Industrial IoT and Industry 4.0 in manufacturing: The applications driving real business value

IIoT and Industry 4.0 in Manufacturing: The applications driving real business value

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WHY WE MADE THIS GUIDE: THE TIME FOR IIOT TO DELIVER REAL BUSINESS VALUE HAS COME

Recent studies reveal that for the majority of companies who are implementing IoT, the organisations have moved on from small-scale test projects to making IoT a central part of their operations. And the adoption of IoT initiatives at full-scale is higher in manufacturing than in any other sector.

The Industrial IoT connectivity of devices across manufacturing is providing a digital backbone for the emergence of Industry 4.0, the broader set of operating principles that are set to deliver the smarter factories of the future.

And as manufacturers prepare for the widespread implementation of Industrial IoT and Industry 4.0, we ask:

- What will this new reality look like?
- How close is this new mode of operation?
- And when the dust of all the hype has settled, how will real business value be delivered?

The conversation around the Industrial IoT is shifting from the 'what' to the 'how'. Most manufacturers are fully aware that advances in automation, software and connectivity can deliver enormous productivity and efficiency benefits to their operations, and are now looking at ways to apply the technology.

In this guide, we take a look at the key applications of IoT in manufacturing, and identify the different ways in which these innovations are delivering real business value–changing the ways manufacturers design and build their products.

WHAT'S IN THE GUIDE?

In this 10-part guide, we'll cover:

Industrial IoT in manufacturing: Turning hype into reality

- How close we are to turning the vision of IIoT into reality
- The primary applications and business benefits of the IIoT
- The six most common uses of IIoT in manufacturing and their benefits
- The challenges to Industrial IoT adoption

Industry 4.0 in manufacturing: 26 applications driving real business value

- The eight business value drivers of Industry 4.0
- The 26 business levers: The industry 4.0 applications that will really change manufacturing

Four Industry 4.0 trends transforming manufacturing

- How cobots will augment people on the production line
- How 3D printing will make production faster and easier
- How factories-in-a-box will bring automation on demand
- How VR and AR headsets can reduce human error & production time

Industrial IoT and Industry 4.0 in manufacturing: The applications driving real business value

Seven game-changing Industrial IoT applications

- The arrival of free-roaming robots on the factory floor
- Using performance data to optimise machine utilisation
- The benefits of connected tooling
- How IoT-enabled vision systems can improve quality control

Industry 4.0: The disruptor of supply chains

- How Edge AI offers a solution to the supply chain data challenge
- Why organisations are implementing digital twin technology
- How blockchain can improve supplier validation, onboarding and life cycle information management

An unlikely tale: Wearables heading for success in IIoT

- How wearables are proving their value beyond the consumer market
- Barcode-scanning gloves that save up to four seconds per scan
- Smart PPE devices, AR/VR operation manuals and other implementations

IIoT's biggest challenge: Integration

- The barriers between proof of concept and deployment
- Seeking solutions to a fragmented market
- From the floor to the cloud: The four layers of connectivity

Predictive maintenance: The 'killer app' of IIoT

- Realising the promise of predictive maintenance
- Three examples of predictive maintenance across different sectors

Predictive maintenance with IoT: The road to real returns

- The business case for predictive maintenance
- The challenges of implementing predictive maintenance
- Six tools for best-practice in predictive maintenance

Towards proof-of-value: A tale of IIoT maturity

- After a slow start, what does the future of IIoT look like?
- The key barriers to large-scale implementation
- The beginning of proof-of-value
- The emergence of diverse use cases and real rewards

Industrial IoT and Industry 4.0 in manufacturing: The applications driving real business value

HOW TO USE THIS GUIDE

While we've put the sections of this guide in a deliberate order, it doesn't need to be read from start to finish in a linear fashion. You can pick and choose the parts most relevant to you, and consume them in whichever order you like.

As more manufacturers approach the implementation phase of IIoT and Industry 4.0, the guide is designed to lay out the landscape of applications and the different forms of business value being generated.

This will hopefully provide useful frameworks for considering the value of your next innovations.

Avnet Abacus prides itself on enabling the technology of tomorrow, today. And we're here to support and guide design engineers through the ever-changing landscape.

DESIGNING FOR THE IIOT?

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Industrial IoT in manufacturing: Turning hype into reality

There's been a lot of hype around the Industrial IoT. For a long time now, it's been predicted that the networking of assets through the use of sensors, software and connectivity will transform the way factories operate, and products are made. This, in turn, will make manufacturers faster and more flexible, boosting their bottom line.

Well that's the theory, anyway.

But just how close are we to turning this bold vision into reality?

How exactly has the Industrial IoT helped manufacturers improve their productivity and efficiency? And what are the primary applications and business benefits?

THE PACE OF DIGITAL TRANSFORMATION

To find out the answers to these important questions, Avnet Abacus recently curated research on the Industrial IoT from a variety of sources, to help paint a picture of the current state of implementation.

The data casts a spotlight on the rate of adoption of connected technologies in manufacturing environments, along with the different types of use cases.

One study, taken from a survey of senior executives from 316 organisations that are implementing IoT initiatives, revealed that 62% of manufacturers are deploying IoT at full-scale – across all regions, geographies and sites, for at least one application. This uptake shows that, for the majority of organisations, IoT has moved on from small-scale test projects to become a central part of their operations. Interestingly, the adoption of IoT initiatives at full-scale was far higher in manufacturing than any other sector, including retail and utilities.

As well as leading the way in implementation, manufacturing is expected to top spending on IoT solutions, reaching a total of $197 billion in 2019. Again, that beats sectors such as transportation and utilities which have significantly lower predicted spends.

This amounts to a serious level of investment in Industrial IoT within manufacturing environments. But what benefit is that activity expected to deliver?

The study showed that reducing costs and improving processes were the top business drivers, followed by factors such as improving employee productivity and increasing competitiveness.

IOT USES AND BENEFITS

What is clear from the research is that the time for Industrial IoT is well and truly upon us, with the C-suite increasingly recognising just how connected technologies can transform their businesses. So, with that in mind, let's turn our thoughts to the main areas of impact. As a growing number of manufacturers have started to adopt Industrial IoT, it's possible to categorise the most common uses around six prominent themes.

Industrial IoT in manufacturing: Turning hype into reality

1. Predictive maintenance

By using sensors and collecting data, in combination with big data analytics to spot patterns and trends, it's possible to identify and prevent equipment failure before it occurs. Eventually, artificial intelligence and machine learning can also be deployed to drive totally intuitive condition monitoring methodologies with very little human input.

2. Continuous process improvement

The use of Industrial IoT and real-time dashboards delivered to mobile devices provides manufacturers with far greater visibility of production-line performance than ever before. This means plant managers can quickly identify inefficient processes such as bottlenecks, allowing them to make changes and improve overall equipment efficiency.

3. Smart energy consumption

Automated building management systems connect sensors, actuators, controllers and other equipment over one IP backbone, enabling the monitoring of energy usage from machinery, lighting, HVAC and fire safety detector systems. This information can be combined with broader datasets such as weather forecasting and real-time pricing of electricity to give a more informed view of building performance.

4. Supply chain optimisation

Supply chains in the era of Industrial IoT are faster, more flexible, and more transparent, with manufacturers having total visibility of their incoming and warehoused components. Meanwhile, networked machines give feedback on real-time production rates, which in turn drives more effective purchasing operations.

5. Equipment tracking

Imagine knowing the location of every asset – down to individual hand-tools – inside your manufacturing plant. That is what equipment tracking, delivered through Industrial IoT, is bringing to the factories of the future. Connected tools can also be taught to `learn' the task at hand, ensuring operational performance within pre-set parameters. This improves production quality and reduces the chance of operator error.

6. Connected products

It's possible to boost customer engagement and operations by creating products with smart components that collect usage data. By fitting sensors to products out in the field, valuable real-world data gained throughout the lifecycle can be used to drive future product refinement.

CHALLENGES TO FURTHER IOT ADOPTION

This IoT-enabled architecture is also leading to the creation of new business models based on servitisation, where the manufacturer effectively leases a service or a solution rather than selling pieces of equipment. This new approach results in far more predictable revenues over longer periods of time.

Industrial IoT in manufacturing: Turning hype into reality

The emergence of these six main areas of impact shows that Industrial IoT is driving business advantage across a wide scope of activities. However, while some forward-looking organisations have been quick to embrace the power of connected technologies, there are still plenty of companies that are holding back. Research from management consultants Bain and Company shows that this reticence is fuelled by concerns over the cost of adoption of Industrial IoT, along with the challenge of integration with existing processes and systems. Other barriers to adoption include uncertainty over how to measure returns on investment, and fears that the digitalisation process will be hampered by a lack of qualified staff.

So how do these organisations overcome concerns and get on the path to digitalisation? One means of kickstarting new Industrial IoT projects is to follow some best-practice recommendations which help to deliver a structured and considered approach to implementation. Firstly, it's important to define your ambitions from the outset, being realistic with expectations for first-time adoption and establishing a clear roadmap of what you want to achieve. It's also sensible to embrace Industrial IoT gradually, with due consideration given to issues such as interoperability with legacy processes, which can minimise the risk of disruption to production lines that could result in downtime.

Also, teamwork is key: digital transformation is as much about people as it is technology, and good communication lies at the heart of any successful business change. People are likely to have different levels of IT abilities, and this needs to be carefully considered when outlining the scope of activity and allocating responsibilities.

And finally, be empowered by partnership. The route to digitalisation is not a journey that needs to be taken alone, and fortunately, support is at hand. Avnet Abacus, for example, can act as a trusted adviser on IoT deployment, with experts on hand to discuss factors such as wireless protocols, sensing capability and powering solutions. This is backed up by a breadth of products such as antennas, batteries, connectors and wireless charging modules.

THE FUTURE IS BRIGHT FOR IOT

It's clear that Industrial IoT is no longer some fuzzy future technology that holds the potential to transform manufacturing. It's already here, right now – finding widespread adoption and delivering real business benefit. New use-cases of Industrial IoT are continually emerging, driving new business models and alternative ways of working.

There is little doubt then that for manufacturers, Industrial IoT has moved on from the initial early hype. It is now delivering and truly transforming the means of production.

Manufacturing is entering the fourth industrial revolution. Digitalisation - powered by the use of sensors, software, connectivity and big data analytics - is resulting in leaner and more efficient factories, and driving the introduction of flexible new business models.

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Industry 4.0 in manufacturing: 26 applications driving real business value

It's been quite the journey to get to where we are today. The first industrial revolution, kick-started by the invention of water and steam-powered engines, led to the first organised means of production. The second was characterised by the invention of electricity, resulting in the first moving assembly lines. The third industrial revolution was made possible by the advent of the computer. And now we stand ready for Industry 4.0, with technologies such as sensors, connectivity, communication, data and artificial intelligence-powered analytics combining to create the factories of the future.

But what does this all mean in reality?

How is Industry 4.0 actually changing the face of manufacturing as we know it?

EIGHT BUSINESS VALUE DRIVERS AND 26 LEVERS

A good starting point in all of this is the McKinsey digital compass, which identifies eight business value drivers. These comprise:

- Resource/process
- Asset utilisation
- Labour
- Inventories
- Quality
- Supply/demand match
- Time to market
- Service/after sales

Within these eight drivers come a total of 26 business levers – the Industry 4.0 applications that are changing the way that manufactured goods are planned, designed, made and repaired. Here we take a look in turn at each of these business applications, explaining what they are and how they are delivering benefit to the manufacturing industry.

THE RESOURCE/PROCESS LEVERS

1. Smart energy consumption

Automated building management systems connect sensors, actuators, controllers and other equipment over one IP backbone, enabling the monitoring of energy usage from machinery, lighting, HVAC and fire safety detectors systems. This information can be combined with broader datasets such as weather forecasting and real-time pricing of electricity and other utilities to give a more centralised and informed view of building performance.

This kind of automated building management system has been installed at a Schlumberger factory in France, monitoring air quality, temperature and lighting. The aim, ultimately, is to use energy more efficiently and to drive down costs.

2. Intelligent lots

Industry 4.0 is proving to be a key driver of improved process effectiveness inside manufacturing plants. Digitisation of the supply chain through methods such as intelligent lots – characterised by smart information storage in products and pallets – is a good example of that, encouraging the adoption of just-in-time manufacturing. Through use of technologies such as RFID tags and sensors, with cellular 3G, LoRa WAN, NB IoT, Wi-Fi and Bluetooth connectivity, items such as containers, pallets and roll cages can be tracked and monitored prior to delivery and once stored inside the warehouse. This data can reveal information on location, inventory and temperature, and can act as the foundation for advanced technologies such as automated picking.

This kind of technology has been used to good effect by NGK Ceramics, which makes parts for catalytic converters at a 500,000 sq. ft plant in the US. The company is using IoT-enabled tracking to help workers monitor the pallets across the entire facility, while always maintaining an up-to-date inventory.

3. Real-time yield optimisation

The networking of industrial assets through sensors, software and wired and wireless connectivity can be used to provide an accurate snapshot of equipment performance at any point in time. With the addition of machine learning, this evaluation can be progressed to provide real-time yield optimisation in manufacturing environments – with outputs continually re-calibrated to achieve optimal performance, depending on a host of variable factors. This ensures that industrial assets are always working to maximum efficiency.

One of the first examples of real-time yield optimisation was reported by engineering giant ABB, which has used the technology for the control and optimisation of a cement kiln in Australia, mimicking the actions of an "ideal" cement plant operator and implementing automatic adjustments to achieve targets. This has boosted kiln stability and helped deliver a reduction in energy used per ton of clinker produced.

THE ASSET UTILISATION LEVERS

4. Routing flexibility

Modern manufacturing requires new levels of plant adaptability as companies look to become more responsive to changing customer needs.

This has resulted in the increasing use of flexible manufacturing systems, which use IoT-enabled technologies to help companies become more reactive. Routing flexibility, for instance, represents the ability of manufacturers to cope with factors such as equipment breakdowns to enable continuation of production for any given component. This could be achieved in several ways, such as manufacturing a particular part through different routes or by continuing operation on more than one machine. Routing flexibility is performed by employing hierarchical models of job shop activity, allowing dynamic simulation of production activities. This flexible approach increases factory adaptability by maximising asset utilisation and increasing uptime.

5. Machine flexibility

As the implementation of Industry 4.0 methodologies result in manufacturing becoming a more decentralised, autonomous process, so machine flexibility is likely to become an exciting area of development. This trend will be driven by the use of standard interfaces and intelligent infrastructure that enables a far more modular approach to industrial networking and automation, with 'plug and produce' modules encouraging the swift reconfiguration of production-line facilities. That might mean quick-fit data/communication cables for robotic arms, or high-level sensors that interface with Ethernet – eliminating the need for a standard I/O module. Such machine flexibility drives more dynamic manufacturing lines, with much faster and more intuitive maintenance.

6. Remote monitoring and control

Manufacturing plants are complex ecosystems with hundreds or even thousands of pieces of equipment working seamlessly together for an end result. When you add in the fact that some production plants don't stand in isolation – being perhaps part of a global network of facilities – then the importance of having visibility of all operational processes becomes clear. IoT-enabled architecture offers this insight, in real-time, from anywhere in the world. Engineers can plug into networked systems through tablet, laptop or mobile dashboards, allowing them to drill into the performance of individual assets.

This remote monitoring and control can be used as a primary means of identifying and eliminating bottlenecks and reducing waste. US automotive component manufacturer Varoc has been using such an approach to monitoring machine health, resulting in a 20 per cent increase in overall equipment effectiveness.

7. Predictive maintenance

The combination of sensors and wireless connectivity means industrial equipment of all kinds can be monitored in real-time, with data analytics powered by machine learning then used to identify trends and anomalies. Instead of performing traditional calendar-based maintenance using the periodic examination of equipment, or adopting 'if it ain't broke, don't fix it' strategies, engineers can track patterns of failure more effectively, spotting any potential problems before they occur.

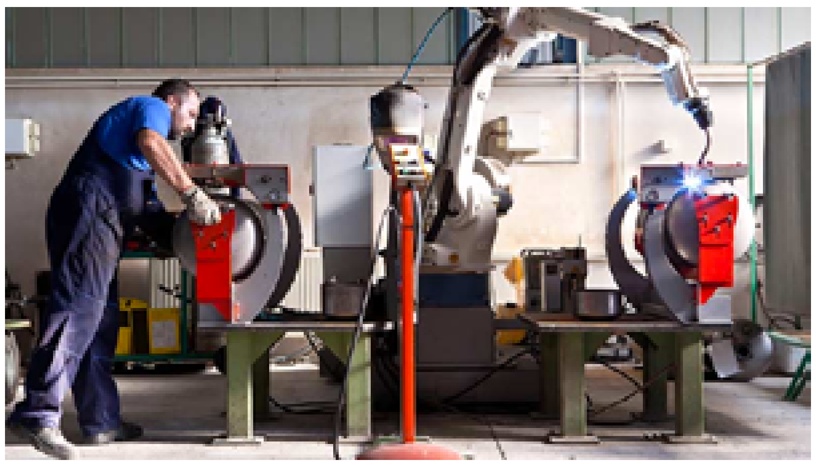
By unleashing the potential of truly predictive maintenance regimes, manufacturers can reap enormous benefit through the eradication of unplanned downtime and associated costs, particularly when it comes to mission-critical pieces of equipment. Valve and control components manufacturer Gemu has been using such an approach to good effect, monitoring its production processes and detecting and replacing any under-performing components before they fail.

8. Augmented reality for MRO

The days of maintenance professionals referring to well-worn instruction manuals as they repair machinery in manufacturing plants is becoming a thing of the past. These days, workers are just as likely to be equipped with augmented reality headsets – providing them with a wealth of information such as computer-aided data, diagrams and drawings in their line-of-sight as they go about their tasks. Such capability is being driven by rapid advances in image recognition technologies, computing power, wireless connectivity and the Internet of Things.

The benefit of augmented reality-enabled maintenance is clear: immediate access to the right information, delivered in an intuitive way, means employees can perform higher quality work in less time, with reduced errors. Festo, for instance, is trialling Microsoft HoloLens augmented reality headsets glasses to conduct a wide range of maintenance activities at its sites in Europe and the US.

THE LABOUR LEVERS



9. Human-robot collaboration

Lightweight, space-saving robots that can operate alongside humans without safety caging are delivering new levels of flexibility within smart factory environments. These collaborative robots, which are fitted with a suite of sophisticated motion, vision and positioning sensors, can perform a host of repetitive and dull jobs, freeing up workers to add value in other areas.

At thyssenkrupp, cobots have been installed at one of its plants producing automotive suspension systems performing roles associated with machine tending, assembly, and product inspection. This has allowed thyssenkrupp to improve efficiency and expand its business during a period of skill shortages.

10. Remote monitoring and control

Cloud-based remote monitoring answers two primary questions: Where are my assets? And how are they doing? That information – accessible in real-time with the information delivered to dashboards on mobile devices – frees up the worker in the manufacturing plant to an enormous extent. Having information on factors such as temperature, pressure, volume, energy consumption, loaded hours and unloaded hours within instant reach, workers can make smarter decisions based on more reliable data, which improves productivity and increases uptime.

11. Digital performance management

Digitalisation provides the opportunity for manufacturers to monitor more than just the performance of machines. Other cost drivers such as materials and manpower can be assessed, and KPIs automated, through digital performance and operations management systems. Such an approach provides a more accurate means of cost allocation across an organisation, and therefore an ability to improve cost calculations and overall financial performance.

12. Automation of knowledge work

We are familiar with robots taking over manual tasks that were previously performed by humans. But what if automated technologies could also start performing some aspects of 'knowledge work' currently performed by employees? The phrase was first adopted by McKinsey to mean the use of computers to perform tasks that rely on 'complex analyses, subtle judgments, and creative problem solving'.

Industry 4.0 in manufacturing: 26 applications driving real business value

A report from the McKinsey Global Institute, suggested automation of knowledge work will be high up in its list of top ten disruptive technologies by 2025. This automation of business processes could have a big impact on manufacturing in areas such as procurement, marketing and customer services – not necessarily replacing humans, but complementing them in certain roles.

THE INVENTORY LEVERS

13. Batch size

Industry 4.0 is driving faster and more flexible production, with increasing levels of customisation. Taken to an extreme, seamless production systems should be capable of switching out of serial processes to manufacture a single part just as quickly and efficiently as they can make multiple parts. This ability to produce 'batch size 1' provides firms with the opportunity to achieve new levels of mass customisation – effectively 'making to order' for individual customers.

Automation is key to batch size 1 methodologies. At bespoke beauty product manufacturer AlpStories, for example, robotic arms are used to start making its customers' 'beauty boxes' as soon as an order is received. The dual-arm Motoman CSDA10F robots use multifunctional tools and grippers to pick and pack, and the arms can be quickly re-programmed to learn new workflows. It is this type of approach to batch size 1 – the ability to produce single units flexibly and economically – which will drive new approaches to inventories, based on more dynamic demand forecasting.

14. Real-time supply chain optimisation

Supply chains in the era of Industry 4.0 are faster, more flexible, and more transparent. The combination of ubiquitous sensors and connectivity, in combination with big data analytics, means manufacturers can have total visibility of their incoming components, knowing the exact location and condition of each shipment. Automated handling ensures goods are picked and placed in exactly the right spot in the warehouse, while networked machines give feedback on real-time production rates. This creates an optimised loop back to the purchasing department.

Real-time supply-chain optimisation can deliver some marked benefits. Hitachi, for example, has embarked on a complete optimisation of inventory and supply chain across its production facilities in Asia, therefore reducing goods in stock, cutting logistics costs, and improving logistics flexibility.

15. In-situ 3D printing

The performance of 3D printing equipment has improved dramatically in recent years, with the latest machines able to produce polymer and metal components in a reliable and repeatable manner. This has led to 3D printers escaping the confines of traditional prototyping roles to provide a flexible means of making spares or replacement parts. In this way, manufacturers can reduce the need for warehousing in favour of on-demand production of some components in or near its own facility, providing greater supply-chain resilience.

Some big players have already recognised the value of in-situ printing: Siemens Mobility, for example, has established a digital machining centre at its train manufacturing plant in Germany, making 3D print replacement parts and tools on demand.

THE QUALITY LEVERS

16. Digital quality management

We've discussed Industry 4.0, but what about Quality 4.0? It represents the use of big data analytics to deliver a shift in the way that quality is measured.

It's no longer good enough just to measure quality by looking at the integrity of products – digital quality management provides an opportunity to integrate quality throughout the value chain, from supply through to delivery.

According to Sparta Systems' 3 Steps to Quality in the Cloud, a move away from old-style quality measurement based on paper records towards adoption of a digital quality management system in the cloud can result in lower costs, better compliance and an improved user experience.

A case study published by quality management software supplier Cebos shows how it has helped components supplier Vishay Dale get better control of its internal documentation, creating a system that significantly minimised time and effort required to execute engineering challenges. This has supported product quality and increased operational efficiency.

17. Advanced process control

Modern facilities comprise an intricate network of production processes, controlling a multitude of factors such as feedstock, temperature and other operational targets. Increasingly, the application of advanced process control is being used to provide a common platform for procedure optimisation through activities such as data collection and analysis and dynamic modelling, with a view to improving quality, increasing throughput and reducing energy use.

The software can be used to oversee a broad range of variables such as feed rates, inlet air temperatures and powder moisture, making minute adjustments to improve product quality and boost plant performance. Advanced process control is finding particular application in the food and beverage manufacturing sector, with an Aveva case study showing how spray dryer optimisation for one particular client resulted in a 10 per cent increase in throughput and an 8 per cent reduction in specific energy consumption, with zero product quality violations.

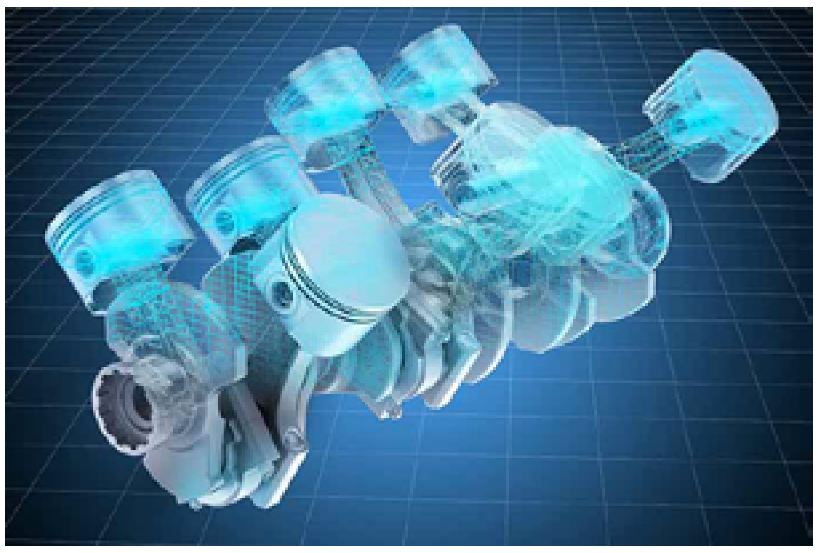
Industry 4.0 in manufacturing: 26 applications driving real business value

18. Statistical process control

Numbers matter in manufacturing, with a slew of statistics available to provide insight into quality during the production process. This data is captured in real-time, and then plotted on graphs with predetermined control limits based on the capability of the process. Variations that occur outside of the parameters provide insight into faltering operations, which can have an impact on quality.

This type of statistical process control has been used to good effect at Nestle Waters, the bottled water manufacturer, which has used an InfinityQS statistical process control software to replace a cumbersome paper-based system to collect and analyse data, providing real-time visibility across 26 factories. By tracking trends in data, the company has been able to make more accurate decisions about process improvements in areas such as cap torque, providing more consistent levels of product quality.

THE SUPPLY/DEMAND MATCH LEVERS



19. Data-driven design to value

Ubiquitous sensors are changing the way that discrete manufacturers bring products to market. By connecting sensors to prototypes, and using the data created from testing to get a better idea of real-life operational scenarios, manufacturers are able to develop better-performing products that are more closely aligned to their customers' needs.

This approach, known as data-driven design to value, doesn't stop with prototypes, though. Sensors fitted to products out in the field continue to provide operational insight, allowing further product refinement.

PTC is a leader here, with a case study outlining the design requirements of a tractor. Instead of making assumptions about factors such as what the maximum load the tractor's bucket should support, data-driven design to value is applied to ensure the product isn't over-engineered (adding time and cost) or under-engineered (decreasing performance and customer satisfaction).

20. Data-driven demand prediction

External factors can have an enormous impact on manufacturers. Sudden changes in consumer spending can, for example, drive a hole through the most careful forecasting and decision making. Enter data-driven demand prediction – cloud-based predictive economic intelligence software that provides a 360-degree view of future demand. In manufacturing environments, the software uses global data, analytics and expert services to identify future threats or opportunities to business performance across finance, sales, marketing and operations.

Research by Prevedere suggests that data-driven demand prediction can provide accurate insight into future activities, being used to make changes in production levels or to validate expansion plans, with manufacturing companies improving demand forecast accuracy by more than 20 per cent.

Industry 4.0 in manufacturing: 26 applications driving real business value

THE TIME-TO-MARKET LEVERS

21. Rapid experimentation and simulation

Software has long since been used to increase the speed of experimentation. Now, though, advanced hardware such as 3D printers are being used to further accelerate time-to-market. The additive process is particularly suited to rapid creation of prototype parts, with the findings looped back into the design and simulation process for further refinement. Previously, manufacturers would have needed to pass each design iteration to its production department, or outsourced the work, causing delay.

According to Sculpteo's 4th edition of The State of 3D Printing report, accelerating product development is the highest priority for companies that are relying on 3D printing. Prototyping (55%) production (43%) and proof of concept models (41%) are the three most popular 3D printing uses today.

22. Concurrent engineering

The parallelisation of tasks – often referred to as concurrent engineering – can quicken the product development process. But structuring those parallel processes can prove difficult if collaborative tools aren't in place as part of wider Industry 4.0 strategies.

This is where the latest software from organisations such as PTC aid the concurrent process, by providing a 'skeleton' planned out by the lead designer to ensure that everyone has access to the information they need and have a common basis from which to work.

Engineers can then go about concurrent tasks without fear of accidentally overwriting one another's files. Once the primary design is in place, the individual subassemblies will adapt. The motorcycle manufacturer KTM has been using this approach on its KTM 690 DUKE bike which was developed in just 22 months from first concept to start of production, a 15% reduction in time-to-market compared to the previous generation.

23. Customer co-creation/open innovation

Industry 4.0 is creating a more collaborative environment in manufacturing, which is increasing levels of customer co-creation and open innovation. Through this, the design process can be shared by other parties such as customers or suppliers, or students at a local university. Such an approach builds transparency and trust, encourages lateral thinking and often results in more customer-centric products. It can also reduce time-to-market.

The French automotive supplier Valeo has been particularly active in this area through its Innovation Challenge, which uses an innovation contest to generate ideas. The company has chosen students from all over the world as its target group. The competition brings the company into contact with high potentials from all over the world – with the latest contest involving 1,627 teams from 748 universities from 80 countries, competing for the two prizes of $100,000 each.

THE SERVICE/AFTER SALES LEVERS

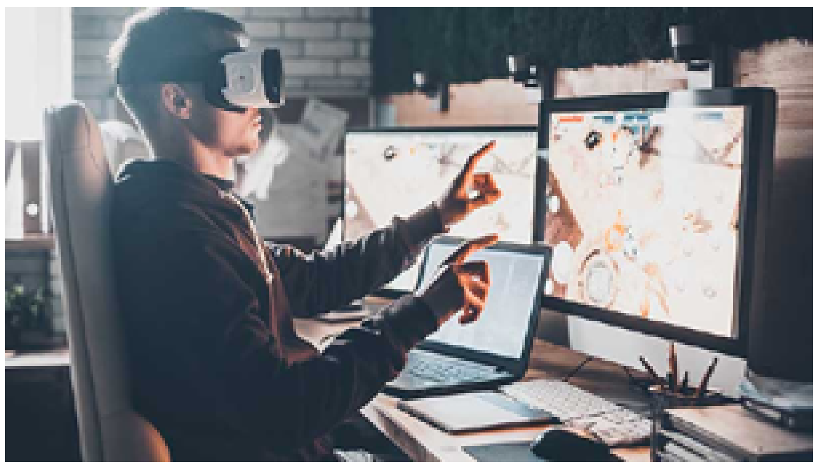
24. Predictive maintenance

Digitalisation is transforming the servicing of industrial equipment. Under some after-care packages, sensors, software and connectivity enable the manufacturer of machines such as drives and motors to assess the performance of their products in-situ, helping the customer to avoid downtime by predicting problems before they occur.

This IoT-enabled architecture is also leading to the creation of new business models based on servitisation, where the end-user effectively leases a service or a solution rather than buying a machine, therefore avoiding large upfront capital cost. This service is based on KPIs such as available uptime, giving the manufacturer clearer visibility of maintenance schedules. The seller of the service, meanwhile, receives predictable revenues.

25. Remote maintenance

Traditionally, if a machine failed at a manufacturing plant, the in-house maintenance team was charged with carrying out the repair or calling the OEM to book a service engineer. Now remote monitoring of in-situ equipment can be extended to remote maintenance, with experts from the OEM able to perform some tasks without the need for a physical presence.



For example, software updates and rectifications can be securely installed over the air, bringing equipment quickly back online. Remote maintenance can also be delivered through augmented reality headsets, with maintenance workers at the plant receiving repair instructions in their line-of-sight. For example, Plex Systems is using remote maintenance with mixed reality to bring customers' equipment back into operation, supporting the in-house maintenance team.

26. Virtually guided self-service

The application of artificial intelligence within manufacturing isn't restricted to the production function – it's also making its mark on customer service and after-care. Virtually guided self-service denotes the use of virtual agents on company websites, helping customers to resolve problems.

According to Gartner, a quarter of digital workers will use a virtual employee assistant (VEA) on a daily basis by 2021. This will be up from less than 2 percent in 2019. While virtual agents have been used in sectors such as insurance and financial services, Gartner suggests they will find their way into manufacturing.

Nokia's Multi-purpose Intuitive Knowledge Assistant (MIKA) helps engineers find answers as they perform complex tasks or diagnose problems on their network. Ultimately, these virtually guided self-service assistants provide OEMs with an additional communication channel, while helping to drive down costs.

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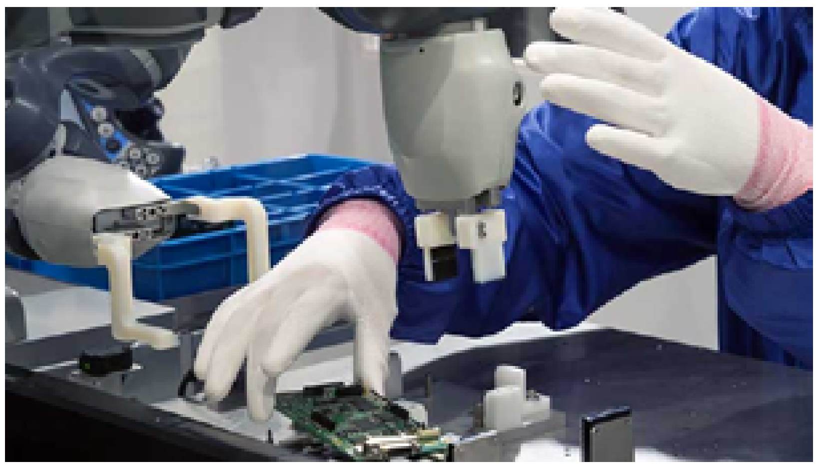
Four Industry 4.0 trends transforming manufacturing

The Industrial IoT is driving the intelligent connectivity of devices across manufacturing. Through the combination of sensor data, machine communications and automation systems, IIoT is providing a digital backbone for the emergence of Industry 4.0, the broader set of operating principles that are set to deliver the smarter factories of the future. Here we outline four key technology trends that have the potential to change the face of industrial production.

COBOTS WILL AUGMENT PEOPLE ON THE PRODUCTION LINE



Not too long ago, robots in factories knew their place – behind safety cages, well out of harm's way. But that has changed. Now, a new breed of collaborative robots (cobots), comprising a suite of positional sensors along with connectivity, has been developed to work safely alongside humans, increasing the flexibility of the production line and boosting productivity.

Indeed, the market for cobots is growing at an astonishing rate, with research by Markets and Markets estimating that it will increase from $900 million to $12 billion by 2025, at a compounded annual growth rate of 50.31% during the forecast period.

Importantly, the affordable nature of cobots – driven in part by their lower payload capacity than traditional robotic arms – means that small companies are expected to become significant adopters of the technology.

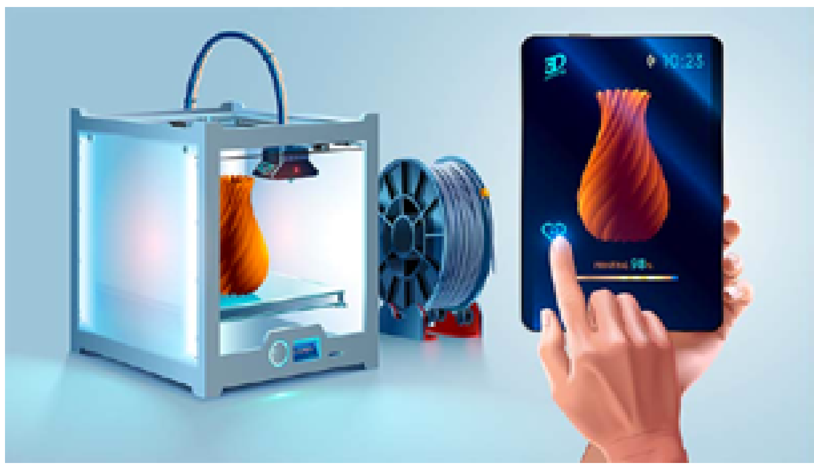
These organisations, with a firm eye on Industry 4.0 techniques, are keen to embrace cobots as a means of introducing new production methods, helping workers to increase their productivity.

So far, it has been the automotive manufacturing sector that has been the most active adopter of cobots, using them for tasks such as pick and place, machine tending and materials handling. Continental, for example, has started using cobots to automate the handling of PCB boards, relieving production-line workers of the manual task of moving components from one station to the next. This has allowed the workers to concentrate on other more skilled tasks that contribute to improving production. This simple application of cobots has seen Continental slash changeover times to 20 minutes, a reduction of 50% when compared to performing the task manually.

So, the march of the cobots is underway, and the future will see a broader range of use-cases. While automotive has set the pace, expect other sectors such as electronics, food and beverage, and metals and machining to follow suit.

3D PRINTING IS MAKING PRODUCTION FASTER AND EASIER

For many years, 3D printing was viewed as an exciting technology looking for an application. Yes, the ability to produce parts additively rather than subtractively was a novel idea and promised significant design advantages, but limitations in machine reliability and quality meant many manufacturers viewed the technique quizzically from afar.



That is no longer the case. Rapid advances in 3D printing mean the latest generation of machines can be used to produce prototype and production parts, quickly and accurately, in both metals and polymers. That means 3D printing is finding an increasing role on the factory floor, helping manufacturers to become faster and more flexible by eliminating the need for new moulds and tooling. This is delivering exciting new techniques such as mass customisation

Some companies are already ahead of the game. Volkswagen, for instance, has been using additive technology to build personalisation into its range of luxury vehicles, producing individualised gear knobs. The company is also thought to be looking at customised tailgates, while other automotive firms are also embracing the technique for different applications.

The opportunity in other sectors is equally compelling. Sports companies are looking at 3D printing-enabled mass customisation as a means of adding different elements to their latest designs of trainers and clothing, while consumer electronics makers are using it to experiment with delivering a choice of colour, size of hard drive and keyboard language.

Of course, mass customisation is just one application of 3D printing in manufacturing. It can also be used to build production parts with optimised internal design, such as cooling channels, which couldn't be produced through subtraction.

Such flexibility means 3D printing is really finding its footing within manufacturing, being used as a primary tool in the pursuit of Industry 4.0. According to the Wohlers Report, the forecast for 2020 is $15.8 billion for all 3D printing products and services worldwide, with manufacturing expected to account for a significant portion of those sales.

As technology continues to improve, and new use-cases are found, 3D printing will never again be viewed as a technological oddity – it will be central to the future of manufacturing.

FACTORIES-IN-A-BOX BRING AUTOMATION ON DEMAND

Manufacturing is an expensive business, with plenty of upfront costs. Buildings, equipment and skilled staff all act as a drain on resources, preventing many innovative smaller companies from putting their good ideas into production.

But what if things could be done more flexibly and cost-effectively, and with less capital-intensive expenditure? That's the promise of the factory-in-a-box, which is ushering in the era of automation-as-a-service.

So, what's in the box? That depends on the specific configuration, but it usually comprises robotics and additive manufacturing alongside augmented reality/virtual reality, powered by full over-the-air connectivity through 4G/5G networks

The technologies, which can be packed in a container, transported and brought back into service in a matter of hours, means manufacturers can take advantage of Industry 4.0 solutions in the most agile way possible.

The concept is being developed by organisations such as Nokia, which teamed up with around a dozen other companies in the electronics sector to launch a factory-in-a-box version 2.0 at the Hannover Messe earlier this year. The Nokia consortium thinks that the concept delivers several critical advantages to the manufacturing industry. This includes enabling building for 'country of origin' requirements, delivering faster prototype production for shorter time-to-market, and providing assistance with disaster recovery and business continuity.

Meanwhile, experts at the Manufacturing Technology Centre in Coventry, UK, have also built a factory-in-a-box demonstrator to guide businesses through the process of adopting smart manufacturing technologies and processes. The demonstrator - which is part of the £60 million Innovate UK funded Energy Research Accelerator programme – is being used to show companies how industrial digital technologies can speed up their route to market and result in new business models.

Ultimately, this kind of automation-on-demand will democratise new technology – making the benefits available to all.

Four Industry 4.0 trends transforming manufacturing

VR/AR BUILD PARTNERSHIPS BETWEEN MAN AND MACHINE

The merging of the digital and the physical worlds means manufacturing workers are now more likely to be armed with tablets and headsets than paper-based manuals and drawings. With digital twins being used to create interactive replicas of industrial assets, employees can use innovative methods of making sense of data in real-time, improving their productivity.

Both virtual and augmented reality are already delivering tangible benefits. Virtual reality – characterised by a computer-generated experience taking place within a simulated environment, usually via a headset, completely shutting out the physical world – has found application as a means of providing safe and structured training for manufacturing workers. It has also been used by several large organisations as a means of designing virtual factory layouts, before construction of the real thing.

AR provides other advantages. By building digital elements such as graphics and data into a live real-world view, often by using the camera on a tablet or headset, AR has emerged as a key enabler of more interactive maintenance in manufacturing. With 3D animations and other instructions through head-mounted displays, workers can go about their tasks in a more informed manner, reducing human errors and execution times.

Examples are increasing at a rapid pace. Service engineers at Tetra Pak, for example, work alongside customers using AR to reduce machine downtime. With the use of line-of-sight headsets, experts can be 'beamed in' in real-time to solve any maintenance problems, no matter where they are in the world.

Clearly, the market for AR/VR is already well established – but there's plenty of scope for future growth. Research by the International Data Corporation (IDC) predicts that the market will be worth $16.8 billion in 2019, growing to $160 billion by 2023. Expect the technology to become ubiquitous, especially as AR/VR become cheaper and more accessible through the emergence of new business models such as mixed reality-as-a-service.

Seven game-changing Industrial IoT applications

The conversation around the Internet of Things (IoT) has shifted from the 'what' to the 'how'. Most manufacturers are fully aware that advances in automation, software and connectivity can deliver enormous productivity and efficiency benefits to their operations, and are now looking at ways to apply such technology. But such is the all-encompassing nature of Industrial IoT that it can be hard to see the wood for the trees.

Here we pinpoint some of the key applications of IoT in manufacturing which use the building blocks of core products such as sensors, wired and wireless connectors, while looking at how such innovation is helping manufacturers to transform the way that they design, build and maintain their products.

AUTONOMOUS VEHICLES: FREE-ROAMING ROBOTS MOVE ACROSS FACTORY FLOORS

The march of the robots is well underway, says Deloitte, with swarms of autonomous vehicles having found their way on to factory floors as a means of increasing the speed and accuracy of routine operations. Powered by the Internet of Things, these free-roaming robots can be coordinated to a greater extent than ever before, enabling them to perform automated tasks in a controllable and predictable manner, and with minimum human oversight. This gives them the potential to improve operations inside manufacturing plants, particularly in areas such as component handling and transportation, offering opportunities to increase productivity, reduce risk, decrease cost, and improve data collection. This frees up workers to focus their attention on higher-value activities such as production and assembly.

Historically, automated guided vehicles and conveyors have been installed as a means of moving materials and parts around factories. However, most of these systems have depended on pre-set routes that offer no deviation.

Now with the convergence of technologies such as robotics, sensors, 3D cameras, 5G connectivity, software and artificial intelligence, robots are capable of navigating their way safely around factory floors. Some forward-looking manufacturers are ahead of the curve in adopting such systems. In Italy, for example, automotive systems manufacturer Faurecia is using autonomous vehicles from Mobile Industrial Robots to increase the efficiency of its logistics. The organisations have worked together to reorganise Faurecia's factory layouts to allow robots to navigate their routes using their internal maps. Workers interact with the robots via smartphone, tablet or personal computer interfaces, instructing them of their duties with a push of a button.

Seven game-changing Industrial IoT applications

MACHINE UTILISATION: MAKING THE MOST OF INDUSTRIAL ASSETS

No manufacturer wants to invest in expensive capital equipment, only to see it underused and not earning its keep. That's why IoT architecture has emerged as a popular and powerful means of monitoring machine utilisation – sending valuable performance data to operators via dashboards to let them know what machinery is working most effectively in comparison to other equipment. These platforms can act as a key driver in improving factory floor production, primarily through the elimination of bottlenecks due to under-performing assets. They can also be used to compare the performance of machines across one or many sites.

Recently, MachineMetrics has been working with Fastenal, the Minnesota-based manufacturer of fasteners and tools, to apply an IoT platform that monitors factory floor production. The software can connect to any modern CNC machine by coupling the MachineMetrics Edge to the Ethernet port of the control, while older machines can share data directly to the cloud via the digital and analogue IO module.

In the Fastenal case, the software gave insight into machine utilisation by the hour, shift, day, week, and month to uncover opportunities to make efficiency improvements. This delivered an 11% increase in machine utilisation in the first three months, says MachineMetrics, which translated to a boost in production of 100 hours, and 150,000 more parts produced.

OPERATOR PRODUCTIVITY: CONNECTED TOOLS ELIMINATE HUMAN ERROR

A small to medium-sized manufacturing plant might contain hundreds of operator tools, in various shapes and sizes, which are used for a multitude of functions. For a large factory, that number could rise to thousands. Now imagine if all of those hammers, drills, torque wrenches and shears could always be located in an instant, and that they could never be erroneously used outside of a specific set of operational parameters. That's the promise of IoT-enabled connected tooling, delivering enormous improvements in operator productivity.

Airbus and Bosch have led the way in this area, with the Factory of the Future initiative using connected drilling, measuring and tightening tools. These processes, in aerospace plants, can take place over several work cells and can be performed by different operators. So, says Airbus, there is huge potential for improving these processes by making hand tools more intelligent.

Other manufacturing companies have followed suit. Workers at GE Aviation have, for example, been combining WiFi-enabled torque wrenches with mixed reality headsets to ensure that bolts are tightened most optimally. It is all about improving operator productivity, boosting product quality and eliminate costly re-works.

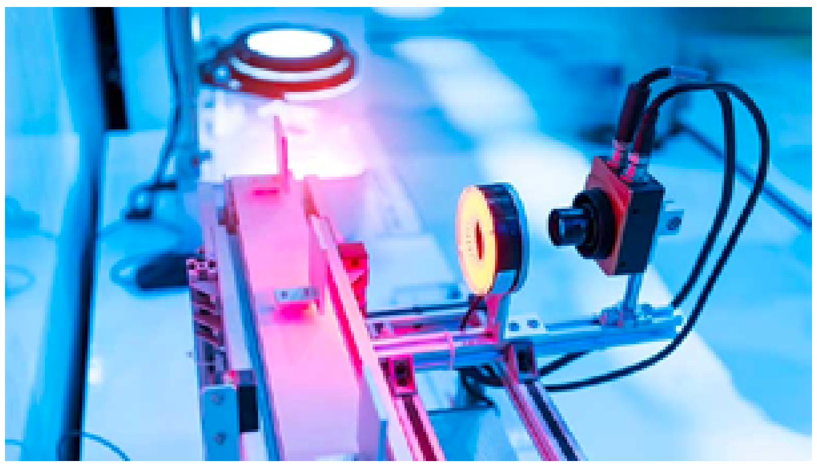
POWER MANAGEMENT: BUILDING AUTOMATION LOWERS ENERGY COSTS

Manufacturing, by its very nature, requires a lot of energy, and that in turn can account for a large percentage of operating costs. That's why factory owners and managers are increasingly turning to IoT-based building management systems to connect sensors, actuators, controllers and other equipment over one IP backbone, enabling the monitoring of energy usage, lighting, HVAC and fire safety systems. This data can also be combined with information from broader datasets such as weather forecasting and financial information - such as the price of electricity and other utilities - to give a far more rounded view of building management. This type of architecture is finding increasing adoption in manufacturing environments, to make buildings smarter, more sustainable and more efficient.

BAE Systems has, for example, worked with Schneider to install its Ecostruxure building management systems platform at one of its production facilities in the UK.

In this particular case, the Ecostruxure platform is being used to monitor HVAC in the warehouse and office areas, along with other equipment including destratification fans, heat recovery units and electric panel heaters. In terms of system configuration, two panels were built by systems integrator Aimteq for the offices and warehouse containing Schneider SmartX AS-P controllers and I/O modules, as well as intuitive touchscreen tablet displays.

QUALITY CONTROL: VISION SYSTEMS DELIVER PERFECT PRODUCTS, TIME AND AGAIN



Faster and more flexible production lines might be the key to meeting customer demand, but there can also be a negative impact on quality control if monitoring isn't up to scratch. These days, as plants look to automation to replace tasks such as manual inspection, new technology is being used to ensure there is no deviation from quality parameters. Increasingly, the function of replacing the human eye has been performed by IoT-enabled high-pixel camera vision systems in combination with other devices such as acoustic sensors, along with high-performance image processing software. These can be used to identify defects such as size, shape or finish, and to check the accuracy and readability of labels, barcodes or QR codes.

This information can then be looped back to earlier stages in the production line, allowing production managers to identify and classify the root cause of the problem before rectification action can be taken. Over time, artificial intelligence can be applied to learn from feedback and continuously refine and improve the production process.

This type of vision system is being used across manufacturing to monitor the quality of a wide range of products, including electronic devices, consumer goods and metal finished parts. For example, the automotive component supplier Getrag has been using a vision system to inspect teeth and clutch body parts, supplying engineers with real-time data on non-conforming parts, and trends emerging from the manufacturing process. The aim is to improve product quality, reduce costly re-work and enhance brand reputation.

SMART LOGISTICS: KEEPING TRACK OF ASSETS IN REAL-TIME

The benefits of IoT for manufacturers don't end once products have reached despatch. Indeed, the delivery and logistics function has become one of the primary beneficiaries of digitalisation, with asset-tracking sensors able to provide real-time information on asset location, the surrounding temperature, humidity and motion.

These smart logistics systems now benefit from a wide range of connectivity options delivered through low-power, wide-area cellular and noncellular technologies such as LoRa and Narrowband IoT. These networks stream sensor data to the cloud safely and seamlessly, offering a breadth of performance capabilities around latency, data rates and operational range, depending on what is required.

The latest supply chain logistics software means manufacturers can track the movement of their assets via easy-to-read dashboards on devices such as laptops and smartphones, giving managers a complete view of the outbound logistics function.

Manufacturing is expected to be one of the leading industries adopting asset tracking, with the food and beverage sector in particular keen to use it to move perishable goods quicker and more efficiently, and with less damage.

Recently, a joint venture between Hoopo and Polymer Logistics delivered full IoT tracking of pallets and containers using LoRa, meaning it can locate assets without the need for GPS. This maintains the device's low power consumption and enables extended battery life, while providing data on assets in real-time.

Seven game-changing Industrial IoT applications

WEARABLES: ENSURING WORKER SAFETY AT ALL TIMES

Wearable technology might be closely associated with the consumer sector through the use of fitness monitors, but it is also delivering enormous benefit in industrial environments. In manufacturing, for instance, wearables are increasingly being used to ensure worker safety, with body-worn connected sensors being used to monitor environmental conditions, and to provide insight into vital signs such as temperature, pulse and respiration rate.

By embedding personal protective equipment with sensors or radio-frequency identification technology, they become edge devices in the Industrial IoT, collecting and transmitting data to provide insight.

These connected worker platforms aim to more effectively manage worker safety, especially in manufacturing plants where employees perform tasks alone or handle potentially hazardous substances. It also acts as a means of lowering an organisation's compliance and administrative costs. Meanwhile, wearables are also being used within manufacturing for ergonomic reasons, to reduce the toll that physical activities take on its workers' bodies.

The German carmaker Audi is using has been using exoskeleton ergonomic aids in its press shops to provide support for workers when they are lifting and carrying heavy materials. The exoskeletons also allow workers to assume a sitting position when required.

These capabilities have been shown to reduce the strain on the back by 20 to 30 per cent and to promote a healthier posture over the long-term. Increasingly, such devices are being IoT-enabled, allowing occupational health experts to utilise more accurate data for ergonomic purposes, with the right regulatory agreements.

DESIGNING FOR THE IIOT?

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Industry 4.0: The disruptor of supply chains

Industrial IoT is already changing the supply chain dynamics for thousands of businesses, and even more disruptive technology is on the way, altering the supply chain on a fundamental level. We take a look at some of the biggest and most disruptive technologies and trends in Industry 4.0.

The industry as a whole faces a sea change in the coming few years, as Industry 4.0 gathers pace in a market predicted to be worth $4.4 trillion in value by 2020, according to KPMG.

The term might sound like yet another buzzword, but in fact, represents a huge shift in the way that business operates - and how the enterprise as a whole will need to operate to remain competitive. Made up of a series of building blocks, including IIoT, AI and blockchain, Industry 4.0's power is already visible in many areas of business, such as Amazon's same-day delivery. And a host of innovations and new technologies will continue to drive adoption exponentially.

EDGE AI: SMARTER NETWORKS

While AI in the cloud is a fairly established concept (and indeed is available for a limited free trial via Amazon Web Services), IIoT-powered supply chains have a data challenge to solve. A network of sensors embedded in the supply chain provide powerful data, but in serious quantity, potentially driving up network traffic to expensive and impractical levels. Edge AI offers a solution to this problem by processing data on device, ensuring that only actionable data needs to be fed back to the cloud, reducing network congestion.

An additional layer is a growing ability to deliver on-chip processing, such as patented by US startup AIStorm, which offers the potential to handle sensor data within the sensor itself (for example by responding to movement in a particular visual sector of a security camera), saving significant system resources, power and time.

The result is an increasingly 'smart' network, with devices at the edges of the network capable of intelligent operation, as well as delivering visibility throughout the supply chain.

Industry 4.0: The disruptor of supply chains

DIGITAL TWINS: PREDICTIVE DATA

According to a recent study by Gartner, 13 per cent of organizations implementing IoT are already using 'digital twin' technology, while 62 percent are either in the process of establishing the technology or plan to do so in the next year. The analyst firm said that a major driver of digital twin uptake is that the technology is already delivering genuine business value, and has become part of enterprise IoT strategy.

A digital twin is a clone of physical and digital processes, a mirror that allows enterprises to model results of a process or technology change without impacting day-to-day operations. The concept combines technologies such as IIoT sensors, AI, Machine Learning and cognitive data analytics to create a powerful predictive tool.

The digital twin can be used to predict increased demand on a particular component or product, for example, allowing upstream and downstream supply chain factors to be simulated, optimised, then actioned in advance. The result is enhanced efficiency and improved responsiveness - with all the benefits that brings.

Indeed, Gartner predicts that before 2022, over two-thirds of companies that have implemented IoT will have deployed at least one digital twin in production.

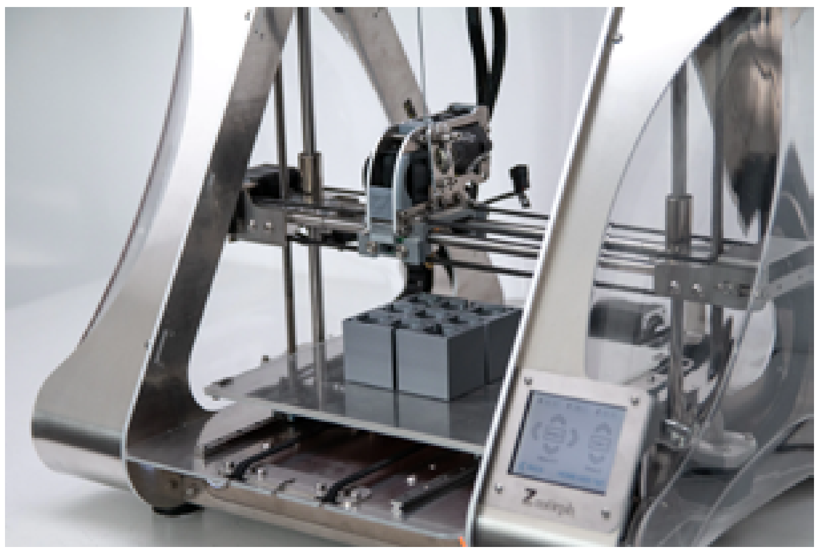
BLOCKCHAIN: IMMUTABLE CONTRACTS

While blockchain has been the prescription for many ills, some of which are more plausible than others, in the world of increasingly automated supply chains it has considerable value. IBM's most recent blockchain product - Trust Your Supplier (TYS) network - is designed to "improve supplier validation, onboarding and life cycle information management" by creating an immutable blockchain audit trail for supplier firms.

Information such as ISO and tax certifications, bank account information and insurance certificates can be reviewed in seconds, replacing cumbersome manual checks and potentially enabling smart contracts to replace traditional bespoke agreements. IBM claims that the network will bestow a 70% to 80% reduction in the cycle time to onboard new suppliers, significantly enhancing the efficiency of a supply chain. Other founding participants include Cisco, GlaxoSmithKline, Lenovo, Nokia, Schneider Electric and Vodafone.

3D PRINTING: WHY WAIT?

Of course, some verticals have simplified their supply chains in an unexpected manner - by simply printing the parts they need in-house. Not only can this strategy pay dividends in time and efficiency, but it can also be used in conjunction with IIoT data flows to deliver far more substantial improvements.



For example, upstream demand and inventory data can be used to ensure that production of the most vital parts is prioritised, while tiny improvements can be made on the fly as usage data is re-incorporated into base designs. This flexibility and efficiency have made commercial-grade 3D printing an increasingly popular supply chain tool in the automotive, electronics, and healthcare industries. As hardware costs reduce and new materials and processes become possible, adoption will likely broaden.

In short, the very near future will change the way the traditional industry functions on a fundamental level, automating thousands of processes throughout the supply chain. From Industry 4.0 trends like real-time IIoT networks, powered by edge AI, through to smart contracts and 3D printing, the future is already here - is your business ready for it?

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An unlikely tale: Wearables heading for success in IIoT

Wearables might have become firmly entrenched in consumers' minds, but in the world of IIoT they have been sidelined due to a host of practical and operational complexities. However, as Industry 4.0 technologies evolve, wearables in IIoT have changed course dramatically.

A perennial talking point in the consumer market, wearables were initially widely heralded as the most visible and most successful face of IoT - until it became clear that initial interest had slowed. This was due to a variety of factors, including the usual 'new technology' overhype, battery technology, fragmented connectivity and data standards, and a lack of compelling applications. While the world of Industrial IoT might have very different frames of reference, the same challenges resulted in a similarly low level of uptake for industrial wearables.

IF THE GLOVE FITS

Despite a slow start, as battery, display and connectivity technologies have evolved in parallel with wider IIoT deployments, wearables in IIoT have begun a resurgence. One example is industrial wearables firm ProGlove, a startup from 2014 that has just closed a €36 million investment round. The company's scanner glove might sound like blue-sky thinking - a hands-free barcode scanning device that provides direct feedback to the user via optical, haptic and acoustic signals - except it has been deployed by Audi, BMW, Bosch, Daimler, DHL and Lufthansa Technik. Because of the cumbersome nature of traditional warehousing and fulfillment barcode scanners, baking their functionality into a glove saves up to four seconds per scan, according to ProGlove, an efficiency improvement of up to 50% for some ProGlove customers.

An unlikely tale: Wearables heading for success in IIoT

WIRELESS E-INK MAKES A MARK

The promise of low-power displays has been well-acknowledged in IIoT environments, from smart warehousing to fulfillment applications, but a combination of battery life and cost implications has restricted market growth. However, a new take on the scenario from Ossia, E-PEAS & E Ink shows an encouraging direction of travel. The trio of companies have developed a wirelessly-powered Electronic Paper Display prototype that is entirely battery free, designed for dynamic environments. This could include electronic shelf labels for retailers and warehouse use, digital signage, logistics tags and distributed sensor networks to name but a few. The companies plan to release the technology for commercial use by the end of 2020.

SEEING THINGS VIRTUALLY

Another solution to the problem of portable, connected industrial displays is Virtual Reality (VR) and Augmented Reality (AR), two 'emerging' technologies that have been on the cusp of widespread adoption for some time. However, inroads are being made, with commercial VR headsets being used in applications from aircraft maintenance to F1 pit crew training. DAQRI's industrially-targeted VR headset is designed to provide a valuable overlay of AR data to industrial settings, enabling workers to have operating manuals immediately available, for example, to highlight which valve requires maintenance, or to have a remote expert guide them in repairing a specific module. As more industrial settings incorporate IIoT sensors to provide this type of operational data, it requires little imagination to see the value in intuitively visualising cloud-based, contextualised data in the field.

SAFETY TRACKING

Safety is one of the major standout themes in IIoT wearables, especially in North America and Europe, where a tight regulatory environment makes automated approaches to compliance highly desirable.

An unlikely tale: Wearables heading for success in IIoT

Employee tracking might sound somewhat draconian in an office setting, but when the frame of reference is shifted to heavy construction or mining-style applications, it seems much more sensible. More practical still, attaching battery-free rugged devices (such as Opal) to key items of PPE such as hardhats or safety vests means that not only are workers easily accounted for on larger construction sites, but the system also mitigates potential personal data issues by not tracking individuals offsite. In the event of an emergency or evacuation, this type of technology saves valuable time in determining that all workers are safe. It also ensures that individuals are not working too many hours, as accident rates can rise when tiredness kicks in.

LAYERING ON INTELLIGENCE

Beyond basic tracking of construction workers, companies such as Eleksen have created smart PPE devices with additional sensors that monitor noise, gas and other environmental factors. This data is streamed back to a central hub to monitor safety as well as build up a complete picture of the work environment. This is especially valuable in high-risk oil and gas industries.

Aside from individual sensors, broader approaches to health, safety, and environment (HSE) compliance are becoming increasingly widespread, with suites such as IBM Maximo Worker Insights delivering wearable device monitoring, as well as an overlay of predictive context that can reduce workplace incidents. One interesting example from IBM is using wearable decibel meters to monitor exposure to loud noises for individual technicians, so that potential impact can be measured and the correct PPE issued. The problem being particularly relevant for mobile workers such as engineers or inspectors, who come into contact with high levels of noise irregularly, but at degrees that may well have a cumulative effect that would be near-impossible to measure in any other way.

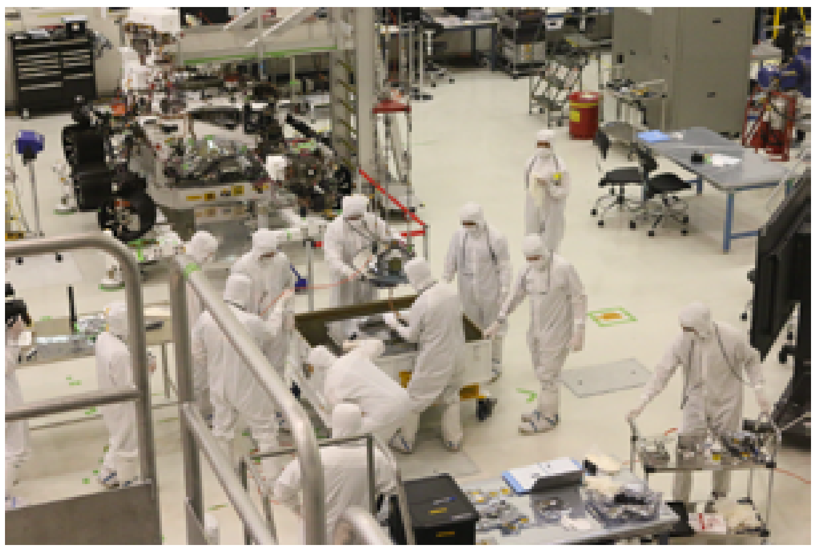
While consumer wearables continue to seek out 'killer applications', the same is not true of IIoT wearables. A host of use-cases already exist, and as the supporting environment matures, many of these niches are being filled with positive results. As the move to Industry 4.0 gathers pace, it is clear that creating intuitive interfaces for workers on the ground–in order for them to benefit from the increasing volume of valuable cloud data–is only going to rise in importance. The IIoT wearables are coming - and this time they are here to stay.

IIoT's biggest challenge: Integration

The Industrial IoT market has seen huge growth over the last few years, but has also demonstrated that moving from proof-of-concept to real-world deployment can take longer than expected. Integration is one of the biggest causes of friction in this process, but there are strong success stories emerging.

Integration has been a challenge for technical deployments since the Industrial Revolution, but IIoT faces a particularly complex operating landscape that has specific requirements per vertical, as well as regulatory specifics to boot.

Indeed, a recent survey found that more than 55 per cent of manufacturers stated integration as a key inhibitor to achieving value and scale in IIoT deployments. These manufacturers are particularly engaged with the IIoT market, with 80 per cent seeing it as an imperative part of their business. The study found that IIoT deliverables that create products-as-a-service are seen as a top priority, then optimising existing operations, followed by optimising maintenance, and finally the development of new products.



HEAVY INDUSTRY LEGACY TECH

While legacy integration is a common bugbear across almost every industry, it can be a particular challenge in heavy industry, where manufacturing processes tend to be costly to initially establish. This not only applies to plant machinery itself, but also software upgrades (many of which carry additional upfront costs), leaving many heavy manufacturing plants running very outdated software. The depth of recent concerns over end-of-life for Windows 7, launched in 2009, highlights the issue.

Just as in the consumer IoT space, fragmentation has proven a significant market inhibitor, presenting a broad array of similar technologies and complicating strategic purchasing decisions. However, as the market has matured standards have emerged–albeit slowly–it is still estimated that there are more than 400 competing IoT platform offerings: some proprietary, some standards-based.

An abundance of dedicated IoT wireless and networking standards have begun to coalesce around Sigfox, LoRaWan, LTE-M (Long Term Evolution for Machines) also known as Cat-M1 or Cat-M & NB-IoT (Narrowband IoT) also known as LTE CatNB1 or LTE-M2, depending on the operator or geographical location. It should not be ignored that while some technologies are developing strong followings - such as CAT-M in North America - the picture in Europe is still varied. Just in the UK for example, Vodafone's NB-IoT, O2's LoRaWAN and Sigfox deployments compete against each other, and simultaneously against EE's LoRaWAN - a complex topography to navigate.

IIoT's biggest challenge: Integration

FORGOTTEN HERO PROTOCOLS

However, in spite of the confusion and the many competing standards, industry consensus is emerging. One interesting example is the rising use of an existing incumbent protocol, HART, in IIoT architectures. With more than 40 million installed HART devices worldwide, HART is already deeply entrenched in utility and industry sectors, which solves a significant cost and implementation/integration barrier. Manufacturers can access existing HART-equipped sensors with a central HART interface device or gateway, which can then backhaul via IP, delivering a wide range of IIoT-relevant and easily dashboarded data, including battery information and a host of other variables, at a stroke.

POST FRAGMENTATION CONSENSUS?

A potentially significant move is the establishment of the Open Industry 4.0 Alliance (OI4), a pan-European alliance founded in recognition of the fact that the fragmented market is damaging IIoT uptake, and limiting long term potential. The founding members – Arvos GmbH, Balluff, Beckhoff, Endress+Hauser, Gebhardt Fördertechnik, IFM, Kuka, MultiVac, Hilscher, Pepperl+Fuchs, SAP, Schmidtsche Schack, Samson, and Wika Alexander Wiegand – are committed to combating integration headaches for customers by creating "holistic interoperable Industry 4.0 solutions and services in a common framework".

The OI4 framework consists of four layers connecting physical assets on a plant floor for example, to OI4's central 'Open Manufacturers Cloud Platform'. Layer One is 'Open Edge Connectivity' where common industrial communication protocols such as OPC UA, HART, Profibus/Profinet, Modbus and EtherCat operate, connected to Layer Two 'Open Edge Computing', which brings together edge hardware and a containerised enterprise platform. The final two layers, 'Open Operator Cloud Platform' and 'Common Central Cloud' make the data available to cloud-based APIs.

COLLABORATION THE KEY

While the specific requirements of project integration will continue to be a challenge at the individual enterprise level, a new spirit of collaboration and transparency in the wider IIoT market should begin to pay significant dividends. Companies able to strategically evaluate an IIoT technology stack faster and more easily will be far more likely to benefit from investments, and able to quantify them to boot. In short, the time has come for wider and deeper collaboration across the IIoT value chain in order to deliver on the potential of the technology, both today and tomorrow.

DESIGNING FOR THE IIOT?

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Predictive maintenance: The 'killer app' of IIoT

Once headlined as the 'killer app' for IIoT, predictive maintenance seems to have taken a while to find its feet. But progress has in fact been sure and steady, with some standout examples of successful niches.

Back in 2016, predictive maintenance was touted as one of the key applications for IIoT, and even 2018 saw analysts such as Gartner return to the well with strong predictions of future success. Gartner predicts that by 2022, spend on IoT-enabled predictive maintenance will increase to $12.9 billion, up from $3.4 billion in 2018, with improved operational efficiencies through predictive asset maintenance leading to substantial savings of up to 40 per cent.

However, the market has not exploded quite yet. Indeed, a new survey of more than 600 high-tech executives from Bain found that industrial customers were less bullish about predictive maintenance in 2018 than they had been in 2016. This was mainly due, according to the analyst firm, to challenges in effectively gaining insight from IIoT data once gleaned, and at the other end of the equation, difficulties in implementing systems in the first place.

According to Bain, another key barrier could be summarised as: "device makers and other vendors of industrial and operational technology need to dramatically improve their software capabilities—not a historical strength for most of them." In spite of this, the analyst firm predicted rapid growth for IIoT, with the market doubling in size to more than $200 billion by 2021.

PREVENTIVE VS PREDICTIVE

One of the biggest challenges to predictive maintenance adoption has been the fact that many industry sectors are still working their way through implementing preventive maintenance. Arguably the forerunner of predictive, preventive maintenance systems can range from quite simplistic–such as a 'traffic light' health system for individual machines or plant elements–through to far more complex networks of sensors feeding data back to centralised dashboards. However, it generally relies on manufacturer lifetime predictions, human operators or direct sensor data to highlight potential problems, rather than utilising complex algorithms to predict maintenance schedules.

This means that the benefits of preventive maintenance are becoming well entrenched, but the staged adoption has left many industrial players waiting for the machine learning and AI market to mature further, easing adoption pains and lowering costs.

Predictive maintenance: The 'killer app' of IIoT

FOOD FOR THOUGHT

The current situation has created a range of opportunities, such as in the food industry, where Mitsubishi Electric's Smart Condition Monitoring (SCM) solution slots neatly into the niche between traffic light preventive systems and full-fat predictive IIoT. The system not only monitors the condition of individual assets, but layers these up to provide a holistic picture of overall plant health.

Local traffic lights still provide visual 'health check' indicators, but real-time data is transferred over Ethernet to a Mitsubishi Electric PLC for in-depth monitoring and cloud-based analysis. A teach function 'learns' the normal operating state of the machine, then vital information such as bearing defect detection, imbalance, misalignment, temperature measurement, lack of lubricant, cavitation detection, phase failure recognition and resonance frequency detection can be viewed in a cloud dashboard.

IMPROVING TRANSPORT EFFICIENCY

There are certainly clear indications that predictive maintenance is still front of mind in many sectors, such as the transport industry. One example is trackside maintenance, a significant operating cost for rail firms that also requires qualified personnel to operate around the clock in potentially dangerous conditions. However, by deploying IIoT sensors and analytics technologies, rail operators can move from wasteful inspection cycles (where perfectly serviceable equipment is checked and rechecked irrespective of condition) towards preventive, conditions-based and predictive maintenance.

For example, Nokia has created a rail asset lifecycle optimisation application that brings all three elements together. Not only does it model maintenance schedules for each asset based on learned operating parameters and incorporating external data such as weather conditions, but also building in crucial risk-related data around the consequences of a component failure.

Predictive maintenance: The 'killer app' of IIoT

KEEPING TRACK OF RENEWABLES

Predictive maintenance technology originally designed for the mining industry has found an application in the renewables industry, in an interesting pivot. An Australian startup, Ping Services, developed an acoustic sensor that was intended for mining and drilling applications. It was able to monitor the acoustic signature of a drill bit over its lifetime, and then harness machine learning to predict fault development ahead of time. While reducing astronomically expensive drilling stoppages is clearly an area of considerable interest, the company has embarked on pilot programmes with Australian and US-based wind farms to monitor turbines, with similar goals in mind.

The solar-powered, satellite-connected sensors actively listen to the turbine blades' acoustic signature to detect the development of pitting or cracks, caused by lightning strikes or hail. As such issues begin to develop, they can be monitored and targeted for maintenance remotely, rather than requiring highly trained teams to tour windfarms and conduct routine testing.

PREDICTIVE COMES OF AGE

Overall, while predictive maintenance may have taken some time to mature, there are signs that the market is beginning to open up, especially in niche use cases. More generalised 'plug-and-play' systems targeting wider industry sectors are also beginning to emerge, highlighting that R&D investment is beginning to translate into real-world demand. It seems that predictions of demise have, in this business case at least, been exaggerated.

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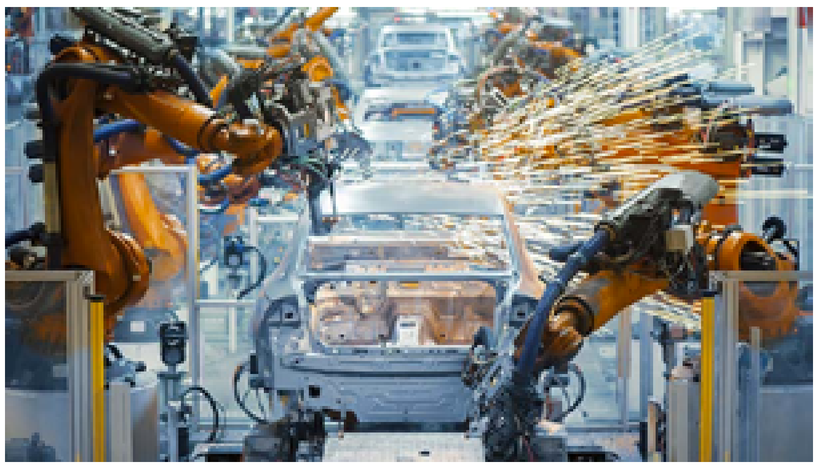
Predictive maintenance with IoT: The road to real returns



The Internet of Things is having a profound effect on the manufacturing sector, leading to increased automation, more efficient operations, and the creation of valuable new business models. While the application of digital technologies can bring benefits across the value-chain, it is arguably in the area of predictive maintenance that the most significant impact can be derived.

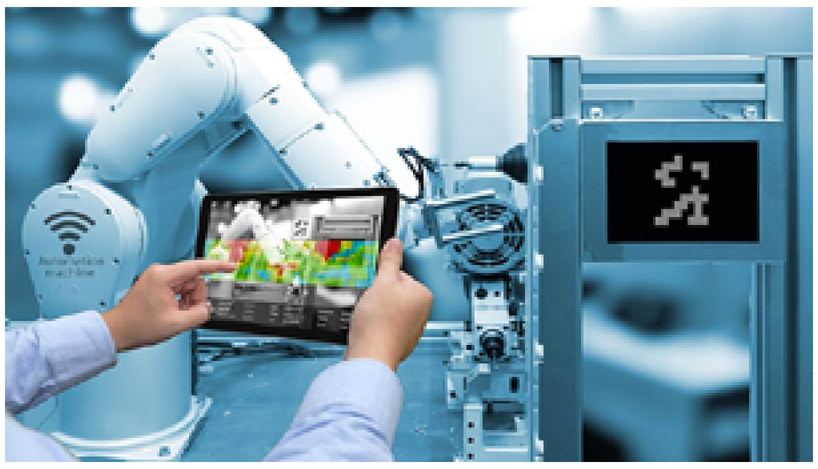
The use of sensors and data analysis means companies can spot patterns in equipment condition and performance, and accurately predict when a failure might occur. Such foresight eliminates unplanned downtime, delivering substantial productivity benefits.

THE BUSINESS CASE FOR PREDICTIVE MAINTENANCE WITH IOT

Before we outline how IoT can underpin the implementation of predictive maintenance, it's useful to set some context by looking at how maintenance activities have traditionally been performed. In most cases, schedule-based maintenance using predetermined intervals has been the most common method of reducing the likelihood of equipment and plant failure. There's a problem with that, though - age isn't always an accurate indicator of condition.

So, this preventative approach has often resulted in parts or machinery being replaced after a specific period even though they could have lasted much longer.

Indeed, this type of maintenance assumes a higher likelihood of failure with increased use or age. However, according to research from the ARC Advisory Group, this only applies to 18



per cent of industrial assets, with the other 82 percent displaying a random failure pattern. This inevitably results in unplanned downtime and lost productivity, along with other less obvious factors which need to be considered too. Random failure can cause damage to other associated equipment, and with that comes safety risks. Also, unplanned downtime requires urgent rectification, and that can result in higher salary payments through unexpected overtime and other associated costs. In short, preventative maintenance has some severe limitations that impact the bottom line.

So, what is needed is a genuinely predictive approach – using sensors, data collation, analytics and machine learning to monitor equipment continuously and predict failure with far greater accuracy. This kind of plan – utilising the full benefit of the Internet of Things - delivers maintenance that is necessary rather than possibly required. Moreover, in the future, some types of machines will be able to perform self-maintenance, eliminating the need for human intervention.

Predictive maintenance with IoT: The road to real returns

The size of the prize for predictive maintenance within manufacturing is immense.

According to management consulting firm McKinsey, predictive maintenance could reduce the costs of factory equipment by up to 40 per cent, while reducing downtime by up to 50 per cent. It also has the opportunity to reduce capital investment by up to 5 per cent, by extending the life of existing industrial assets. As a result, these savings could amount to a staggering $630 billion per year by 2025, predicts McKinsey. No wonder manufacturers are embracing IIoT-enabled predictive maintenance as a means of transforming their businesses.

THE CORE TECHNOLOGIES ENABLING PREDICTIVE MAINTENANCE

So how does predictive maintenance work? At a top-line level, it's delivered through the coming together of several mega-trends, most notably big data, cloud computing, edge computing, machine learning and connectivity. Then, the challenge for design engineers developing IoT solutions is to build a supporting platform using core products that are suitable for the specific task at hand. These products include sensors, wired and wireless solutions, antennas, batteries and increasingly smaller connectors and passive components to enable small, often remote, low-power connectivity. Also, these products will need to have been designed to withstand adverse conditions often found within industrial environments.

Once in place, sensor data can be taken from assets such as actuators, motors and drives, and filtered through field gateways, before being pushed on the cloud through wireless connectivity. The sensor data is then effectively repacked so it can be streamed in an orderly flow to a data lake for filtering. Once structured at a big data warehouse into more meaningful information relating to specific performance indicators, such as vibration or temperature, the data can be analysed with machine learning to identify any anomalies. As predictive models are built and trained over time, they become more accurate and therefore deliver more value.

What's crucial here, of course, is to ensure that the right data is collected, and the right datasets are analysed. IoT data that's used to determine the condition of a machine might cover factors such as temperature and vibration, while other static data feeding into the model might cover the specifics of make, model or configuration. Usage history data and service information can also be used to improve the effectiveness of the model and improve its predictive outcomes.

There also needs to be an element of contextual awareness, taking into account the complex static and dynamic variability of physical devices, often influenced by the specifics of the operating environment. By gradually recognising patterns and identifying abnormal behaviour in the context of the kinds of variable conditions found in industrial settings, machine learning software can more accurately understand long-term trends and spot undesired events before they cause downtime.

TWO EXAMPLES OF IOT-ENABLED SMARTER MAINTENANCE

Such techniques are already being used to good effect in discrete manufacturing as part of initiatives to develop the smarter factories of the future. One example of this is Sandvik, the tooling and tooling systems manufacturer, which has teamed up with Microsoft to create sensorised cutting equipment. This combines data collection, streaming analytics and machine learning to notify engineers when tool-bit maintenance is required, or to provide an alert of impending failure.

Meanwhile, the engineering group ABB has developed a predictive maintenance solution for critical motor and drive applications in manufacturing environments. In this example, sensors, cloud computing and machine learning combine to provide an overview of equipment performance to keep production running as planned. This has been used to good effect at Tenaris, the steel pipe manufacturer in Italy, which has used the technology to monitor high and low-voltage motors running critical pumps and fans, 24/7. The predictive maintenance solution has been used to collect and analyse vibrations to indicate bearing failure, and voltage and power anomalies that indicate a short circuit.

THE CHALLENGES OF IMPLEMENTING PREDICTIVE MAINTENANCE

If the concept of IIoT-enabled predictive maintenance is now well-understood, and some forward-thinking companies are using it within their plants, why is it that recent research shows that adoption across manufacturing has been slower than expected?

A survey of 600 high-tech executives by the global management consulting firm Bain and Company found that industrial customers were less excited about the potential of predictive maintenance in 2018 than they had been two years earlier. This shift in sentiment, said Bain and Company, had come about because manufacturers had found implementing predictive maintenance harder than they had expected, and that deriving insight from the data had proved more challenging than they had initially thought. As proof-of-concept projects had been set in motion, many of these companies had identified concerns over integration issues, particularly relating to a lack of technical expertise, data portability and transition risk.

Predictive maintenance with IoT: The road to real returns

The survey found that although manufacturers retained long-term enthusiasm for IIoT-enabled predictive maintenance, many companies were pausing for thought, as they recognised that implementation of digital projects might take longer than initially thought, and that return on investment might be longer than expected.

SIX TOOLS FOR BEST-PRACTICE MAINTENANCE

This newfound sense of realism could well prove beneficial in the long-term. As the initial hype around predictive maintenance fades away, it's likely to be replaced with more considered debate around the pros and cons of adoption. It also provides an opportunity to take stock and learn from best-practice advice from organisations that have led the way.

Hitachi, for example, has identified six primary tools and techniques that all successful predictive maintenance programs should have to make them function effectively and deliver a reasonable chance of success. They are:

- Small early pilot programs
- A technology suite for aggregating data
- Algorithms to monitor patterns and events in real-time
- Effective workflows
- Service management
- A change management agreement

These best practices should assist engineers as they grapple with issues such as the business case and promised value of predictive maintenance, the technological and data requirements, and the challenges to full implementation and delivering on that promise.

Even though the journey may take longer than initially expected, ultimately, IIoT-enabled predictive maintenance provides a brave new world for manufacturers looking to improve productivity, underpin safety and deliver lower costs.

Towards proof-of-value: A tale of IIoT maturity

IIoT deployments are moving fast up the maturity chain, from pilot projects to large-scale implementations that are delivering real value today. We take a look at some examples and figures to map out where the market is today, and what will shape tomorrow.

'Think big, start small, scale fast' has been a tagline for digital startups for many years, but the story of the maturing Industrial IoT market brings new meaning and perspective to the phrase. Initially tipped to be a runaway success, with a market worth $933.62 billion by 2025, at least according to the latest analyst estimates, the IIoT market has been a slower starter than initially forecast.

OVERCOMING THE CHALLENGES

A fragmented market, competing technology standards, and lengthy cost and implementation periods have been key barriers preventing IIoT adoption at explosive rates. Other challenges have included complex integration procedures, with multiple new sensors and data streams generating false positives and requiring recalibration.

The journey from concept to full maturity has been plotted in many different ways over the years, including Gartner's much-quoted 'hype cycle'. Gartner's Hype Cycle for Emerging Technologies in 2018 placed IoT in general at the "peak of inflated expectations", ready to crash down into the "trough of disillusionment" before beginning the plateau into maturity. But the big question unanswered was when this plateau would be reached.

THE BEGINNING OF PROOF-OF-VALUE

Analyst house Deloitte recently went on record to state that they believe IIoT is finally reaching that maturity, and that their clients are now looking beyond proof-of-concept and towards proof-of-value. Speaking to Information Age, Robert Schmid, chief IoT technologist at Deloitte, gave an example of a plastic manufacturer client that planned to build a new production line to satisfy demand for a specific product. However, by connecting a variety of processes with IIoT devices and overlaying analytics, Deloitte were able to help increase the manufacturers throughput by almost 10%, as well as save £20 million by not building a new manufacturing line.

Towards proof-of-value: A tale of IIoT maturity

DIVERSE USE-CASES EMERGE

Manufacturing turns out to be the tip of the iceberg in terms of live IIoT applications, with significant traction in oil and gas, mining, utilities and agriculture adding fuel to the fire. One example via McKinsey is of an anonymous top ten global energy company using IoT applications and devices as part of a broader programme of process and technology upgrades, which has resulted in a 33% reduction in unit production costs over five years. According to the analyst firm, the enterprise saved more than $9 billion in capital costs, and in addition deployed IoT analytic tools to assess drilling data, which resulted in increased yields from existing mature oil wells.

UTILITIES SEE THE VALUE

Another early adopter, GE, has been developing IIoT solutions to the challenges of renewable energy generation, attaching sensors to wind turbine blades to finesse blade angles in order to maximise efficiency in changing winds. Feeding the overall windfarm data into efficiency analysis tools meant that the economic loss from downtime for each turbine could be used to drive maintenance schedules, enabling engineer time to be used more effectively.

A slightly more left-field IIoT pilot launched recently is tracking water leaks in Kent, UK. South East Water has partnered with Vodafone's low-power NB-IoT network to deploy digital water meters, sensors and acoustic loggers on underground mains water pipes. This will enable the system to `listen' for escaping water within the network to determine when leaks have occurred and pinpoint the precise location. The move may not be entirely unprompted, as UK utility watchdog Ofwat has demanded that all water companies reduce water leakage by 15% by 2025.

HEALTHCARE DATA ANALYSIS DELIVERS

Philips has been actively piloting IoT in healthcare devices for some years, and has migrated from proof-of-concept towards proof of value as a result of analysing IIoT data garnered from the firm's ultrasound and CT scan machines. The data harvested by Philips showed that healthcare providers waste significant amounts of time recalibrating CT machines between head and abdominal scans, and used this information to create scheduling software to ensure the number of recalibrations are minimised.

IIOT MATURITY BECKONS

In short, IIoT is maturing fast, and while enterprise scale is clearly a factor in forging successful applications and value chains, these early successes should serve to anchor standards and blaze a trail for smaller enterprises and second-generation adopters alike. Another key factor will prove to be the network operators themselves, as they move from beta testing next-generation networks, and into active promotion of commercial packages based on them.

Think big, start small, scale fast. As the technology continues to mature, fast in the context of IIoT is likely to prove very fast indeed.

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