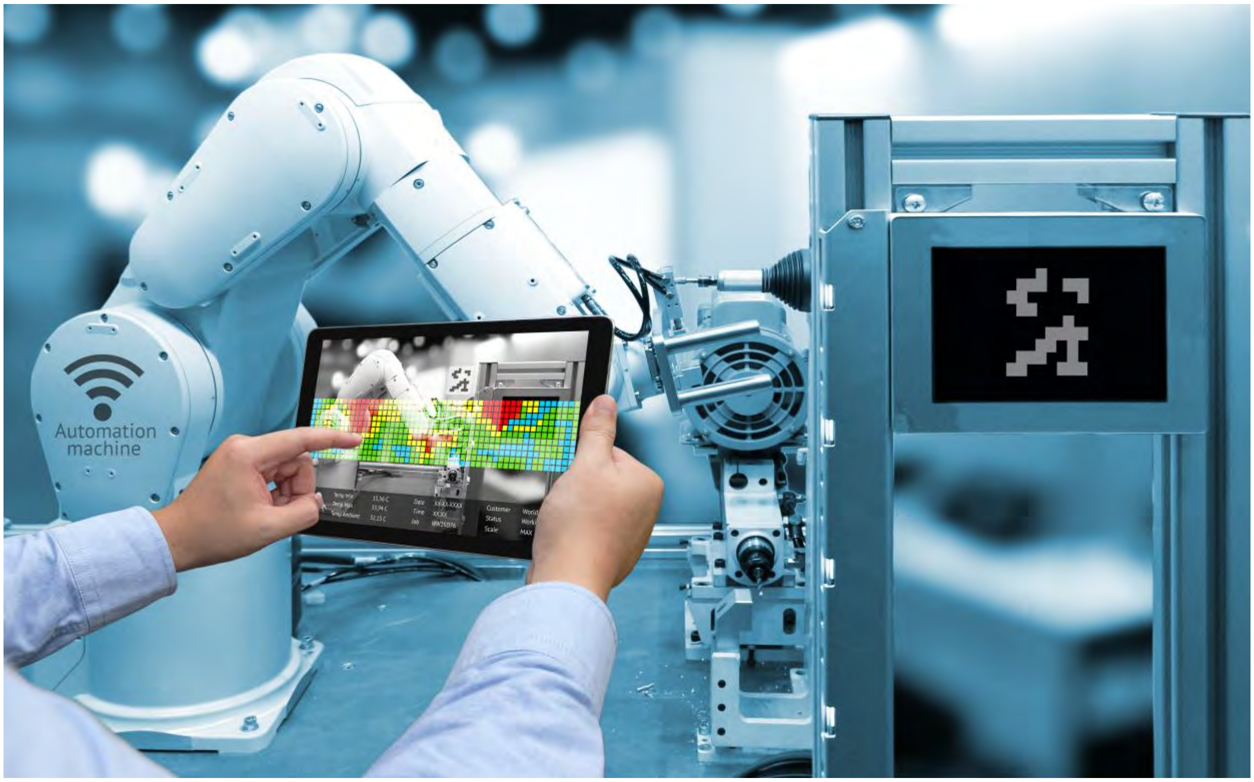

Digital Transformation in Manufacturing: Key Insights & Future Trends

An Industrial Internet Consortium Tech Brief

2020-09-21

industrial internet
CONSORTIUM

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ABOUT THIS TECH BRIEF

This Industrial Internet Consortium (IIC) Tech Brief was conceived, written and compiled by the IIC's *Manufacturing Industry Leadership Council* (MILC). It is the first in a series of Tech E-Briefs that the MILC will publish in the coming months and years. The MILC, which features some of the brightest minds in the manufacturing world, is an active advocate for the manufacturing industry.

Our goal with these publications is to provide guidance. We help manufacturing leaders keep pace with the rapid emergence of new technology while shining a spotlight on the remarkable advancements driven by the MILC, the IIC working groups, and the IIC members. In this initial entry, we tackle digital transformation, which promises to disrupt manufacturing processes and improve business outcomes in the next decade. As you'll see, digital transformation is already changing how manufacturing IT organizations operate, service and maintain equipment.

From thought-leading papers, to real-life implementations, IIC members are the pioneers in this worldwide adaptation. This effort currently includes: The Smart Factory Task Group; Foundational frameworks related to manufacturing; IIC Testbeds, Test Drives and Challenges. Learn more about our ongoing initiatives at *https://iiconsortium.org*.

How the Pandemic Accelerated Digital Transformation

Digital Transformation in manufacturing has been an inevitability for quite some time. In an industry where scalability is everything, digital transformation paves the way for the advanced solutions which make rapid scalability realizable. Organizations can either adopt change willingly and proactively, or forcibly by market demand. Any choice in the matter faced an unlikely dictator this year, in the form of a worldwide pandemic. One in which some organizations had no choice but to scale in ways that they had only previously envisaged, within the context of a long-term strategy.

On the flip side, some manufacturers faced the tough decision of how to move forward and to prioritize investment strategies, when the markets they serve had grounded to a resounding halt. In this scenario, organizations could have remained idle, and attempt to shoehorn existing practices into a drastically changed world. The forward thinkers reinvested in technologies that will allow for future growth, reduced risk and reduced overhead. Results which will become increasingly important as the market becomes more and more attuned to the reality that no one is insulated from natural disaster.

For example, automotive manufacturers currently confront tremendous disruption from companies like Tesla, at a time when their balance sheets have been weakened by reduced vehicle sales during the pandemic. As automotive manufacturers retool their facilities to support market demands for key technologies for autonomous vehicles and vehicle electrification, they depend on digital technologies and must be bold, while at the same time avoid series missteps in their transformation efforts.

Analyst Insights: Dr. Phil Marshall, Chief Research Officer, Tolaga Research

The Promise of 5G and Industry 4.0

Industry 4.0 is a hot topic for manufacturers as they play their part in the Fourth Industrial Revolution. With Industry 4.0, manufacturing equipment is augmented with wireless connectivity, sensor technology and intelligence to enable cyber physical capabilities and digitize manufacturing processes. Notable Industry 4.0 use cases include agile factory automation, preventative maintenance, workforce management and augmentation, machine optimization and remote monitoring and control.

Wireless connectivity is needed to achieve the agility demanded by Industry 4.0, particularly in large scale manufacturing facilities. Currently wireless is only used sparingly, typically with unlicensed spectrum technologies. Several competing wireless technologies are emerging as candidates for Industry 4.0, including WiFi-6 for unlicensed spectrum, and 4G-LTE and 5G in licensed spectrum bands. Recent 5G technology releases (Releases 15, 16 and 17) have incorporated key capabilities for Industry 4.0, such as ultra-reliable low latency connectivity (uRLCC), Ethernet-TSN (Time Sensitive Networking) integration, and a variety of features for massive machine type communications (mMTC).

The first 5G networks went commercial in April 2019 and targeted enhanced mobile broadband (eMBB) services for consumers. For communication network operators (CNO), eMBB is a natural extension of their successful 4G-LTE services. However, 5G promises much more as CNOs look to vertical industry applications, albeit with complex ecosystem demands and systems integration challenges.

For 5G to gain a foothold with Industry 4.0, it must have the support of a broad range of ecosystem stakeholders, including CNOs, communication and industrial technology providers, systems integrators, and Tier 1 manufacturers.

At Tolaga Research, we recently conducted a study using natural language processing (NLP) of online content to investigate the 5G sentiment of key Industry 4.0 ecosystem stakeholders. Over six hundred companies were identified from online searches of news and press releases relating to smart manufacturing and Industry 4.0.

Targeted searches for each company were conducted to identify online content published between 2016 and 2019 that related specifically to 5G and manufacturing. In each case where relevant content was identified, it was tagged with a sentiment ranking. The sentiment ranking of the content was then associated with an ecosystem category, so that aggregate category ranks could be calculated, see Exhibit 1. The key ecosystem categories shown in Exhibit 1 include:

- **Communication and connectivity technology providers**, such as Cisco, Ericsson, Huawei, Nokia and ZTE, who have strong incentives to drive demand for 5G technology and are pioneering use cases for industry 4.0. The rank estimates in Exhibit 1 have communication and connectivity providers being the first to become publicly engaged with 5G for manufacturing in the 2017 time-frame.
- **Communication Network Operators (CNO),** such as Deutsche Telekom, NTT, Singtel, Telefonica and Verizon, who have been trialing Industry 4.0 initiatives and are eager to expand 5G into vertical markets. The rank for CNOs shown in Exhibit 1 has a similar profile to communication and connectivity providers, but with a lag of approximately 12 months.
- **IT hardware, software and services companies,** such as Amazon AWS, Dell, IBM, HPE, Mahindra and Microsoft Azure. These companies are already providing solutions to many industries, including manufacturing. The companies are not dependent on the success of 5G but are eager to capitalize on the broader Industry 4.0 opportunities that might depend on 5G connectivity in the future.
- **Semiconductors and embedded system providers** such as Analog Devices, Arduino, Intel, nVidia, NXP and Qualcomm, who have varying degrees of interest in 5G. Companies such as Qualcomm, who are heavily invested in 5G are pioneering use cases, including those relating to manufacturing. Other players recognize that they must be prepared in advance to respond to 5G market demands should they arise.
- **Industrial technology, robotics and automation solution providers** such as ABB, Applied Robotics, Hitachi, Honeywell, Rockwell, and Siemens, who provide a range of general purpose and specialized solutions to manufacturers. Some companies have trialed 5G, but full engagement from companies in this category will only come once there is clear evidence of 5G demand from manufacturers.
- **Manufacturers** including those for the automotive, heavy industries, life sciences and aerospace and defense, will ultimately determine the fate of 5G with Industry 4.0. Some manufacturers are aggressive in their pursuit of 5G. For example, Volkswagen in Germany has acquired industrial radio spectrum resources and plans to deploy private 5G. While other manufacturers have trialed 5G and investigated other technologies like WiFi-6, many manufacturers have yet to investigate their wireless strategies.

Wireless and industry 4.0 adoption are inextricably linked. Industry 4.0 is challenging to implement and has greater prospects with manufacturers that are being disrupted. For example, the automotive industry is being disrupted by companies like Tesla and every industry will be disrupted in varying degrees in the aftermath of the Covid-19 pandemic.

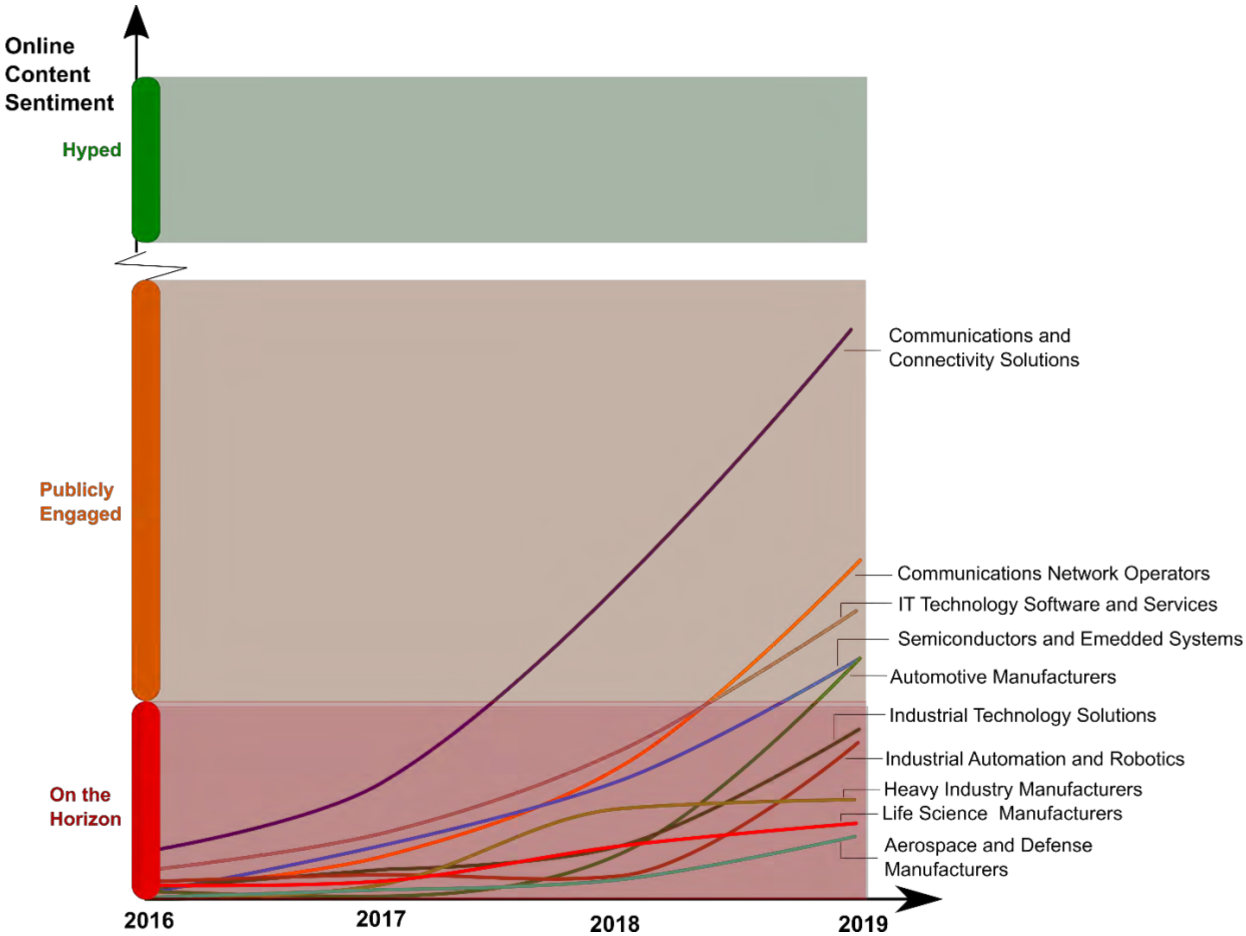

Exhibit 1: Online Content Sentiment for 5G and Manufacturing.

(Source: Tolaga Research, 2020)

Although 5G momentum is increasing, 5G is still nascent and must mature with clear justification for all ecosystem stakeholders. Radio spectrum must also be availed. While some companies (e.g. Volkswagen) are capitalizing on dedicated industrial spectrum allocations for Private 5G, radio spectrum will mostly come through partnerships between manufacturers and local CNOs. The 5G standards must continue to evolve to incorporate industrial technologies and to account for the salient characteristics for Industry 4.0 operating environments.

Manufacturers and industrial technology suppliers must be engaged as these standards are developed and 5G solutions must be created specifically for industrial environments. In addition, 5G has competition from emerging unlicensed spectrum technologies like WiFi-6. Industry 4.0 needs wireless, but there is a lot to be done for 5G to prove that it is the right solution.

MILC Thought Leader: Seth De Santis, Director, Brilliant Manufacturing P&E, GE Aviation

Lessons Learned over the First Five Years of Digital Transformation

GE Aviation started its IIoT journey during the second quarter of 2015. That journey started when a group of engineers were looking to code custom PLC logic to capture a handful of machine variables, with the goal of better understanding the process better and then making it more efficient.

While they were performing this work, they realized there were many more variables that could be captured in near real time. These variables could enable not only learning out a process, but also understanding the condition of the machine to better predict the likelihood of it breaking. And the likelihood of it producing a non-confirming part.

The initial scope of this work in 2015 was spread out across ~15 manufacturing assets [ex: Furnaces] at two different sites. The approach involved writing custom drivers for these assets, flowing the data from the PLC into Kepware middleware, and then ultimately into a local SQL Server database. Many stored procedures were used to attempt to action the data and there was no vehicle for easily viewing the data.

That first approach led to some initial lessons learned, including:

- **Driver Standardization**: Creating custom drivers for manufacturing assets was not an efficient approach. This resulted in a mandate on new asset purchases that they come standardized with MTConnect. This provided a semantic layer for common data understanding
- **Data Visualization**: An end user not being able to easily access and review the data precludes identifying potential collection issues as well as stalls the cultural change to make manufacturing decisions by using machine data. This resulted in an ongoing data visualization journey.

With some Proof of Concept experience under the team's belt, 2016 brought in a more centralized approach to sensor enabling manufacturing assets. Part of this approach was ensuring that the assets in scope for sensor enablement were appropriately defined to ensure that a positive ROI would be possible for any data insights gained and actioned.
This was made possible by only sensor enabling constrain assets, assets that cause a bottleneck and are a limiting factor to an organization's performance, the obstacle to the organization achieving its goal across our supply chain.

With scope defined, the teams focused on their tech stack and approach. Having already made the decision to standardize on MTConnect at the driver layer, the team also standardized on their storage vehicle. Here, the team would deploy local GE Digital Historian time series databases locally at each site and then also centrally to aggregate the changes in the data. One central Historian instance is deployed for each different type of data classification (Export Controlled, non-Export Controlled, etc.).

The team also explored different visualization tools, ultimately landing on Cimplicity, a GE Digital product already in use at Aviation for Human Machine Interface but not for machine data visualization. These Cimplicity instances were built per site and were customized based on each site's needs. Data that one would see would range from the operating status of enabled assets to KPI's on uptime and availability.

During 2016 and 2017, the number of connected assets grew from ~15 across two sites to ~350 across 7 sites. Benefits that were starting to appear in pockets included:

- The reduction of scrap by stopping a process before it completes a non-conforming part.
- Cost avoidance through increased utilization of constraint machines; from visually seeing when a constrain machine becomes available to being able to analyze asset usage patterns, the teams were able to avoid purchasing new assets by getting more cycles out of existing assets.
- Reduction of maintenance hours in the capability to programmatically monitor an asset's variables, as opposed to a human checking those variables (via, say, a gauge reading), allowed more assets to be maintained by a smaller number of workers.

In 2018 and beyond, the sensor-enabled footprint continued to grow. The number of connected assets grew from ~350 across 7 sites in 2017 to ~1700 across 27 sites by the end of 2019. In addition to the footprint growing, so did the team's experience.

MILC THOUGHT LEADER: FARID BICHAREH, CTO, AASA, INC.

IN RESPONSE TO THE PANDEMIC, CONSIDER RE-ASSESSING YOUR DIGITAL PORTFOLIO

The global pandemic is shaping a different world. In this new world, despite the short-term decrease in demand, in the medium-to-long run, the COVID-19 digital transformation impact, seems to be extremely positive. The need for organizations to transform and respond to an unprecedented change in customer behavior and market risks – with extensive digitization being one of the key enablers of such positive impact. In response to the pandemic, longer term strategies and digital portfolios need to be re-assessed and re-prioritized and manufacturers need to accelerate their digital transformations to remain relevant and capture opportunities or risk their very survival.

In the time of pre-COVID-19, approximately 92% of manufacturers were thinking that their business models would need to change given digitization. Studies from the same period indicate that the top 10% of manufacturer, grow revenue at two times the rate of the bottom 25%.

The difference in their respective approaches come into play among the top 10% manufacturers. Manufacturing technologies such as AI and automation, are adopted five times faster and strategies are put in place that give high confidence in the reliability of the data.

Let's make an example, a global manufacturer that had implemented Digital Twin capabilities and AI tools to optimize its supply chain before the COVID-19 outbreak. They were able to access and analyze critical information quickly, enabling it to deglobalize and move supplies as close to production sites as possible; avoiding shutdown of a single production line for lack of materials or any other possible disruption.

This proves the manufacturers with the right digital foundation, adapt to crises quicker.

On the other hand, the latest analysis after the 2020 pandemic shows that Internet of Things projects will shift the focus to Manufacturing and IIoT and in the comeback of industries. Thus, Connected Supply Chain, Connected Product and Connected Transportation will be leading the connectivity world.

Due to Covid-19, manufacturers think of not only resuming operations in a safe and responsive manner, but also in setting the groundwork for long-term resilience through the successful integration of IT and OT systems. Now the question is how the combination of technological capability and business impact can be successful and help the manufacturer. Many manufacturers will look for business impact in three levels:

1. Immediate: Efficiency and cost saving,

2. Midterm: New revenue streams and customer experience and
3. Long term: Business transformation

While the technology provider's response is in three levels:

1. Immediate: Monitoring and reporting tools,
2. Midterm: Control capabilities and tools and
3. Long term: Autonomy

That being said, manufacturers will be looking for solutions that:

- Directly solve the pain points,
- Can be implemented quickly (days and weeks, not months), and
- Have the potential for long-term, post-COVID-19 impact.

IIoT and Connectivity

IIoT, as a critical part to digital and Industry 4.0 transformation, features the use of sensors to connect manufacturing equipment to IT systems, driving valuable insights about manufacturing operations and performance. With the proper sensors and analytics tools, manufacturers can capture and analyze data from every point in the manufacturing process, driving business benefits. Digital Transformation and IIoT are enabling manufactures to discover new information and make informed, predictive decisions about their operations and supply chains.

Cloud, AI

By passing manufacturing data to cloud-based analytics platforms for deep analysis and modeling of machine learning, they can benchmark operational performance to identify improvement areas and make predictions and proactive responses to future operational outcomes or industry-wide events. As a result, the adoption of cloud data which unlocks other innovative technologies and AI will be among top priorities for manufacturers.

MES, Monitoring and Dynamic Scheduling

With manufacturing applications such as MES, performance monitoring and dynamic scheduling, manufacturers can increase transparency into production and product quality, scale productivity and adapt to shifting regulatory requirements without overtaxing existing resources. For example, many estimates show improved performance management though such tools and applications can boost labor productivity by 20% to 40%.

5G, Li-Fi

The use of wireless sensors, enabled through 5G and Li-Fi, in manufacturing environments makes it easier for manufacturers to collect and analyze real-time performance metrics about their equipment and labor. 5G and Li-Fi with low latency and greater bandwidth, accelerate the rate of data download, enabling the use of real-time data in industrial operations. Images and data can be downloaded much faster with Li-Fi and 5G integrated IIoT devices. As a result, data can be easily shared remotely. Li-Fi and 5G location system can also provide real-time track and trace capability, as well as accurate indoor autonomy such as autonomous indoor vehicles and navigation for true Smart Factory implementation.

Automation

While pre-COVID-19 manufacturers were a bit hesitant to take on large capital-intensive projects like automation, considering social distancing regulation, production line flexibility and increasing capacity right now, the payoffs of a workforce that doesn’t take breaks, doesn’t get sick and do not need training and insurance will be appealing to those with strong capital positions – enabling acceleration in efficiency during this time that will cut costs and boost bottom lines.

Smart Cybersecurity, AI, ML, Automated & Adaptive Network

With five times the increase of cybersecurity attacks, the manufacturing industry has become the reported the second highest rate of such attacks. In general, AI technologies can be used to help protect against increasingly sophisticated and malicious malware, ransomware, and social engineering attacks. Machine Learning (ML) can certainly provide an important component for cybersecurity in threat intelligence. Both can be applied to monitor and detect anomalies in the network and identify new threats without known signatures. Automation also allows for the monitoring of networks and automatic updating of defense framework layers, in addition to diagnostic and forensics analysis for cybersecurity.

The conclusion is that manufacturers must embrace a business environment where the focus will no longer be only on efficiencies and cost-effectiveness. Digitalization and IIoT solutions that boost responsiveness and resiliency have emerged as an even greater business consideration. That being said, manufacturers must engage in renovation of their operations, including digital transformation and IIoT solutions. It is now more essential than ever to start this journey towards a more agile, secure and productive manufacturing future.

HOW THE IIC IS ADDRESSING DIGITAL TRANSFORMATION

The *Industrial Internet Consortium* (IIC) was established in 2014 to look ahead to these inevitable changes in business practices, and to form a blueprint for making them realizable. Representing industrial organizations across over thirty nations, our role is to bridge the gap between technology vendors and the industries they serve.

Equipped with a foundational library of horizontal digital transformation expertise, the IIC has enlisted industry to assist in creating solutions which will optimize efficiency, improve business practices and deliver return on investment. In Q2 2020, the IIC held its Manufacturing Industry Leadership Council (MILC) to draw in the expertise of technology users, who are driving the need for scalable solutions in manufacturing across multiple vertical markets.

A rich tapestry of technologies is being developed to support digital transformation for manufacturing. These include:

- Edge computing and artificial intelligence (AI) to support capabilities such as condition monitoring and predictive maintenance;
- Connectivity technology robotics and autonomous systems to enable agile factory automation, and;
- The convergence of operational technologies (OT) with information technologies (IT) to enhance workflows and drive factory efficiencies.

Since the rich tapestry of technologies that underpin digital transformation are complex, the IIC has collaborated with its members to develop a range of test beds for industrial companies to establish digital best practices. These collaborative efforts are a rising tide that lifts all ships, in the wake of challenges and opportunities that face us all.

IIC Testbeds

IIC Testbeds are where innovative opportunities can be initiated, thought through, and rigorously tested to ascertain their usefulness and viability before going to market. New technologies, services, processes and applications can be trialed in a live environment by one (or more) member companies, with the guidance of the IIC Testbed Working Group. Below are some examples of IIC Testbeds which have been making waves in manufacturing.

Three testbed smart factory case studies are presented in this Tech Brief:

1. Smart Factory machine learning for predictive maintenance
2. Smart Factory web
3. Time Sensitive Networks for flexible manufacturing.

Smart Factory Machine Learning for Predictive Maintenance

Participants: ***Aingura IIoT*****,** ***aicas GmBH*****,** ***Bosch*****,** ***Microsoft*****,** ***Real-Time Innovations.***

Companies are continuously searching for innovative ways to remain competitive by evolving their analytics approach to gain more meaning from the data they are acquiring. With proper analysis, the information can provide a wealth of insight into company's system operations, overall operating and maintenance costs.

This knowledge leads to actionable insight, enabling companies to move away from traditional preventative maintenance, with regularly scheduled maintenance times, to that of Predictive Maintenance, for optimized system operation and asset utilization.

This testbed focuses on exploring the application of Machine Learning techniques and algorithmic approaches using new innovative technology. This includes Aingura IIoT's Oberon intelligent systems performing data acquisition, sensor fusion, analytics and Machine Learning powered by Xilinx ZU9 Programmable SoCs for time-critical Predictive Maintenance and increasing energy efficiency, availability, and lifespan of manufacturing production systems.

Case Study: Value of Predictive Maintenance in a High-Volume Manufacturing System. Shortly after experiencing initial problems, an unknown degradation in system operation led to an extremely costly system failure during operation. This description is an actual failure that happened to a production line with an average cost of $50K per hour lasting a total of 10 days, with critical impact in turnover. The repair time was directly related to the availability of spare parts.

A machine learning-based monitoring system would have detected the first failure peak indicating the system degradation and providing adequate time to stop the line in a controlled manner. A production and workforce could then have been reassigned to reduce the failure impact over production line productivity.

In this case, application of a machine learning algorithm would have detected the anomaly within a suite of variables, effectively identifying and alerting operators to the problem when first encountered. Advanced failure prediction through the application of Predictive Maintenance can help to reduce unplanned downtime, in this example case study savings would have reduced the downtime from ten days to only eight hours.

SMART FACTORY WEB

Participants: *Fraunhofer IOSB*, *Korea Electronics Technology Institute*, *Microsoft, SAP SE.*

The Smart Factory Web aims to form a network of smart factories with flexible adaptation of production capabilities and sharing of resources and assets to improve order fulfilment. Key questions are: How can we connect factories to the Smart Factory Web and exchange data reliably? How can we provide the information securely at the right granularity to authorized partners? How can production capabilities be adapted quickly and efficiently in response to orders?

As shown in Exhibit 2, the Smart Factory Web applies a dual plane three-tier IIC implementation architecture with IIoT technologies on both planes.

Exhibit 2: IIC three-tiered architecture for Smart Factory Web.

Source: IIC, "*The Industrial Internet of Things, Volume G1: Reference Architecture*"

The upper plane comprises the Smart Factory Web portal to handle cross-factory interactions through gateways to the individual smart factories. The lower plane is a Smart Factory with a

Factory Digital Image for secure, performant communication with the Smart Factory Web.

Secure Plug & Work techniques based on the standards AutomationML and OPC UA are applied to adapt factories on-the-fly by inserting new manufacturing assets into the factory production with a minimum of engineering effort. These standards are applied for information modelling and communication in both planes.

The testbed creates and validates new business models with flexible assignment of production resources across factory locations. This will create new opportunities for SMEs, allowing them to respond flexibly to manufacturing orders.

The Korean-German collaboration between KETI and Fraunhofer IOSB will advance the international usage of key standards such as AutomationML for the plant description and OPC UA as a communication mechanism as well as architectures for Industrial Internet of Things systems. This will reduce IT system integration and installation costs with faster engineering and ramp-up of components, machines, plants, and IT systems. The mission of Fraunhofer IOSB and KETI is to transfer research results to real applications in industry.

According to Byunhun Song, head of the KETI Smart Factory ICT Center, "the Smart Factory Web is the first testbed in Korea approved by the IIC. This will have great influence on the distribution of the smart factory technology in Korea, especially, as it will enable interoperability between IIC and Industrie 4.0". This activity is established and operated by the Korea Smart Factory Foundation (KOSF) and financed by a grant of the Ministry of Trade, Industry and Energy (MOTIE).

"The Smart Factory Web is open to other companies. Providers of factory components, in software or hardware, and operators of smart factories around the world are invited to contribute to the Smart Factory Web if they comply with the idea of a collaborative factory network based upon open standards," emphasizes Thomas Usländer, spokesperson of the Fraunhofer IOSB businTess unit Automation and head of the department ILT at Fraunhofer IOSB.

In addition to the technological innovations the Smart Factory Web will enable new business models when implementing the Industrie 4.0 use case "Order driven adaptive production" in the manufacturing domain. This will also strengthen and promote the ITS OWL initiative, explains Jürgen Jasperneite, head of the Fraunhofer IOSB Application Center Industrial Automation (INA) in Lemgo, Germany. The INA is a founding member of the leading-edge technology cluster, Intelligent Technical Systems OstWestfalenLippe (known as OWL).

TIME SENSITIVE NETWORKS (TSN) FOR FLEXIBLE MANUFACTURING

Participants: *University of Stuttgart*, *Bosch*, *Fraunhofer IOSB*, *Kalycito Infotech Private Limited*, *Moxa*, *SICK AG*, *TRUMPF*.

Manufacturing operations require tight coordination of sensing and actuation to safely and efficiently perform closed loop control. Typically, these systems have been deployed using non-standard network infrastructure or air-gapped (unconnected) standard networks. This approach leaves devices and data much harder to access and creates a technical barrier to IIoT which is predicated on the ability to consume data anywhere throughout the infrastructure.

To address these needs of IIoT all the way to the control system, the IEEE organization has been working to update the standards for Ethernet and wireless (IEEE 802) to support TSN. The technology will be used to support real-time control and synchronization of high-performance machines over a single, standard Ethernet network, supporting multi-vendor interoperability and integration.

When appropriate, the TSN Testbed will integrate industrial automation protocols which are adopting TSN, such as OPC UA. The TSN Testbed includes such things as developing simple applications and data definitions to be communicated utilizing TSN over OPC UA Pub-Sub, to be implemented by TSN Testbed participants.

TSN will open up critical control applications such as robot control, drive control and vision systems to the industrial internet. This connectivity then enables customers, suppliers and vendors to more readily access data from these systems and to apply preventative maintenance and optimization routines to these systems.

Since the testbed’s inception, two physical instances have been established. One is hosted in North America at the headquarters of National Instruments and the second is hosted in Germany at the University of Stuttgart’s Institute for Control Engineering of Machine Tools and Manufacturing Units (ISW).

These testbeds are used for plug-fest activities where member companies collaborate to test implementations and interoperability. They also serve as standing units where individual companies can work on updates and integration, and they are transported to various industry shows and events.

The testbed displays the following:

- Combined critical and best-effort traffic flows on a single network based on IEEE 802.1 Time Sensitive Networking.
- Integrate relevant Industrial Automation protocols that adopt TSN, such as the OPC’s United Architecture (UA) Pub-Sub communication.
- Vendor interoperability using standard, converged Ethernet.

- Security architectures in conjunction with critical control traffic and feedback on the secure-ability of initial TSN functions.
- IIoT incorporation of high performance and latency sensitive applications.
- Integration mechanisms and architectures for smart edge-cloud control systems directly connected into flexible manufacturing.

OTHER TESTBEDS OF INTEREST TO BE DISCUSSED IN FUTURE REPORTS

- Negotiation Automation Platform
- INFINTE - SERENA Predictive maintenance use case
- Smart Printing Factory
- Factory Automation Platform as a Service

IIC TEST DRIVES

Test Drives are short-term, rapid-engagement pilots for technology end users to employ and adopt Industrial Internet of Things (IIoT) technologies. They stimulate IIoT adoption across industry through accelerated implementation. The IIC's neutral collaboration platform fosters partnering to address leading-edge IIoT use cases in three to six-month projects based upon technology end users' real problems.

INTELLIGENT VIDEO

Participants: *NetApp, Corlina.*

Video will become a mainstream IoT sensing platform, with use cases such as computer vision, as advanced analytics prove to deliver business value. Currently there lacks the ability to deploy at scale or fully protect devices, or data in transit, from cyber threats.

This test drive focuses on capturing and processing images for content analysis in a secure, open architecture for cross industry use cases including quality assurance, situational monitoring, behavioral analysis and compliance verification. The Intelligent Video Test Drive has previously been deployed in marine waterway management.

Too often the importance of security is underestimated, particularly as manufacturing and industrial environments become increasingly digitized. The use cases addressed by the Test Drive include quality assurance, security surveillance, health and safety of factory workers, customer sentiment analysis, patient condition and monitoring.

The benefits seen thus far have been in quality assurance, security surveillance, health and safety of factory workers, customer sentiment analysis and patient condition monitoring. Industries addressed include manufacturing, energy and utilities, mining and metals, public safety and retail.

OTHER TEST DRIVES OF INTEREST TO BE DISCUSSED IN FUTURE REPORTS

- *IOT Sensor Implementation*

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