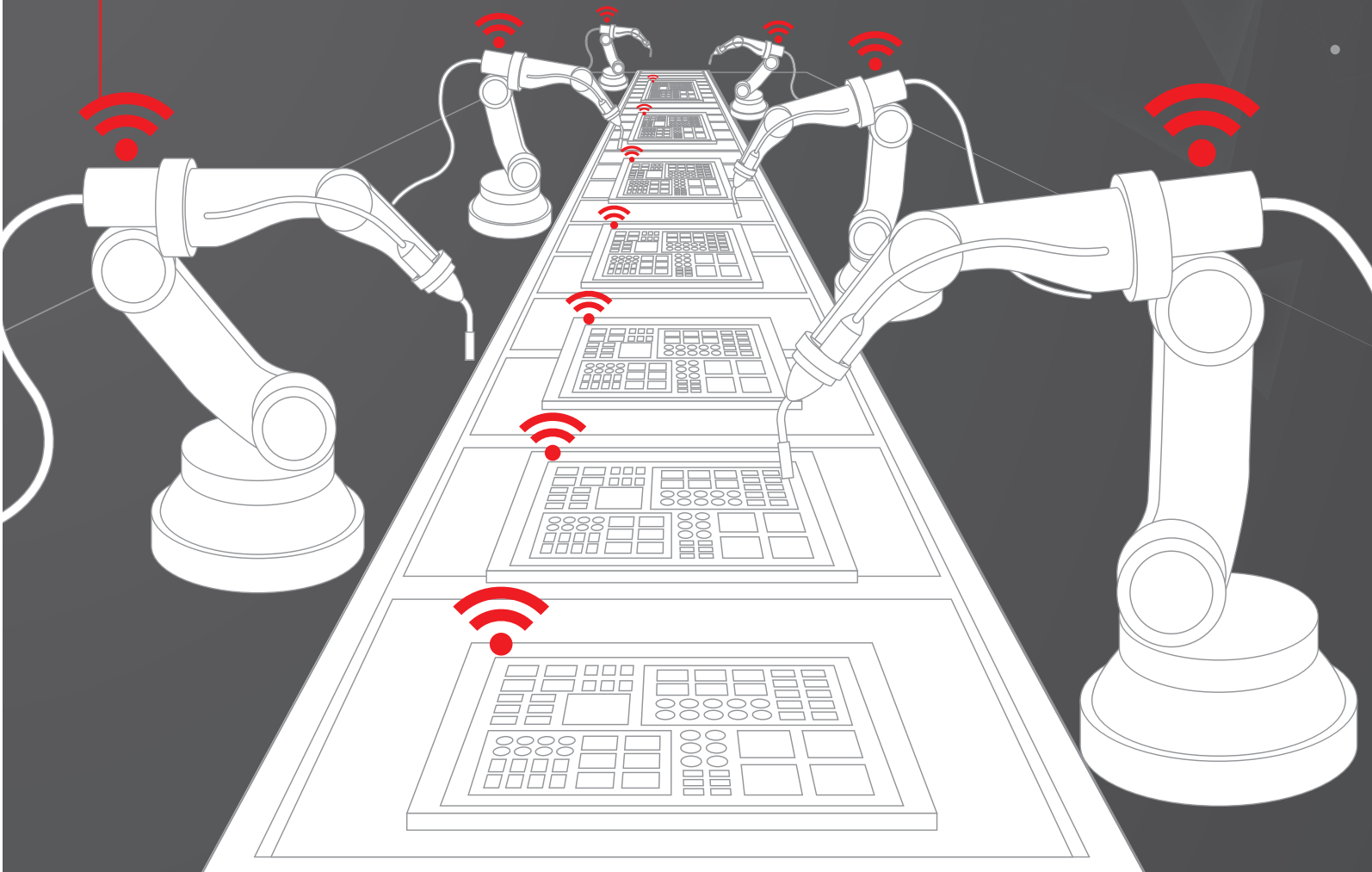
THE FUTURE OF MAINTENANCE ENGINEERING:

How the Industrial Internet of Things (IIoT) will deliver smarter factories with reduced downtime and lower repair costs



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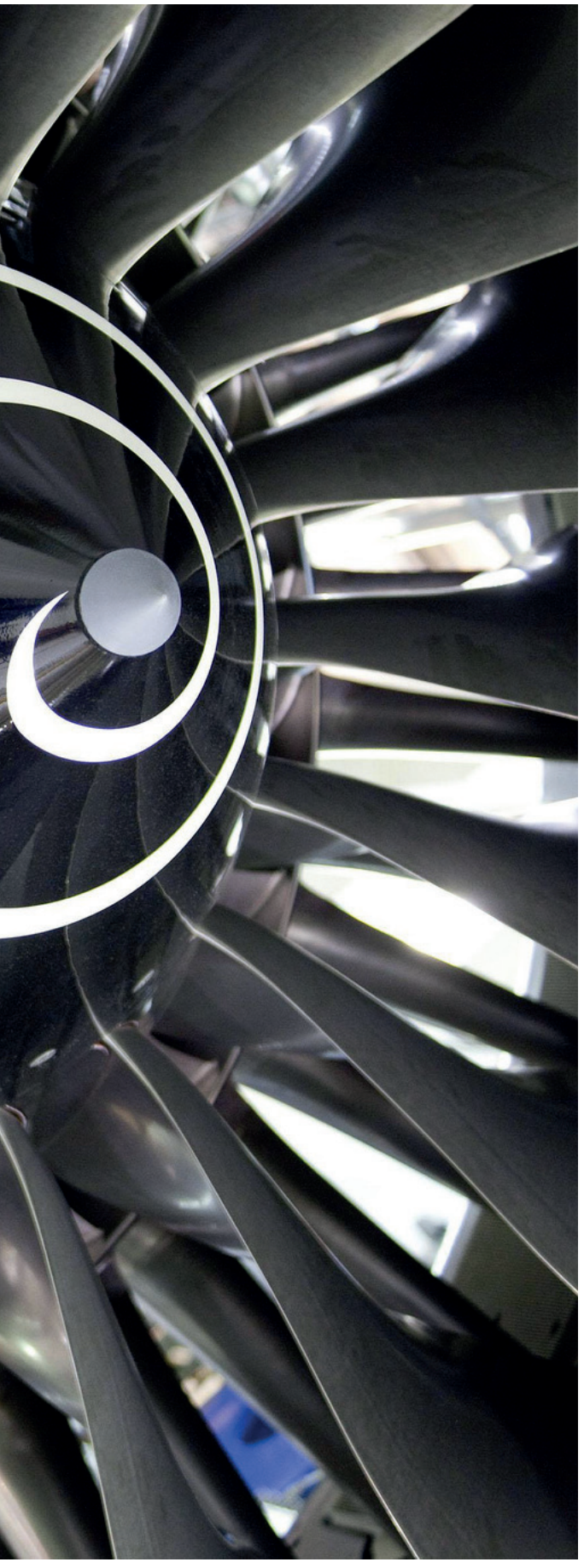
INDUSTRIAL PLANT AND EQUIPMENT

The Industrial Internet of Things (IIoT) will digitize and interconnect factory environments. The fitting of myriad equipment with sensors, and the ability to collect, transmit and interpret data in real-time, will provide companies with far greater visibility of their assets than has ever been possible. This new capability brings the potential for smarter factories based on preventative maintenance methodologies. It will also transform the way that equipment is monitored and repaired out in the field, leading to the emergence of new service-based business models. For maintenance professionals, the IIoT will prompt the use of new technologies such as augmented reality and wearable devices, changing the way they perform their daily roles, and moving them up hierarchical structures.



THE FUTURE OF MAINTENANCE ENGINEERING:

How the Industrial Internet of Things (IIoT) will deliver smarter factories with reduced downtime and lower repair costs

While much of the early focus on the Internet of Things (IoT) revolved around the development of consumer applications such as smart-home heating systems, it has become apparent that even greater potential lies with the promise of improved networked connectivity within industrial settings. Indeed, major industries like manufacturing, logistics, mining, utilities and agriculture have begun to apply IoT systems in imaginative ways, improving the efficiency and productivity of their organisations in the process.

When broadly described, the IoT refers to networks encompassing the use of standard Internet Protocol technologies to connect people, processes, and things to enable new cyber-physical systems. The Industrial IoT can be viewed as a subset of the broader IoT, where these connections exist mainly to improve the efficiency of production facilities and the way that physical goods are maintained. In an industrial context, the 'things' can be a long list of systems and machines that can be fitted with sensors which record data around pressure, level, flow, temperature, vibration and acoustics. This data, combined with sophisticated analytics, can be used to reveal patterns and problems within factories, or with equipment out in the field.

With machines and specialized sensors collecting data at every step of production, the potential gains from the Industrial Internet of Things (IIoT) are enormous. Instead of performing traditional calendar-based maintenance, with the periodic examination of equipment and fixing problems when they occur, the IIoT will help companies capture and analyse data, warning of potential problems before they happen. The tracking of patterns to indicate failure would be an enabler of condition based modelling, unleashing the potential of a truly predictive maintenance regime.

The implementation of IIoT, and the impact it will have on the way that maintenance is carried out within industrial organisations, has become a source of much research and demonstration. The SmartFactory programme, for instance, pulls together companies from across Europe to assess the ways that communication technology can merge with classic industrial processes. The goal of the SmartFactory initiative is to transfer new technologies and concepts into the environment of factory automation. These technologies are constantly being tested on a typical industrial production plant, and then further developed and expanded as required.

One of the partners in the SmartFactory initiative is Festo, which has positioned its Scharnhausen valves, valve terminals and electronics plant at the forefront of IIoT adoption. Sensors have been embedded in a vast amount of equipment across the shopfloor, effectively giving Festo a 'digital map of the plant. This enables it to operate in highly advanced ways. For example, high levels of positional

awareness enable employees to cooperate in safe interaction with a flexible robot, which takes over assembly tasks that are ergonomically disadvantageous. An energy transparency system means all energy flows and consumption in the factory can be tracked. And for maintenance engineers, alongside their usual tools, the tablet represents the principal working tool: with the help of an app, they are able to detect and rectify machine faults as soon as possible and directly on-site.

Another imaginative example of IoT-based architecture inside manufacturing environments comes with the 'Track and Trace' research project, involving Airbus, Bosch, Cisco, National Instruments and Tech Mahindra. In this case, the vision was clear: imagine a factory where all handheld power tools were connected so that their locations could be identified at the touch of a button. Then think of the possibilities that would be offered if those tools were clever enough to work out the immediate needs of the maintenance task at hand, ensuring for instance that those using the tools could only ever tighten bolts with exactly the force required.

Track and Trace envisaged a world where employees wouldn't waste time hunting for the equipment they need to do their job. And it was a world where guaranteed repeatability would mean production and maintenance errors were avoided.

The research partners have brought this seemingly futuristic scenario to life, using the IIoT to drive forward tool connectivity and improve quality and efficiency across manufacturing. The system, which has been trialled at Airbus plants in Europe, uses indoor localisation technologies based on Wi-Fi to determine, to within a couple of metres, the position of a Bosch cordless nut-runner on a shopfloor. The advantages were clear: if the nut-runner was missing, the shopfloor worker could access a human-machine interface to pinpoint its position in the work cell. A second, ongoing phase would enable the tool's position to be combined with the precisely determined location of the component or structure being worked upon, with backend software automatically delivering instructions that specify the exact torque needed to tighten bolts.

Such capability could help manufacturers to ensure repeatability, which is crucial in sectors such as aerospace. Modern civil airliners require 400,000 drilled holes in their structure, with more than 1,000 different tools used to fix nuts, bolts and rivets into their correct positions. There are additional benefits: for instance, the constant collection of data provides companies with a detailed overview of the condition of their tools at all times. This can enable the automation of routine tasks, such as the replacement of worn parts on power tools after a specified number of rotations.

What will the maintenance environment look like in 2025?

"There will be less uncertainty, less firefighting. Maintenance professionals will be directed to maintain machinery by systems that watch over the entire production process and can spot failures further ahead of time and with greater accuracy than humans were ever able to. Costs will go down and performance will go up."

Alexander Hill, co-founder, Senseye

In the future, instead of delivering positioning information to a human machine interface, a Track and Trace system might send data to wearable devices such as optical head-mounted displays. Shopfloor production and maintenance workers might, for instance, be able to look at a part, and receive exact tool positioning and usage instructions to their peripheral vision.

End-user applications of IoT infrastructure

IIoT adoption isn't restricted to the production plants of OEMs. Some blue-chip industrial organisations are already using it to transform the products and services that they offer. Aero-engine giant Rolls-Royce, for example, has long-since embedded its aircraft engines with sensors so that performance data can be collected and transmitted in-flight. If anomalies are detected, maintenance teams

and spare parts can be mobilised for immediate action, once the plane has landed. This approach has enabled Rolls-Royce to expand from an being an aircraft engine maker to become service-based provider, allowing it to charge customers for 'power by the hour'.

Rolls-Royce has now taken its IIoT capability one step further, moving beyond current levels of proactive monitoring of engine health and inflight performance. In a new arrangement with Microsoft, an expanded network of sensors will be combined with digital technologies such as advanced analytics and connectivity to enable Rolls-Royce to collect and aggregate data from disparate, geographically distributed sources, merging information on engine health, air traffic control, route restrictions and fuel usage to detect anomalies and trends. This additional insight will help airlines to fly routes more efficiently, and therefore reduce delays. It's a transformative step in IIoT capability that will allow the aviation sector to integrate much broader quantities of operational data.

The ThyssenKrupp industrial group, meanwhile, is another traditional engineering name that has used IIoT technologies to transform the way it does business. ThyssenKrupp was an early adopter of predictive maintenance, installing its lifts with a suite of sensors that can collect and send real-time data to the cloud, with the information provided used to calculate the remaining lifetime of key components and systems, flagging issues before they occur. Valuable machine data, such as door movements, trips, power-ups, car calls and error codes, is collected from lifts located across the world, providing precise and predictive diagnostics to technical teams in real time, indicating where intervention is required.

A recent addition to this capability has seen ThyssenKrupp work with Microsoft to equip its on-site technicians with mixed reality HoloLens headsets, that will provide them with visual indicators in their field of view to assist with repairs. ThyssenKrupp says that its data-driven approach to maintenance has cut lift downtime by up to 50%, and that the introduction of the mixed-reality headsets has the potential to reduce the average length of its maintenance teams' call-out times to a quarter of current levels.

Both Rolls-Royce and ThyssenKrupp are examples of major companies using IIoT infrastructure on sophisticated, high-tech pieces of equipment. But the increased use of sensor, data collection and connectivity isn't restricted to such expensive pieces of kit. In the professional cleaning sector, for instance, German sweeper and drier manufacturer Kärcher has developed an IIoT-based fleet management service that gives its customers an overview of all machinery, its present deployment and status. Kärcher uses a range of Vodafone connectivity services, which sees SIM cards permanently installed in its machines, allowing them to transmit relevant information such as overview of operating conditions, charging cycles, runtimes, deployment locations and service needs. The data is delivered for display on customer dashboards, delivered through a web-based portal to smartphones or tablets.

The business benefits to end users are clear: cleaning companies can more effectively monitor and optimise the use of their sweeper and drier fleets, knowing where each piece of equipment is at any given time. Communication with the machines is bidirectional, so that machine settings can be made via the IIoT solution if necessary, better matching performance to particular environments. Machine use is increased significantly, as the detection of service requirements

What's the true potential of the IIoT?

"IIoT/Smart Manufacturing offers a golden opportunity for manufacturing to integrate seamless digital technology in effective production processes that should realise greater economies of production, realise improved efficiencies and keep UK industry as a world leader in innovation on the global market."

David Wright, director general, United Kingdom Lubricants Association

and planning of preventive maintenance reduces machine downtime.

The flexibility of IIoT applications, and the multi-faceted nature of its impact on maintenance programmes, is underscored by its use in what previously has been the distinctly low-tech world of pest control. Rentokil has been collaborating with Google and PA Consulting Group to roll out a range of connected rodent control products particularly to customers in the tightly regulated food and pharmaceutical industries. The new digital pest control services use connected rodent devices with embedded sensors and mobile connectivity. The units communicate with Rentokil's online 'Command Centre' and when they've caught a rodent, the technician is automatically alerted while customers are kept informed through myRentokil portal.

In a recent use case, Rentokil used the technology to remotely identify an emerging mouse problem and inform its customer, a large supermarket in the Netherlands, not only that it had a potentially damaging issue in one of its stores, but also precisely where it originated. In consultation with the customer, it agreed an upgrade to the service plan, increasing the service frequency of visits by the local Rentokil technician and targeted this increased activity to maximize impact.

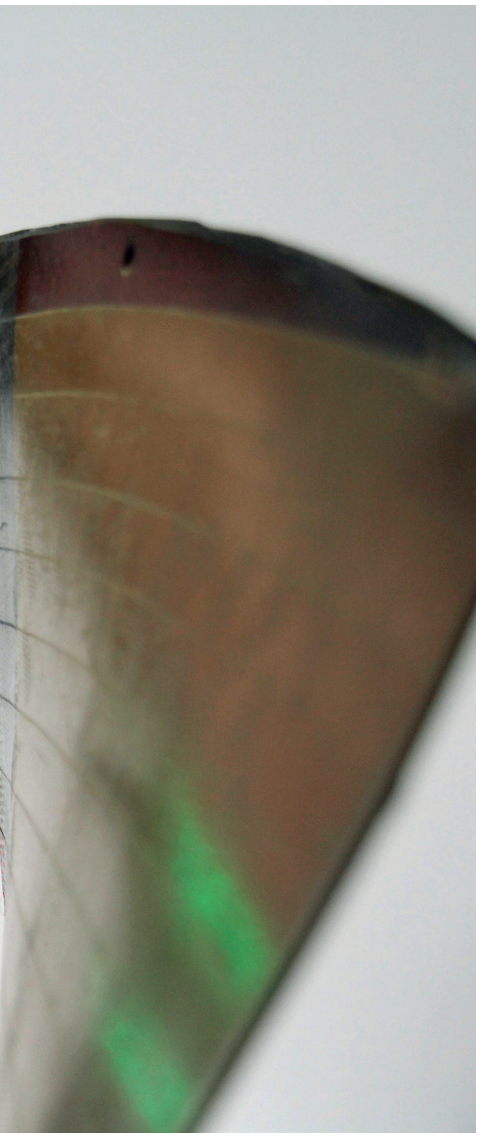
Built on Google's Cloud Platform, and delivered by PA using Agile software, the technology has proved highly scalable. In the field today, Rentokil has more than 20,000 digital devices running in 12 countries which have now sent more than 3 million pieces of data.

How IoT will transform business models

These use-case examples provide clear indication of how IIoT is transforming companies, across myriad industrial sectors. The Rolls-Royce and ThyssenKrupp instances in particular show how it has the potential to change business models, moving companies away from being a traditional supplier of products and towards a more profitable position of being a solutions provider. That transformative journey is commonly referred to as 'servitisation' and involves firms developing the capabilities they need to provide services that supplement their traditional product offerings.

By coupling services to their product offerings, manufacturers put themselves in a far better position to meet the needs of their customers. In return, manufacturers get to offer a full solution, rather than just a product, which in turns brings greater financial stability and stronger customer retention. Essentially, manufacturers do not sell a product but instead enter into an agreement to help customers achieve their objectives. It's about relationships, not transactions. And that will have a huge impact on maintenance frameworks and the role of the maintenance engineer.

ThyssenKrupp is clearly on the road to servitisation. Instead of providing lifts to places like shopping centres as a 'products' which are repaired when they break down, it is starting to servitise what it makes, opening the possibility of getting paid for uptime of even for each lift cycle. So, instead



of making money repairing products when they have stopped working, manufacturers in the people-moving business enjoy bigger margins from the reliability of what they offer.

Potentially, then, servitisation could have a transformative effect on wide-ranging industrial sectors. According to Oxford Economics' Manufacturing Transformation Report, last year the share of worldwide manufacturers using performance-based service contracts jumped to 65 percent. Meanwhile, almost three quarters of manufacturers now rely on services as a key product differentiator. Also, as we enter the era of the IIoT where products will be able to alert service technicians about their requirements in increasingly predictive ways, these sorts of business relationships are likely to get smarter and more rewarding.

Servitisation, then, can effectively be seen as perhaps the most important means of monetising the IIoT. It's a business model that makes sense for the OEM and the end-user. Makers of equipment, be it lifts, pumps, aero-engines or bearings, are rewarded with a more locked-in business model which sees them better rewarded for the reliability of their products, while customers avoid forbidding upfront capital expenditure costs. Ultimately the producer of the goods manages more of the maintenance, enabling the customer to concentrate on its core business activity, whatever that might be.

Servitisation also has the potential to lead to the design of better performance next-generation products. Data collected by IIoT architecture from real-world operating conditions can be looped back into an OEMs research and development function, leading to smarter design and a shortening of time-to-market for new products.

Maintenance engineers embrace new ways of working

If IIoT is changing business models, there is no doubt it will also transform the role of the maintenance professional. Improved connectivity isn't restricted to equipment and devices – it also pulls individuals into smarter networks, with the potential of more efficient working. With a general trend towards having more engineering teams across multiple sites, IIoT can give better visibility of vital maintenance resources,

How will IIoT change the role of the maintenance engineer?

The role of the maintenance engineer and the production engineer will start to merge, with individuals concentrating on solutions and platforms rather than focusing on a very technical and specific task. That's going to be driven by use of technologies such augmented reality. People might start to become more generalist in the work that they undertake.

Chris Richards, senior business environment policy adviser, EEF

allowing more intelligent and effective deployment. The 'thing' in IIoT is not just about assets, it's also about people.

Historically, much maintenance data has been stored in vertical silos – on legacy systems or in weighty instruction manuals. The digitisation of the manufacturing environment allows for more flexible methods of getting the right information to right person at the right time. The increasing use of digital devices in factories and out in the field means maintenance professionals can be provided with equipment documentation and service history in a timelier manner, and at the point of use. Maintenance professionals want to be solving problems, not wasting time trying to source the technical information that they need.

This is bringing advanced technology such as augmented reality - the supplementing of real-world views with computer-generated graphics - to the fore. Instead of using a service manual to assess a piece of kit, with augmented reality the maintenance worker could hold an iPad in front of a section of the machine, with the repair instructions overlaid as required.

The application of augmented reality in maintenance environments could be a game changer. According to recent research carried out by Deloitte Consulting, such technologies will be rapidly adopted by enterprises in the next 18 to 22 months, with field service as an industry poised to benefit most. Some companies have already recognised the potential. Bosch Rexroth, for instance, has developed an augmented reality based programme for remote technical assistance for industrial hydraulics.

The customer's maintenance team connects via software on a smart phone, tablet or optional smart glasses, and works directly with an in-house expert from Bosch. The service expert sees what the on-site operator sees through the camera, and video and audio sync perfectly even with low bandwidth. Smart glasses enable hand-free communication, and the expert can transmit drawings, gestures or additional instructions.

US software giant PTC has emerged as one of the key suppliers of augmented reality technologies, through its recent acquisition of Vuforia from Qualcomm Connected

Experiences. When coupled with PTC's IoT and analytics platforms, Vuforia will provide maintenance professionals with new ways of monitoring products, and to instruct operators and technicians in the appropriate service methods.

For instance, through the use of a mobile device such as an iPad, the Vuforia software would be able to display data such as flow rate or vibration levels in augmented reality over a real asset, providing the maintenance professional with valuable troubleshooting information. Then by applying a 'viewmark' to a particular asset, contextual repair documentation can be delivered. This is all done in a visual manner in augmented reality.

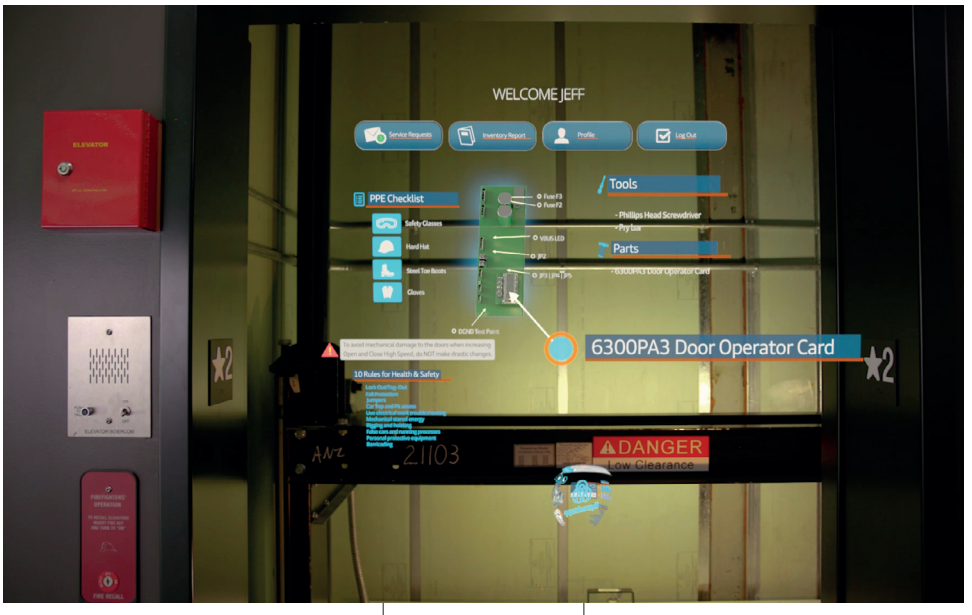
At the moment, such technologies are delivered through a tablet such as an iPad. But in a real-world maintenance environment, it's not ideal to keep picking up and putting down such a fragile device. PTC predicts a move to wearable technologies such as augmented reality glasses, with graphics presented in line of sight.

From maintenance engineer to reliability engineer

The emergence of IIoT infrastructure and the introduction of new technologies such as augmented reality and wearables will ensure that the role of the maintenance professional will change dramatically. The move towards predictive methodologies means the role will become less about how quickly maintenance staff can fix assets, and much more about preventing equipment from failing in the first place. Reading data and taking decisions is not the same profile as changing parts on a machine.

What's happening, then, is that maintenance engineers are morphing into reliability engineers. With the change in title and job description comes a move up the hierarchical chain, with maintenance workers holding more influence as access to wider data streams puts such individuals at the heart of business models.

Technology will also ensure that maintenance engineers become more generalist. Instead of having expert knowledge in a very narrow band of technologies, visual-based support systems such as augmented reality means they will be able to deal with a wider portfolio of equipment. In the future, responsibilities are likely to merge as maintenance engineers focus less on particular products, and more on platforms and solutions.



Such a movement in roles and responsibilities will require careful change management. No business transformation is easy, and for staff to fully embrace and benefit from the increased digitisation of industrial sectors there will be a need for education and training. The OECD(organisation for economic co-operation and development) economic group is currently conducting a review of how the emergence of the IIoT might impact job numbers in areas such as maintenance. It's difficult to predict what the outcome will be: on the one-hand, it could be argued that more predictive methodologies will lead to higher levels of automation, increasingly cutting humans out of the loop. But, there is also a belief that new technologies and advanced ways of working will remove maintenance professionals from low-level tasks, freeing them up to perform higher value activities such as data analysis and production planning. New technology such as augmented reality could usher in more efficient ways of working, enabling the role of the maintenance professional to move into other areas and for individuals to deliver more value to their employer.

Conclusion

In conclusion, it's clear that the IIoT, and the technologies it supports, could transform maintenance engineering. It is already leading to the creation of smarter factories where production managers have far greater visibility of plant assets. Effective use of IoT technologies will allow firms to capture and analyse data, warning of potential problems before they happen, and therefore unleashing the true power of predictive maintenance. It could reduce downtime, cut service and repair costs, optimise products and processes, and lead to far higher levels of customer satisfaction.

That's not to say it's going to be an easy journey, without challenges along the way. IIoT adoption is an evolution, not a revolution, and for many organisations it will involve a series of small steps that will deliver incremental benefits. But the pace of change is quickening, as the increasing use of standards makes it easier to embed intelligence in a wider range of products and machines. In many ways the development of IIoT technology is out-pacing industrial mindsets, and that could act as a major barrier to implementation.

It's not just about technology, either. IIoT adoption will require a cultural shift within organisations, depending on total buy-in from the boardroom to the shopfloor. Many maintenance professionals will have grown used to performing their role in a certain way. Advancement often provokes resistance, and that will require careful change management if IIoT is to fulfil its potential. ■

How is your company preparing for the emergence of the Industrial Internet of Things?

"Smart plastics are becoming an important technology for igus. Our cable, energy chain and linear bearing products can now be embedded with intelligence within the motion plastics via the addition of sensing, monitoring and communi-cations. Using smart plastics, customers can increase plant availability, maximise uptime and reduce costs through condition monitoring and predictive maintenance."

Matthew Aldridge, director, igus

Glossary:

Western Business Exhibitions acquired Maintec in May 2016 and immediately committed itself to driving enhanced insight and educational content for Maintec delegates and visitors.

Maintec itself first began in conference format and while some 40 years has passed since those beginnings, the expectation on exhibition organisers to deliver the highest quality of educational content has never been higher.

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