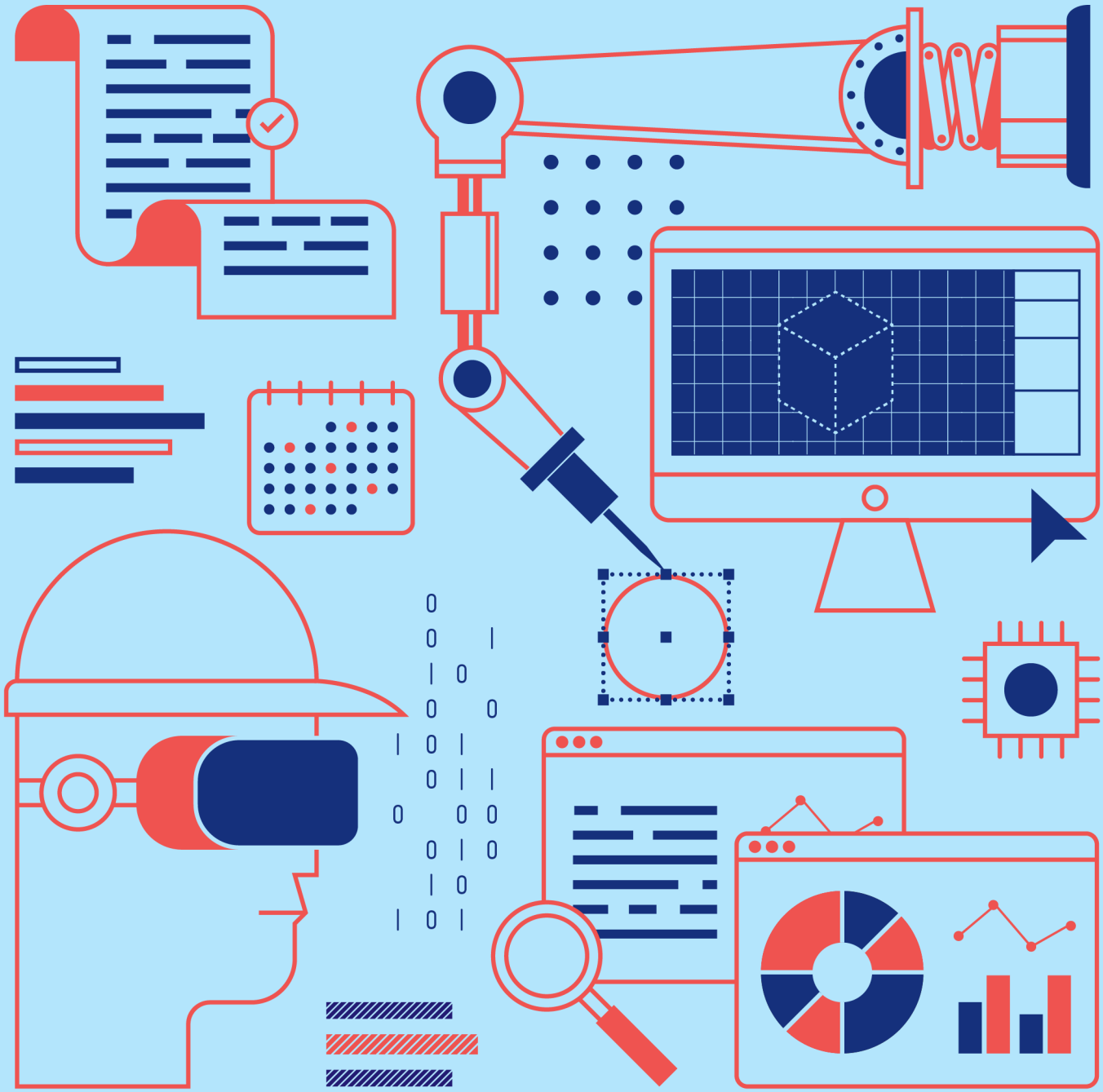
GATEWAY HOUSE
INDIAN COUNCIL ON GLOBAL RELATIONS

इंडिया एक्ज़िम बैंक
India Exim Bank

Digital Manufacturing in India



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DIGITAL MANUFACTURING IN INDIA

GATEWAY HOUSE AUTHORS:

Cdr Amrut Godbole, Indian Navy Fellow
Sagnik Chakraborty, Researcher, Cybersecurity Studies Programme
& **Manjeet Kripalani**, Executive Director

INDIA EXIM BANK TEAM:

David Sinate, Chief General Manager & Economist
Dr. Viswanath Jandhyala, Assistant General Manager & Economist

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Manjeet Kripalani, Executive Director

** Disclaimer:- The contents of the paper are personal views of the author and do not reflect the official position of the Indian Navy or Government of India.*

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Editor: Manjeet Kripalani & Jennifer Netarwala
Special Contributor: Ambika Khanna, Senior Researcher, International Law Studies Programme
Copy Editor: Mark Lewis
Website and Publications Associate: Sukhmani Sharma, Kunal Thakkar & Nazia Altaf
Cover Design: Debarpan Das
Layout Design: Debarpan Das

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Coordinating Team in India Exim Bank's Research and Analysis Group:

Mr. David Sinate, Chief General Manager & Economist
Dr. Viswanath Jandhyala, Assistant General Manager & Economist

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About the Authors

Cdr Amrut Godbole, a senior serving naval officer, is currently Gateway House Fellow, Indian Navy Studies Programme. A mechanical engineer by profession for the last 20 years, he has served on a variety of war ships as Engineer Officer, looking after the operation and maintenance of propulsion (gas turbine engines), power generation and auxiliary systems. Six years into his naval career, Cdr Godbole did his master's in marine engineering from the Indian Institute of Technology, Bombay (2008). He was soon after appointed to the Navy's premier technical training institute, INS Shivaji, Lonavla, as senior instructor of the gas turbine division where he guided the project for the development of controllers for gas turbine generators. He was also associated with the operational audit of warships and the training of their staff at the Sea Training Division, Mumbai. He has also been Manager (Quality Assurance) at the Gas Turbine Repair and Overhaul Facility of the Navy in Visakhapatnam. He is an alumnus of the Naval College of Engineering, INS Shivaji, Lonavla. His areas of interest include: technology absorption and adaptation techniques, disruptive technology, and geopolitics.

Sagnik Chakraborty is a Researcher in Cybersecurity and Manager of the Management Office at Gateway House. His work focuses on technology and national security. A software programmer by profession, with more than nine years' experience in the IT industry, he was with Tata Consultancy Services prior to joining Gateway House. He has held various roles in his IT career, starting from software developer to consultant to an operations and product manager. He is a graduate in physics from Fergusson College, Pune. His areas of research interest are cyber security, digital black markets, digital payment systems, messaging platforms, business analytics and disruptive technologies.

Manjeet Kripalani is the co-founder of Gateway House: Indian Council on Global Relations, and acts as the executive director of the institution. Prior to the founding of Gateway House, Kripalani was India Bureau chief of Businessweek magazine from 1996 to 2009. During her extensive career in journalism (Businessweek, Worth and Forbes magazines, New York), she has won several awards, including the Gerald Loeb Award, the George Polk Award, Overseas Press Club and Daniel Pearl Awards. Kripalani was the 2006-07 Edward R. Murrow Press Fellow at the Council on Foreign Relations, New York, which inspired her to found Gateway House. Her political career spans being the deputy press secretary to Steve Forbes during his first run in 1995-96 as Republican candidate for U.S. President in New Jersey, to being press secretary for the Lok Sabha campaign for independent candidate Meera Sanyal in 2008 and 2014 in Mumbai. Kripalani holds two bachelor's degrees from Bombay University (Bachelor of Law, Bachelor of Arts in English and History) and a master's degree in International Affairs from Columbia University, New York. She sits on the executive board of Gateway House and is a member of the Rotary Club of Bombay.

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Executive Summary

Industry 4.0 promises to create new jobs and products while boosting productivity. The complex array of processes that make this possible – including 3D printing, computer-aided design, data analytics, artificial intelligence, simulation, virtual reality, sophisticated process management and more – are collectively known as Digital Manufacturing.

Since the 1990s, when the U.S. started outsourcing much of its manufacturing to China, Silicon Valley created and developed an unrivalled technology sector whose products and services are now embedded in economies and societies globally. India too has built a world class IT-services industry with an international and domestic clientele. Over the past five years, India too has digitized its governance and bureaucratic processes, using open-source, public-private platforms to enable millions of citizens to have easy access to government services, and creating the world's second largest population of digitized citizens after China.

In India, digital manufacturing has begun in parallel with global efforts. Its most obvious mode of entry has been through multinational companies that are transferring updated technology to their operations in India. Schneider, Siemens, ABB and Rockwell are leaders. Their parent companies are among the 54 entities on the World Economic Forum's prestigious Global Lighthouse Network for effectively integrating digital technologies to enhance manufacturing processes. These companies have long been at the forefront of industrial transformation.

Indian multinationals are catching up. In 2019, Tata Steel in Kalinganagar, Odisha, became the first Indian facility to be given the Lighthouse designation. Others are likely to follow in 2021. Plunging into the new-era digital manufacturing will provide India with an innovative, even futuristic, industrial platform – and build a new ecosystem that can put the country at par with global counterparts.

For digital manufacturing to be truly successful in India, it must be adopted by essentially small and medium enterprises (SMEs), which comprise over 90% of India's industry. Most of India's SMEs continue to depend on low-cost labour, and fear that technology is too expensive to adopt and monitor. Even SMEs that have the financial capabilities often can't fathom it, so they let it lie idle – a waste of capital and a lost opportunity.

COVID-19 has changed all this.

The pandemic has accelerated the process of digital manufacturing, already under way globally, and in India. Within India, digital adoption has outpaced global peers on many counts. Companies that saw it as an option, now understand it as a business imperative. Meanwhile, those companies in India, largely Indian and foreign multinationals, already on the digital manufacturing path, have accelerated their implementation. This is particularly true in the case of older facilities, which have been working on their modernization for several years.

Brownfield facilities traditionally relied on heavy capital investment for infrastructure upgradation – essential replacement of operational but vintage assets. The existing pandemic has shrunk operating budgets and capital. But industry 4.0 technologies have made it possible to operate disparate factory assets by being digitally linked with new generation hardware and software systems at a

fraction of the cost. The pandemic has thus, compressed long drawn digitization plans from two years to just under a month during the pandemic – with immediate results visible.

For India, this is particularly important, as COVID's geopolitical and economic fallout is the realignment of supply chains, largely away from China. India, with its size, market and tech capability, is seen as an alternative site – although it has not been an immediate beneficiary. That has been Vietnam, with its Asian proximity and favourable regulatory environment. To capture this nascent and promising trend, the government moved swiftly in November 2020, to identify and incentivise 13 sectors, some of which India already has manufacturing strength – like auto and pharma - and others like telecom and networking products where China is dominant and where India seeks self-sufficiency.

The ecosystem for digital manufacturing in India, is now visible. It's not deep, as it is in the West or China, but is developing breadth and depth. Four elements of this ecosystem are in place: the digital infrastructure, government schemes, academic learning, and a burst of start-ups. Services, not manufacturing, will continue to be the big employer, but manufacturing will become so advanced that it will be able to capture and create value. India is set to leave behind it's *jugaad* or make-fix era, and step on to the stage, where both services and manufacturing will be a duet, feeding off each other.

Digital Manufacturing in India

by **Cdr Amrut Godbole,** Indian Navy Fellow
& **Manjeet Kripalani,** Executive Director

The world is experiencing two simultaneous transformations: a decoupling from China and the building of an alternate supply chain, and the creation of new, cutting-edge industrial process called digital manufacturing. It is part of the larger wave of Industry 4.0, an integration of industrial processes with the Internet of Things (IoT). India already has some of the key elements in place, and some successes to build on.

During U.S. President Donald Trump's state visit to India in February 2020, Prime Minister Modi heralded what could be a new era of economic cooperation between India and the U.S. He was remarkably prescient when he said that in addition to the strong defence bilateral, "increasing manufacturing in India, expanding infrastructure, will bring new possibilities for America," as will expanding the digital economy in India.[1]

Linking industry 4.0 with bid to renew an American interest in India's economy couldn't have come at a more important – and opportune – time for both countries. As the U.S. decouples from China, and seeks to brings jobs back home, it needs to address a 30-year lapse in its attention to manufacturing. India is in a similar position; with very few exceptions like autos and pharma, the country has never developed a competitive manufacturing base. Now, eager to receive investments and build new manufacturing sectors, both countries must develop new skills, processes and products.

Though largely unnoticed, a new era of manufacturing has dawned – one that conjoins manufacturing and smart computers as never before to make industry more agile, creative and efficient.

Where earlier stages of industrialization replaced human labor with machines to increase output, Industry 4.0 promises to create new jobs and products while boosting productivity. The complex array of processes that make this possible – including 3D printing, computer-aided design, data analytics, artificial intelligence, simulation, virtual reality, sophisticated process management and more – are collectively known as Digital Manufacturing.

Companies that have adopted this process well have gained global recognition through two prestigious awards: the World Economic Forum's Global Lighthouse Network for manufacturers, and Gartner's Magic Quadrant for the technologies that tie digitization and manufacturing together. Both the U.S. and India have the capacity to become powerhouses in this new age of manufacturing. Since the 1990s, when the U.S. started outsourcing much of its manufacturing to China, Silicon Valley created and developed an unrivalled technology sector whose products and services are now embedded in economies and societies globally. India too, over the years, has built a world class IT-services industry with an international and domestic clientele. Over the past five years, India also has digitized its governance and bureaucratic processes, using open-source, public-private platforms to enable millions of citizens to have easy access to government services, and creating the world's second largest population of digitized citizens after China.

Some digital manufacturing already taking place in both the U.S. and India suggests that blending digitization with manufacturing can create a new era of balanced global growth.

In the U.S., the springboard is 3D printing and robotics, especially collaborative robots, or "cobots" – robots designed to operate alongside human workers. According to Michael Mandel, Chief Economist at the Washington, D.C.-based Progressive Policy Institute, cobots are ideal for micro, small and medium-size enterprises (MSMEs),

[1] *White House Government, "briefings statements and remarks between President Trump and Prime Minister Modi", India Joint Press Statement 2.*

and they complement the work of mid-skilled workers rather than replacing them. They excel at repetitive, precise tasks, allowing the humans on the assembly line -- often semi-skilled workers – to focus on higher value tasks. They are increasingly popular: Sales of cobots in the U.S increased 23% in 2018, while sales of robots rose just 5%.

3D printing is already a visible dimension of digital manufacturing, especially in the U.S. Companies like Carbon D, a Silicon Valley start-up co-founded by materials scientist Joseph DeSimone, are already valued at more than $2.5 billion. Carbon D integrates hardware, software and materials science for the first time, making 3D printing an alternative to traditional manufacturing that is workable to scale. It replaces traditional injection molding, using a combination of polymers, ultra-violent light and oxygen to "grow" a product. Among other things, Carbon D makes soles for Adidas sneakers and dentures, partly reclaiming a domestic market that had been captured by China (40% of all US dentures are made in China, as of 2019).

In India, digital manufacturing has barely begun. Its most obvious mode of entry has been through multinational companies that are transferring updated technology to their India operations. Schneider, Siemens, ABB and Rockwell are leaders. Their parent companies are among the 54 companies recognized on the prestigious Global Lighthouse Network for effectively integrating digital technologies to enhance manufacturing processes. These companies have long been at the forefront of industrial transformation. They were early adopters of automation and digitization during what is called Industry 3.0. They are now leaders of Industry 4.0, which is using analysis of the huge amounts of data generated by the digitization of industry to improve the quality, efficiency and productivity of manufacturing processes.

Schneider Electric, whose facilities in France, the U.S. and Indonesia are on the Lighthouse list, aims to bring its Indian facilities in Bangalore and Hyderabad onto the network. For now, it uses electrical and automation equipment hardware and software in its industrial operations in Hyderabad, achieving significant savings up and down the line – $50,000 or 30% of its annual bills for electricity from the local grid and reducing its dependence on captive power plants.

Indian multinationals are catching up. In 2019, Tata Steel in Kalinganagar, Odisha, became the first Indian facility to be given the Lighthouse designation. Tata Steel, which previously was a recipient of the Deming prize for Total Quality Management, a 20th-century predecessor of the Lighthouse distinction, is inspiring others to follow. Eastern Odisha, where the Tata facility is located, will soon have a cluster of excellence in the conglomeration of steel plants from JSW to Arcelor Mittal.

Kalingnagar is Tata Steel's newest plant, and the decision to digitize the processes was made as early as 2005 when the plant was first designed in anticipation of economic growth in India. The machinery was imported largely from Germany, but because the plant was located in an underdeveloped state, Tata Steel engineers did everything else in-house – especially digitization and its integration with the manufacturing process. Production began in 2016, and was so impressive that McKinsey & Company, which was providing consulting services to Tata, suggested the plant apply for a Lighthouse award.

It has been a heroic effort, especially considering that India's manufacturing industry has shriveled, leaving an ecosystem full of holes. Manufacturing adds just 16% of value to India's GDP, and at $390 billion in revenues, accounts for just 2% of global manufacturing compared to 18% for the U.S.,

20% for China, 10% for Japan and 7% for Germany. Only two Indian manufacturing sectors are truly integrated into the global supply chain – autos and pharma. According to the National Manufacturing Policy of 2011 and the Make in India initiative of 2015, India's manufacturing has the potential to contribute 25% of value to India's GDP by 2022.

Plunging into the new-era digital manufacturing will provide India with an innovative, even futuristic, industrial platform – and build a new ecosystem that can put the country at par with global counterparts. India already is half-way there: Its global IT services sector, while currently export-focused, can use its talents domestically to develop models for data analytics. This is the most difficult part of digital manufacturing – marrying machines with digital tools to analyse data.

India still lacks the other 50% of the tools needed for a fully-developed digital manufacturing sector: hardware, including sensors, 3-D printers, and most importantly, cloud infrastructure.

Unlike the West, universities in India do not offer curricula that bridge manufacturing and information technology. Indian engineering students learn either core engineering or computer science. Even outside of formal academia, there are few teaching or certification courses, and no product or process-certification systems by Indian government-approved bodies comparable to ISO (International Organization of Standardisation), DIN Standards (Deutsche Institut fur Normung) or ASTM (American Society for Testing and Materials).

Consequently, Indian manufacturers embarking on the digital journey must train their talent in-house. Many have large IT-export affiliates. Tata Group and Mahindra respectively have TCS and Tech Mahindra, for instance. But neither have been put to work with their sister companies on digital manufacturing, mostly because they lack understanding of manufacturing processes and the digital-manufacturing domain.

Tata Steel Kalinganagar has 370 engineers, with backgrounds as varied as mining and electronics, working on the convergence of manufacturing, digital and data analytics. Most are young engineers who come from Odisha, Bihar and Bengal – all states that rank among the bottom of India's development index. Yet they are working on some of today's most globally sophisticated processes. They are highly motivated. They understand that while the virtual world created a digital universe, the digital manufacturing era will put the old-fashioned, elbow-grease engineer back at the centre of work. "It'll make engineers [be]engineers again," they say. Multinationals in India like Schneider follow the same in-house training model.

The potential for Indian multinationals to adopt digital manufacturing is enormous. But while Tata Steel has shown the way and the cluster of steel companies in Odisha will soon follow, few other companies are aware of the possibilities. While chambers of commerce in India – especially those like the Confederation of Indian Industry that are deeply engaged with the World Economic Forum – have a platform through which their members can follow and pursue digital manufacturing, dissemination of this information has not been vigorous.

Companies can also achieve digital manufacturing goals independently through the Global Lighthouse Network and Gartner's Magic Quadrant for Industrial IOT. So far, India has just one company in each segment – Tata Steel for Lighthouse and Altizon for the Magic Quadrant.

Several others are emerging. Together, these companies could do the critical job of writing software and integrating it with machines and processes in factories. Indian companies, both large and mid-sized, that do not have a bench of available in-house engineers like Tata Steel, could rely on these companies.

Altizon and QIO in Pune are two such emerging players. Alitzon is an Industrial IoT platform that connects assembly lines to the Cloud and analyses the results. Its founders are Indians in California and Pune. It has leveraged its position astride this corridor of global markets with a talented back office in India to get clients in 30 countries. Big domestic exporters like TVS Motors, SRF and multinationals like P&G and Vestas use Altizon's product.

The domestic venture community has taken note. Altizon raised $4 million from Indian giants Wipro Technologies and TVS Motors in February 2016, and another $7 million from the same group in April 2019.

QIO, a London-based Artificial Intelligence company and big data start-up that began with a back-office operation in India in 2015, now has 15 engineers who offer a similar platform as Altizon's. QIO's product specifically helps companies reduce costs by up to 12% by conserving energy while reducing their carbon footprints.

But despite occupying a trendy energy space, QIO's product is a hard sell, even with big companies – particularly in India. So QIO became creative. First, it got itself certified by the National Computing Centre Group (NCCG) in the U.K., which tests and audits Industry 4.0 tools. Second, it became General Data Protection Regulation (GDPR)-compliant – almost a necessity in Europe. And finally it made a winning offer to clients: instead of demanding an up-front payment, it decided to set performance-linked fees. This showed QIO's confidence in its own product. This is a long-term investment: QIO is getting a head-start on competitors by voluntarily following compliance requirements early, since interoperability through common standards will become the norm for digital manufacturing.

For digital manufacturing to be truly successful in India, it must be adopted by small and medium enterprises, which comprise 90% of India's industry. This is not happening yet. Most of India's SMEs continue to depend on low-cost labour, and fear that technology is too expensive to adopt and monitor. Even SMEs that do have technology often can't fathom it, so they let it lie idle – a waste of capital and a lost opportunity.

A slew of start-ups have appeared in India determined to draw SMEs into collaboration involving digital manufacturing. One such company is Chizel, a B2B cloud platform for manufacturing of plastic and metal parts, that works with SMEs. This three-year old start-up, located in a small, 1950s Soviet-style structure in the outskirts of Pune, is full of confidence. It calls itself the Amazon for manufacturing services. There's a reason why.

The company began with 3D printing of metal and non-metal parts for the auto industry. But, says Chizel's product manager, Suresh Salunkhe, it soon ran into classic SME problems: lack of adequate technology and skills, and inability to manage processes that require extensive and tedious follow-up. This was particularly true for the metals manufacturing; even if 3D printing could be used to make moulds, each task required five semi-skilled workers rather than one expert.

Beyond the fear of using technology – many Indian SMEs have little experience with smart digital technology except for an accounting product called Tally – the biggest fear is that technology will result in job loss. So Salunke tells SME clients that the notion tech replaces jobs is no longer true.

"We tell them that by making processes more efficient, they can be free to do more marketing and expand their business," he explains. Chizel has persevered; it now matches 200 manufacturers and 500 suppliers that have registered on its platform. Nearly 10% of its clients are outside of India.

The trade war between the U.S. and China has played nicely in favour of such Indian start-ups, which are seeking to build relationships with the U.S. in particular. There are competitors in the U.S., like manufacturing services provider Xometry and Zetwork, a fabrication outsourcing company, but Indian start-ups are confident they can compete – a notion that gains credence considering that some, like Alitzon, are among the 13 Magic Quadrant companies recognized by Gartner in 2018-19.

The adoption of digital manufacturing in India will see success thanks to start-ups like Chizel, which understand and are tackling difficult problems that are endemic to India. Most of these are very small, self-financed ventures; some like Altizon are starting to attract private venture funding. Others have found a generous funder in the government of India through its many new programmes like Smart Advanced Manufacturing and Rapid Transformation Hub (SAMARTH), Start-up India and Digital India, as well as through the Department of Science and Technology.

Government funds come with a complete package – not quite like Toronto's MaRS Discovery District which offers entrepreneurs everything from venture funding to legal advice – but a good start for India. In the Agnel Technical Complex, a college in Vashi, a Mumbai suburb, is CIBA, the Centre for Incubation and Business Acceleration, funded by the Ministry of Science & Technology. CIBA, which occupies the 2nd floor of the college building, is a modern workspace for start-ups, with all the benefits and none of the restraints of government to inhibit them, as intended. Because it is state funded, it blends in with India's many new programmes for entrepreneurship, like Start-Up India and Digital India. And it has provided entrepreneurs with surprisingly good customers: the Indian public sector has been encouraged to engage with start-ups especially in the Internet of Things, to step up their game.

Clairviz, co-founded by Aditya Vermani, an engineer who worked with India's engineering giant Larson & Toubro and was briefly seconded to the Indian Space Research Organization, has a product similar to Altizon. But Vermani is sitting in a sweet spot because Clairviz participates in the government's Start-Up India programme and is a beneficiary of government's mandate that state companies use start-ups and MSMEs like Clairviz for their procurement of goods and services. State-owned oil refining giant Hindustan Petroleum was among Clairviz's first clients; it installed and monitored sensors at the company's Mumbai refinery and oil depots, resulting in improved regulatory compliance and a saving of almost $20,000 per year on maintenance and labour costs, against a small subscription fee – another creative revenue model.

Undergirding the government programmes is some substantial hand-holding for the small and medium sector akin to what multinational giants get by hiring consultants like McKinsey. In Pune, the C4i4 – Centre for Industry 4.0 – promotes and helps to drive Industry 4.0 adoption by MSMEs. The centre provides a road map for digital transformation through consultancy and skill development, for

a small fee. Dattatraya Navalgundkar, the director of this unique set-up, is driven and enthusiastic, but says the MSMEs are slow to adopt, and inertia is a hurdle. He is teaching them to start small and adapt with confidence.

It's clear that India intends to leapfrog into the age of digital manufacturing. But the hurdles are many, and both the large multinationals and the start-ups have a slew of challenges and opportunities. Still, change has begun.

President Trump and Prime Minister Modi took the first step to creating a new era of economic collaboration between the US and India when Prime Minister Modi pointed to the "era of Industry 4.0, the expansion of the digital economy in India which will create many investment opportunities for the U.S. as well."

How can the next few steps be taken? The defining collaboration of the two countries is defence. India already manufactures an estimated $12 billion in guns, submarines, communications platforms, domestically. In February, India signed an agreement with the US to purchase $3 billion in defence equipment – a small component of which will be locally manufactured. This could be a good place to pilot a bilateral digital manufacturing project that benefits both countries.

Impact of COVID-19 on Digital Manufacturing in India

by **Manjeet Kripalani,** Executive Director, **Cdr Amrut Godbole,** Indian Navy Fellow *&* **Sagnik Chakraborty,** Researcher, Cybersecurity Studies Programme

COVID-19 has forced India and its manufacturers to quickly step up their adoption of digital manufacturing processes. This, supported by key policy decisions by the Indian government, will propel Indian manufacturing to higher levels of efficiency, productivity, and competitiveness.

COVID-19 has accelerated[1] the process of digital manufacturing, already under way globally, and in India. Companies that saw it as an option, now understand it as an imperative. Within India,[2] digital adoption by companies has outpaced their global peers on several criteria including new business and workforce models. A rush of foreign investment into India's digital space will expand this trend. This is a significant shift for India, as COVID-19's geopolitical and economic fallout is the realignment of supply chains, largely away from China. India, with its size, market and tech capability, is seen as an alternative site – though it has not been an immediate beneficiary. That has been Vietnam, with its Asian proximity and favourable regulatory environment.

However, India is cognisant of the opportunity, and the government has enacted some enabling policies. In November 2020, the Production Linked Incentive scheme (PLI) was extended to over a dozen sectors in which India is already competitive, like pharmaceuticals, automobile, telecom, textiles, electronic tech consumer products. These subsidies encourage products to be made in India, for the home and export market. Just prior to this, in September 2020, the government addressed a core problem in India – labour. It replaced 29 old laws with four, simplified labour codes, to modernise labour regulations.

Meanwhile, those companies in India, largely Indian and foreign multinationals, already on the digital manufacturing path, used the year to fast-track their digital adoption. This is particularly true in the case of older facilities, which compressed two-year digitisation plans, into a single month – with immediate results.

Piramal Glass is an example. The $330 million, Gujarat-based company is a global producer of moulded glass for the food, pharma, cosmetics and perfumery industries. When the pandemic hit, the demand for perfumes and nail polish bottles dropped, but the demand for food and pharmaceutical glass rose. This enabled the company to be classified as an 'essential supplies' provider and kept its operations running with a third of its workforce.

In short order, Piramal Glass had to innovate. For starters, factory hands could no longer use their electronic fingerprints to enter the facility, so the company sourced facial-recognition software from a domestic start-up called Smart Infocomm.[3] It had multiple uses – not just at the factory gate but also on the manufacturing line to alert the management on workers violating masks and social distancing placement in the factory.

Samit Datta, Global Chief Supply Chain & Technology Officer at Piramal Glass says that typically, brownfield manufacturers that operate different generations of machines and are looking to upgrade, will replace all at one go. However, they need to think counter-intuitively to optimise capital, and instead use digital technologies to upgrade. "This creates the foundation for their Industry 4.0 transformation also," he says.

[1] A recent McKinsey report titled 'How COVID-19 has pushed companies over the technology tipping point—and transformed business forever' illustrates digital adoption that would have normally occurred between 15 to 22 months being deployed in less than a month during the ongoing pandemic.
[2] In In the report- KPMG in India 2020 CEO Outlook: COVID-19 Special Edition, published by KPMG, stated that 50% of Indian CEOs within the manufacturing space have acknowledged the acceleration of digital growth and also identified a 20% increase in risk due to emerging/disruptive technologies.
[3] Smart Infocom, "Smart Infocom."

Datta used his own advice well. Piramal had planned to commission a new glass furnace, which was to increase capacity from 100 to 145 tonnes per day (tpd). Normally, 10 experts would come from Europe to install the furnace and commence operations. Instead, Piramal tapped into augmented reality using smart glasses most of it procured locally. The furnace was operational in one month. Augmented reality was used for quality assessment too. Foreign customers who would normally be sent physical samples of glass, were able to inspect their purchases via augmented reality.

Piramal had to change the existing on-site operations of its plant to allow for remotely controlled functioning. In seven days, its in-house tech team developed a work-from-home infrastructure to operate the plant remotely, adding on the existing Internet of Things (IoT) stack[4] – i.e. technology, standards and applications - for the manufacturing process.

The success was encouraging, and Piramal decided to accelerate its transformation through data analytics. In July 2020, the company hired a top management consultant to guide the process as also 11 new data engineers and scientists.

Piramal Glass' transformation has been impressive. In recognition of its inherent business value and accelerated digital journey, the U.S. private equity firm Blackstone acquired a controlling stake in Piramal Glass in December 2020.

Another brownfield success story, of an old factory becoming a new digital player, is that of Siemens India. Its factory outside Mumbai, in Kalwa, is 47 years old and makes low-voltage switch gears. In 2016, with an eye on India's growing market and exports, the factory was put on the transformation path, to reconfigure manufacturing lines and double the number of product variants manufactured there to 180. This was done using a proprietary digital twin software and Mindsphere - a cloud and IoT-based operating system developed by the parent company in Germany and resulted in a 20% productivity gain for the facility.

With COVID-19, the factory was locked down. In July, when production could begin again, it was with just 30% of its workers. Using the digital twin that already existed, Siemens Kalwa's engineers reconfigured the production line to accommodate the new rules especially social distancing for the assembly line workers, and get back on track.

Hemant Narvekar, Factory head, Siemens, Kalwa led the effort. He said that the new norms compressed timelines and expense as they "could be quickly simulated and tried in the virtual environment, before executing them in the real world".

The ecosystem for digital manufacturing in India is now visible. It's not as deep as it is in the West or China but is developing breadth and depth. Four elements of this ecosystem are in place: the digital infrastructure, government schemes, academic learning, and a burst of start-ups.

[4] The IoT stack at Piramal Glass consist of the Real Time Manufacturing Insights (RTMI) – a cloud-based, IoT enabled platform to enable real time monitoring and advanced insights for end-to-end plant operations. The stack also included another platform – the Unified Energy Management System (UEMS) for management of utilities like energy, water and air.

Digital infrastructure: A significant part of the digital infrastructure, has been laid by India Stack,[5] an open-source services platform and application programming interface, developed by a public-private partnership as a public good. It is free for entrepreneurs, small and big business, government and developers, to build their products on. During the pandemic, this platform singularly helped the Indian government disburse funding and subsidies to individuals and entities across the country, instantaneously and at low cost.

Now, with the pandemic easing up, and with new legislations and schemes for entrepreneurs, this platform is being used to build and scale up new ideas. It will help India move beyond services to products, says Sharad Sharma, founder of iSpirt, the non-profit which created India Stack. If the transition is smooth, India can become like Korea – a high-value design and product manufacturing powerhouse. While services will continue to be the big employer, he foresees manufacturing becoming advanced – and creating the kind of value that companies like Piramal Glass have done, and beyond that. India will finally leave behind its *jugaad* or make-fix era.

Government schemes: To capture this nascent and promising trend, the government has moved swiftly. November 2020 saw a $20 billion incentive scheme for 13 competitive sectors of manufacturing to create domestic self-sufficiency. In addition, a serious effort is underway to create the supporting institutions for manufacturing and for the Micro, Small and Medium Enterprises (MSMEs), which comprises over 90% of Indian business. Nitin Gadkari, India's infrastructure and MSME minister, said on December 15, 2020 that he expects MSMEs to create 50 million new jobs over the next five years, and contribute 40% to India's GDP, up from 30% now.

To make this happen, new initiatives like Smart Advanced Manufacturing and Rapid Transformation Hub (SAMARTH) by the Ministry of Heavy Industries, have begun. One such government initiative in Pune is C4i4, which provides a transformation road map for its customers, both MSME and MNC. C4i4 offers coaching and consulting specifically for manufacturing MSMEs that are looking to digitise. During the pandemic, demand for its services have grown by 30%, not just from small business but big exporters too.

Dattatraya Navalgundkar, Executive Director at C4i4 Pune, says, "The pandemic has accelerated the adoption of digital technologies across the value chain. Although MSMEs face cashflow challenges, lack trained manpower and expertise, they need business continuity and are eager to start the digital transformation journey."

C4i4 is now developing its own standards, to create an Indian version of the World Economic Forums' Lighthouse Network, but for MSMEs, to encourage their endeavors.

For the first time, Indian states have started to take manufacturing seriously. The mass migration of workers from various parts of India during the early months of the lockdown, was an opportunity for state governments, to identify the skill sets of their residents. Three Indian states with large migrant populations stand out in this – Uttar Pradesh, Madhya Pradesh and Bihar. As the migrants came home, while they were being tested, treated and quarantined, their work and skills were also being recorded and mapped.

[5] *India Stack, "WHAT IS INDIA STACK?"*

Subsequently, the states developed industrial policies/manufacturing policies and frameworks – and some like UP, Gujarat and Karnataka also revised their outmoded labour laws to create a positive environment for investors. For instance, the government of UP passed an ordinance, the Uttar Pradesh Temporary Exemption from Certain Labour Laws Ordinance, 2020, which relaxes laws related to unions, work dispute settlement, regulations on work conditions, for three years.

Academic learning: India is also the first country in the world to develop and run a post-graduate degree course in digital manufacturing, at the prestigious Birla Institute of Technology and Science–Pilani, Rajasthan.

P. B. Venkataraman, the Associate Dean of the institute, had been hearing industry leaders talk about digital manufacturing since 2014, so a survey was conducted to see if it would be a compelling course. The survey found that though the existing programmes were suitable for the current generation of manufacturing, the manufacturing of the future needed much more. Like skills in industrial IoT, additive manufacturing, big data analytics, industrial cybersecurity, logistics and supply chain optimisation, autonomous equipment, and digital tools for product and system design, simulation and production.

The institute decided to take the initiative and teach the subject. There was no faculty readily available to teach, and without working experience, it would be meaningless for undergraduates. So, BITS nurtured and developed a faculty andintroduced the two-year course for working professionals from the manufacturing industry.

Companies like GE, Tata Motors, Mercedes Benz, Bharat Forge, Alstom, JSW Steel and Bosch, supported the course – 800 inquiries were received in the first year, 2019. The fifty applications that were accepted became the first batch for Digital Manufacturing/Industry 4.0, starting June 2019 – on a virtual campus for the working executives. Therefore, the pandemic didn't change much, except for not conducting some on-campus lab work. With two batches inducted in an academic year, the fourth batch has now commenced, with another 50 working professionals. That makes 100 digital manufacturing graduates from India, every year.

Burst of start-ups: Multiple government schemes like Make in India, Start-up India and Digital India, initiated in 2014, had seen a limited response. But 2020 saw a surge of digitisation, intra-company and in start-ups. According to Nasscom,[6] the software industry association, 1,600 new start-ups were added in 2020, and 12 new unicorns are now added to the total of 38 unicorns. Indian states have invigorated and updated their own start-up policies, in order to reach grassroots talent. They have begun to compete with each other,[7] each offering start-up challenges, incubation and acceleration programmes, and venture funding.

The start-ups already established pre-COVID 19, have seen bustling business. Aditya Vermani, Co-Founder and Business Head of ClairViz Systems, says that digitisation which was seen as a 'Good to Have' feature in the pre-COVID 19 era, is now an imperative. "Despite factories running at 30%, manpower, digital work instructions and maintenance gained traction. We were able to maintain our revenue growth, in the constrained financial environment," he says.

[6] *"Indian Tech Start-up Ecosystem – On the March to a Trillion Dollar Digital Economy." NASSCOM, January 7, 2021.*
[7] *Ministry of Commerce and Industry, Department of Promotion of Industry and Internal Trade. State Ranking System. Accessed February 10, 2021.*

Yash Rane, CEO at Chizel, a unique platform that offers manufacturing as a service and sees itself as a budding Amazon for manufacturers, says that manufacturing shops are shifting to cloud-based, mobile-first accounting systems and human resource solutions, and to IoT devices to track machine performance. "Although they look like small adoptions, they are laying a solid foundation for the next wave of transformation. In very short order, digital manufacturing will become the new normal," he says.

These are all good signs – but they are not enough. COVID-19 has depleted the reserves of governments, companies and individuals, making China's efficiency of supply and production, and affordability, still very attractive. Countries like Japan that are officially supporting their companies to rehabilitate their industries are still not depending on India to either become a reliable "+1" for their China strategy or be part of their multiple supply chains. The old India problems of "issues of land use and allocation, working infrastructure, logistics, transport, and consistency of tax administration" continue to create hesitancy amongst foreign investors.[8]

Still, the efforts being made are significant.[9]

Consultants like McKinsey have played a significant role, quietly evangelising digital manufacturing with Indian companies that are ready for the next leap forward. Their work is paying off – 2021 will likely see more than two Indian companies join the Lighthouse network. Gartner's Magic Quadrant, which had one Indian software company – Altizon – and two others with back offices in India (QiO and Flutura) on their list, may also see a surge in the coming years.

[8] Singh, Gurjit. "Enticing Post-COVID Japan to India." Gateway House, June 25, 2020.

[9] Since Dec 2017, UP has done road shows across India, and seen investment start to come in the state. In July 2019, Uttar Pradesh launched 250 investment projects worth Rs. 65,000 crores. The Defence Expo 2020 saw 23 MoUs worth Rs 50,000 crores being signed. Additionally, UP received an FDI of $467 million from October 2019 till September 2020. Other states such as Jharkhand and MP have received an FDI of $2644 million and $225 million respectively in the same period.

Industrial Internet of Things (IoT)

Connecting physical to the digital

by **Cdr Amrut Godbole,** Indian Navy Fellow
& **Sagnik Chakraborty,** Researcher, Cybersecurity Studies Programme

Industrial Internet of Things (IIOT) has enabled machinery on the factory floor to be connected to the internet. Real time analytics and action has become possible through data collected from these interconnected devices. IIOT leveraging cloud infrastructure and Artificial Intelligence has created a cyber-physical world of smart machines.

Traditional factory assets have a large number of sensors fitted on crucial and expensive machinery to monitor real-time performance of operational functions. Historically, the data generated from these sensors remained localised to the company and required human intelligence to provide meaningful insights on efficiency, productivity, equipment health, safety, quality and many other Key Performance Indicators (KPIs).

Industrialisation and globalisation have led to a geographic expansion of the value chain and generation of voluminous amounts of data. Engineers, operators and managers across industry were overwhelmed by processing the big data that would provide those critical insights, especially in time-sensitive business operations.

Enter The Internet of Things, or IoT. Market researcher Gartner identified it as early as 2011 as a new, emerging phenomenon. The Internet of Things (IoT)[1] was defined as the network of physical objects that contains embedded technology to communicate and sense or interact with their internal states or the external environment.

Simply put, IoT enabled the connectivity of various hardware devices (things) over the internet. Devices such as meters, home appliances, security systems that were traditionally hard-wired for communication, could now communicate directly through the internet without the need of human-to-human or human-to-computer interaction.

The feasibility of IIoT became evident that same year with a showpiece by Nest Labs a smart home products company based in California, now acquired by Google. By leveraging IoT technology, NEST demonstrated an electronic, programmable, and self-learning Wi-Fi-enabled smart thermostat to provide optimised heating and cooling solutions for homes and businesses to conserve energy.

This invention opened up a range of possibilities in the wider industry, which was looking for a system that could convert sensor data to digital data. Nest's programming created a bridge that transferred information directly from the physical world to computers. These IoT capabilities were then extended to actuators, the devices responsible for the motion of a machine. Controlling an actuator helped to exercise control over the physical world of a factory through a digital medium.

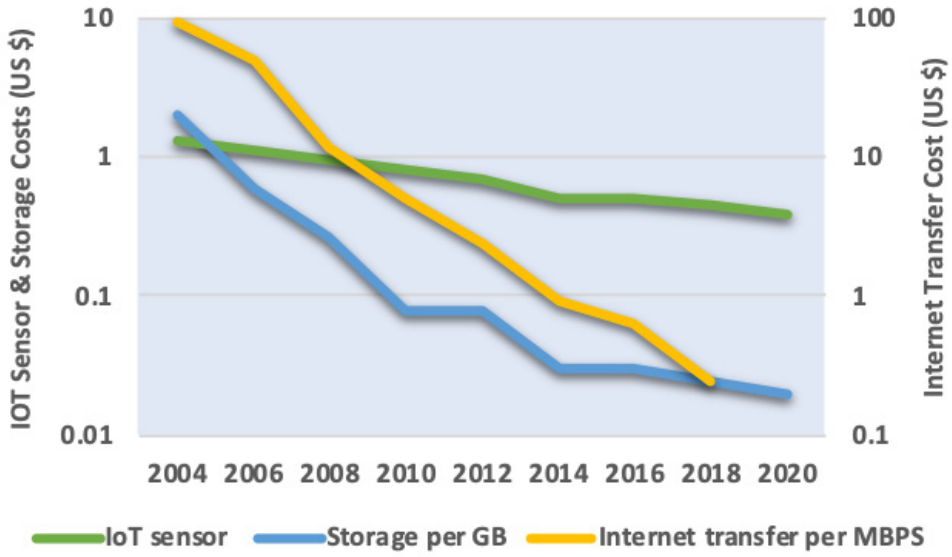
In the last two decades, the simultaneous convergence of four key elements have helped usher new applications for IoT especially in the Industrial sector, now collectively called Industrial IoT (IIoT). They include: -

- Evolution of Cloud infrastructure as Cloud as a Service to provide low cost storage and computing solutions
- Increase in data transfer speed and drop in cost of data transfer
- Drop in cost of IoT sensors by 50% in the last decade

Increasing and successful use of Artificial Intelligence within the industry

[1] *Gartner_Inc. "Definition of Internet of Things (Iot) - Gartner Information Technology Glossary." Gartner Glossary. Accessed February 10, 2021.*

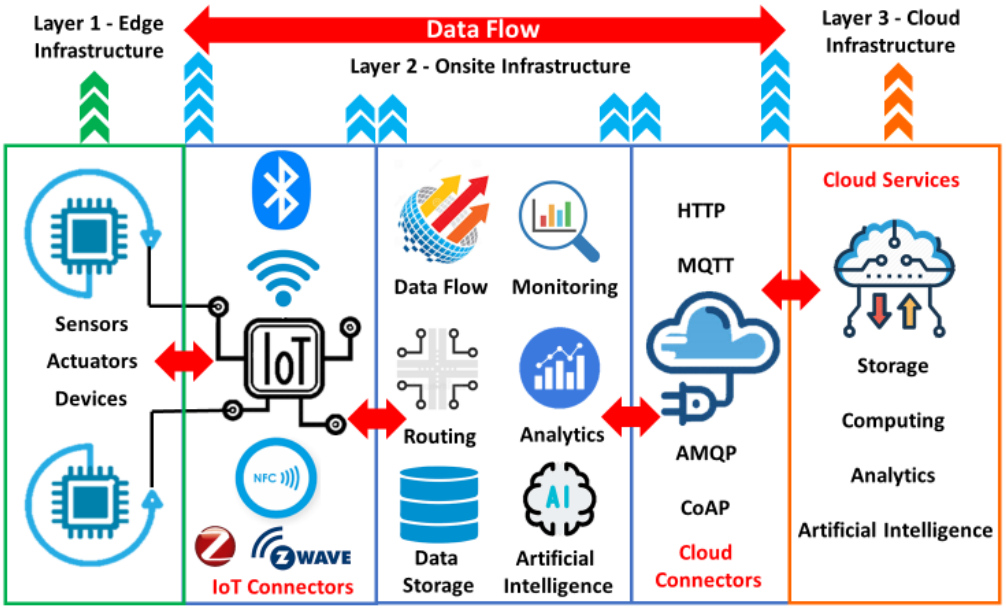
Figure 1: Cost convergence of data transfer, storage and IoT sensors



Source: Gateway House Research

A broad Industrial IoT (IIoT) architecture is depicted below. The architecture comprises three levels:

Figure 2: Basic IIoT Architecture



Source: Gateway House Research

Level 1 – Edge Infrastructure: Located near the physical device, this frame comprises sensors, actuators and devices that are connected to the physical industrial asset. The term "edge" indicates the boundary of the network i.e., the first point where the physical device connects to a computing infrastructure. Data generated through sensors is transmitted to either an on-premise or off-premise server to develop actionable insights through an analytical model. Such insights can also be utilised to control the actions of a machine through devices like actuators[2] fitted on the asset located at the edge.

Details of some popular IoT sensors, actuators and devices are tabulated below.

Table 1: Sensors and Actuators

Sensors	Actuators
Electrical Voltage, current, power, resistance, capacitance, inductance, frequency and phase	**Linear Actuators** Used to enable motion of objects or elements in a straight line.
Mechanical Level, temperature acceleration, flow, weight, speed, force, tension, pressure, torque, magnetic field, humidity, etc	**Motors** Enable precise rotational movements of device components or whole objects. They include servo motors, stepper motors and DC motors
Acoustic Sound, vibration, seismic	**Relays** Includes electromagnet-based actuators to operate power switches in lamps, heaters or even smart vehicles.
Image Light intensity and cameras	**Solenoids** Most widely used in home appliances as part of locking or triggering mechanisms, they also act as controllers in IoT-based gas and water leak monitoring systems.
Infrared	**Motor Starters**
Chemical Properties pH[3] , composition, purity, and concentration	**Variable Speed Drives**
Motion Sensors	
Proximity Sensors	

Source: Gateway House Research

[2] *Actuators:A device that controls or moves other devices.*
[3] *pH: PH is the measure to determine the degree of acidity*

Level 2 – Onsite Infrastructure: This level houses the IT/IoT infrastructure that helps connect the Edge environment (Level 1) to the cloud service that is (Level 3) managing the data storage, computing and analytical model by means of interconnectors – IOT connectors. The degree of dependence on cloud infrastructure largely depends on the data security requirements within a company and also the latency,[4] i.e., the accepted lag in response time of the analytical solutions.

Based on these requirements, an enterprise can opt for an onsite architecture with its own cloud services or can subscribe to a third-party cloud platform. A hybrid of edge and cloud are used concurrently at different levels.

Level 2 is the layer at which various insights created from the analytical model are made accessible to the factory line and process engineers, plant managers and operations managers.

Table 2: Basic IoT Hardware

Type	Application
• Microcontroller based development boards like Arduino[5] , Node MCU.[6]	• Read data from sensors • Push data to computing devices on-site or on cloud through established communication protocols • Receive data from devices/cloud and provide necessary controlling signals to the actuators
• Single board powerful computers like Rasberry Pi[7] which is essentially an affordable tiny computer • Beaglebone Black[8] is a low-cost wireless credit card sized LINUX computer. It has in-built ethernet connectivity and a HDMI port for connectivity to a display. • Intel Edison[9] uses an Intel Atom processor with a dual-core CPU at 500 Mhz and a microcontroller at 100 Mhz. The Edison board sports 1GB of memory, 4GB of storage, and even has Wi-Fi and Bluetooth 4.0 capabilities. It also has 40 General-Purpose InputOutputs(GPIO) for plugging in sensors.	• Read data from sensors • Rapid edge computing • Connectivity with displays

Source: Gateway House Research

[4] Latency: In computing and networking, latency is the time delay or lag in response time between the input and the output
[5] "Home." Arduino. Accessed Feb 10, 2021. • [6] "An Open-Source Firmware Based on ESP8266 Wifi-Soc." NodeMcu. Accessed Feb 10, 2021. • [7] Raspberry Pi. "Teach, Learn, and Make with Raspberry Pi." Raspberry Pi Foundation. Accessed Feb 10, 2021.
[8] "BeagleBone Black." Beagle Board - beagleboard.org. • [9] "IntelEdison." Arduino. Accessed Feb 10, 2021.

Level 3 – Cloud Infrastructure: These can include onsite proprietary cloud networks or third-party cloud platforms like Amazon Web Services[10], Microsoft Azure[11], IBM Cloud[12] and Google Cloud.[13] Indian players such as Reliance have also entered this market with Jio Cloud.[14] The Government of India uses its own called MeghRaj.[15] Recently, India's largest data centre has been operationalised in Mumbai by the Hiranandani group[16] to provide IT and cloud infrastructure as a service. More Indian players are expected to enter the Cloud and data centre space with the Indian government's push for self-reliance or Atmanirbhar. Enterprises can also use hybrid infrastructure wherein on-premise cloud is used for business-sensitive classified data and third party cloud is used for less sensitive commercial data.

Elements of Industrial IoT

Apart from elements like sensors, actuators, IoT connectors, IoT processors and Cloud services. several IIoT elements are bringing rapid change into the manufacturing process, for example,

- **Edge Vs Cloud Computing:** Edge computing is used to process time-sensitive data in real-time as its infrastructure is near the data source. Cloud computing is used to process data that is not time-driven. For instance, in cloud computing it may take up to two seconds to relay information to the centralised cloud-based data centre, thereby delaying the decision-making process. Sometimes, in high precision machinery like temperature sensitive metallurgical furnaces, even this slight delay in signal transmission can lead to the organization incurring losses. Hence, some organisations prefer edge computing to cloud computing.

  However, unlike common computers, Edge computing has limited computing capabilities, often analysing only specific parameters originating from sensors to provide localised outputs. The following table compares the two computing technologies :-

Table 3: Edge Computing Vs Cloud Computing

Edge Computing	Cloud Computing
• Used in applications where signal latency is critical. Response is in micro seconds in edge computing	• Up to 2 seconds delay in signal round-trip transmission
• Applications where connectivity is unavailable.	• Data connectivity to remote servers essential.
• Limited processing capabilities & storage	• High computing and storage capabilities
• Edge computing is used to create a continuum for distributed data processing	• Cost of improvement in connectivity, data migration, bandwidth, and latency can become expensive as compared to edge computing.

[10] "Start Building on AWS Today", Amazon • [11] "Cloud Computing Services: Microsoft Azure." Cloud Computing Services | Microsoft Azure. Accessed February 10, 2021 • [12] "IBM Cloud." IBM. Accessed February 10, 2021 • [13] "Google Cloud", Google. Accessed February 10, 2021. • [14] "Jio Cloud", Jio. • [15] "Infrastructure & Platform as a Service", National Cloud, Ministry of Electronics and Information Technology, Government of India. • [16] India's Biggest Hyperscale Tier 4 Data Center Service Provider." Yotta Infrastructure, January 20, 2021.

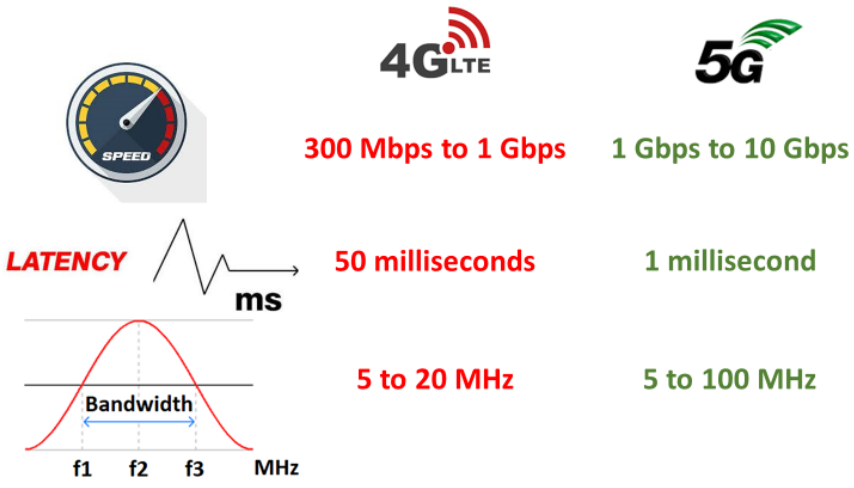
Edge Computing	Cloud Computing
• Ownership of data security	• Third party guarantee on data security
• Limited scaling opportunity due to limited computing and storage capabilities	• Easy to scale
• In-house responsibility for infrastructure setup and maintenance	• Infrastructure and maintenance and bundled as a service
• Remote connectivity restricted to edge	• Enables remote connectivity

Source: Gateway House Research

- **5G Technology:** Existing factory floor communication largely relies on Wi-Fi and 4G networks. With digitisation, the number of devices inter-connected on the factory floor is increasing exponentially, placing huge demands on the data handling capabilities of these networks. A multitude of devices results in massive volumes of data being transmitted and can create network bottlenecks, slowing the entire system.

  The entry of new fifth generation of mobile networks (5G) is a catalyst for data-hungry smart factories as it offers enhanced speed and bandwidth whilst substantially reducing latency. A comparison of the two technologies is depicted in Figure 3 below.

Figure 3: Performance comparison: 4G LTE vs 5G



Source: Gateway House Research

- **Artificial Intelligence:** Artificial Intelligence leverages technologies such as machine learning, augmented reality and many others. The current use of AI on the factory floor can range from predictive maintenance of machinery to defect detection in an assembly line. Several surveys[17] show that labour productivity improvements will contribute 55% of the forecasted $ 16 trillion GDP gains from AI between 2017 – 2030.

  Some of the common applications of AI in the industry value chains are tabulated below: -

Table 4: Edge Computing Vs Cloud Computing

Technology	Use Case
• Machine Learning	• Predictive maintenance • Equipment health monitoring • Product design • Demand forecasting • Improve safety • Real-time value chain optimisation • Enabling new and improved products and services • Optimisation of consumptions of utilities like power, water, air, raw materials • Big data analytics
• Computer Vision	• Operator procedural compliance • Quality inspection • Smart retail
• Augmented /Virtual Reality	• Training • Adherence to SOPs during maintenance tasks
• Digital Twin	• Remote monitoring of equipment performance
• Autonomous robots	• Warehousing solutions • Safety improvement

Source: Gateway House Research

- **3D-Printing:** 3D-printing or Additive Manufacturing (AM) uses digital 3D models to create metal and non-metal parts with a 3D-printer layer by layer. Already, 3D-printing technology is showing tangible value. For instance, the turnaround time to prototype a product can be reduced significantly resulting in more design flexibility. Manufacturers[18,19] of 3D printers expect 3D-printing technology to be the game-changer that will disrupt traditional manufacturing value chains.

[17] *Sizing the prize What's the real value of AI for your business and how can you capitalise?*
[18] *"3-D Printing: A Game Changer for Manufacturing (Ebook)." Infosys Consulting - One hub. Many perspectives., December 7, 2018*
[19] *"3D Printing Growth Accelerates Again." Deloitte Insights. Accessed February 10, 2021.*

It will shift centralised mass production to distributed and fully-customised production. Such a decentralised approach to manufacturing can eliminate transportation costs, as well as simplify inventory management by storing digital files instead of physical parts. With decentralised manufacturing localisation will also get a boost.

For now, though 3D printing faces some challenges like the 1) Inability to produce parts that can withstand harsher operating conditions such as extreme temperature, humidity, or salinity 2) Unsuitability for mass production, which is one of the main objectives in manufacturing, 3) Challenge in selection of the right material and 3D-printing technique. The required characteristics of a final product can change even with the slight deviation in properties of the input material, 4) Inconsistency of production due to its layer-by-layer production process where even a minor deviation affects repeatability, 5) Error-free production, 6) Need for skilled process and design engineers and 7) Expensive equipment

- **Robotic Automation:** In a country like India that is sensitive to employment generation, robotic-automation is a delicate issue. But automation is already in practice, and the larger companies typically adopt a gradual and phased approach to robotic-automation. That's because automaton of factory-floor operations is key to improved productivity and quality. Manufacturers desirous of implementing robotic automation must focus their capital on the 4Ds[20]: Tasks that either Dull, Dirty, Dangerous, or Difficult[21,22]. Supporting Robotic automation is Robotic Process Automation (RPA),[23] a software which allows the robot to mimic digital human actions.

  In a country like India, complete robotic automation can be detrimental to jobs. Here, cobots can be a middle way. Cobots or collaborative robots aid manpower without replacing them. Instead of separating humans and robots, cobots work through human-machine interaction. For instance, single arm cobots of Universal Robots help human employees to pick heavy objects or handle sharp items.

Industrial IoT is not a one-size-fits-all solution. Every application and every situation in an industry is unique and therefore the selection of appropriate IIoT tools also needs a unique approach. Adopting standards-based hardware and software can save time and expenses in the early stages of development, without sacrificing flexibility. Capital availability is at premium for the MSMEs. They should first identify pain-points in their value chains, where digital tools will be the most beneficial for achieving the Key Performance Indicators (KPIs).

MSMEs can get assistance from organisations like C4I4 (Centre for Industry 4.0 Lab) setup under Government of India's Samarth Udyog initiative, to conduct pilot projects with very little investment. Such projects must be implemented within selected elements of the value chain to verify their efficacy. The learnings from the pilot implementation will influence the choice of hardware and software required for deploying the IoT solution at a larger scale. Indian MNCs can also play a huge part by training and hand-holding MSMEs to adopt IIOT solutions. All parties are expected to gain when the entire supply chain is digitally transformed.

[20] *Marr, Bernard. "The 4 Ds Of Robotization: Dull, Dirty, Dangerous And Dear." Forbes. Forbes Magazine, October 16, 2017.*
[21] *Yakowicz, Will. "Robots Are the Future of Employment." Inc.com. Inc., April 15, 2016*
[22] *Marr, Bernard. "The 4 Ds Of Robotization: Dull, Dirty, Dangerous And Dear." Forbes. Forbes Magazine, October 16, 2017.*
[23] *Inc., UiPath. "What Is Robotic Process Automation - RPA Software." UiPath. Accessed February 10, 2021.*

Industrial Cybersecurity

Preventing and mitigating cyber-attacks

by **Sagnik Chakraborty,** Researcher, Cybersecurity Studies Programme

The growth of digital interconnectedness between the factory floor and the internet has led to a corresponding growth of potential risks with both humans and machinery susceptible to manipulation. This has deep implications for the safety of personnel, plants and machinery, and profits.

The December 2020 cyber-attack on the information technology monitoring and management company SolarWinds' Orion platform, used by governments and corporations, has once again brought forth the vulnerabilities of an interconnected world. The U.S. Computer Emergency Response Team (U.S. CERT) has released an emergency directive to tech companies and government agencies to unplug from the Orion platform immediately.[1]

Cyber-attacks pose a greater threat to industries like manufacturing and energy than to software or service-based companies. The realm of cyber-physical systems allows the cyberworld to manipulate the physical. The Ukraine power grid crisis,[2] the Stuxnet attack, the Saudi Aramco[3] attack had all resulted in crippled systems, not only causing business loss but also endangering lives.

A compromised electric system can cause fire safety issues in the office premises. A compromised safety system in a manufacturing plant is a threat to all employees. A compromised safety system in a nuclear power plant can be a threat to an entire city.

Thus, the threat spectrum in the era of industrial internet of things moves from just data security, intellectual property theft, and industrial espionage to the security of physical assets such as machinery to the safety and security of people.

The table below lists industrial cyber-attacks in the last decade.

Table 5: Industrial cyber-attacks since 2010

Year	Attack	Description
2010	Stuxnet attack	Malware which damaged Iran's nuclear programme
2011	Duqu and Flame attack	Malware targeting Middle East
2012	Shamoon malware attack	Attack on Saudi Aramco
2013	Attack on New York Dam	DDOS using botnets on the SCADA systems
2014	Attack on German Steel Mill	Phishing email to gain access to control systems
2014	Black Energy	Trojan to conduct DDoS, cyber espionage and information destruction attack in ICS systems globally
2015	Attack on Ukranian Power Grid	Attack on control systems disrupting electricity supply
2016	Attack on Ukranian Power Grid	Malware called Crash Override used to disrupt electricity supply
2017	NotPetya	Global impact of a malware which encrypted hard drives preventing usage of computer systems
2017	Triton/Trisis	Attack on Saudi Arabia Petrochemical companies
2017	WannaCry Attack	Global Ransomware attack on Microsoft Windows Operating Systems

[1] *"Emergency Directive 21-01." cyber.dhs.gov. Accessed February 10, 2021*
[2] *"ICS Alert (IR-ALERT-H-16-056-01)." Cybersecurity and Infrastructure Security Agency CISA. Accessed February 10, 2021*
[3] *"ICS-CERT MONTHLY MONITOR." Industrial Control Systems - Cyber Emergency Response Team. U.S. Department of Homeland Security*

Year	Attack	Description
2019	Attack on Norsk Hydro	LockerGaga ransomware affected Norsk Hydro, a Norwegian Aluminium Company
2021	Attack on Florida Water Systems	Attack by a remote hacker. Nature of attack under investigation

Source: Gateway House Research, US CERT, ISA/IEC 62443 Guidebook

Industrial Cybersecurity can be divided into two parts: Information Technology (IT) security and Operations Technology (OT) security. Operations Technology is defined as hardware and software used to control industrial assets. It includes Industrial Control Systems (ICS), supervisory control and data acquisition (SCADA) systems, and Programmable Logic Controllers (PLC) which provide an interface between the virtual and physical worlds.

As per IBM's Threat Intelligence Index report 2020, attacks on Operational Technology saw a 2000% year on year increase in 2019. Though cybersecurity in IT systems have matured over the ages, applying only IT solutions in industries will not provide 360-degree security. This is because the primary goal of IT security is to protect information while the primary goal of OT security is to protect physical assets and people.

Traditionally, OT systems were not connected to the internet – which helped with immunity to cyber-attacks that the IT industry encountered. The drive to digitise and connect everything brought with it the additional risk of cyber-attacks. With the current digitisation blitz, industrial systems are getting connected to the world wide web at an unprecedented rate. Juniper Research predicts that the total number of Industrial IoT connections will reach 36.8 billion by 2025.[4] It is difficult for security providers to match this speed.

Malware and ransomware are the major attack vectors.[5] Stuxnet, NotPetya, and LockGrid were all malware. The 2019 attack on Norwegian Aluminium company, Norsk Hydro, was through the LockGrid ransomware which caused an estimated damage of $75 million.[6]

Amongst other challenges, legacy operating systems[7] which are not supported by software providers are a major concern. These systems run on workarounds, as there are no security patches available for old operating systems. It is imperative that migration of legacy systems to newer IT solutions is done quickly to counter modern day cyber-attacks.

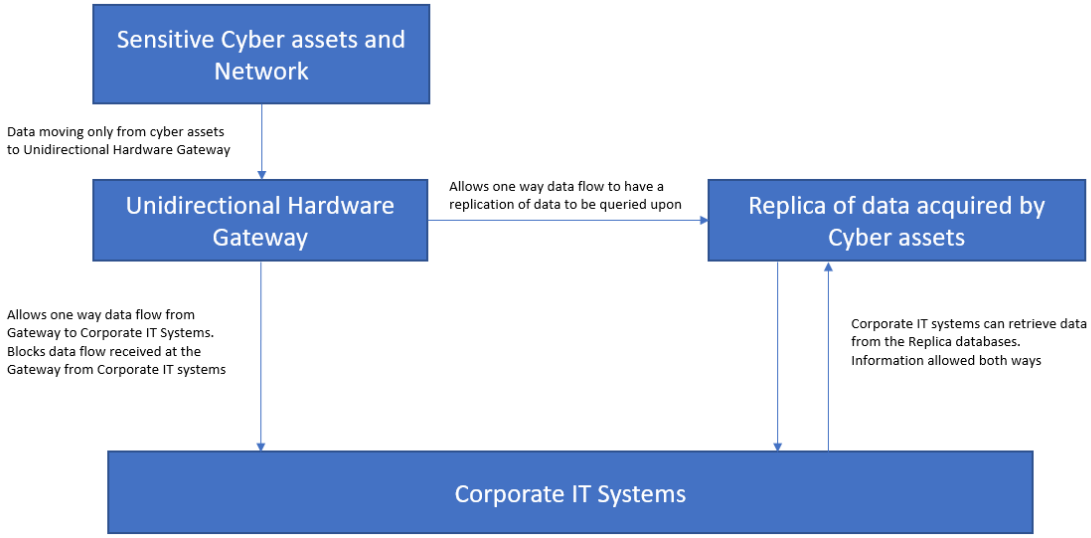
The nature of attack changes with industrial internet of things. For instance, a distributed denial of service (DDoS) attack on an IT system will only prevent users from availing of a service. However, a DDoS attack on a temperature control system may cause overheating and a breakdown of machinery. Thus, the surface area of attack is more and the ability to cause physical damage is vast. Organisations must apply existing IT security solutions to their processes. For example, updating software with the latest patches, firewalls to protect the companies' networks, and whitelisting and access control to ensure only authenticated individuals can operate a machine are some of the measures to be implemented.

[4] "Industrial IoT Connections to Reach 37 Billion Globally by 2025, as 'Smart Factory' Concept Realised." Industrial IoT (IIoT) Connections to Reach 37bn globally by 2025. Accessed February 10, 2021. • [5] Ginter, Andrew. "THE TOP 20 CYBERATTACKS on Industrial Control Systems." Waterfall Security Solutions LTD. • [6] "Cyber-Attack on Hydro." Hydro.com. Accessed February 10, 2021 • [7] Patil, Sameer. "India's Vulnerable SCADA Systems." Gateway House, December 21, 2017.

Apart from IT security solutions, OT requires additional security. A cyber-physical system requires both software and hardware solutions. IT provides software solutions; however, software tends to have bugs and vulnerabilities. So, to ensure depth in defence, hardware security solutions need to complement software. Air gaps and Unidirectional hardware gateways are two solutions that can increase security exponentially.[8]

- **Air gaps:**[9] These are isolated networks where critical infrastructure is physically segregated from the corporate network. Air gaps disallow systems like Wi-Fi and allow only specific modes of network communication. Insider threats – such as malicious USB ports – pose a major risk to air gapped systems. The success of the Stuxnet attack on an air gapped Iranian nuclear facility was allegedly due to an insider attack.[10]
- **Unidirectional hardware gateways:**[11] This equipment allows network traffic to flow in only one direction and is physically unable to send any information at all back into the source network. For instance, data captured through sensors on a factory floor and stored on servers can be prevented from external access through a unidirectional hardware gateway. Any analysis or data access requests can be fulfilled by replicating the data on a different server which can be accessed by external IT systems. This prevents any attacker trying to get in the system as the gateway blocks all incoming traffic.

Figure 4: Network Traffic Flow in Unidirectional Hardware Gateway



Source: Gateway House Research, NIST SP 800-82 Rev. 2 [12]

It must be noted that whatever measures are implemented in an existing system, they have to be first run in a test bed or sandbox, simulating a real-life attack scenario before being applied in a production environment. Security measures can be administered only after thorough penetration testing.

Such measures and other strategies can be found in two guiding documents for industrial cybersecurity: a framework by U.S. government's National Institute of Standards & Technology (NIST) and a standard by International Society of Automation (ISA) & International Electrotechnical Commission (IEC).

[8,9] Ginter, Andrew, 'Secure Operations Technology', (Abterra Technologies Inc. 31 December 2018) • [10] Pompon, Raymond. "Attacking Air-Gap-Segregated Computers." F5 Labs, September 5, 2018. • [11] Ginter, Andrew, 'Secure Operations Technology', (Abterra Technologies Inc. 31 December 2018) • [12] Editor, CSRC Content. "Unidirectional Gateway - Glossary." CSRC. Information Technology Laboratory. Accessed February 10, 2021.

- NIST Cyber framework for Improving Cybersecurity of Critical infrastructure:[13] The framework helps in categorising risks into various buckets with corresponding standards that may apply. The framework is divided into three sections:

Table 6: NIST Cyber Framework for Improving Cybersecurity of Critical Infrastructure

Section	Sub-section	Description
Framework Core Functions	• Identify • Protect • Detect • Respond • Recover	• Develop organisational understanding to manage risk • Develop appropriate safeguards • Develop activities to discover cybersecurity event • Action against a detected incident • Restore services
Implementation Tiers	• Tier 1 Partial • Tier 2 Risk Informed • Tier 3 Repeatable • Tier 4 Adaptive	• Least rigour with ad hoc processes • Awareness at the highest level but organisation wide adoption pending • Formally approved policies with organisation-wide adoption • Maximum rigour with an adaptive approach to evolve with the threat landscape
Framework Profiles	• Current Profile • Target Profile	• To chart the 'as-is' state • To chart the desired 'to-be' state

- ISA/IEC 62443[14] – The International Society of Automation and International Electrotechnical Commission have jointly produced the ISA/IEC 62443 standard for security of Industrial Automation and Control Systems (IACS). IACS is defined by this standard as "a collection of personnel, hardware, software, and policies involved in the operation of the industrial process and that can affect or influence its safe, secure and reliable operation".[15] OT systems are covered by this standard. The standard highlights that extending purely IT security solutions to industrial cybersecurity will not provide a comprehensive security solution. The ISA/IEC 62443 family of standards is divided into four sections:

[13] *Barrett, Matthew P. "Framework for Improving Critical Infrastructure Cybersecurity Version 1.1." NIST, January 27, 2020.*
[14,15] *Automation, International Society of. Download ISAGCA's Quick Start Guide for the ISA/IEC 62443 Standards. Global Cybersecurity Alliance. Accessed February 10, 2021.*

Table 7: ISA/IEC 62443 Standards Documents

Section	Type of document	Purpose
General	Terminology, Models, System security conformance metrics, IACS security lifecycle and use cases	To familiarise the audience with basic standards
Policies & Procedures	Program to establish IACS cybersecurity management system, Security Programs Ratings, Patch Management	Targeted specifically for industrial asset owners
System Requirements	Security Technologies, Risk Assessment for System Design, System security requirements & security levels	Describes applicability of specific technologies
Component Requirements	Product security lifecycle requirements, Technical security requirement for IACS components	Provides detailed requirement for IACS products

Despite applying all standards and taking maximum precautions, a system may still be penetrated. Therefore, standard operating procedures (SOPs) should exist for not only what needs to be done before an attack, but also during and after an attack. An end-to-end incident response mechanism can minimise damage during a crisis. After an attack has been contained, special attention needs to be given to recovery. The Mean Time to Recover (MTTR) in IT systems is quite minimal, but industrial systems could take much longer to recover. An IT system can be restored fairly quickly with previous data and system backups. However, an attack that has led to, for example, shutting a furnace in a steel plant, can cause heavy business losses and recovery could take months.

The following recommendations can help mitigate industrial cyber risks:

1. **Physical protection along with IT protection:** Software security solutions alone cannot protect physical assets and machinery. Integrated software and hardware protection are needed for maximum protection.
2. **Security Drills:** Cybersecurity attack and response drills help an organisation to manage attacks. Appropriate response protocols prevent sudden panic and help to contain an attack.
3. **An integrated Chief of IT & OT:** Chief Information Officer and Chief Information Security Officer (CISO) are traditionally from the IT industry. To protect cyber-physical systems, manufacturing organisations need to have a security head who is an expert in both IT and OT.
4. **Industrial Computer Emergency Response Team (CERT):** Just like the proposed CertFin, a dedicated CERT for Industrial Cybersecurity can provide dedicated focus to the sector.

The world of industrial cybersecurity is evolving. Industrial cybersecurity needs to mature to the level of Information Technology security to provide a safe environment in this interconnected universe.

Regulations for 3D Printing

by **Ambika Khanna,** Senior Researcher, International Law Studies Programme

3D printing has the potential to revolutionize manufacturing. To do this, it needs a conducive regulatory environment, both at the domestic and global level, especially as it is becoming a critical element in industry and national security. This will be a game changer for countries that are heavily reliant on China for manufacturing.

3D printing (3DP), a critical emerging technology, has come into the limelight in the last decade. Industries such as pharmaceuticals, bio-medicine, aviation and automobiles have rapidly adopted 3D printing. Space agencies such as NASA and India's ISRO have been using 3DP components in spacecrafts. Its use is becoming so pervasive, that the 3DP industry is expected to grow dramatically from $9.9 billion in 2018 to $42.9 billion by 2025.[1]

However, in spite of its huge potential and significance for the digital economy, there is no global policy on 3DP. While it has mostly escaped relevant regulation in countries such as India, in some countries the regulation is centered only around singular sectors such as medical devices. Now, industries across the board and round the world are looking at 3DP to define the future of technology, and governments must focus their attention on regulating 3DP as a whole, and sector-wise wherever the need arises. This is especially relevant as different countries are at different stages of adoption of 3D technology, greatly varying from sector to sector.

The countries leading in the implementation and regulation of 3DP are China, the US and the EU. China, has been working extensively to develop its 3DP market and the regulations to govern it. In 2017, it formulated an action plan for the development of the 3DP industry 'Additive Manufacturing Industry Development Action Plan (2017-2020)'.[2] A year later, China's Center of Medical Device Evolution, issued guidelines[3] for the regulation and registration of 3DP medical devices including custom-built additive-produced medical devices. China has since released several guidelines for different 3DP medical devices including a 2020 technical guidance for 3D printed artificial vertebrae[4] and an acetabular cup.[5]

The US government too is keeping pace. In 2017, the Food and Drug Administration (FDA) issued guidance for additive manufactured medical devices, including recommendations for testing of devices that include at least one additively manufactured component or additively fabricated step. In the aerospace industry, the Federal Aviation Administration (FAA) has developed an eight-year Additive Manufacturing Roadmap which will cover manufacturing and certification policies.[6] FAA has also approved the manufacturing of 3D printed components for commercial engines.[7] The US, through the introduction of several bills before the Congress, has tried to curb and control the misuse of 3D printing of firearms.[8] However, none of these have seen the light of day yet.

The EU has specific legislations for the use of 3DP for manufacturing of medical devices.[9] During COVID-19, it issued special guidelines on using 3D printing for providing COVID-19 relief.[10] In fact, the pandemic has accelerated the importance and implementation of 3DP.

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[1] *Markets and Markets, "3D Printing Market worth $42.9 billion by 2025 with a growing CAGR of 23.3%".*
[2] *"Multi-departmental joint publication to support the development of additive manufacturing industry", December 14, 2020.*
[3] *Centre for Medical Device Evaluation, National Medical Products Administration, People's Republic of China, "Guidelines for the Technical Review of Custom Additive Manufacturing Medical Device Registration", February 26, 2018.*
[4] *Centre for Medical Device Evaluation, National Medical Products Administration, People's Republic of China, "3D printing artificial vertebrae registration technical review guidelines (No. 36 of 2020)", June 5, 2020.*
[5] *Centre for Medical Device Evaluation, National Medical Products Administration, People's Republic of China, "3D printed acetabular cup product registration technical review guidelines (No. 36 of 2020)", June 5, 2020*
[6] *Martin, Nichols, "FAA Drafts Plan to Regulate Additive Manufacturing of Aerospace Components", October 23, 2017.*
[7] *General Electric, "The FAA Cleared the First 3D Printed Part to Fly in a Commercial Jet Engine from GE", April 14, 2015.*
[8] *H.R.7115 - 3-D Firearms Prohibitions Act, 115th Congress (2017-2018).*
[9] *Council Directive 93/42/EEC of 14 June 1993 concerning medical devices*
[10] *Conformity assessment procedures for 3D printing and 3D printed products to be used in a medical context for COVID-19.*

In March this year, an Italian start-up, Issinova, used 3D printing to manufacture respiratory valves to swiftly meet a supply shortage, arising out of increased demand, in a hospital.[11] These were made under the EU COVID-19 guidelines for 3DP medical devices. Recently, US' FDA allowed 3D manufacturing of ventilator tubes and other accessories.[12] So did the UK.[13]

With 3DP set to dominate the future of manufacturing, standardisation is a key concern. Therefore, the International Standards Organization (ISO) is currently developing a standard on 3D printing: IEC CD 23510.[14] ASTM International and ISO set up a working group in 2016 which has been recommending standards on additive manufacturing.[15] It has created a framework on 3DP called the Additive Manufacturing Standards Structure. ISO already has various standards on additive manufacturing, some of which have been developed while others are under development.[16]

Where does India fit in? Just two states, Maharashtra and Rajasthan[17] recognise the importance of smart manufacturing in their industrial policies, yet do not provide policy guidelines required for 3DP, an important component of smart manufacturing. One of the salient features of the National Policy on Electronics, 2019 is to promote R&D and start-ups in emerging areas of technology including additive manufacturing.[18] However, domestic manufacturing has yet to realise the full potential of 3DP.

Currently, India has only some sector specific laws, such as in medicine, which can be interpreted to include 3DP. In the medical/ pharmaceutical field, where 3DP is most used, 3D printed objects include:

1. Anatomical elements of the human body (organs, bones, glands, etc.);
2. Pharmacological, immunological or metabolic in nature (eg. medicines like tablets, capsules, etc.) and;
3. Those that assist in the treatment, monitoring, alleviation, etc. (eg. ventilators, scanning machines, medical instruments like forceps, scalpels, protective gear, etc.).

India's Drugs and Cosmetics Act, 1940 does not specifically include such 3D printed objects but the Ministry of Health and Family Welfare expanded the definition of 'drugs' under the Act in February 2020[19] to include appliances whose function is the diagnosis, prevention or treatment of a disease. However, there is lack of clarity on the applicability of this legislation to 3D printed devices.

Similarly, while the Transplantation of Human Organs and Tissues Act, 1994 deals with transplantation of organs from a person-donor, transplanting a 3D printed organ/gland is beyond the scope of this legislation.[20] These laws must be amended to include 3D printed devices and organs, or separate policy guidelines must be established for these.

[11] Zarzalegos, Ana; Moynihan, Ruqayyah, "A startup in Italy used 3D printing to make valves for COVID-19 patients", World Economic Forum, March 18, 2020.
[12] U.S. Food and Drug Administration, "3D Printing of Medical Devices, Accessories, Components, and Parts During the COVID-19 Pandemic"
[13] Medicine and Healthcare products Regulatory Agency, Guidance, "3D printing (additive manufacturing) of medical devices or component parts during the coronavirus (COVID-19) pandemic", June 4, 2020
[14] ISO/IEC CD 23510, Information technology — 3D Printing and Scanning — Framework for Additive Manufacturing Service Platform (AMSP)
[15] Naden, Clare, "ISO AND ASTM INTERNATIONAL UNVEIL FRAMEWORK FOR CREATING GLOBAL ADDITIVE MANUFACTURING STANDARDS", October 7, 2016.
[16] "ADDITIVE MANUFACTURING." ISO, February 5, 2021.
[17] Rajasthan Industrial Development Policy 2019, Government of Rajasthan.
[18] Press Information Bureau, "Cabinet approves the proposal of National Policy on Electronics 2019", February 19, 2019.
[19] Department of Health and Family Welfare, Ministry of Health and Family Welfare, Government of India, Notification, February 11, 2020.
[20] The Transplantation of Human Organs Act, 1994

The COVID-19 pandemic will certainly boost the use of 3DP. Any relief material, cure or preventive vaccine or drug that is discovered can quickly go into mass production using 3DP.

This is an opportune moment for India to consider a comprehensive policy on 3DP, or even the principles that should govern 3D printing. It can be the model for global guidelines. The comprehensive policy should address:

1. purchase of 3D printers and scanners;
2. manufacturing processes using 3D printers;
3. quality of input material and final product;
4. classification of computer-aided design (CAD)/digital file, and whether it is a good or a service, which will determine its sale, distribution and taxation;
5. product sale and distribution, including intermediary liability;
6. Governing body and single window clearance for businesses;
7. Standardisation:
   - 3DP should be explicitly included under Bureau of Indian Standards (BIS), the nodal standards body in India, BIS' compulsory registration scheme for printers [21]
   - BIS should consider establishing separate standards for input units used in 3DP, in addition to standards for the final product;
   - Central Drugs Standard Control Organisation, which sets the standards for drugs that are manufactured in and imported into India, should set standards for 3D printed medical devices and drugs.

While policy and standards will create a conducive framework for the regulated growth of 3DP in India, the government needs to supplement this impetus with fiscal and tax incentives for those businesses adopting 3DP. There are examples to follow, For instance Australia, to promote advanced manufacturing including 3DP, created an ecosystem which included different funds for R&D and capital investments in emerging tech companies, and innovation labs that support new ventures in this sector.[22] Recently, India announced production-linked incentives for electronics manufacturing and for the domestic manufacture of medical devices and drugs. The government is also in the process of considering similar schemes for other sectors such as auto components. Such incentives should be considered for 3D printing, across sectors.

With India's increased focus on self-reliance, 3DP can be a game changer especially in critical sectors where India is heavily reliant on raw material or final product from countries such as China. Sectors such as electronics, pharma, aviation or defence, can all be developed at home with a focus and clear policy on 3DP, with enormous benefit to the economy.

[21] *Scheme - II (Registration Scheme), Foreign Manufacturers Certification Scheme, Bureau of Indian Standards, The National Standards Body of India.*
[22] *Department of Industry, Science, Energy and Resources, Government of Australia, "Supporting Advanced Manufacturing".*

Case Studies

by **Cdr Amrut Godbole,** Indian Navy Fellow
& **Sagnik Chakraborty,** Researcher, Cybersecurity Studies Programme

CASE STUDY

01

Tata Steel: Lighthouse for Indian Manufacturers

Vision of digital manufacturing:
Efficiency, safety, cost-savings, quality

Potential benefits for India:
Regional clusters of industries adopting digitization, becoming export-worthy

How to accelerate adoption:
Start small, internal buy-in, building in-house talent

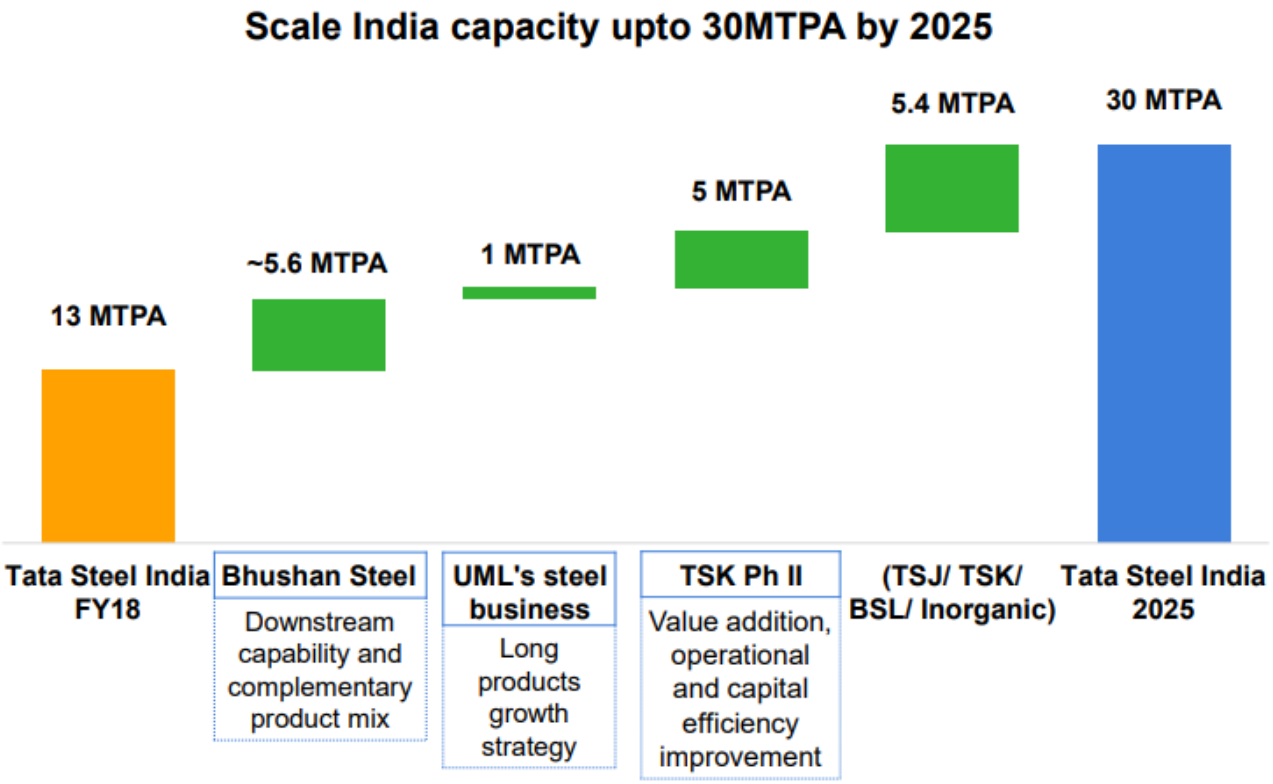
The vision of a digitally integrated manufacturing facility was introduced when the design for the Tata Steel Kalinganagar plant (TSK) was envisaged way back in 2006. The subsequent implementation and continuous upgrade of the facility, has made it a global benchmark in India. It involved end-to-end digitization of the manufacturing floor, structural changes and intensive skilling and training of in-house personnel, to meet the goal of Industry 4.0. It has inspired the other steel plants in the regional domestic cluster, to aspire to the same level. Learnings from TSK can guide other companies, MNCs and MSMEs, to overcome challenges in upgrading systems, using artificial intelligence and big data analytics to increase efficiency and drive innovation.

1. Introduction

Tata Steel has two steel manufacturing facilities in India, at Jamshedpur (TSJ) and Kalinganagar (TSK). The Jamshedpur plant has been operating for more than 100 years, while the Kalinganagar plant began operating in May 2016. The company currently has a capacity of 13 Metric Tonne Per Annum (MTPA) (10 TSJ+3 TSK) and plans to scale production by 17 MTPA to 30 MTPA by 2025.

The acquisitions of Bhushan Steel and Usha Martin in 2019, are set to contribute 5.6 MTPA and 1 MTPA respectively. The expansion currently underway at TSK will increase existing capacity from 3 MTPA to 8 MTPA. Additionally, Tata Steel has targeted organic growth of 5-6 MTPA.

Figure 5: Capacity Expansion at Tata Steel



Source: Tata Steel

Tata Steel's management believes that digital transformation initiatives will be a major contributor towards this inorganic growth. In July 2019, TSK became the first facility in India to be recognised by the World Economic Forum (WEF), and included in the 'Global Lighthouse Network' list of 54 global facilities. As a result of this Tata Steel has since been organising 'Go and See' events for more than 30 Indian and international MNCs to increase awareness on Industry 4.0.

The TSK plant, designed in 2005, provided the plant designers an opportunity to map and introduce technologically advanced infrastructure as part of the plant design. These features incorporated at the design stage have helped TSK plant upgrade to Industry 4.0 solutions with relative ease as compared to TSJ.

Digital transformation initiatives at Tata Steel are not limited to TSK but are also being implemented at the older TSJ facility. With the aim to accelerate technology adoption, an Analytics and Insights (A&I) Centre has been setup in Jamshedpur. In 2020, analytics projects worth approximately $ 25 million were executed across the value chain.

2. Transformation Philosophy

Sarajit Jha, Chief Business Transformation and Digital Solutions Officer, at Tata Steel, believes the maturing of IT infrastructure and Manufacturing Execution System (MES) under Industry 3.0 is a fundamental requirement for a successful, digitally driven, Industry 4.0 transformation.

Learn Global – Implement Local

According to Tata Steel, while the journey for digital transformation is internally driven, understanding and implementing global industry best practices is crucial for accelerating the transformation. Tata steel brought in McKinsey and Company as 'Value Discovery Consultants' to assist in establishing a framework and roadmap for a sustainable digital transformation infrastructure, at the Kalinganagar facility.

Tata Steel's management believes that transformation cannot be driven by outsiders. Outsourcing of skill and expertise for digital transformation will not only prove costly but also fail to address a defined business problem. Process insights are crucial for a sustainable transformation and to consistently deliver valuable business insights. Across its HR chains, Tata Steel therefore encourages people to explore, fail and innovate in-house. Amit Kumar Chatterjee, Chief Analytics Officer, identifies the following as key drivers for a successful, enterprise-wide, digital transformation:

- Leadership
- Patience and perseverance
- Tough strategic decisions
- Collaboration
- Resources
- Mind-set transformation
- Democratisation of analytics

It is interesting to observe that a majority of on-site engineers and technicians at TSK come from universities in Odisha and surrounding areas, making this a truly local effort at competing on a global scale.

3. Methodology

- **Opening Day Requirements (ODR):** ODR is a check list that is thoroughly scrutinised by site engineers to ensure that all essential requirements impacting plant commissioning are met in a time-bound manner. Through 2014, the ODR was continuously monitored to ensure timely availability of critical digital infrastructure such as fibre-optic cables, radio, and data centres. A year ahead of the plant commissioning, site engineers started ensuring stabilisation of the digital infrastructure aimed at reliable and trouble-free operation.

- **Digital Value Acceleration Team (DVAT)**. In May 2016, the DVAT was created to focus on two aspects – organisational policy interventions and resource allocation. The DVAT evaluated each digital transformation project for its potential in solving key problems across value chains, and the project's ability to provide business intelligence leading to value addition. The team followed a 'Value Discovery 'path for digital solutions using a combination of data science, 'App' based tools, cameras, and Industrial IoT among others. The DVAT not only enabled value creation but also aided in projecting the capabilities of digital technologies to top management.

- **Structural Changes:** Prior to Dec 2017, Tata Steel had three separate verticals - the Group Information System (GIS) Division (for IT infrastructure), the Automation Division (for automation requirements) and the Digital Value Acceleration Team (DVAT) catering to digital requirements within the enterprise. The digital initiatives attempted by the independent divisions often lacked meaningful impact on business outcomes. To facilitate unity in digitisation, in Jan 2018, the three divisions were merged as the 'One IT' division to form a client (plant) - partner ('One IT' at TSK and McKinsey) team. The partner arm under this team became the single point origin for all efforts pertaining to the enterprise wide Business Transformation through Digital Solutions (BTDS). The structural changes were implemented with an aim to provide – (a) scale for future expansion (b) structural alignment to facilitate rapid change and (c) agility.

- **Making Analytics Real, Valuable, Efficient and Logical (MARVEL).** After convincing top-management of the model, in Sep 2017, the MARVEL wave 1.0 was kicked-off under the aegis of DAVT. The MARVEL wave 2.0 coincided with the amalgamation of various IT divisions under One IT in Jan 2018. This programme was aimed at accelerating enterprise wide transformation. The broad steps involved in product development under the MARVEL programme included: -
  - Proof of Concept:
    - Impact Assessment on Key Performance Indicators (KPIs)
    - Cost Benefit Analysis
  - Develop
  - Deploy
  - Impact re-assessment

- **Human Resource Training:** The implementation roadmap for digital transformation requires substantial skilling and continued re-skilling of the existing workforce. To achieve this, a virtual Tata Academy for training was set up. Training was imparted through the following programmes:

  - **Digital Awareness Programme:** This programme was run between Aug 2015 to Dec 2016. In-house personnel identified by Tata Steel were chosen from various verticals in the manufacturing cycle and exposed to the capabilities of digital technologies under the Industry 4.0 umbrella.

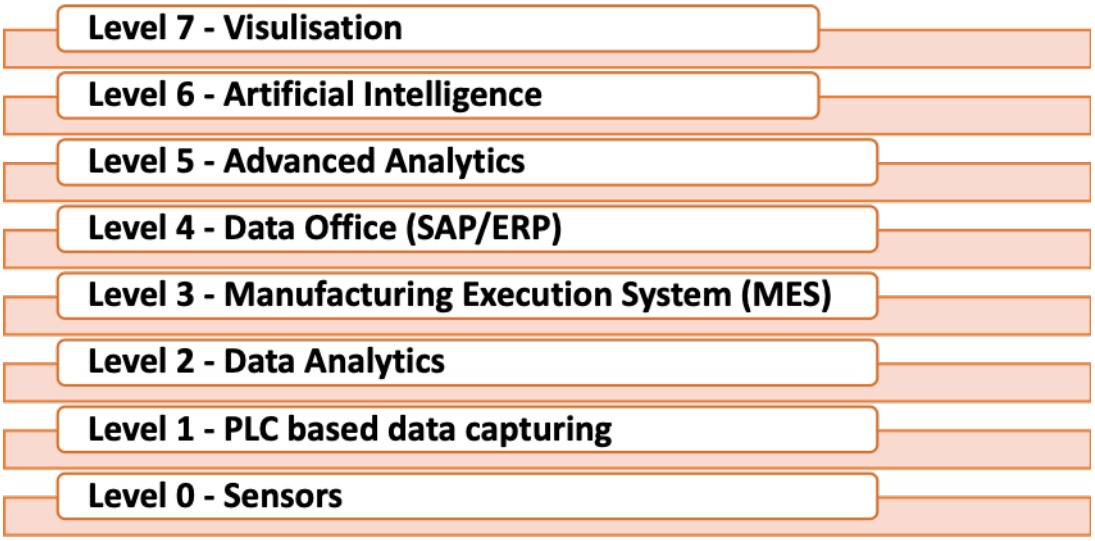
- **Digital Immersion Programme:** This programme commenced in Jan 2016 with the aim of scaling up the application skills of a select group of people who were chosen post the Digital Awareness Programme. As part of the programme, visits to other industries that leverage specific digital tools were undertaken.

- **Digital Enthusiast Exploration Programme:** This programme was implemented between Aug 2015 to Dec 2016. Personnel from the Digital Immersion Programme were selected to further improve their skills in analysing problem statements by categorising them into digital and non-digital problems, and subsequently developing digital solutions to optimise process performance. Participants were required to create at least one digital solution to a process problem by utilising data analysis.

- **Implementation:** Cross Functional Teams (CFT) also called 'Digital Squads' were set up to execute the transformation. The teams comprised of a mix of personnel with vertical expertise. Reverse mentoring within the team was encouraged. These teams consisted of:

  - **Data Architects:** Data Architects from the IT sector were responsible for designing the blueprint for organisational data management. They visualized, designed, and prepared data in a framework that was then utilised by data engineers and scientists. At Tata Steel, enterprise wide operations are structured in six levels. The data analytics layer provided insights to the MES. The MES based on the inputs of the data Analytics managed the planning, scheduling, production recording and quality requirements.

Figure 6: Elements of Manufacturing Data Architecture



Source: Tata Steel

- **Data Engineer:** Data Engineers from the IT sector were responsible for testing and maintaining digital architectures, such as databases and large-scale processing systems. They dealt with raw data from the field and delivered data to the data science team in a format that was easy to analyse.

- **Data Scientist:** Data Scientists from the IT sector were responsible for converting the data from the Data Engineers to generate meaningful business insights by using sophisticated data-analytics programs, machine learning and statistical methods. Once a solution was accepted, they presented a clear story to key business stakeholders on a daily, monthly or yearly basis.

- **Operations Translator:** Operations Translators, were vertical specialists and the eventual end-users of the digital solution developed. They were responsible for defining the problem and the desired outcomes, and also validating the effectiveness of a given solution at addressing a specific operational problem. This knowledge was essential for a viable and sustainable solution.

- **Business Translator:** The Business Translator was a finance specialist responsible for ensuring financial prudence during the R&D process and to assess and certify the Return on Investment of deploying a particular solution based on the Proof of Concept.

4. Success Stories

The two-billion-dollar transformation program announced in Aug 2018 and has already saved 1.47 billion dollars for the company cumulatively till March 2020.

Some of the Use Cases developed through the above framework at Tata Steel have resulted in the following benefits:

1. Tata Steel Jamshedpur (TSJ).

- Reduction of scrap by 25% by optimization of bar drawing equipment through use of a camera
- Digital twin of sinter plant that predicts performance 90 minutes in advance
- Supply and network optimization to reduce cost in product distribution and logistics
- Development of machine reliability model to detect anomalies and forecast performance 72 hrs in advance
- Development of a raw material cost forecasting model

2. Tata Steel Kalinganagar (TSK).

- Optimisation of Coke Dry Quenching processes to improve quality and improve energy efficiency
- Smart raking system to democratise decision making skills, to improve yield, and ensure compliance with set quality grades for the finished product
- Optimisation of reagent utilisation for the desulphurisation process
- Development of Tata Steel app store with more than 110 applications for Level 5 operations

5. Future Plans

The Tata Steel Kalinganagar facility, at present operates a large number of digital and data science initiatives that are aiding various manufacturing value chain processes. As part of future digital expansion, Tata Steel aims to scale-up digital transformation across various elements of the entire supply chain so as to transform into the World Economic Forum's Edge to Edge (E2E) lighthouse facility. Towards this, a 'Reliability Centre of Excellence' has been setup to integrate current and future digital initiatives. Such digital architecture will provide a centralised and connected decision making platform through the single-point access of plant-wide assets and operations.

6. Key Findings

MNCs Centric

- Tata Steel has assessed a 20X multiple for ROI on the various digital initiatives implemented.
- Many MNCs, large cap and SMEs with capital expenditure capacities should consider an internally driven transformation. Availability of skilled manpower and agile digital infrastructure are important components. The strategy must be carefully crafted based on individual business needs and inputs from experts. A top down approach is more successful than a bottom-up one.
- Vintage facilities and assets will have to undergo a sensorisation and IT infrastructure upgrade to facilitate generation of data which is important to build business insights based on data analytics.
- The recognition of Tata Steel, Kalinganagar, by the WEF as part of the 'global light house network' is an important consequence and acknowledgement of the sustained modernization drive by the group since 2005, despite hurdles, to become a global benchmark for digital transformation.

MSMEs Centric

- The metrics of manufacturing do not change. Yield, energy, throughput, quality, productivity and supply chains are equally important for MSMEs as they are for MNCs. Considering the capital-intensive requirements however, MSMEs should consider deploying solutions developed by the start-up ecosystem.
- MSMEs are drivers for employment within India and have to therefore integrate employment generation considerations in their roadmap for digital transformation
- MSMEs are often in control of operations that are internal to their organisation but are often challenged in external value chains. They should consider a discontinuous digitisation approach, in specific external value chains nodes to maximise impact.
- For MSMEs the concern is integration in the existing external digital value chains of MNCs especially if they are a Business to Business (B2B) provider. MNCs can be incentivised to collaborate with MSMEs that feed directly into their supply chains, and assist them with digital expertise for mutual benefits.

CASE STUDY

02

Schneider Electric:
A Smart Move to Industry 4.0

Vision of digital manufacturing:
Leap-frogging from Industry 2.0 to 4.0, cost-savings

Potential benefits for India:
Will bring new technology to India, bringing India operations at par with their global facilities

How to accelerate adoption:
Including their MSME supply chain to adopt small packets of digital enablers

Schneider Electric's domain expertise in hardware and software has helped it create a proprietary and comprehensive suite of Industry 4.0 solutions. The company is now deploying these in all of its eight manufacturing facilities spread across India with favourable results: 30% reduction in energy costs, 10% improvement in mean time to repair and 5% improvement in logistics. Schneider intends to make these Lighthouse network facilities, thereby setting the standard for other manufacturing MNCs in India.

1. Introduction

Schneider Electric is a French company that provides energy, automation, and digital solutions for efficiency and sustainability. By combining energy technologies, real-time automation software and related services, Schneider Electric provides solutions for digital infrastructure requirements across industries, data centres, as well as private residences, buildings, etc.

As a leading manufacturer of critical components, hardware systems and software used in a range of industrial automation and control applications, Schneider Electric is in a unique position to accelerate Industry 4.0 adoption, by building a manufacturing factory infrastructure that is ready for automation and data generation. The types of products offered are covered in Table 8.

Table 8: Industrial Automation Products from Schneider Electric

Hardware	Controllers	Accessories	Software
• Human Machine Interfaces (HMI) • Safety and control relays • Instrumentation • Motor starters and protection components • Power supplies • Power protection • Transformers • Signaling devices • Variable speed drives and soft starters	• Motion control and robotics • Programmable Logic Controller (PLC) • Programmable Automation Controller (PAC) • Dedicated Controllers • Telemetry systems	• Boxes • Cabling • Enclosures • Push Buttons • Switches • Pilot lights • Joysticks	• Industrial communication software • Radio Frequency Identification (RFID) system • Energy management software • Industrial automation software

The wide range of the company's products solutions and services, also give it an unparallel domain expertise. This has allowed Schneider Electric to develop an end-to-end, patented, digital architecture platform called EcoStruxure™ that delivers IoT-enabled solutions to various industries. The platform has been deployed at more than 4.8 lakh sites, globally.

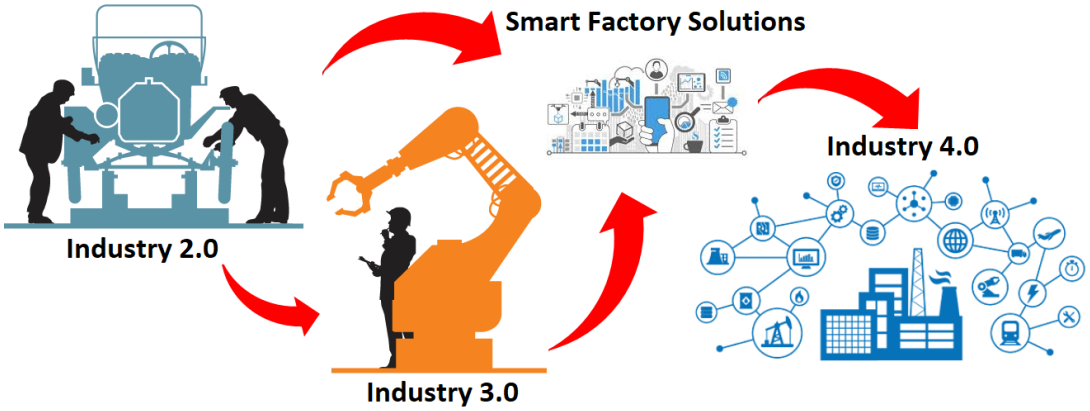
Schneider Electric's solutions are applicable not just on the factory floor but also for a series of nodes within the digital value chain. As a result, the company has jumped to 4 on the Gartner Supply Chain Top 25 for the year 2020, from 11 in 2019. Equipped with the EcoStruxure™ platform, between 2017 and 2019 Schneider Electric launched 17 smart factories around the globe including three facilities in India, at Hyderabad, Bengaluru and Mumbai.

In India, Schneider Electric has a total of eight manufacturing plants. Of these, the switchgear manufacturing plant in Hyderabad, commissioned in 2006, has become the first Indian facility to join the smart factory network in Feb 2019. This was followed by the Bengaluru facility in Nov 2019.

2. Smart Factory Solutions Enable Industry 4.0

Industry 3.0 saw the rapid deployment of automation within manufacturing lines using PLCs, PACs, SCADA and sensorisation of process lines. Industry 4.0 relies heavily on data analytics to develop Business Intelligence (BI). Smart Factory solutions such as EcoStruxure™, not only help to bring Industry 3.0 compliant facilities to Industry 4.0 readiness, but can also assist older facilities with low automation and data generation capabilities, to leapfrog to Industry 4.0 readiness, albeit with greater investment in digital and Information and Communications Technology (ICT) infrastructure, upgrade.

Figure 7: Elements of Manufacturing Data Architecture



Source: Tata Steel

Data generated across various nodes in the value chain in a manufacturing factory, need to be connected over a platform to enable centralised data analytics. The EcoStruxure™ platform with its open architecture permits integration of IoT solutions even with legacy components, and connects plant assets on the shop floor, to the enterprise and supply chains. The open architecture capabilities of the EcoStruxure™ platform substantially reduce the cost of digital transformation.

3. Transformation Philosophy

Eat your own food: Schneider Electric is the Original Equipment Manufacturer (OEM) of critical automation and IIoT hardware components. This unique knowledge and expertise allow the group in a position to follow an 'Eat your own Food' philosophy for designing and developing digital smart factory solutions in-house. These solutions build on hardware and software originating from a single source brings in high degree of reliability in performance and post-sale service.

Pankaj Goyal, Vice President, EcoStruxure™ and Digital, Schneider Electric, India, states that a multipronged strategy is essential for accelerating Industry 4.0 product development. At Schneider Electric, this strategy is primarily driven through acquisitions, outsourcing to start-ups and utilising commercially available technology.

In Sep 2017, Schneider Electric reverse acquired U.K. based Aveva, an engineering software developer, and merged its software division with Aveva. This merger has been a primary contributor towards product development.

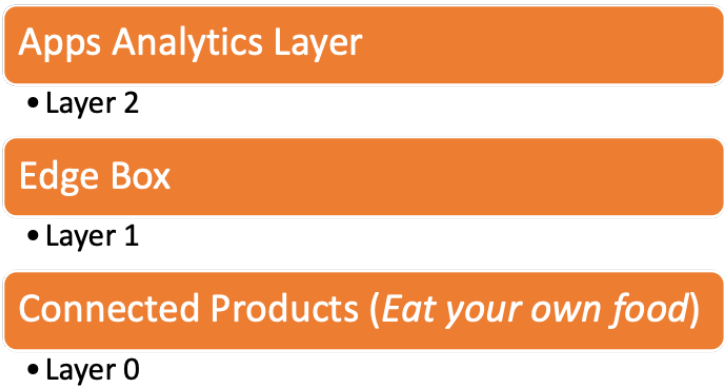
4. Methodology

A smart factory is essentially a facility that is capable of generating data in every process of the value chain. The capability of a factory to generate data is directly proportional to its depth and spread of automation and sensorisation. A Smart Factory platform and architecture such as EcoStruxure™ can aid manufacturing units to progress on the path of automation, sensorisation and provide connectivity for enterprise-wide operations.

- **EcoStruxure™:** The EcoStruxure™ architecture and platform provides IoT enabled solutions for various verticals, which are referred to as Lean Digitisation Systems (LDS). These include:
    - **EcoStruxure™ Building:**This is used for facility management, and improves the engineering efficiency of the building, ensuring productivity, safety and comfort for occupants.
    - **EcoStruxure™ Grid:** This is used for seamless connectivity between local power production and integration at the grid edge, thereby bridging demand and supply. This LDS aids in increasing the power grid's efficiency.
    - **EcoStruxure™ Power:** This digitises and simplifies medium and low-voltage electrical distribution systems. It provides actionable data that help in decision making that can protect people, safeguard assets, maximize operational efficiency and enhance business continuity.
    - **EcoStruxure™ Plant & Machine:** This is most suited for digital manufacturing. It provides digital transformation solutions for various processes in the manufacturing value chain and connects them across the company.
    - **EcoStruxure™ IT:** This caters to the data center's physical infrastructure and provides extendibility to future demand driven by IoT, growth in the cloud, and edge computing technologies without compromising operational efficiency.

- **Architecture:** The architecture of a manufacturing line needs to monitor Man, Material, Machine and Process. This can be achieved by applying a range of EcoStruxure™ LDS at level zero, that bring in connectivity between shop floor assets and beyond. At Schneider Electric, Hyderabad, the Layer 1 and Layer 2 components are a mix of proprietary and commercially available solutions and products. A basic architecture structure is shown in figure 8.

Figure 8: Smart Factory Enabling Industry 4.0



Source: Schneider Electric, India

5. Success Stories

Of the 17 Schneider Electric smart factories equipped with EcoStruxure™, two facilities – one each in France and Indonesia have been able to scale-up to an Industry 4.0, World Economic Forum (WEF) recognised Global Lighthouse Network.

Some of the major benefits accrued at Schneider Electric 'smart factories' are outlined in Table 9.

Table 9: Schneider Electric smart factory beneficiaries

Smart Factory Location	Benefits
Le Vaudreuil, France	Augmented reality, and connected machines reduced maintenance costs by 30% and increase Overall Equipment Effectiveness (OEE) by 7%.
Lexington, USA	Digitisation with a focus on operational efficiency helped reduce Mean Time To Repair (MTTR) by 20%.

Smart Factory Location	Benefits
Monterrey, Mexico	Reduced maintenance costs by 20% and increased OEE by 7%.
Plovdiv, Bulgaria	Reduced maintenance costs by 7% and improved overall performance by 5% in the first year.
Dubai, UAE	The first Smart Distribution Centre in the Middle East. It increased efficiency of operations by 5% and reduced overall power consumption by approximately 10 - 12%.
Beijing, China	Improved productivity by 8 -10% and energy efficiency by 5 -8%.
Wuhan, China	This is a completely digitised factory. It achieved a 15% decrease in quality related issues and a 10% cut in energy use.
Shanghai, China	Achieved 99.99% inventory accuracy ratio and a 30% increase in efficiency.
Hyderabad, India	This is a completely digitised site. It has achieved a 30% reduction in energy costs and expects full ROI in two years. Annual savings in electricity consumption of € 45000 and reduction in captive DG plant utilisation factor from 11% to 1%have been reported.
Bengaluru, India	Real-time monitoring of machine performance and preventive maintenance has helped with a 10% reduction in the MTTR of critical equipment and digitised processes have helped eliminate paperwork by 95%.
Mumbai, India	End-to-end efficiency in industrial processes and sustainability in the logistics and warehousing environment resulted in energy saving of 10 - 12% and a 5% improvement in logistics efficiency.
Cavite, Philippines	Achieved 14% increase in production growth and more than 13% energy savings annually.
Batam, Indonesia	Achieved a 44% reduction in machine downtime in one year.

Source: Schneider Electric

EcoStruxure™ can be leveraged for the following benefits within an enterprise:

- Agile management and improved process visibility
- Life cycle and maintenance management
- Man-machine-process integration
- Facilitating preventive, predictive and prescriptive maintenance
- Empowering operators
- Improving reliability
- Traceability of product
- Supplier-manufacturer-customer connection
- Bringing standardisation across manufacturing facilities
- De-skilling the process to make it error proof

6. Key Findings

MNC Centric

- Adoption of EcoStruxure™ LDS has helped three of the 17 Schneider Electric smart factories scale-up to Industry 4.0, WEF recognised, global lighthouse networks within the span of two years. The EcoStruxure™ platform's open architecture offers plug-and-play solutions across a range of verticals, thereby reducing the time and cost of transformation.
- Adoption of digital solutions will result in increased productivity and savings. These savings can then spur capital expenditure within the enterprise for creating productivity linked infrastructure and aid job creation.

MSME Centric

Schneider Electric's views on adoption of Industry 4.0 solutions by MSMEs are:

- MSMEs in the value chains of Schneider Electric have shown a keen interest in absorbing digital solutions to bring about enhanced connectivity with the parent enterprise.
- The MSME sector in India is an untapped market for EcoStruxure™ products. Lack of awareness and limited capital availability, are challenges that hinder growth of Industry 4.0 solutions within MSMEs.
- Micro and to some extent small-scale industries, must focus on adopting commercially available solutions targeted at external nodes within the value chain.

CASE STUDY

03

QiO:
Answering Questions inside Outcomes

Vision of digital manufacturing:
Data security, innovation and standards compliance

Potential benefits for India:
Building data sovereignty and certification into digital architecture early

How to accelerate adoption:
Adopt ROI based subscription model of digital adoption

QiO Technologies a UK-Pune based company is an industrial, SaaS, and software analytics company that focuses on providing extensive digital transformation solutions, that are conscious of the data security and build on existing end-user protocols. QiO has differentiated itself by complying with and certifying its products with European GDPR standards, creating trust and a wider client-base. QiO offers a unique ROI based subscription plan making it an attractive option for the manufacturing MSMEs.

1. Introduction

Established in 2015, QiO Technologies is an Industry 4.0, advanced analytics and artificial intelligence, software company based in the U.K, with a presence in India, Germany, Singapore and the U.S. QiO helps customers to drive value-based innovation by removing the burdens of legacy software, vendor requirements, and dependencies. The product and service suite offered by QiO does not lock companies into perpetual software licenses, embed immovable consulting teams, or monetise their customer database. The customers own their data, their client's data and their own innovation. The QiO platform is built to securely accommodate any data, any asset, any source, at any scale, and on any cloud - edge, private, hybrid or public.

Traditionally, data has been used to generate business insights by the 'White Collar' workforce, while 'Blue Collar' workforce, which accounts for more than 50% of the workforce in a manufacturing industry, largely remained impervious to data insights related to the factory floor. Industry 4.0 has led to greater sensorisation and connectivity within assets on factory floor. There is a growing convergence between Information Technology (IT) and operational technologies. This increased digital connectivity between manufacturing processes and machinery with IT systems is changing the way 'Blue Collars' work. QiO aims to empower industrial engineers by providing them Artificial Intelligence (AI) infused digital tools that aid greater visibility of the entire value chain.

In May 2017,QiO was recognised in the Gartner Cool Vendors in manufacturing operations. The company also found a place in the 2018 inaugural Gartner Magic Quadrant for Industrial Internet of Things (IIoT) and maintained its presence in the Magic Quadrant in 2019 as well.

2. Products

- **QiO Foresight Energy:** This solution enables to optimise energy usage and cut carbon footprint. This application finds wide usage across customers that have high energy usage such as manufacturers in the steel, cement, and shipping sectors.
- **QiO Foresight Maintenance:** This solution helps predict failures and recommends the best course of action to prevent downtime. Prescriptive recommendations significantly improve safety, lengthen asset life, and reduce unplanned downtime and costly outages. In order to assess the health of any equipment, a scoring system based on Performance, Availability, Reliability, Capacity and Serviceability (PARCS score) has been developed. Industries operating an array of capital-intensive machinery such as aviation and automobile are some of the prominent users of this platform.
- **QiO Foresight Platform:** This is an enterprise wide solution providing augmented analytical applications to predict and prescribe next course of action for performance, production, maintenance and energy. This platform operates at five levels. They include: -
    - **IT/OT Enablement** – This involves convergence of Information Technology (IT) and Operational Technology (OT) data for analytics in real-time. This feature is crucial to generate insights at a rate that is faster than the process.

- **Application Enablement –** This involves development of configuration driven application services for user management, workflow, notifications, visualisation and analytics.
- **AI Infused Applications –** These provide augmented analytical applications to predict and prescribe the next course of action for performance, production, maintenance and energy.
- **Cloud –** The platform supports cloud providers: AWS, Microsoft Azure, Google and a combination of deployments - public, private and edge.
- **Security–** The platform enables secure access control (machines and humans), data protection and encryption. It is ISO 27001 certified and externally validated by accredited agencies.

3. Implementation Model

According to QiO, industrial and manufacturing companies struggle to follow a proven roadmap on how to tackle transformation projects. QiO offers a five-point plan that has been successfully implemented in the industry, at scale, by their customers. The action plan entails: -

- **Think Big, Start Small and Scale Fast**
  - Think Big is about a vision within the organisation that goes well beyond one that is currently predictable in order to focus on achieving high-value business outcomes rapidly.
  - Start Small helps achieve high-value quick wins that reflect impact on the bottom-line results which aid in decisions on organisational buy-in. This early success not only inspires the customer to take on more Industry 4.0 challenges; but the cost savings these efforts create can help fund future projects by identifying high value, transformative, use-cases tied to clear business outcomes, which can be delivered within weeks.
  - Scale Fast helps manufacturing and industrial leaders to create and launch initiatives that deliver their visions for their plants — co-creating digital solutions with fast agile pilots lasting a few weeks, which achieve a tangible return (within a year or less).
- **Protect Digital Sovereignty -** Control over data is a critical topic that needs to be considered before embarking on digital transformation initiatives. QiO engages with internal IT teams to ensure security gets built in at the design stage in a collaborative manner. Client review and audit of the developed products, that are industry standards complaint, are also subjected to internal security protocols before deployment. Once the QiO product achieves the full security compliance, it then becomes easy to scale up implementation enterprise-wide. To achieve this, QiO teams up with customers to: -
  - Transfer knowledge to customers to create self-sufficiency through internal digital teams
  - Co-create and innovate by making the created IP accessible
  - Provide expertise on manufacturing and software knowledge to upskill workers

- Provide digital tools that do not lock the customer into any cloud or IIoT provider, thereby enabling greater interoperability
- Secure, protect and rapidly leverage competitive advantage

- **Digitally Equip Workforce –** Alignment of individual factory engineers with the internal digital organisation is crucial to the success of a digital transformation. The outcomes desired from Industry 4.0 tools should be meaningful and help unlock innovation and free factory engineers working at crucial performance frontiers. QiO helps customers create digital cells (teams of 6-8 engineers) that co-create and collaborate, and sit between the enterprise, its customers, its supply chain and the information and operational systems within the enterprise.
- **AI Infusion–**This entails achieving transformative outcomes using AI toolkits to gain insights from system-wide data. Like the Credit Score used in the financial sector, QiO has developed an AI-based PARCS score that helps development of Digital Twins through modelling and simulation.
- **Servitisation of Products and Outcomes –** Selling products and outcomes is the new 4.0 business model. The two models at QiO include: -
  - Pay-per-Usage Pricing - This model helps the customer save money and eliminate the archaic perpetual licensing model and high maintenance fees.
  - Pay by Return on Investment – In this model, subscription to the platform entails no upfront payment and customers are charged as fraction of incremental profit accrued through the implementation of their platforms. This model is helping QiO gain wider traction and acceptability in the industry.

4. Success Stories

Some of the QiO success stories are tabulated below: -

Table 10: QiO smart factory beneficiaries

Use Case	Benefits
QiO teamed with Lloyd's Register to build and deploy a software-based solution that could ingest high-frequency sensor data in real time, provide on-board analytics and bespoke visualisations, scale rapidly across the operator's fleet, and be delivered as a low-cost service.	• Detect anomalies that drive excess fuel usage, mapping to historic, current and predictive insights - for a single ship or across the entire fleet • 5-8% improvement in fuel efficiency in every voyage • Approximate $200k savings per ship, per year

Use Case	Benefits
A major steel producer integrated QiO's application with plant and IT data systems to baseline and predict energy efficiency indexes for the plant furnace in real time.	• Energy savings of $3 million (8%) per annum • Carbon reduction of 4000 tonnes at one plant
Rolls-Royce implemented QIO Foresight Maintenance to improve Maintenance Repair Overhaul (MRO) and warranty resolution times.	• Deployed at scale on all 80 sites • Used by 800 users daily • Digitally tracking and monitoring spare parts, in real-time, for over 9000 engines • Cut lead times by 20%
ARC, the world's largest tableware manufacturer implemented QiO Foresight	• Created energy efficiency indexes • Identified improvements in quality
Energy integrates with plant and production planning systems in real time, to create dynamic energy efficiency indexes to baseline and predict energy reductions.	• Improved furnace efficiency and energy

Source: QiO Technologies

5. Key Findings

- Industries should identify the pilot use cases that are easy to implement and bring in immediate value addition in terms of ROI. Most manufacturing firms can focus on two areas to start their journey for digital transformation. These are: -
    - Pilot cases tracking energy consumption can generate about 10% cost savings and also help reduce the carbon footprint, which is vital to compliance of environmental regulations
    - Applications for generating predictive maintenance insights can help reduce maintenance cost by upto 15%
- Scalability is crucial for acceptance of any product or service. The solutions developed by QiO can be rapidly scaled to other plants and assets without large consulting implementation costs, high software license fees and unforeseen rework.

- QiO solutions do not lock the customers into proprietary software thereby offering a high degree of interoperability across various architectures and frameworks.
- Co-creation by bringing in greater objective and capability alignment between the factory engineer and the internal digital organisation is key to the success of any developed solution.
- As more and more assets, especially those of importance to a nation (power plants, oil and gas, etc) get connected through Industry 4.0 solutions; there is a need to ensure data security and privacy. The unavailability of industry standards and integrated certification for Industry 4.0 are therefore crucial challenges that need to be overcome through the development of new protocols. Some of successful attempts at establishing such protocols and certifications include the following: -
    - **IMDA, Singapore:** The Infocomm Media Development Authority, a statutory board in the Singapore government, seeks to deepen regulatory capabilities for a converged info-communications and media sector, safeguarding the interests of consumers, and fostering pro-enterprise regulations. It also promotes and regulates data protection in Singapore thereby ensuring public confidence in the private sector's use of personal data. The certification process entails an audit of the applicant firm for its financial stability, and quality of service and product. A certification for an organisation from the IMDA, makes the organization eligible to bid in any government, and private tender process with minimum paperwork.
    - **National Computing Centre Group, U.K.:** This U.K. based group undertakes security testing and audit of software solutions through the lens of cyber-security. QiO products are complaint to NCC audit and certification.
    - **GDPR:** The General Data Protection Regulation came into force on 25 May, 2018 in Europe, and is designed to modernise laws that protect the personal information of individuals. It has overhauled how businesses process and handle consumer data. QIO platforms are compliant with the GDPR and are therefore preferred by many customers.

CASE STUDY

04

ClairViz:
A Start-Up Engine for Industry 4.0

Vision of digital manufacturing:
Converting legacy factories into modern facilities

Potential benefits for India:
Use of government programmes and schemes will make them robust and popular

How to accelerate adoption:
Make the most of state support, offer best value to and by public sector units

ClairViz offers products and services that help manufacturing companies digitally transform the factory floor. It positions data-carrying sensors on legacy assembly lines, and uses its project engineering, design, electricals, automation and software skills to transform them into modern, data-driven facilities. This start-up smartly benefits from government programmes: housed in a state-supported incubator, and clients are public sector enterprise which are mandated to use small and medium entrepreneurs in their supply chains.

1. Introduction

Established in 2015, ClairViz is a Mumbai based technology company providing solutions for digitization of the manufacturing industry. The company focuses on providing Smart Factory solutions by leveraging technologies such as Big Data, Internet of Things (IOT) and Internet of Services (Cloud).

Global competition, increasing consumer demands, availability of choices and paucity of skilled manpower are driving manufacturing organisations to adopt digitalization across value chains. These factors are creating a huge demand on product and solution providers to convert legacy factories into modern data driven factories of the future. ClairViz provides its customers end-to-end solutions for Manufacturing Intelligence projects that are backed by expertise in project engineering, design, electricals, automation, sensors, and software development.

2. Products and Services

Products

ClairViz has a range of products targeting various problems on the factory floor or value chains. These are : -

Table 11: ClairViz Product Range

Product	Applications & Features
Opsrey Factory	**Application:** It is a customizable 'Manufacturing Intelligence Platform' based on Industrial Internet of Things (IIoT), Big Data and Analytics that provides data driven intelligence to improve process efficiency and maximize profits. **Features:** • Customizable electronic logbook integrated with real-time machine data acquired using IIoT • Downtime data entry and analysis • Total Productive Maintenance (TPM) loss analysis • Monitoring of Key Performance Indicator (KPIs) – Overall Equipment Effectiveness (OEE), production, productivity, performance, availability, quality, efficiency and utilisation • Energy management • Maintenance management

Product	Applications & Features
Osprey Digital Operations & Maintenance Management System	**Application:** An Android/iOS Mobile App to digitalize maintenance management. It gives notifications and alerts for scheduling various maintenance, inspection and calibration tasks. The platform has checklists that help execute activities in a planned manner. Escalation mechanisms are in place to alert the management in case of any missed tasks. **Features:** • Quick Response (QR) code-based asset tagging • Department wise or sections wise alerts and notifications • Data check points to ensure operators don't make mistakes • Digital SOPs feature for operators to follow a standard/defined procedure • Offline capabilities – network unavailability does not stop operators from taking readings as the App works in offline mode also
Opsrey Insights	**Application:** This is a Machine Learning (ML) and Artificial Intelligence (AI) based platform for predictive maintenance and analytics that can predict machine breakdowns, and highlight quality and safety issues. It helps in improving factory up-time, minimising breakdowns, improving quality and minimising waste. **Features:** • Early maintenance warnings and alerts • Can be integrated with Osprey factory
Osprey Production Analyser	**Application:** It is a light weight server that can be connected with two machines for collecting production data and providing productivity dashboards and reports. It's a plug and play product which can be setup quickly. **Features:** • Production and productivity analysis • Dashboard reporting • Reports download • Easy and quick to setup
Opsprey Track and Trace	**Application:** Barcode and Radio Frequency Identification (RFID) based product for tracking and tracing needs. Compatibility matrix, sub-component level back tracing along with test reports for quality and supplier information can be tracked right from beginning of the process till dispatch. **Features:** • Real-time Work in Progress (WIP) status. • Workflow management. • Integration with other enterprise applications • Product and Stock Keeping Unit (SKU) reports based on shifts, days, months or years

Services

Apart from providing the products for digitisation of the factory, ClairViz also offers services for: -

- Manufacturing intelligence solutions
  - Enterprise Resource Planning (ERP) integration
  - Business Intelligence (BI)integration
  - Statistical Process Control (SPC)analysis
  - Online production systems

- Automation solutions
  - Programmable Logic Controllers (PLC)
  - Supervisory Control and Data Acquisition (SCADA) systems
  - IOT controllers
  - Manufacturing Execution System (MES)
  - Process and electrical control systems

3. Implementation Model

Factors Impacting Implementation: The following factors are taken into consideration prior to implementation: -

- Maintaining integrity of existing production processes
- Providing real-time capabilities
- Modularity
- Information Technology (IT)security
- Reliability and stability
- Protection of industrial know-how
- Interoperability

Start Small: The ClairViz Osprey Production Analyser employs data logging of three basic parameters on a machine or a process – production count, rejection count and machine status. These parameters are logged by introducing four additional sensors into the production line. Data logged by these sensors is processed by Osprey Factory to implement real-time, digital, OEE in the production line. The OEE parameters analysed include: -

- Line status (on/off)
- Production
- Productivity
- Rejection rates

- Availability
- Quality
- Downtime (planned and unplanned)
- Production reports (according to shift, day, month, year)
- Batch reports
- Operator performance
- TPM loss analysis

Pricing Models:

- **OPEX Model:** This model is more suitable for the smaller entities within the MSME sector. This model is essential as a 'Pay as Use' model. At ClairViz, pricing models are available on the basis of number of machines connected to the specific digital tool.
- **CAPEX Model:** This model is more suitable for the larger companies in the MSME sector capable of investing in up-gradation of infrastructure at the enterprise level. These models are customised to suit individual requirements of data analytics and integrate with existing systems within the factory floor such as ERP and MES.

4. Success Stories

Hindustan Petroleum Corporation Limited (HPCL)

- **Background:** HPCL is a global energy major that operates refineries, oil terminals, LPG plants and retails outlets.
- **Problem Definition:** With the goal of setting new standards in operation and maintenance, the company wanted to tap IoT and digitalization of assets across their businesses; to deliver sustainable benefits in terms of improved uptime, efficiencies and asset utilisation.
- **Solution:** HPCL implemented Osprey Digital Operations and Maintenance Management System (DOMMS) at HPCL's Mumbai Refinery & Oil Depots.
- **Benefits:** Post implementation the following benefits were accrued: -
  - Improved regulatory compliance to Oil Industry Safety Directorate (OISD) guidelines and procedures
  - Improved audit and regulatory compliance due to automated data collection and reports
  - Digitalisation of manual processes leading to better coordination and management
  - Savings in 2.5 man-hours per day for data compilation, reporting and analysis, resulting in savings of more than $6000 per annum
  - Improved equipment life through preventive maintenance resulting in savings of $ 7000 per annum
  - Savings of over $ 20000 per location

Aditya Birla Yarn

- **Background:** Aditya Birla Yarn (ABY) has five manufacturing plants in three countries – Indonesia, Philippines and Thailand. As part of the day to day operations, ABY's maintenance staff had to undertake and record several tasks related to preventive maintenance, inspection, testing and calibration.
- **Problem Definition:** All reports pertaining to maintenance and inspection activities were being maintained in manual copies and in excel tables. Lack of homogeneity in data collection and storage made data analytics very difficult.
- **Solution:** ClairViz implemented a complete digitisation of the original manual reporting and tracking system.
- **Benefits:** Post implementation the following benefits were accrued: -
  - Reduced breakdown incidents
  - 100% adherence to Standard Operating Procedures
  - Reduced maintenance cost
  - Proper planning, tracking and scheduling of tasks

Aditya Birla Insulators

- **Background:** Aditya Birla Insulators (ABI) is India's largest and the world's fourth largest manufacturer of electrical insulators.
- **Problem Definition:** ABI wanted to improve productivity by leveraging technology for: -
  - Reducing manual checkpoints and errors
  - Increasing productivity and efficiency
  - Improving machine utilisation
  - Achieving real-time monitoring of assets
  - Timely information of faults
  - Correlating the process parameters with quality
- **Solution:** ABI implemented Osprey Manufacturing Intelligence System at their Halol plant in Gujarat.
- **Benefits:** Post implementation the following benefits were accrued: -
  - 360-degree view of operations
  - 25% increase in capacity utilisation
  - Reduction in defects by 15%
  - Real-time monitoring of Critical to Quality (CTQ), to facilitate zero defects and subsequent improvements in productivity

Autofits Packaging

- **Background:** Autofits Packaging is one of the biggest manufacturers of primary and secondary packaging materials for pharmaceuticals, beverages and food processing industries. Operating since 1985, it has three manufacturing plants in Nasik.
- **Problem Definition:** Autofits Packaging wanted to utilise digital tools on their manufacturing lines to improve productivity.
- **Solution:** ClairViz implemented the Osprey dash-board and reporting platform, which is a module under the Osprey Factory product line.
- **Benefits:** Post implementation the following benefits were accrued: -
  - Real-time visibility of plant operations
  - Paperless production
  - 40% improvement in productivity
  - 24% increase in asset utilisation

5. Start-Up Enablers

- Technology stacks developed by Google, Microsoft and Amazon have helped democratise technology thereby aiding competitive product development by the start-up ecosystem.
- Cloud storage and cloud computing have eliminated the requirement to maintain a robust IT infrastructure and associated cyber-security aspects.
- Till 2015, the cost of uploading a large volume of data to the cloud was very high. Competitive data bandwidth prices offered by companies such as Reliance Jio, etc. have helped reduce the cost of high-speed connectivity substantially, thereby providing a much-needed cost benefit for start-ups.
- The 'Start-Up India' programme in partnership with the Department of Science and Technology has rolled out on-campus, incubation centres at various academic institutions. These incubation centres not only provide common office infrastructure at affordable rates, but also aid crucial student and start-up interaction.

6. Challenges for Start-Ups

- **Business to Consumer (B2C).**
  The start-ups in the B2C segment, have to reach a large number of customers. In order to be competitive, B2C start-ups need to spend substantial capital on advertising to improve their reach and customer base.
- **Business to Business (B2B).**
  Most of the start-ups offering Industry 4.0 solutions to manufacturers operate in the B2B segment. Start-ups in this segment often have to work against the client's hesitancy, which is usually centred around the quality of product or service, post-sale service and the sustainability of the start-up on a long- term basis as compared to already established players.
- **Skilling of Workforce.**
  Aditya Vermani, Business Head at ClairViz laments the unavailability of a certified and tested talent pool capable of product development and utilising programming skills in data analytics, Internet of Things (IOT) and Artificial Intelligence (AI). Typically, start-ups cannot hire already experienced workers and have to rely on fresh gradates. Unlike larger MNCs which run their own training and certification courses at in-house centres, the training of workforce skills for start-ups pose a significant challenge.

7. Key Findings

MSMEs Centric

- MSMEs are not aware of the inefficiencies in their factory systems. In addition, many are not digitised enough to generate data that can be used to develop actionable process insights. Deployment of even the most basic digital tools can help significantly improve productivity for such companies.
- Adoption of technology at an enterprise level will aid efficient integration of products and value chains with global standards and customer demands. Export oriented MSMEs will therefore be early drivers of Industry 4.0.
- MSMEs will need to adopt a middle path between automation and employment generation.

Start-ups Centric

- Start-ups need to limit their focus on specific technologies, products, and services under the wide ambit of Industry 4.0, in order to develop expertise and build reliability in their product.
- The products developed by start-ups need to be generalised and not customised to attract a larger customer base.
- Democratisation of technology has helped start-ups build quality products and services at competitive costs.
- The agile structure of a start-up as compared to the relatively rigid structure of larger players offering similar products and services provides additional flexibility for the customer and also aids in compression of project execution timelines.

CASE STUDY

05

Soulpage: Democratising Data Intelligence

Vision of digital manufacturing:
Offering data intelligence to MSMEs

Potential benefits for India:
Increasing adoption by MSMEs

How to accelerate adoption:
Be part of government network of digital adoption

Soulpage IT Solutions provides data intelligence services through big data analytics especially for MSMEs. With Soulpage's Data Intelligence as a Service (DIaaS), Indian MSMEs can bypass expensive IT infrastructure and highly skilled human resources, with a service which enables it to easily embed data science and data intelligence in its business.

1. Introduction

Soulpage IT Solutions (Soulpage) is a data science technology company based in Hyderabad, India, with offices in Abu Dhabi, UAE and Berlin, Germany. Started in 2018, the company offers a range of products and services that leverage new-age technologies such as big data analytics, computer vision tools and AI applications.

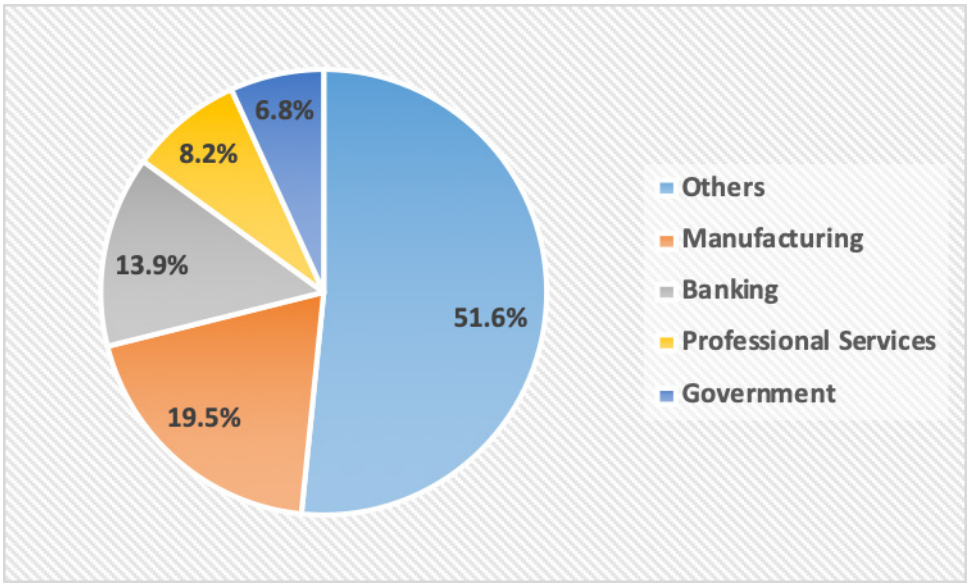
In 2019, Soulpage started providing Data Intelligence as a Service (DIaaS), which helps customers with actionable Business Insights through core data analytics. The sharply growing demand for these types of services has been integral to the company's growth, allowing it to expand swiftly to 50 employees in 2020 from just 15 in 2019.

Currently (2020) Soulpage's operations in the U.S. contribute 70% to the company's revenue stream while the remaining 30% is from Indian operations.

The entry barriers for many Indian organisations to implement data intelligence solutions are high. These include expensive IT infrastructure and highly skilled human resources among others. DIaaS can help eliminate these hurdles by introducing a product-based service that makes it easy for businesses to embrace data science and gain data intelligence.

The International Data Corporation (IDC) expects a CAGR of 13.2% from 2018 to 2022, with global revenues of $ 274 billion in 2022, for the data intelligence services industry.

Figure 9: Share of Business Intelligence service industry revenue



Source: IDC

2. DIaaS Solutions offered

Products:

- **Simpliin:** Simpliin is a cloud-based software solution that provides ease of access to inventory data from any device. Using AI and advanced analytics, Simpliin provides optimized reports along with a deeper insight that help in evaluating multiple inventory strategies, compare outcomes and make data-driven decisions.
- **EVNet:** EVNet is an AI-powered architecture and solution that enables utilities, smart cities, workplaces and businesses to simplify the management, monitoring, and analysing of their network of Electric Vehicle (EV) charging stations, by harnessing data through machine learning and advanced analytical tools.
- **FaceReg:** FaceReg is a 'computer vision' and AI powered facial recognition application that can be easily integrated with any system to detect, organize, and tag, objects and faces. Common applications include; biometrics and authentication, video surveillance, fraud prevention and digital documentation.
- **ChestX:** ChestX is a medical imaging solution powered with AI that detects and identifies lung-related acute abnormalities and ailments. It can detect 14 pathologies including pneumonia and tuberculosis in less than 5 seconds.

Services:

Soulpage offer a range of services that can be applied across various sectors. These include- big data analytics; machine learning, predictive analytics, text analytics, recommendation engines, computer vision tools and reinforcement learning.

3. Implementation Model

Soulpage's business model is based on implementable solutions that can be applied across industries to democratise the usage of data analytics. This is useful for companies, especially MSMEs that do not have the capability to build and sustain an internal digital analytics infrastructure. Implementation of data intelligence services typically entails the following stages:

- **Stage 1** - Study existing data gathering mechanisms within an organisation.
- **Stage 2** - Propose and implement optimal changes in data collection infrastructure to enable capture of data points that can impact Key Performance Indicators (KPI).
- **Stage 3** - Harness historical data to identify all possible transformative interventions that can be introduced at the customer site.
- **Stage 4** - A low intervention to high productivity ratio is followed - 20% of select interventions that have the capability to provide 80% impact on the KPIs are applied.

4. Success Story

Bhaanusha an IT Equipment rental company in Hyderabad, deployed Simpliin for inventory management which allowed for better transparency, and enhanced tracking and control of the entire inventory. Some major benefits included:

- Improved delivery performance
- Automated notifications upon stock run-outs
- Transparency throughout the supply chain
- Lower inventory management costs
- Increased customer satisfaction
- Optimized payment management systems

5. Challenges

Customer Base: In order to extend business operations, Soulpage partnered with Qualetics Data Machines, U.S. which has helped them grow their business in U.S. and European markets. This partnership also helped Soulpage get contracts overseas. In India however the market for DIaaS is still developing. Murali Krishna Karuturi, Managing Director, at Soulpage notes that it is difficult to attract Indian customers as compared to international customers.

Skilling of Workforce: Ramesh Damma, Director, Marketing and Operations at Soulpage, observes that there is a substantial skill gap in graduates trained from a majority of academic institutions in India. The lack of adequate Industry 4.0 and data science skill certification programmes in the formal education system is forcing fresh graduates to undergo courses in data science and statistics in private institutes to achieve basic employability standards. Even after these skill interventions, new employees at Soulpage still need to undergo in-house training to ramp up their skills required for product development to meet specific market requirements.

6. Key Findings

Use of DIaaS is seen rising globally, but demand in India is still catching up. IDC data indicates that the manufacturing sector is a large adopter of this technology.

MSMEs Centric

- Lack of clear awareness and understanding of the capabilities of various Industry 4.0 technologies is impacting the widespread adoption of digital tools and solutions available in the market.
- Many companies in this sector are not digitised enough to generate data that can be used to develop actionable process insights. This has also led to lower adoption of data sensitive tools offered by DIaaS.

Start-Ups Centric

The workforce graduating from various academic institutions is not geared towards Industry 4.0 related product development, and requires further in-house training to meet market needs.

CASE STUDY

06

C4i4 Pune:
A Smart Move to Industry 4.0

Vision of digital manufacturing:
To be consultant for MSMEs to adopt Industry 4.0

Potential benefits for India:
Developing similar centres of excellence for MSMEs

How to accelerate adoption:
Working in tandem with government programmes, now housed in Pune University and accessible to students

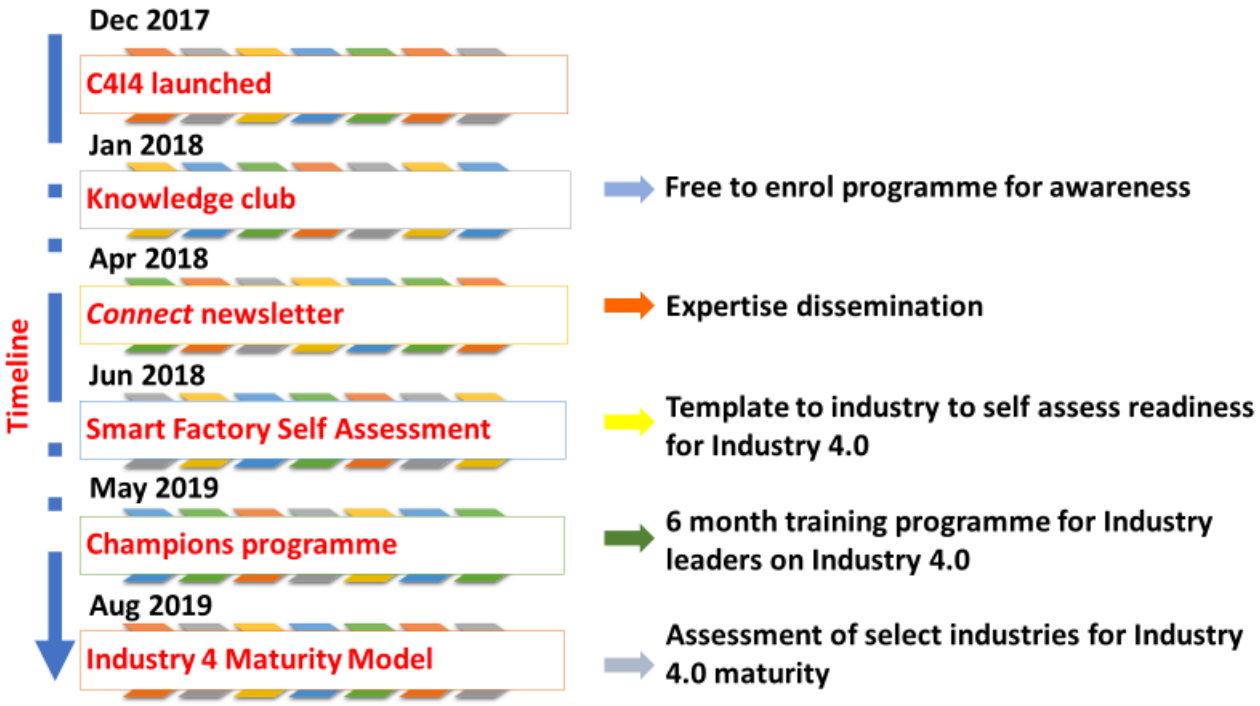
This Indian government initiative to promote and facilitate the adoption of Industry 4.0 technologies across micro, small and medium enterprises, is gaining traction. MSMEs account for 45% of the manufacturing output and 40% per cent of the exports, but almost 90% of them lack access to markets beyond their limited geography. Adoption of digital technologies will help them scale productivity and quality, compete in global markets. C4i4 hand-holds these small companies, and also works in coordination with Indian government programme like Start-up India, Digital India.

1. Introduction

The Centre for Industry 4.0 (C4i4), Pune, launched in December 2017, functioning under the aegis of the Make in India programme, is an organisation that aims to drive Industry 4.0 adoption in MSMEs (Micro, Small and Medium Enterprises), by providing a roadmap for digital transformation through consultancy services and skill development. This centre at Pune is part of a larger network, SAMARTH (Smart Automated Manufacturing and Rapid Transformation Hub) Udyog, which is a national initiative by the Department of Heavy Industries, Government of India. Apart from C4i4 Pune, the SAMARTH Udyog network comprises of four other centres across the country. These are located at IIT Delhi, IISc Bangalore, CMTI Bangalore and IIT Kharagpur. Each centre works on unique aspects of the Industry 4.0 ecosystem.

C4i4 Pune, specifically, promotes adoption of Industry 4.0 technologies through (1) various awareness and training programs, (2) technology demonstrations and (3) industry and academia collaborations; all aimed at handholding Indian manufacturing companies for subsequent implementation of Industry 4.0 technologies. It operates on a PPP (Public Private Partnership) model with approximately 75% funding from the government.

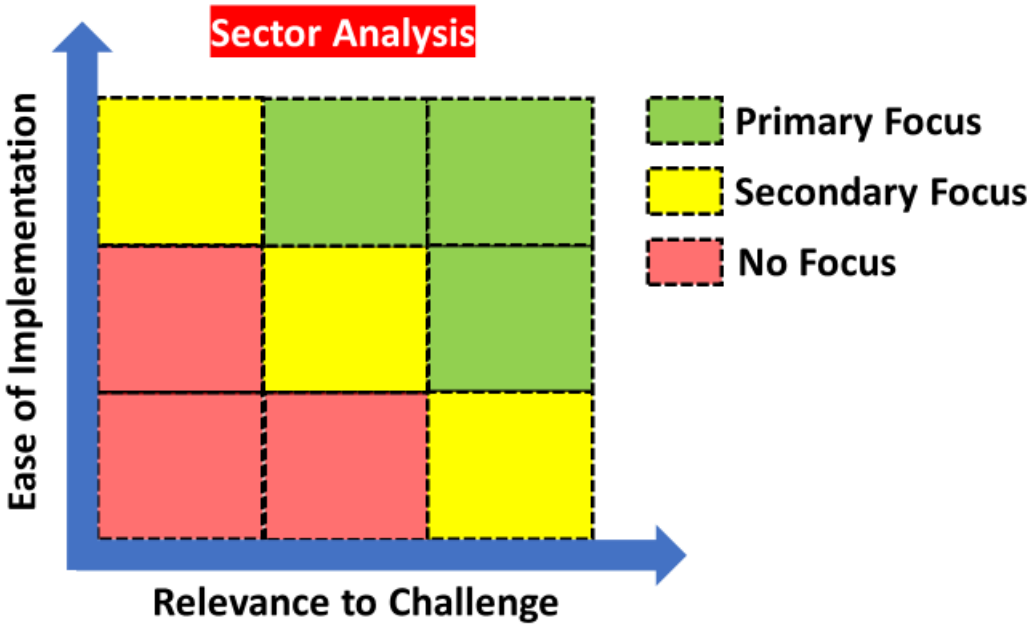
Figure 10: Significant Programs



Source: C4i4, Pune

Industry 4.0 Readiness Assessment: A 'Joint Industry Survey' was undertaken by C4i4 and the Department of Heavy Industries (DHI) in collaboration with the Tata Strategy Management Group. The report recommended focussing Industry 4.0 implementation efforts in sectors and industries where both ease of implementation and impact on problem solving were high.

Figure 11: Sector Suitability Assessment



Source: C4i4, Pune

2. Methodology

- **Awareness Programmes:** Collaborative programmes with Indian and foreign industry experts are run to intensify Industry 4.0 capability and awareness. These programmes are run at various locations but specifically target designated industry clusters in Pune, Delhi, Ahmedabad, Chennai, etc.
- **Demonstration Labs:** On the basis of the 'Joint Industry Survey', C4i4 aims to facilitate an Industry 4.0 immersion experience for over 2000 companies within next three years. An inhouse Demonstration Lab has been setup with working prototypes, providing crucial insights on Industry 4.0 adoption and the impact on various value chains.

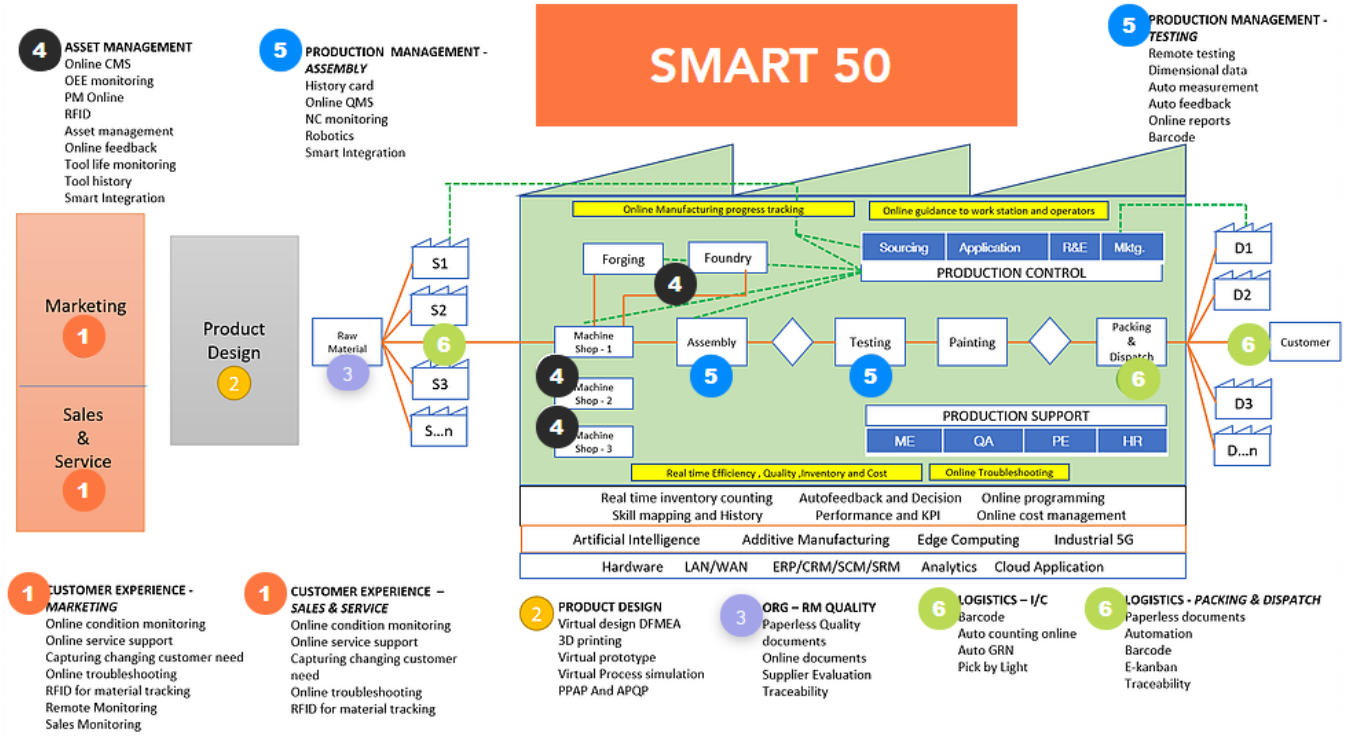
Figure 12: Demonstration Lab

Source: C4i4, Pune

- **Skill Development:** Skill development is targeted for industry, faculty and students.
  - **Industry:** C4i4 provides enablement learning, model factory demonstrations, assessment and roadmap workshops, and implementation advisory for Industry 4.0 as part of its skill development goals for the manufacturing industry. This is done through initiatives such as the 'Are You Ready?' awareness workshops and the 90-day, training and mentorship 'Champions Program' among others.C4i4 Pune has also developed standard implementation advisories for SMEs involved in foundry, forging, plastic moulding, quality management and process operation monitoring. In addition, they have also developed a 'Digital Tool Kit' for the SMEs in the automobile industry.
  - **Academia:** Industry-academia collaborations focused on best industry practices, for inclusion in the training curriculum, aid in the up-skilling of faculty and students equally. A MoU has been signed with the Centre for Development of Advanced Computing (CDAC)for Industry 4.0 certification programmes, with the intention of further developing the skills of India's current and future manufacturing workforce.
  - **Experience Centres:** Experience centres are being set up in the College of Engineering, Pune, and other reputed colleges nearby manufacturing clusters in collaboration with industry to improve industry-academia synergy.

- **SMART 50:** The digital transformation of MSMEs will vary on a case to case basis depending on the degree of automation required by each in various value chains. Dattatraya Navalgundkar, Director at C4i4 Pune, emphasises that 'MSMEs should adopt a menu-based approach for Industry 4.0 implementation. They must pick and choose technologies that can provide crucial business insights to deliver maximum ROI'. To help MSMEs with this, C4i4 Pune has developed the SMART 50 tool, which is a menu of 50 Use Cases, of Industry 4.0 technologies, linked to specific nodes in the value chain. This tool is useful guide for MSMEs to start their digital transformation journey.

Figure 13: Smart 50



Source: C4i4, Pune

- **Industry 4.0 Maturity Model (I4MM):** C4i4 has also developed the I4MM as a tool to assist manufacturing organisations across all industries to identify their current state of Industry 4.0 maturity and readiness. The model helps enterprises, in formulating a comprehensive and sustainable digital transformation roadmap. The roadmap includes strategies for effective data capture and aggregation from external and internal sources, and finally for data intelligence to create valuable business insights.

3. Challenges

Many MSMEs and SMEs in India are still operating at a relatively low level of automation resulting in limited data collection. They must first resolve some basic 5S issues (Sort, Set in Order, Shine, Standardize and Sustain) internally, before attempting an Industry 4.0 transformation.

4. Key Findings

- **Early Drivers of Industry 4.0 for MSMEs:**
  - MSMEs should target external value chains first, by utilising commercially available Industry 4.0 tools in the e-commerce and logistic sectors.
  - Batch and continuous manufacturing MSMEs will be the early beneficiaries of Industry 4.0 solutions as compared to those involved in process and discrete manufacturing. This is because they rely on an established Bill of Material (BOM) and defined work processes in the form of assembly lines, while process manufacturing relies on a process formula.
- **Start Small:** MSMEs intending to digitally transform their internal value chains, should adopt a 'Start Small' philosophy. Optimal utilisation of commercially available technologies is important to conserve resources, especially for organisations lacking in a robust IT infrastructure. Such an approach will not only keep the cost of transformation low, but also usher in faster implementation and ROI. Pilot projects can be built as a proof-of-concept and implemented in localised value chains. Scaling of pilot projects should be undertaken only in cases where they demonstrate direct impact on the problem.

Figure 14: Industry 4.0 Deployment

Source: Gateway House Research

- **Menu Based Approach:** Any Industry 4.0 solution for SMEs has to be India specific, as Indian SMEs operate in an ecosystem that has unique challenges and opportunities as compared to more industrialised countries. Using a menu-based approach such as the one developed by C4I4's SMART 50 tool, can be beneficial for SMEs to correctly select Industry 4.0 solutions that help address specific value chain challenges, for swift and impactful solutions.

CASE STUDY

07

Chizel:
Amazon for Manufacturers?

Vision of digital manufacturing:
Getting manufacturing MSMEs on the digital floor

Potential benefits for India:
Integration of MSMEs with MNCs

How to accelerate adoption:
Patiently work with MSMEs to accept digitisation

Chizel is a cloud-based B2B platform that aggregates manufacturers, suppliers and buyers to provide better access, pricing and cost savings, and improve quality control. In India, 90% of MSMEs' supply chain is restricted to their city boundaries, as they lack the capacity to access wider export markets. Chizel takes full ownership of their service, from assessing product quality to scheduling to making the match between buyer and seller. It now has 200 companies and 500 suppliers on its roster. Chizel now also has an 8% overseas clientele and is helping domestic manufacturing MSMEs expand scale and reach through modest digitisation.

1. Introduction

Established in 2014, Chizel is a Pune based company that began as a consultancy for 3D-printing. In 2017, Chizel rolled out a Business to Business (B2B) cloud manufacturing technology platform for digitalisation of the manufacturing industry. This platform offers Manufacturing as a Service (MaaS) by connecting manufacturers and suppliers in the ecosystem with buyers. Within 3 years, the platform has garnered registrations from more than 200 companies and 500 suppliers.

This cloud-based platform helps simplify manufacturing workflow from the Request for Quotation (RFQ) to delivery, thereby providing transparency and predictability for the entire process. Increased digital connectivity within the manufacturing value-chain permits real-time visibility of operations through alerts at various stages during the process – raw material receipt, manufacturing start and completion, pre-dispatch inspection and delivery tracking. In addition, a mandatory pre-registration audit of the prospective supplier and manufacturers along with the end-product quality checks enforced by Chizel helps achieve 99% On Time in Full (OTIF) delivery compliance.

Chizel helps suppliers and manufacturers attract more customers through improved market accessibility, resulting in increased demand and higher asset utilisation. The buyers on the other hand, get a cost advantage of up to 25% through a proprietary reverse bidding strategy implemented by the platform.

2. Products

At present Chizel has enlisted five verticals within the capabilities of its platform. These include: -

3D-Printing
Within this vertical, Chizel offers manufacturing services in four technologies essentially in the non-metal segment:

- **Fused Filament Fabrication (FFF) -** an extrusion-based 3D-printing technology used to manufacture cost-effective prototypes.
- **Selective Laser Sintering (SLS) -** a powder-based 3D-printing technology used to manufacture production grade, end-use parts. Some applications include prototyping and low volume batch production.
- **Stereolithography (SLA) -** a 3D-printing technology that makes use of photopolymer resins to manufacture proof of concept prototypes.
- **Polyjet (PJ) -** is a 3D-printing technology that makes use of a liquid photopolymer resin which cures when exposed to UV light. It helps in the manufacture of aesthetically pleasing full colour, multi-material prototypes.

Computer Numerical Control (CNC) Machining
Within this vertical Chizel has enlisted pre-audited workshops that can execute CNC milling and CNC turning operations. Major applications include manufacturing of parts in both metal and non-metal segments for a range of industry sectors.

Vacuum Casting
This technique is used for cost-efficient, quick and production-level quality, parts. Some applications include electrical enclosures, medical parts, food packaging and automobile industry.

Injection Moulding
This technique is used for moulded plastic and rubber parts for prototyping as well as production. Common applications include wire spools, packaging, bottle caps, automotive parts and components, toys, etc.

Sheet Metal Fabrication
Some of the common applications include manufacturing of parts such as enclosures, chassis, brackets, clamps and application across medical, automotive, aerospace, and power equipment sectors.

3. Implementation Model

Supplier and Manufacturer Registration

- **Digital Know Your Customer (KYC) –** As part of the digital KYC, the following data is obtained from a prospective supplier or manufacturer:
  - Manufacturing capability
  - Data on financial stability
  - Feedback from previous customers
  - Certification of processes, equipment and quality checks on the end product

- **On-Site Audit –** Once manufacturer's credibility is verified digitally, Chizel undertakes an on-site audit of the manufacturer's facilities. Following checks are included:
  - On-site verification of manufacturing capacity of the facility to fulfil the order.
  - The facility is assessed on critical manufacturing parameters such as, process implementations, availability of skilled work-force, functioning of the quality checking department and others.
  - A Chizel qualified supplier rating is provided to the supplier. Only those suppliers or manufacturers scoring more than 80 rating points are eligible to register on the platform and receive orders.

- **Onboarding**
  - Once certified by Chizel, the manufacturer is on-boarded to the digital platform. The registration is absolutely free and does not entail any recurring subscription.
  - Training of the manufacturer's staff for optimising the use of the platform is provided free of cost.

Buyer Integration

- **Budgetary Offer**
  - Once an enquiry is received, the internal manufacturing team utilises the digitally available parameters to establish the feasibility, costing, and turnaround time.
  - Based on the internal evaluation the top three suppliers within the Chizel network are shortlisted.
  - A transparent, online, bidding between the three shortlisted suppliers is evaluated for Total Cost of Ownership (TCO).
  - A budgetary offer is created and sent to the buyer
  - The platform's inbuilt technology provides details of the cost and turn-around time instantaneously based on the internally developed costing and capability matrix.

- **360 Degree Ownership**
  - Chizel takes full responsibility of the product including the generation of the offer, compliance, quality and delivery schedule, pre-payment to the manufacturer, and receipt of payment from the buyer.

4. Success Stories

A majority of Chizel's buying side customers are B2B companies from the heavy engineering sector that need to procure thousands of parts and assemblies. According to Yash Rane, founder, purchase teams often find it difficult to find the most optimum supply chain to source parts. Even though buyers have a known and trusted supplier network, it does not guarantee the best pricing for an order. This is where Chizel steps in to offer the following unique benefits: -

- Optimisation of TCO by upto 25%
- 360-degree ownership of the manufacturing and delivery process
- 80% efficiency in time-management regarding negotiations and supplier verification and identification
- Real-time tracking of the delivery
- 99% On Time in Full (OTIF) delivery compliance
- Greater market access for the suppliers due to digital connectivity
- Access to potential international customers since 8% of registered buyers are international

5. Challenges

Both buyers and manufacturers are hesitant to adopt technology. Manufacturers do not adapt technology for the lack of awareness and buyers are not comfortable with placing order using digital platforms as against e-mail order.

6. Future Plans

Chizel has recently developed a cloud-based, supply chain, software 'CPro' to simplify procurement workflows. This tool enhances offering in addition to MaaS. With this tool, buyers can manage a private network of their own suppliers, securely share data with them, conduct close and open biddings, render quotes and manage them, place orders, track the order till delivery and control quality. Scaling up this platform is part of Chizel's strategy to expand its customer base.

7. Key Findings

MSMEs Centric

According to Ravi Ranjan, co-founder at Chizel, the supply-chains of all the large manufacturing companies are directly or indirectly heavily dependent on MSMEs for order fulfilment. Every central ministry, department, and PSUs have an annual target of 25% procurement from the MSME sector. Despite such strategic impetus, manufacturing MSMEs face challenges on multiple fronts:

- **Procurement of raw materials at competitive prices** Access to raw materials can make a significant difference in operational efficiency and margins for MSMEs. Unfortunately, due to small volumes they find it difficult to get raw materials at reasonable prices thereby reducing margins. Often due to lack of bargaining power, MSMEs end up paying in advance for the raw materials, which blocks working capital.
- **Lack of access to markets** In India, even in the digital age, 90% of MSMEs supply within their respective city boundaries as they face the challenge of accessing wider markets. Most of these companies are single owner or proprietor run businesses where the owner (or a small team) manages all roles of customer support, engineer, technician, accountant, etc. thereby leaving very little scope to focus on growing the market.
- **Lack of skilled manpower** Given the small size of manufacturing MSMEs, many find it difficult to pay higher salaries and provide amenities for employees. The informal modus-operandi also results in attrition of skilled manpower to larger companies that can provide better pay, benefits, amenities and stability. The lack of skilled manpower hugely affects quality, delivery and growth of MSMEs.
- **Lack of availability of adequate, timely and cheap credit** Manufacturing industries are the most capital intensive as they have some of the longest working capital cycles, leading to cash flows being locked-in for prolonged periods. This makes the access to adequate and timely capital extremely important for MSMEs to grow successfully.

In Dec 2020, Australia-based Truventor.ai, a deep-tech led manufacturing company has acquired Chizel.io.

CASE STUDY

08

Drishti:
Bringing Visibility to Manufacturing Lines

Vision of digital manufacturing:
Making human actions on factory floor available for analytics

Potential benefits for India:
Increase competitiveness of Made in India products by improving quality and reducing line inefficiencies

How to accelerate adoption:
Incorporate computer vision and AI on factory floor

Despite automation and robotics, humans are responsible for 72% of the tasks on the factory floor, create three times the value of machines but yet remain invisible to factory analytics. Using computer vision and AI to capture factory wide data of human operators, Drishti Technologies corelates human actions to line efficiencies, bottle necks and root-cause analysis. The Indian manufacturers operating at the lower end of automation curve can improve productivity, safety and quality by deep-diving into human-action analytics through a combination of computer-vision and AI.

1. Introduction

Established in 2016, Drishti Technologies (Drishti) is a U.S. based company that uses AI and computer vision to produce continuous, system-wide data for manual factory tasks, by providing video analytics and video traceability for assembly lines. Improving a manual assembly line takes a huge amount of effort by engineers, supervisors, trainers, line associates, and others. Drishti provides data and insights for improving manual assembly lines faster, with much less effort, and much greater impact.

In 2019, Drishti was named a Gartner 'Cool Vendor' in manufacturing operations, as well in the World Economic Forum (WEF) Technology Pioneer, a group of 56 early to growth-stage companies from around the world that are involved in the design, development and deployment of new technologies and innovations, and are poised to have a significant impact on business and society. Drishti's India office is based in Bengaluru.

The proprietary neural-network architecture at the core of the Drishti offerings, are 100% Made in India. Drishti has a presence in the automotive and electronic manufacturing sectors that have extensive assembly lines. It has customers such as Denso, a $ 48 billion, Japanese company with multiple lines in North America. Three of the top six global auto OEMs, two of the top five auto tier-one companies, and two of the top three electronics contract manufacturers are also customers of Drishti.

The unique solutions offered by Drishti has seen the company attract $10 million series A funding in May 2018, followed by $25 million series B funding in June 2020. Toyota AI ventures, one of the investors in the Jun 2020 funding sees Drishti's technology as a way to help everyone on the factory floor identify opportunities that can improve performance and create greater value.

2. Products

Pioneers of the manufacturing world started using the stopwatch to measure human efficiencies. In an IoT based manufacturing environment, stopwatches are no longer an effective option to measure productivity. Dr.Prasad Akella, founder and CEO of Drishti states "Despite all of the industry hype around robotics and automation, humans still do the vast majority of factory tasks, in fact, humans are responsible for 72% of the tasks on the factory floor, and create three times the value of machines". That means more than 70% of the tasks behind global manufacturing GDP are effectively invisible to analytics. This large dependence on human activity in manufacturing introduces 73% variability, and 68% defects due to human actions.

The products at Drishti aim to convert human activities into data at scale. Bringing invisible human actions in to the data pool drives productivity, quality and safety at scale on the factory floor. Drishti's computer vision technology creates data from something that has been historically very difficult to measure: manual activities on the assembly line. Dave Prager, Head of Marketing and Business Development at Drishti states that "In the same way SAP transformed the financial data set into a business tool almost 30 years ago, Drishti believes the manufacturing data set is the new business tool today".

Drishti uses a combination of deep learning and computer vision techniques to digitise activities by humans on the assembly line. Some of the applications include: -

- Process cycle detection that aids in generating insights such as average cycle time and average job time. These can also be used to build analytics such as line efficiencies and productivity.
- Process action detection that helps detect bottlenecks in sequential lines, as well as provides a step-by-step verification of operator actions on an assembly line. It is akin to having a Google Map for all the human operators on the manufacturing lines. Extensions of the process action detection also can include missed step detection and introducing digital Poka-Yoke.

According to Drishti's research, a process engineer on an average, spends a third of his time on motion studies on the assembly line and an almost equal time on root cause analysis. These activities are not value creating. Optimising assembly lines to improve productivity and quality requires a lot of data. Manual motion-time studies and root cause analysis are time consuming and are often hindered by a small dataset size and inherent observer bias. Assembly line optimisation in such an environment is therefore slow, costly, often ineffective and completely insufficient to meet business needs.

The solutions offered by Drishti capture video and data from activities on the line, creating datasets with a scope and richness that has never before been available for manual assembly operations. Their solutions offer real-time process optimisation tools through: -

- Live streaming for remote visibility
- Video capture, storage and search - to quickly identify root cause of anomalies and defects
- Easy video tagging and sharing throughout the organisation
- Time-motion study analytics based on computer vision and deep learning models
- Training tools like annotation and tagging that drive standardized work adherence

Multiple stakeholders on the factory floor can benefit from the solutions provided by Drishti. Some of these benefits are tabulated below: -

Table 12: Factory Floor Beneficiaries

Stakeholder	Benefits
Quality Engineers	• Faster and more accurate root cause analysis • Countermeasure design and evaluation • Lower defect rates due to standardized work adherence
Process Engineers	• Line balancing • Data creation for improvement projects • Faster process design for new product introduction • Simpler data gathering for line transfers • Fewer defects and reduced scrap costs

Stakeholder	Benefits
Line Associates	• Faster training and upskilling • Faster identification of challenging processes • Real-time feedback on assembly performance • Decreased training time
Line Associates	• Live unit count • Live bottleneck monitoring • Instant replay of abnormalities for spot training and solutions
Supervisors	• Live unit count • Live bottleneck monitoring • Instant replay of abnormalities for spot training and solutions
Plant Management	• Greater visibility into line and stations • Faster time to market for newer products • Traceability for recall risk management
Product Designers	• Greater assembly line visibility of • Faster design iteration for manufacturing
Trainers	• Use videos as training content • Rapidly update curriculum when the process changes • Using instant replay for operator spot training and upskilling

Source: Drishti

3. Implementation Model

One of the line manager's jobs is to walk up and down the line and check things. A human supervisor can only see a few things at a time. Drishti, with its technology stack provides far insights on the line than possible with human eye and intelligence. Some important features of Drishti's solutions are: -

- The solutions augment people instead of displacing them.
- They reduce operator errors and improve productivity
- The technology aims to improve the whole system at once, not just isolated stations or steps
- Customers do not need programmers or data scientists. Drishti offers a full-stack solution with apps that anyone can use on the factory floor

Most customer engagements begin with a Value Assessment Workshop (VAW). This methodology helps the customer quickly isolate the impact of Drishti's video analytics and video traceability on quality, productivity and training. The VAW is an 8-week programme structured to achieve two goals: create immediate operational Return on Investment (ROI) in terms of quality or productivity, and provide the data necessary to calculate the business value of a larger-scale.

A VAW typically takes place on 1 to 2 lines, on up to 30 stations. The VAW focuses on more complex problems, such as the ones that have the most variability, the largest quality issues, or the most operator turnover. Drishti then focuses on use cases that can: -

- Improve efficiency by understanding the causes of bottlenecks and production anomalies
- Optimise process through identification of process variability and inefficiencies
- Reduce defects through an instant replay, for root cause analysis and to review historical build-up episodes

Provide remote accessibility through live streaming for increased visibility, remote collaboration and reduced travel time and cost

The VAW typically involves the following methodology: -

- Pre-Project – Deploy Drishti cameras on live stations.
- Week 1 to 5 - Prove the ROI for Drishti's video analytics tools. Use cases include training, remote visibility, inspection, and root cause analysis. Drishti assists with site selection, education and workflow design.
- Week 6–Prove the ROI for Drishti's process optimization tools. Drishti facilitates a kaizen event, using process analysis data created by Drishti's tools and services.
- Week 7 to 8 - Post-kaizen monitoring to confirm impact and ROI.

Once Drishti provides data that has the potential to improve productivity, it is very important to re-build work flows to utilise the growing data points made available by Drishti. Some of the improvements seen after the VAW are tabulated below: -

Table 13: Value Creation through Value Assessment Workshop

Stakeholder	Benefits
Electronics Contract Manufacturing (ECM) company in Guadalajara	• 25% reduction in labour cost • 8% throughput yield improvement
Power tool manufacturer in North America	• 35% reduction in labour cost • 50% reduction in duration of Kaizen event
Airbags factory in Mexico	• 20% improvement in throughput
Japanese auto tier 1company in Michigan	• 60% reduction in duration of Kaizen event

Source: Drishti

3. Key Findings

Industry 4.0 has a massive blind spot – people. Time-and-motion studies are a poor source of data as they are performed manually, which means they produce minuscule sample sizes and the very act of one person observing another introduces significant observation bias. Introducing video-analytics on process lines can significantly impact productivity, quality and safety.

Manufacturing lines with a high degree of repetitiveness and predictability offer patterns that are used to create models for delivering process insights through video analytics. Factory floors with a high degree of variability - introduced by the process itself or by line-operators find it difficult to tap the benefits of computer vision-aided analytics. Manufacturers must therefore focus on building repeatability and predictability into their manufacturing lines.

Non-Disruptive Integration: The solutions offered by Drishti can be implemented without significant disruption to assembly lines or interference with existing processes. Some of these features include:

- No heavy IT integrations
- No need to redesign stations
- No need to redesign processes
- No requirement of Augmented Reality (AR) or Virtual Reality (VR) glasses
- No specialised operator training
- No heavy equipment to install

The tools offered by Drishti also aid in preservation of jobs as manual performance in each category improves. This offers companies an important alternative to expensive automation solutions.

CASE STUDY

09

Altizon:
Niche Industrial IoT

Vision of digital manufacturing:
Globally recognised niche player for IIoT

Potential benefits for India:
Providing proven products to the SME sector

How to accelerate adoption:
Go global, then local

Altizon's product uses machine data to helpbetter business decision-making for its majority overseas manufacturing customer base. It particularly improves productivity, power and utilities consumption and predictive maintenance. Altizon is one of the 16 globally-recognised niche players for Industrial IoT (IIoT) platforms, by the Gartner's Magic Quadrant. It is now turning to Indian SMEs with its proven IIoT product Datonis.

1. Introduction

Altizon, a global industrial IoT company, headquartered in Palo Alto (USA) with offices in Boston (USA) and Pune (India), powers digital revolutions by helping enterprises leverage machine data to drive business decisions. Altizon has been spearheading digital transformation initiatives in Industry 4.0 across a range of industry verticals, including Automotive, Tire, Consumer Packaged Goods (CPG), Chemicals and Remote Industrial Assets.

Established in 2013, Altizon launched its proprietary Datonis Internet of Things (IoT) platform in Oct 2013 to provide enterprise-grade technology across the functional breadths of operations to deliver rapid business outcomes. Since inception, Altizon has attracted the first round of Series A funding for $ 4 million in 2016, consequent to which it expanded its operations in the U.S. In Apr 2019, Altizon secured a second round of $ 7 million in A series funding that is being utilised to strengthen international presence and support investments in Intellectual Property (IP) development.

With a global footprint of over 100 enterprise users in over 30 countries, Altizon is now a leading Industrial IoT platform provider recognized in the Gartner 2019 Magic Quadrant for Industrial IoT Platforms, for the second consecutive year.

2. Products

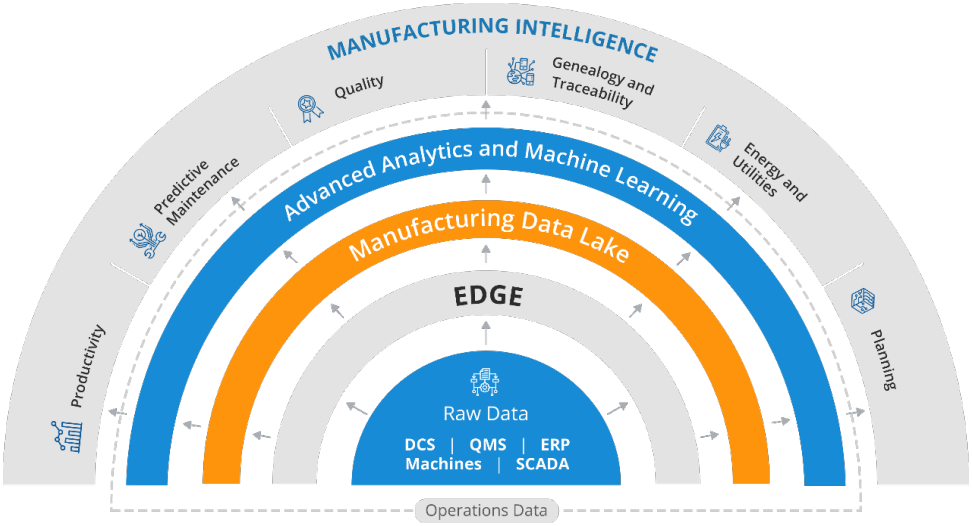
Datonis IIoT platform: Datonis Industrial IoT platform is a highly scalable, cloud-based IoT platform that acts as a manufacturing data lake and allows factory assets to securely connect and exchange information in real-time. Some of the prominent features are listed below:-

- **Device management** – The cloud-based platform facilitates management, control and upgrade of the connected devices in a secure environment.
- **Real-time analytics** – The platform permits streaming and analytics of data from the machines in real-time using a powerful real-time analytics engine that supports complex streaming logic.
- **Machine Learning** – The platform helps users interactively build and deploy powerful models to predict outcomes using a pre-built library of statistical and machine learning algorithms.
- **Deployment Flexibility** – Datonis is available as a cloud-hosted multi-tenant PaaS and it can be hosted on any cloud infrastructure or installed on-premise.
- **Seamless Integration** – Datonis can integrate IoT and operations data with enterprise IT systems such as Enterprise Resource Planning (ERP) and Manufacturing Execution System (MES) using pre-built adapters or an open Representational State Transfer – Application Program Interface (REST API).
- **Alerts and Notifications** – The platform generates real-time alerts and notifications on anomalies, thereby improving action-response effectiveness.

Datonis Manufacturing Intelligence (MInt): Manufacturing plants are a highly complex environment consisting of machines, automation systems and management software that generate a tremendous amount of data in silos. These data silos often result in decision making that might work for a specific area but miss out on the bigger picture. Datonis MInt is a manufacturing data lake for a digital enterprise. It can combine manufacturing process and Information Technology (IT) data from multiple operation sources like ERP, MES, Supervisory Control and Data Acquisition (SCADA), Distributed Control Systems (DCS) into a single data repository to deliver actionable insights. The data from this lake is then made available to different modules that help generate actionable insights in various verticals of the manufacturing value chain. Some of the prominent features are listed below:-

- **Modules**
  - **Productivity Analytics** – MInt helps analyze productivity metrics such as Overall Equipment Effectiveness (OEE) and define actions to drive change.
  - **Machine Maintenance** – MInt helps identify machine parameters that are critical to maintenance and build models that can predict performance degradation and breakdown.
  - **Quality** – MInt enables real-time batch and product traceability through tracking across the manufacturing process to ensure compliance in the event of a product quality audit, withdrawal or recall.
  - **Energy and Utilities** – MInt helps measure, analyze and optimize key consumables such as power, steam and compressed air, critical to a manufacturing process. Tracking of consumption pattern changes can help address inefficiencies in the process.
  - **Correlation Analytics** – MInt helps analyze and corelate information across all the dimensions of a manufacturing process to identify Key Performance Indicators (KPIs) that matter most for an enterprise.
  - **Digital Twin** – MInt creates a virtual replica of a physical product or process to identify and address problems before they even occur.

Figure 15: Datonis Manufacturing Intelligence Architecture



Source: Altizon

- **Value-Chain Beneficiaries** - The beneficiaries on the factory floor due to implementation of digitally enabled tools are summarised in the table below.

Table 14: MInt insights

Plant Head	Quality Head	Maintenance Head
• Plant performance index across productivity, quality, maintenance, energy and order fulfilment • Actual conversion cost vis-à-vis budgeted cost • Actionable insights to improve overall performance and bring predictability in operations	• Process quality assessment • Off-design operation resulting in variance of process parameters • Dominant process variables contributing to quality deterioration • Violations in the process from an audit perspective	• Total unplanned downtime attributed to engineering and maintenance • Work centres with low Mean Time Between Failures (MTBF) • Machines overdue for preventive maintenance • Machines showing early signs of performance deterioration

Source: Altizon

Datonis Edge: As IoT devices become more common and incorporate more processing power, vast amount of data is being generated on the outer "edge" of computing networks. This data needs to be sorted into structured identifiable formats, without introducing additional latency to the already time-sensitive process. Datonis Edge is a distributed computing platform that analyzes data from devices and systems closer to the source of the data. Edge is installed on-premise inside the factory network and can be installed on an industrial PC or on a virtual machine. It only requires a machine with an operating system, and the configuration of the machine depends on the amount of data to be processed. Edge deals with data at a very high latency and processes it by using simple mathematics or even advanced machine learning algorithms. The platform then ensures that part of this process data shows up in the industrial IoT platform for further analysis. Some of the prominent features are listed below: -

- **Industrial Connectivity** – Edge helps rapidly connect machines and shop-floor IT systems to Datonis by using a pre-built library of Industrial and software adapters.
- **Edge Analytics and Artificial Intelligence (AI)** – Edge can help define analytics and AI-based machine learning models and pushed to the Edge for greater performance and faster response times.
- **Scalability and Resilience** – Edge can help set up a distributed, resilient and fault-tolerant infrastructure that never loses data. Increasingly, computing, storage, and analytics capabilities are compressed into IoT devices that can be situated nearer to end users. Edge computing therefore offers a less expensive route to scalability, allowing companies to expand their computing capacity through a combination of IoT devices and edge data centres.

- **Custom Plugins:** Data processing, device connectivity and system integration capabilities can be added using the Edge Plugin API.
- **Device Management:** Edge devices can be managed, secured, controlled and upgraded from the platform using a powerful policy engine.
- **Security:** Edge comes with the option for users to define key-based authentication for every connected Edge device and to set up specific policies.

3. Implementation Model - 4 Week IIoT Challenge

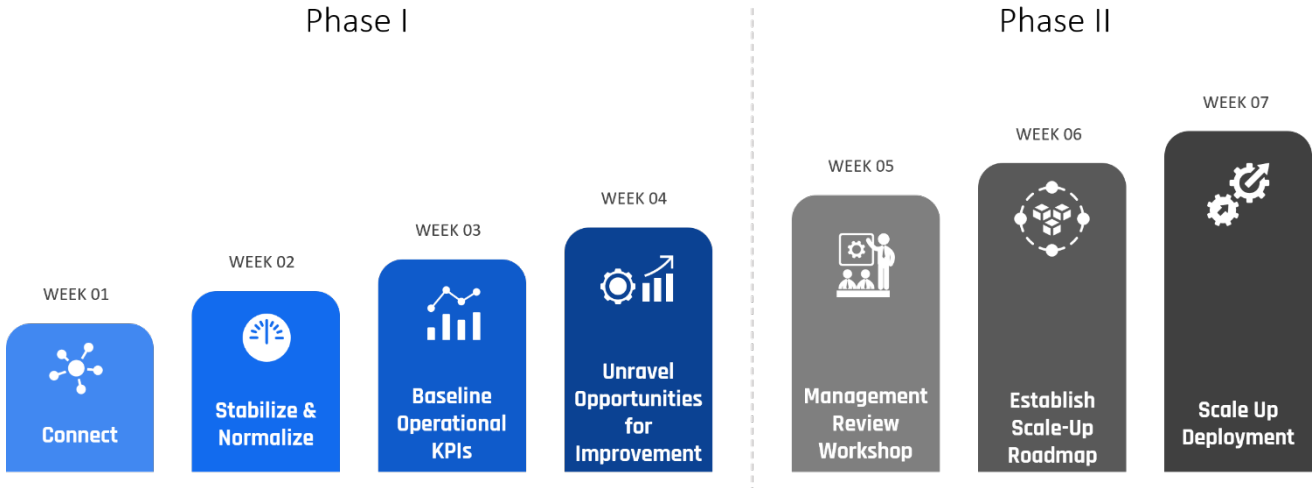
Altizon has identified that many companies are wary of Industrial IoT implementation primarily due to apprehensions on the length of the transformation process timelines. To overcome customer apprehensions, Altizon has rolled out a 4 Week IIoT Challenge.

During the challenge, Altizon will work directly with participants to integrate a specific manufacturing process with Altizon's Datonis platform, with the goal of leveraging machine data to improve Overall Equipment Effectiveness (OEE), improve process adherence and improve specific energy consumption, while delivering the foundation for a scalable enterprise-wide IIoT strategy.

As per Altizon, within 4 weeks of deploying Datonis participants would begin to uncover opportunities to improve base line productivity by 15% and process quality by at least 3%, along with a drop in energy consumption by 5%.

The implementation process entails:

Figure 16: Implementation Phases of 4 Week IIoT Challenge



Source: Altizon

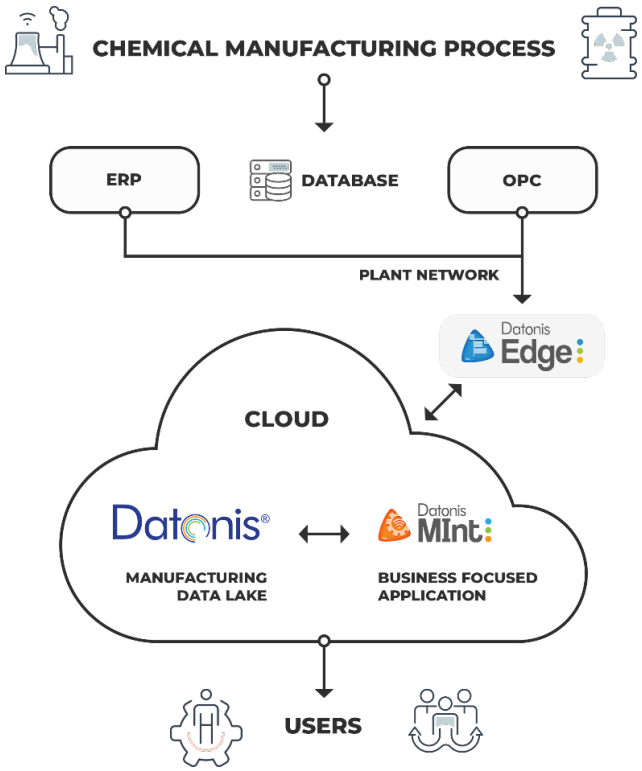
Co-Founder and CEO Vinay Nathan believes that the implementation of IIoT into an organization does not have to be a lengthy or complicated process to deliver business results. "We are confident — and have proven — that manufacturers can unravel opportunities to improve business results from IIoT within four weeks," he shares.

4. Success Stories

1. A leading organization in technical textiles

- **Problem Definition:** The client wanted to accelerate their IoT-enabled digital transformation by connecting critical processes in the manufacturing of technical textiles. The focus areas included improving quality by analyzing parameters critical to the manufacturing process, optimizing fuel consumption, reducing power consumption, minimizing line breakages and improving overall productivity by predicting stoppages using condition monitoring. Some of the challenges that the solution needed to overcome included:-
  - A brownfield solution that would integrate with a fully functional line and existing IT systems
  - Support heterogeneous machines with a variety of connectivity protocols
  - Provide extreme accuracy and reliability as the system would be used as point of reference
  - Support a set flexible, multivariate analysis techniques that suit a range of complex processes
- **Solution:** Altizon's Datonis IoT suite was deployed at client with Datonis Edge operating in a fail-safe configuration inside the customer's network. Datonis IoT platform and MInt were deployed on the cloud. The Datonis IoT API was leveraged to integrate with all dependent systems including ERP.

Figure 17: Implementation at a leading textile manufacturer



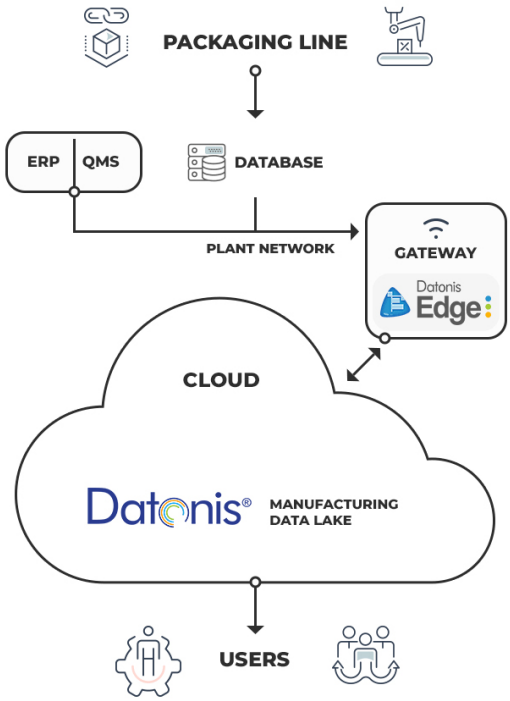
Source: Altizon

- **Benefits:** The client leadership team identifies projects with payback ~1.5 years, to be able to assess the impact and plan ahead, as in the case of Altizon. The leaders determined key focus areas or use cases and began the implementation for one use case in one plant, moving on to other plants after a successful implementation. Post implementation the following key benefits were accrued: -
- 10% improvement in quality
- Reduced material wastage
- Real-time process visibility

2. A leading global multinational in the CPG space

- **Problem Definition:** The company operated several warehouses, mostly closer to the last distribution point (large retailers). Products in various categories are packaged in specific delivery or display cartons at these facilities. As most CPG businesses consist of high volume with low margins, optimizing every operation and effective utilization of resources add up to profit margins. The key problem at these warehouses was the lack of visibility into reasons for machine breakdowns or idle time, thereby delay in delivery. The customer wanted to implement real-time line monitoring and alert system to gain control over downtime issues and implement improvement measures. Some of the implementation aims included: -
  - A complex, wireless sensor-based tracking of line performance, along with plug and play sensors and hardware with minimal installation overhead
  - A cloud-based, multi-tenant hosted platform as the single data repository for plant data across the globe
  - Extreme accuracy and reliability as the system would be used as point of reference
  - A highly customized application for business KPIs along with an open platform that provides the ability to easily integrate with IT systems
- **Solution:** Parts of the Datonis IoT suite were deployed. Wireless sensors and a hardware communication gateway with Datonis Edge embedded in it were deployed inside the customer's network. Datonis IoT platform and a custom business application were deployed on the cloud. The Datonis IoT API was leveraged to integrate with all dependent systems including ERP.
- **Benefits:** Post implementation the following benefits were accrued: -
  - 8% improvement in line performance
  - Real-time visibility of process lines to identify downtime sources, inefficient teams and ageing equipment
  - Real-time analysis of consumption of utilities such as power and water

Figure 18: Implementation at a leading CPG facility

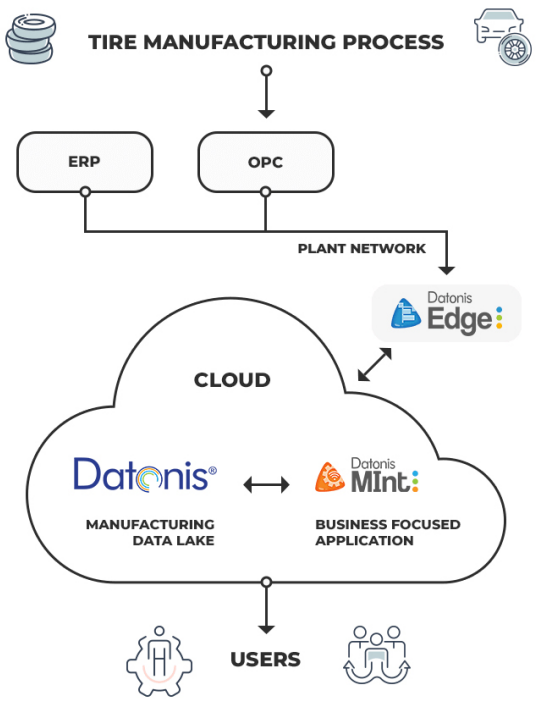


Source: Altizon

3. A leading tire manufacturer, among top 25 in the world

- **Problem Definition:** The client needed to drive IoT-enabled digital transformation by connecting critical processes in tire manufacturing. The processes included mixing, calendering, extrusion, cutting, winding and curing. Here's what the implementation needed to achieve:
  - A brownfield solution that would integrate with a fully-functional line and existing IT systems
  - Support heterogeneous machines with a variety of connectivity protocols
  - Provide extreme accuracy and reliability as the system would be used as point of reference
  - Support a set flexible, multivariate analysis techniques that suit a range of complex processes
- **Solution:** Altizon's Datonis IoT suite was deployed at the client site, with Datonis Edge operating in a fail-safe configuration inside the customer's network. Datonis IoT platform and MInt were deployed on the cloud. The Datonis IoT API was leveraged to integrate with all dependent systems including ERP.
- **Benefits:** Post implementation the following benefits were accrued: -
  - Reduction in mean time to repair
  - Elimination of unplanned machine downtimes
  - Improvement in productivity
  - Reduction in cost of energy consumed per unit production

Figure 19: Implementation at a leading tire manufacturer



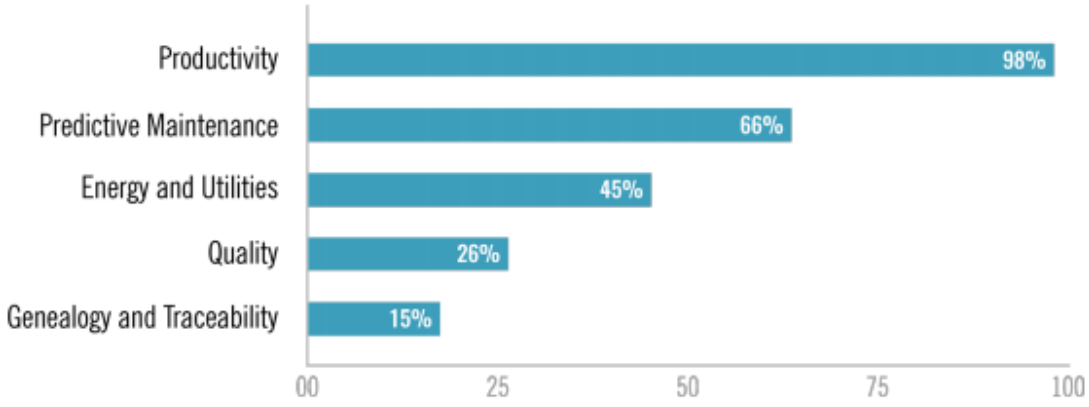
Source: Altizon

5. Key Findings

Early adopters of IIoT

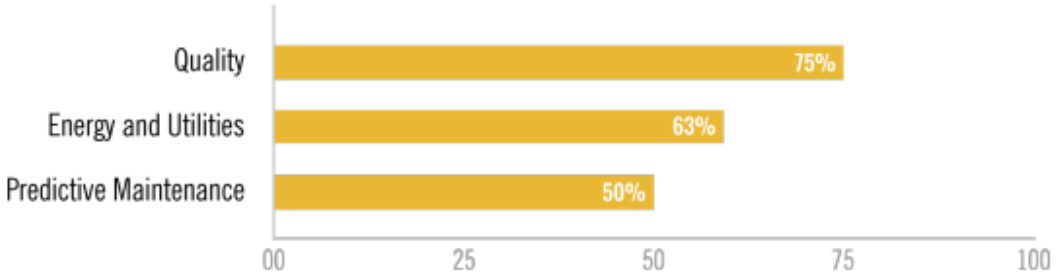
A study conducted by Altizon has mapped certain benefits accrued by early adopters of Industrial IoT. The details are depicted in Fig 20 to 23 below.

Figure 20: Use Cases percentage in Automobile Sector



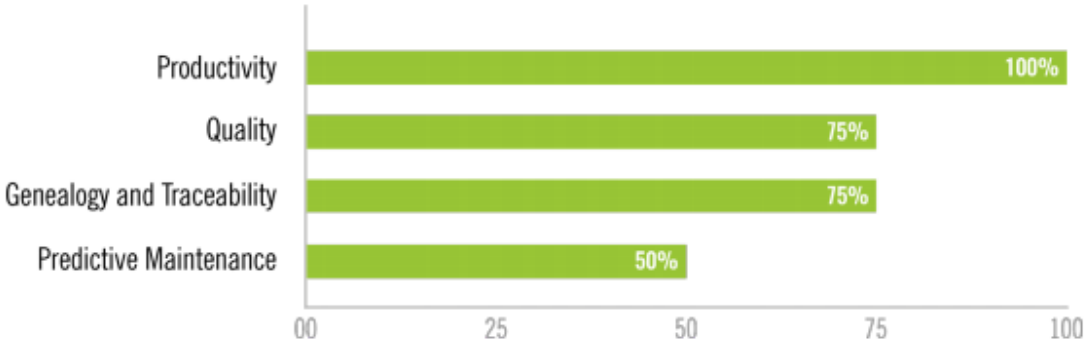
Source: Altizon

Figure 21: Use Cases percentage in Chemical Manufacturing Plants



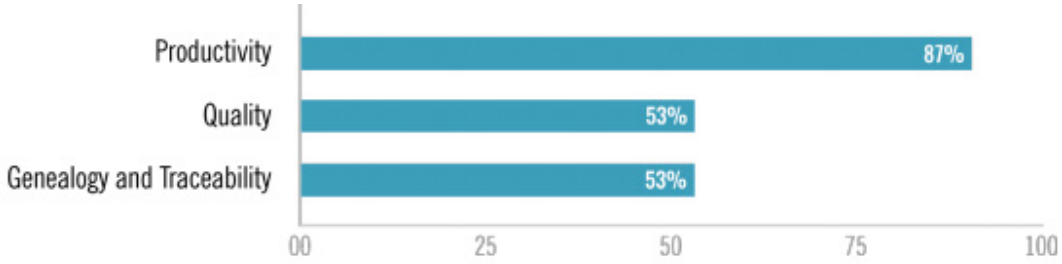
Source: Altizon

Figure 22: Use Cases percentage in Textile Manufacturing



Source: Altizon

Figure 23: Use Cases percentage in CPG Plants

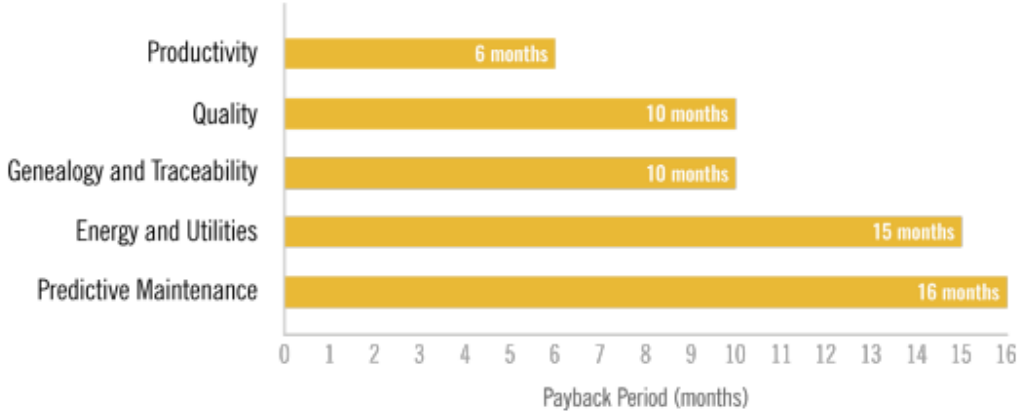


Source: Altizon

Payback Timelines

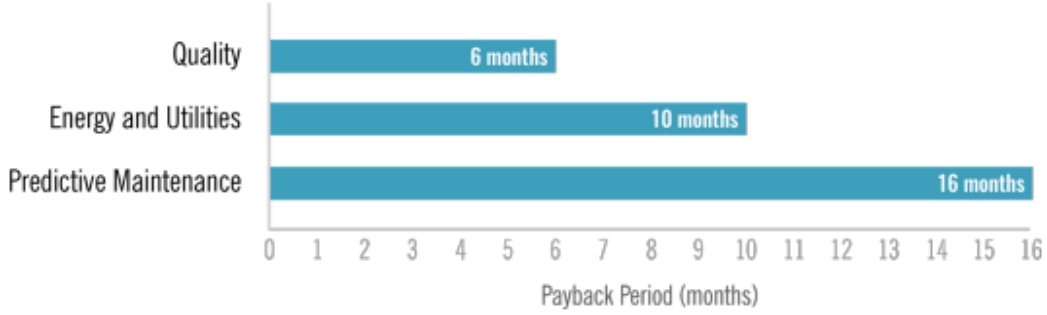
Altizon has also mapped the expected payback periods on investments in IIoT for early adopters. The details are depicted in Fig 24 to 27 below.

Figure 24: Use Cases with associated payback period in Automobile sector



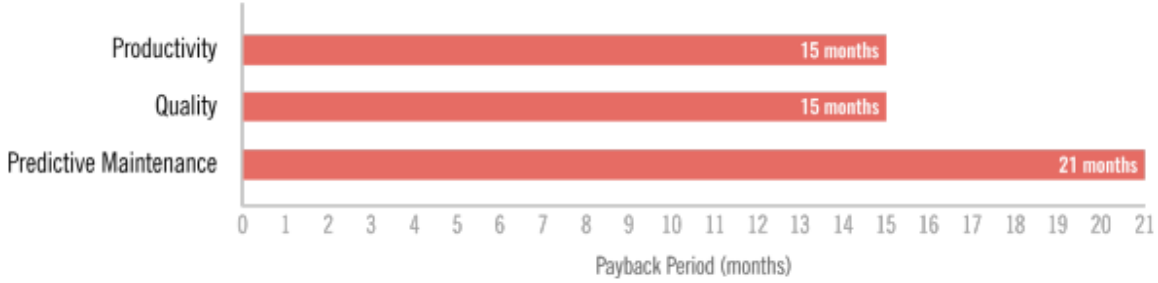
Source: Altizon

Figure 25: Use Cases with associated payback period in Chemical Manufacturing Plants



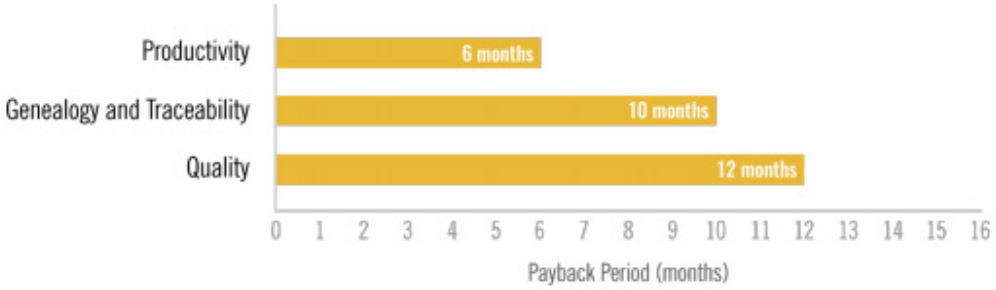
Source: Altizon

Figure 26: Use Cases with associated payback period Textile Manufacturing



Source: Altizon

Figure 27: Use Cases with associated payback period CPG Plants



Source: Altizon

- Altizon's inclusion in the Gartner IIoT Magic Quadrant has helped it gain global recognition for their products and services. A similar recognition within the Indian Industry 4.0 start-up ecosystem will be useful to identify leaders in various verticals.
- Adoption of IIoT will result in freeing up engineers from management related jobs and aid them in getting back to their core profession.
- Adoption of IIoT in India is yet to gather momentum when compared to U.S. and European markets.

CASE STUDY

10

Piramal Glass:
Breaking Manufacturing Myths

Vision of digital manufacturing:
Start-ups speed up digital transformation through frugal and customised innovations, especially with brownfield ventures

Potential benefits for India:
Start-ups can catalyse Industry 4.0 especially within cost-conscious MSMEs

How to accelerate adoption:
Create a national ecosystem and directory of Industry 4.0 start-ups

Established in five decades ago, the Piramal Glass plant in Kosamba, Gujarat, is an export powerhouse which has adopted digital technologies like IoT and cloud rapidly and effectively. Piramal Glass is a lodestar for brownfield facilities looking to transform themselves into a globally-competitive, data-driven, Industry 4.0-enabled facility. Piramal Glass has minimised the cost of transformation by using largely domestic Indian start-ups that offer frugal and customised solutions to specific challenges on the factory floor and across the supply chain. Piramal Glass' early foray into digital innovation helped restore plant-wide operations within a week of the Covid-19 pandemic, whilst adhering to stringent regulatory norms and workforce restrictions.

1. Introduction

Piramal Glass is a leading moulded glass bottle manufacturer in India. The $330 million company has four manufacturing facilities globally - two in India, at Kosamba and Jambusar in Gujarat, two overseas, in Sri Lanka and the U.S. The four facilities (with a combined infrastructure of 12 furnaces and 60 production lines) with a capacity of 950 tonnes of glass per day. Piramal Glass is predominantly an exporter of specialised glass bottles for perfumes, beauty products and medical vials, with 65% exported to the U.S. and Europe. It is the world's third-largest producer of nail polish bottles, with a 6% market share of global cosmetics and perfumery glass. In India, is one of the larger producers of bottles for the pharma industry.

This case study is based on the transformation of the Piramal Glass manufacturing plant in Kosamba, the company's oldest and the largest facility, and how this brownfield factory accelerated digitization during the Covid-19 pandemic. Acquired in 1984, it began with the manufacturing of vials, liquor bottles and food jars, and today makes high-value perfume and medical glass products.

Figure 28: Piramal Glass, Kosamba

Source: Piramal Glass

2. Transformation Goal

The company began its digitization journey in 2014, to ensure that the entire production line was connected with sensors, the data collected and analysed for efficiency, quality and safety. Samit Datta, the company's Global Chief Supply Chain & Technology Officer, led this initiative.

3. Methodology

- For its digital transformation, Piramal Glass has used a judicious mix of products and services from established players and start-ups.
- Between 2007 and early 2014, a number of digital processes were introduced, leveraging its existing IT assets and SAP. to enhance productivity. The focus was to enhance the productivity of existing factory assets, human resource management, quality, and safety.
- By 2014, the company initiated transitioning from on-site servers to cloud-based tech. The management then brought the employees into the transition process, asking for ideas based on their experiences. The ideas began to pour in by the thousands. By 2015, it became clear that digitization was enthusiastically embraced, and Piramal Glass described it as part of its manufacturing DNA.
- Piramal Glass was growing rapidly, tripling from Rs 6.5 billion in 2006 to Rs 22 billion in 2016 – all on 2007 technology. and a year later in 2017, undertook comprehensive revamping of IT infrastructure both hardware and software across all facilities in India, Sri Lanka and the United States. This included – revamping the network elements, upgrading servers at the data centres and endpoint devices across the company.
- In 2016, Piramal Glass undertook an extensive business process reengineering study to map the relevance of existing IT applications to the business processes and realities. As an outcome of this study, in the ensuing one year, the company upgraded SAP to the latest version (SAP S/4 HANA) and shifted to Microsoft Azure – with its enhanced capabilities.
- In 2016, Piramal Glass also appointed a Chief Digital Officer. It then hired a consultant – Wipro to develop a digital strategy and a three-year implementation roadmap that closely aligned with the overall business strategy. A digital integration was begun, for a smart manufacturing process, a connected supply chain, and externally, for a customer-centric digitization.
- A Pune-based start-up, Websym[1], was hired to implement an IoT pilot on two manufacturing lines. At each stage, the digital process or product was evaluated by efficacy, contextual fit, impact on employees and customers, and cost-benefit analysis. It was hugely successful, and cost efficient; Websym charged just over $ 5000.
- In six months, by the end of 2017, the digitization process[2] was implemented in all the four facilities, at a cost that was 70% lower than if a large MNC had been hired for it. Over 4,000 sensors are now connected to each other, generating millions of data points and enabling the goal of productivity, quality and safety. The company's efforts were showcased by Microsoft CEO Satya Nadella at the 'Future Decoded 2020' forum to India's leading CEOs, as a model use case for Microsoft Azure.
- A major cost for the company, are its 12 energy-guzzling furnaces. Half of these are at the Kosamba plant. Existing solutions came from MNCs, mostly one-key-fits-all solutions. Piramal Glass wanted a customised solution, and turned once again to start-ups – this time to a Ahemdabad based company called Ecolibrium Energy[3]. Over 800 meters with sensors were installed[4] in the Kosamba factory, and the data mined therein opened up opportunities for energy savings and reduction of carbon footprint.
- An on-going effort, begun in 2019, is the creation of a digital twin for all the furnaces, with Piramal Glass' in-house engineers. This will provide a simulation platform for predictive performance of assets.

[1] "Solutions to Drive Operational Excellence!" Websym. Accessed February 10, 2021. [2] This digitization effort led to the implementation of Real Time Manufacturing Insights (RTMI) platform – the flagship transformation programme at Piramal Glass. [3] "Industrial Equipment Predictive Maintenance Software - Ecolibrium Energy." Industrial Equipment Predictive Maintenance Software@Ecolibrium Energy. Accessed February 10, 2021. [4] These sensors feed into another inhouse platform – Unified Energy Management System (UEMS) that is used to build insights into consumption of utilities like electricity, gas, air and water.

4. Success Stories

Pre-COVID-19

1. Factory Floor

- Some of the digital innovations on the factory floor and the benefits accrued are tabulated below: -

Table 15: Value Creation

Applications	Benefits
• Real Time Manufacturing Insights	• 5% reduction in critical bottle defects • 40% reduction in manual data gathering • 25% improvement in productivity • 2% improvement in production efficiency
• Unified Energy Management System	• 1% in energy savings
• Digital Twin for furnace	• Furnace temperature prediction • Optimised energy spends advisory

Source: Piramal Glass

2. Connected Supply Chain.

- Piramal Glass ships 600 containers of its product to over 80 countries every month. That's 250 million bottles being sent out globally every month. The tracking system was manual. In 2018, Piramal Glass switched to geo-tagging and satellites for tracking its shipments in real-time over surface (trucks) and ocean (container ships). A German company (Ocean Insights[5]), provided tracking system for shipped containers at sea that also included a seamless platform for secure e-sharing of various documents pertaining to the shipment with customs departments of various countries. It coordinates multiple data feeds from customs databases, GPS, shipping line databases.
- For tracking its container trailers Piramal Glass successfully developed, in-house a smart- phone GPS based tracking system. But this could not be replicated to the Indian trucking system as many truck-drivers did not have smart phones. So, its engineers adapted to use Base Transceiver Station (BTS) technology – a relatively lower technology compared to GPS based tracking. BTS works with GSM and CDMA mobile handsets – a feature common to Indian truck drivers. Piramal Glass once again tapped a local Indian Start Up – Freight Tiger[6] for this innovative solution.

3. Human Resources.

- A gamified crowd-sourcing platform called Innohub was developed in house to encourage employees to ideate on innovations. It has generated over 16,000 ideas, many of which have been implemented. Innohub was also built on a platform provided by an Indian start up – WorXogo[7]. This not only resulted in democratisation of innovation, but also accelerated small ticket capex projects that resulted in monetary savings.

[5] *"About Us." Ocean Insights, January 19, 2021.* [6] *"Logistics That Empowers." Freight Tiger. Accessed February 10, 2021.*
[7] *"Drive Sales Behaviors." worxogo. Accessed February 10, 2021.*

- A multilingual, cloud-based e-learning platform was developed in-house for on-demand training to employees, with over 40 courses that include technically intensive sessions critical to factory floor operations.

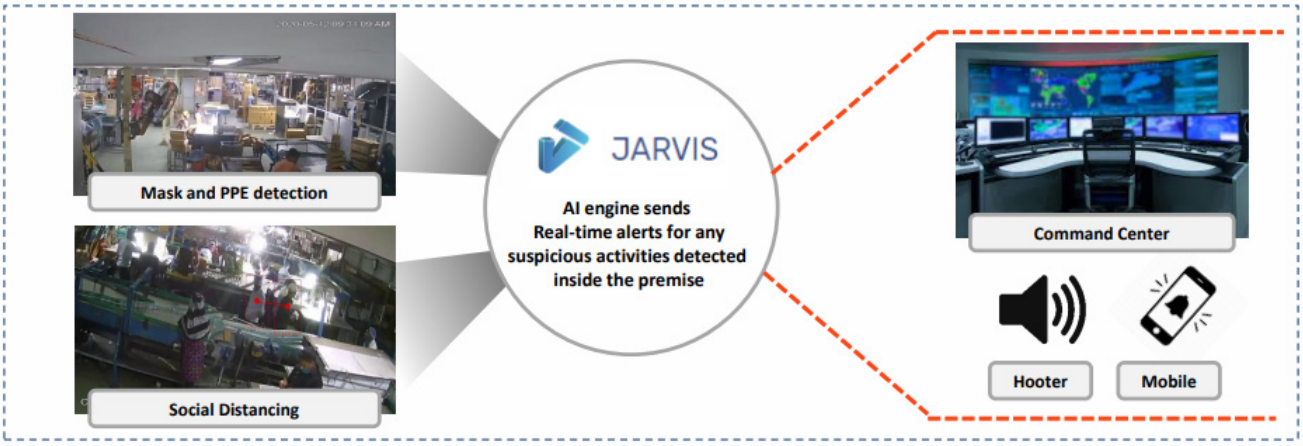
COVID-19

Since 2017, Piramal Glass has developed, a strong digital innovation ecosystem that has helped create connected infrastructure and supply chains. This early impetus to stay abreast with the digital revolution has progressively built resilience into their operations. In Mar 2020, as the country went into nation-wide lockdown due to the COVID-19 pandemic, the company that otherwise would have required to shut down, was able to operate remotely, maintaining *business continuity*. In April when the lockdown was lifted for essential services, Piramal Glass' Indian factories resumed normal operations within a week, with 30% of the workforce, as permitted by the government.

1. Regulatory Compliance.

- Compliance to COVID-19 protocols for workers was mandatory and required rapid innovation. Pre-Covid, at the factory gate company workers used finger-print biometrics to enter the factory premises. That became impossible and the company switched to a computer-vision based non-contact biometrics with which workers could enter and login attendance. Piramal sourced this domestically from a start-up called Smart Infocomm implemented a facial recognition & IR-based system called WebSmart that registered contactless attendance and logged body temperature of individuals prior their entry into the factory premises even with their faces partially covered with mask.
- Similarly, the companies' engineers adapted the existing CCTV network with another computer-vision based algorithm which was used to create alerts for those factory-floor personnel who violated mask and social distancing norms. Alerts were generated and logged automatically that helped in flagging habitual offenders and increasing regulatory compliance.

Figure 29: Video Analytics for COVID-19 Norms Compliance



Source: Piramal Glass

2. Virtual Assist.

- Virtual Reality (VR)-based technology was used to commission the upgraded a furnace to increase its capacity by 50%. Under normal circumstances it would have taken 10 experts from Europe to be onsite. The augmented reality technology comprised of smart glasses which were procured locally. It took the same time, but it saved costs and boosted in-house engineering capabilities.
- Secondly customers who would normally be sent physical samples of glass, were able to undertake virtual inspection of products using Virtual Reality. Piramal engineers indigenously developed a light box with high resolution cameras which enhanced virtual inspection of glass quality in real-time. Personnel from Piramal and its customers used virtual assist technology (voice and visual) to collaborate for dimensions and visual defect detection.
- Thirdly, the virtual reality technology allowed a virtual plant walkthrough for customers.

5. Future Plans

Since 2014, Piramal Glass has generated billions of data points, by leveraging the power of IIoT. This will now be used to create new analytical models to generate deeper insights into various operations for creating a truly end-to-end digital enterprise.

In July 2020, the company hired a leading consultant to scale-up the digitisation journey Digital 2.0 will focus on Artificial Intelligence and machine learning techniques to increase business and enhance work-force digital capabilities.

6. Key Findings

Brownfield operations can digitally transform by building on existing IT infrastructure by implementing a mix of physical and digital innovations. Adoption of IoT and cloud-based digital innovations, using start-ups and blending indigenous and foreign technologies can help older facilities conserve capital and build agility and resilience in their operations. They must seize the opportunities presented by the ongoing pandemic crisis to rethink their business models, set ambitious goals and trust employees with ideation and innovation.

- **Building on existing IT Infrastructure:** A robust IT infrastructure is a stepping-stone for digital transformation. Factories must upgrade IT assets to a level that can facilitate adoption of IoT and cloud-based technologies.
- **Using Start-Ups:** Start-ups must be considered for digitisation and digitalisation efforts as they offer high-customisation and frugality. This approach reduces upskilling demands internally within the organisation and also aids in capital conservation.
- **Blending technology:** There is no silver bullet for digital transformation and organisations must deep-dive into the problem statement at hand and available technologies. The choice of technology must be based on its ability to address a problem statement and create value. Technologies chosen must cater for accuracy, reliability, interoperability, agility and most importantly scalability.

- **Seizing crisis:** The ongoing pandemic has enforced challenges on traditional business models. Companies like Piramal Glass that have adopted digital as a strategic tool for business operations are reaping the benefits of accelerated transformation during the pandemic. Others must seize this opportunity to rethink their business models and make them future-ready.
- **Developing inhouse culture for ideation:** Core manufacturing knowledge is crucial for customisation of digital tools that can be deployed and accepted on the factory floor. Involving inhouse workforce in ideation and problem solving has not only helped Piramal build an innovation culture across the workforce, but also has resulted in development of solutions that work and are accepted at the grassroot of the factory.
- **Setting ambitious goals:** The need for change must be top-driven and must seep into the organisation vertically and horizontally. Putting an ambitious goal in front has helped Piramal Glass to put digital transformation at the forefront of their entire operations and culminate in global recognition in the coming years – perhaps as the latest Indian entrant into the prestigious World Economic Forum recognised Light House network.

CASE STUDY

11

Siemens (Kalwa): A Successful Brownfield Transformation

Vision of digital manufacturing:
Digital Twin helps brownfield factory scale-up productivity, optimise transformation cost and improve product quality

Potential benefits for India:
Improve global competitiveness of products manufactured in India

How to accelerate adoption:
Use digital twin platforms to simulate and re-engineer shop-floor transformation

Established in 1973, the Siemens factory at Kalwa, Mumbai is a manufacturer of low voltage switchgears. This brownfield facility adopted IoT, cloud and digital twin technologies to transform the plant from three production-lines producing 77 variants of switches to a single production-line manufacturing over 200 variants. The facility leveraged the digital twin to optimise manufacturing processes, saving money on transformation initiatives, and reducing the manufacturing cycle time per product from 22 seconds to nine seconds – a 20% productivity improvement. Automation has facilitated increased quality checks in a compressed time frame: 68 checks compared with 22 checks in the pre-transformation, and lower costs, to make their product competitive with their German counterpart.

1. Introduction

Siemens India, a subsidiary of Germany's Siemens AG has been operating in India for over 150 years. It has 23,000 employees, annual revenues of $1.5 billion, 22 factories, eight centres of competence and 11 R&D centres in India. Over the past few years, Siemens AG has been diversifying from conventional engineering products and services, to becoming a total technology and digital solution provider across all its verticals. Siemens is also amongst the top 10 software companies in the world. By the year 2030, Siemens aims to manufacture all green products as part of its global vision and focus in three core areas/ functions - electrification, automation and digitisation.

The Siemens factory at Kalwa near Mumbai is an electrical/electronic manufacturing company. This over 50-year-old brownfield factory established in 1973, manufactures low voltage switchgears. Till 2017, it made 80 variants of switchgears on three separate production lines. With rapid improvements in design and technology, Siemens wanted to introduce new global products and variants to boost productivity in this Indian facility plant. Ideally, such capacity addition in a brownfield asset would have entailed substantial capital expenditure on upgradation and setting up new production lines.

This is a classic challenge not just for large multinationals, but one faced by many Indian SMEs that are typically brownfield and seek to strike a balance between possible productivity improvement and necessary capital infusion.

2. Transformation Philosophy

The Kalwa plant manufactured the earlier generations of low voltage switchgears, while the latest generation switchgears were imported from Germany for the Indian market. Siemens found it increasingly difficult to keep the product-competitive in India Local manufacturing of new gen switchgears was necessary and found resonance in the 'Make in India' initiative. The challenge was to match the quality of the German origin product and introduce additional variants to boost productivity.

As pioneers of digitisation and digitalisation across Oil and Gas, marine, aerospace, food and beverage, electronics, pharmaceutical and other sectors, Siemens decided to demonstrate value of digital transformation in its own brownfield factory – a challenge common to the Indian manufacturing sector. Starting early 2016, an automation and digitalisation-based transformation plan was rolled out at the Kalwa facility. Within 18 months, the three production lines were merged into a single line that today rolls out over 200 variants of switchgears. In Jun 2017, Siemens decided to showcase Kalwa as an example of a brownfield industrial installation being transformed into becoming more efficient through automation and digitalisation.

3. Methodology

Business and Operation Needs

Having set the goal for manufacturing the latest generation switchgears in India, the following needs were consolidated: -

- Merge the three conventional lines into a single production line capable of handling more variants and higher volumes as compared with the combined capacity of the existing three production lines
- Build flexibility in production – that allows manufacturing of a batch size consisting of a single switch
- The next generation product meant higher quality compliance – 68 checks compared with the 22 checks on the older generation switchgears, a 200% increase
- Reduce cycle time to bring it par with the German counterpart
- Reduce time-to-market for a new product to 18-20 months from 36 months and
- Build-in capacity for five years of business expansion.

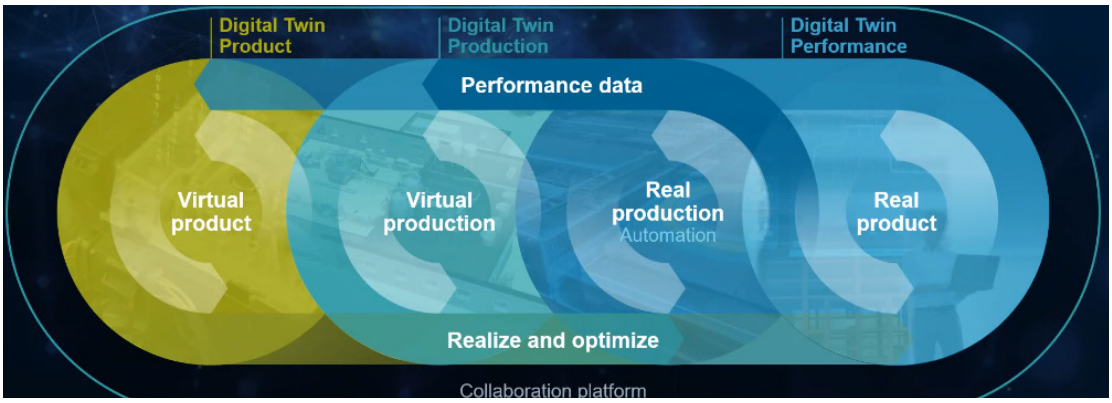
At the heart of this transformation are three in-house technologies – 'Digital Twin', 'Mindsphere' - a cloud and IoT based operating system and 'Video Analytics'.

Digital Twin

Siemens used the Digital Twin concept to virtually simulate the entire manufacturing process. The Digital Twin concept was used to simulate – (a) virtual product design, (b) virtual production and (c) virtually create the end product. This virtual simulation of the entire manufacturing process helped Siemens to optimise the entire process-based iterations drawn from performance data of the Digital Twin model. This simulation helped in: -

- Eliminating expenditure for creating real and full-sized prototypes
- Creating and evaluating virtually, a process that can operate within the boundary conditions of productivity, quality and cycle time
- Conserving capital through optimisations of the process that in a physical world could have resulted in rework and execution delays from variances in specifications from the drawing board to implementation on the factory floor
- Building drill-down traceability to the sub-component level during the manufacturing process.

Figure 30: Use of Digital Twin to simulate the manufacturing process

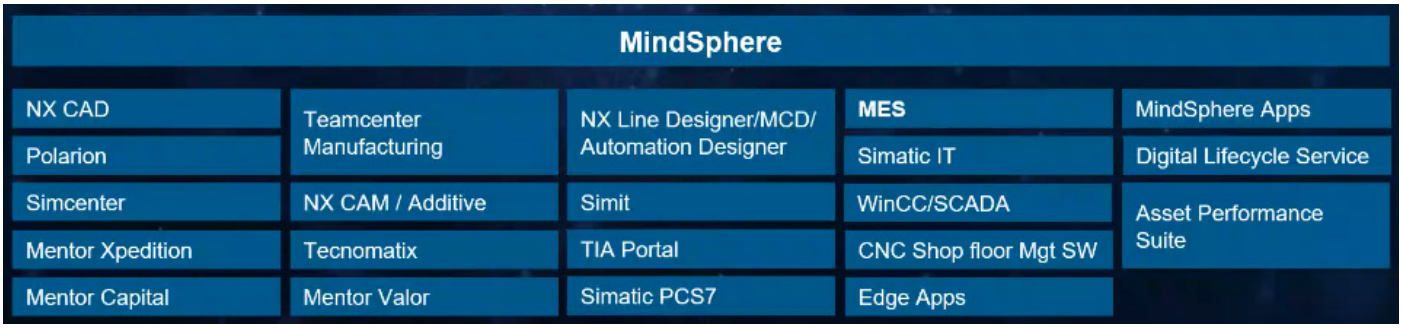


Source: Siemens India

MindSphere

'MindSphere' is a Siemens proprietary cloud and IoT-based operating system, that connects physical assets to a digital ecosystem to harnesses data analytics for driving process innovation. 'Mindsphere' leverages the company's in-built excellence in software development, digitisation and automation. This platform was utilised in Kalwa to digitally thread the business-side software systems such as ERP and SAP with the operations-side Manufacturing Execution System (MES). This end-to-end digital connectivity has provided greater business visibility across the value chain - from order-to-order execution to delivery.

Figure 31: MindSphere Ecosystem



Source: Siemens India

Video Analytics

At the Kalwa plant, video analytics has been used extensively at every stage of the production process. This feature helps in: -

- Capturing process parameters with respect to design and generate correction factors for next steps in the sequential manufacturing process stage
- Making the machines smart in deciding the kind of correction factor and fine-tuning required, thus providing individualised treatment for each product and
- Bringing down cycle time from 12 seconds to the targeted value of 9 seconds by generating data sets that were reprocessed through the Digital Twin.

Challenge Mitigation

- Implementing a digital transformation project in a brownfield facility had it challenges, but none that technology and upskilling could not overcome.
- Transformation executed within the target of 18 months whilst continuing production operations and maintaining delivery reliability in green over the entire period of transition.
- To keep capital investment low, Siemens adopted a mix of physical and digital interventions to help build a process that now matches the German product on quality and cycle time.
- Providing traceability for low-cost products like switchgears, manufactured in a semi-automated process; overcome through adoption of MindSphere platform seamlessly integrating and analysing data from various production points.
- Enhancing existing skill sets to include new disciplines to match the requirements of a digitised setup. Siemens started a program at its training centre within Kalwa, where Industry 4.0 specific-training is imparted to its white- and blue-collar work force - essential for navigating the transformation through change management.

4. Success Stories

- In 18 months the Kalwa switchgear facility has been able to roll out large-scale production of new generation products. The plant manufactures over 200 variants on a single manufacturing line compared with 77 variants on three manufacturing lines in 2016.
- Fewer manufacturing lines has reduced maintenance and labour costs.
- The facility is now capable of producing 1.5 million devices a year on a single line with a more than three times capacity in spare – a 20% jump in productivity compared to the pre-transformation setup.
- The Overall Equipment Effectiveness at the semi-automated Kalwa facility is comparable with fully automated process line in Germany.
- The cycle time per product has been cut by over 50% from 21 seconds to nine seconds even after quality checks increased by over 200% from 22 to 68.
- Increased flexibility has been built into the single production line where now a batch size can include a single piece of device variant. The agile setup ensures that the product line can continue its operations and requires no setting time for change in product variant cycles.

5. Key Findings

- The benefits of digital transformation are not limited to new generation greenfield projects but are equally viable and beneficial in brownfield setup as demonstrated by Siemens at the Kalwa facility.
- Digital Twin is a technology that can bring immense benefits and result in optimisation and customisation. Some other benefits include: -
    - Optimisation of the transformation roadmap through iterations leading to capital savings and faster execution of transformation projects. Digital Twin can be used to simulate the factory, the machines, their functionalities, workflow, work processes, throughput and costing of the whole set-up.
    - During the COVID-induced lockdown, to achieve regulatory compliance of social distancing and reduced manpower norms at the work place, the Kalwa facility once again leveraged its investment in the Digital Twin. The end-to-end visualisation of the entire manufacturing process allowed Siemens to run simulations and reconfigure the production line with new norms within a short span of three hours – thus adding significant resilience to its operations and aiding agility and business continuity during the pandemic.
- Change Management is crucial and must be addressed through upskilling and cross-skilling training programmes.
- SMEs can utilize digitalisation to address growing demands such as mastering increasing product and process complexity, reducing time to market, adapting to changing market requirements, deliver individualized products and secure continuous product improvement.

CASE STUDY

12

BITS Pilani: Preparing for the New Digital Era

Vision of digital manufacturing:
Academia can lead research and workforce upskilling to accelerate digital adoption nationally

Potential benefits for India:
The only academic course offered globally can attract professionals locally and internationally, increase industry-academia collaboration and expand the pool of skilled professionals for advanced manufacturing

How to accelerate adoption:
Create a National Skills Qualification Framework (NSQF) specifically for Industry 4.0, and encourage private technical and business schools to offer the subject

BITS Pilani is a premier Indian institute for technical higher education. In June 2019, it became the first academic institution globally, to offer a Master's programme in Digital Manufacturing for working professionals. The programme focuses on developing expertise on manufacturing of the future including Industrial IoT, additive manufacturing, big data analytics, industrial cybersecurity, logistics and supply chain optimisation, autonomous equipment, etc. The ongoing pandemic has exponentially increased digital adoption, increasing the demand for digital literacy within corporate India.

1. Introduction

The Birla Institute of Technology & Science (BITS) in Pilani, Rajasthan, offers the world's only master's degree in Digital Manufacturing – so far. BITS is one of India's most prestigious private universities of higher education. From its main Pilani home and two satellite campuses in India and one in Dubai, it offers bachelors and masters in various engineering streams (BE/ME), doctoral (PhD) and Masters of Business Administration (MBA). Its unique proposition is collaborating with industry to understand and impart the latest technology trends through its curriculum, bridging the skill gap between academic yield and industry needs. A speciality is its Work Integrated Learning Programme (WILP) for working professionals, whose curriculum and faculty are synchronised with the industry. BITS-Pilani has gained deep insights into emerging industry trends and skill demands. Since inception, over 500 organisations, including prominent one such as Maruti, Mahindra and Mahindra, Tata Motors, Mercedes Benz, Cummins, Bharat Forge, Bharat Petroleum, GE, Alstom, JSW Steel, Bosch and other have benefited from the WILP.

It is under this programme that the 18-month-old Digital Manufacturing course was created, with the fourth batch commencing in Jan 2021.

2. Methodology

Creating the Course: Even before 2016, when Klaus Schwab, founder and executive chairman of the Geneva-based WEF coined the term 'Fourth Industrial Revolution', BITS-Pilani was already engaged with Indian industry to identify future training needs, especially in the manufacturing sector. Between 2014 and 2015, BITS-Pilani conducted a survey to identify the training needed for this. Industries, business houses such as FICCI and CII, individuals, alumni and faculty were surveyed. The survey also revealed that Industry 4.0 will make production systems faster by up to 30% and increase efficiency by 25%.

The survey results also showed that though the existing programmes were suitable for the current generation of manufacturing, future of manufacturing needed more. It needed skills in Industrial IoT, additive manufacturing, big data analytics, industrial cybersecurity, logistics and supply chain optimisation, autonomous equipment, and using digital tools for product and system design, simulation and production.

Prof PB Venkataraman, Associate Dean who led the Digital Manufacturing programme introduction, saw clearly that "role of the engineer is changing in a digital factory -supervision and management tasks will reduce, while engineers will be more involved in building deep operational insights and decision making".

The institute reviewed over 80 relevant courses offered by various universities across the globe, to identify academic trends arising from Industry 4.0. This was combined with the insights from the 2014-15 survey, and in June 2019, India's - and the world's - first Post Graduate programme in Digital Manufacturing was begun. Like other WILP certifications, the Digital Manufacturing programme too is offered only for working professionals. Factory-floor experience aids in accelerating skill build-up and provides an immediate opportunity for application of acquired skills at workplace.

The three foundational themes for the Digital Manufacturing programme are: -

- IoT in manufacturing (data management, data analytics, robotics and cybersecurity);
- High-precision manufacturing (including metal based additive manufacturing) and
- Change and behavioural aspects of a digital factory.

3. Opportunities and Challenges

The applications received for the 2019-21 class, were numerous - 700. Only 52 candidates were admitted to the course based on the selection criterion and target industry envisioned while framing the course curriculum and desired outcome. The pandemic, lockdown and recognition of upskilling in the manufacturing sector has resulted in another 50 students being admitted in the fourth batch commencing Jan 2021. It's not a large number for a country like India, which is seeking to draw manufacturing and its supply chain away from China – but it is a respectable start.

Prof PB Venkataraman, emphasises – "Manufacturing sector has been significantly impacted due to the pandemic, as it relied on physical presence of the operators and engineers. Despite lockdowns and job losses, interest in the Digital Manufacturing course remains undiminished. The institute continues to receive good number of enquiries but the stringent selection criteria limits the admissions. The pandemic has accelerated digital adoption and this programme will cater to the future upskilling demands".

Equipping the College

- New infrastructure, both faculty and physical were needed. Infrastructure and faculty development had to be creative, given the newness of the subject.
- Faculty. It comprises a mix of resident faculty and knowledge partners from leading industries, like GE, Bosch, Cummins and others. BITS-Pilani continues to invest and focus on building in-house expertise for this programme through a combination of: (a) shadow following of industry experts; (b) upskilling through certification programmes from renowned institutions and (c) faculty industry immersion to provide factory-floor experience.
- Lab Infrastructure.These are a mix of virtual and physical labs.
    - **Remote Lab:** The Remote lab is a physical lab that can be controlled from anywhere in the world. The IoT enabled lab equipment and the integrated remote access network makes this possible. The lab is open 24x7, 365 days. This helps in bringing the campus learning experience to the working professionals.

[1] The M tech programme is a two year – four semester course, that requires the candidate to undergo a minimum of 12 courses within first three terms, while the fourth semester is exclusively dedicated for the dissertation that is supervised and guided by student's organisational mentors and evaluated by in-house faculty. Online classes are conducted mostly on weekends or after business hours. Enrolled students are required to commit 32 hours for online classes, 32 hours for lab work and 64 hours for self-study per course per semester.

- **Physical Lab:** The campus has a miniaturise bottling plant with dedicated workstations for heating, cooling, mixing, filling and other real-life manufacturing processes. Students undergo a three-day boot camp at this plant to understand and experience various elements of a digital-factory. This lab is IoT enabled to provide an interface with the remote lab.
- **3D Printing Lab:** This lab has multiple metal 3D-printers used to train students on additive manufacturing concepts. Students are also required to design a component/system at their workplace. This involves creating a 3D design confirming to performance specifications, simulate performance of the designed product and the eventual manufacturing using 3D-printers. These manufactured components are then tested and validated in the candidate's workplace.
- **Cybersecurity Lab:** This upcoming lab will provide students practical experience on the vulnerabilities of Industrial IoT and their mitigation.

4. Success Stories

In less than 18 months since its introduction in June 2019, the programme has successfully admitted over 200 working professionals from the manufacturing sector. With over 100 engineers completing the Masters' programme annually, this programme serves as a game-changer for upskilling demands within the manufacturing sector - a crucial link for India to emerge as a popular manufacturing destination as companies look to diversify their supply chains to trusted destinations.

5. Key Findings

- Large businesses can invest in internal training programmes but smaller organisations that are constrained to develop inhouse training facilities and programmes for the future, can benefit from an academic Digital Manufacturing programme.
- The virtual format for this course is best suited for industry and can be scaled up to meet the increasing demand for digital skills in the manufacturing sector.
- The sustained interest by applicants indicates the programme's relevance and ability to bridge industry needs.
- The collaboration with industry is valuable, but must be deepened to develop an ecosystem for digital manufacturing in India.