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Smart Production

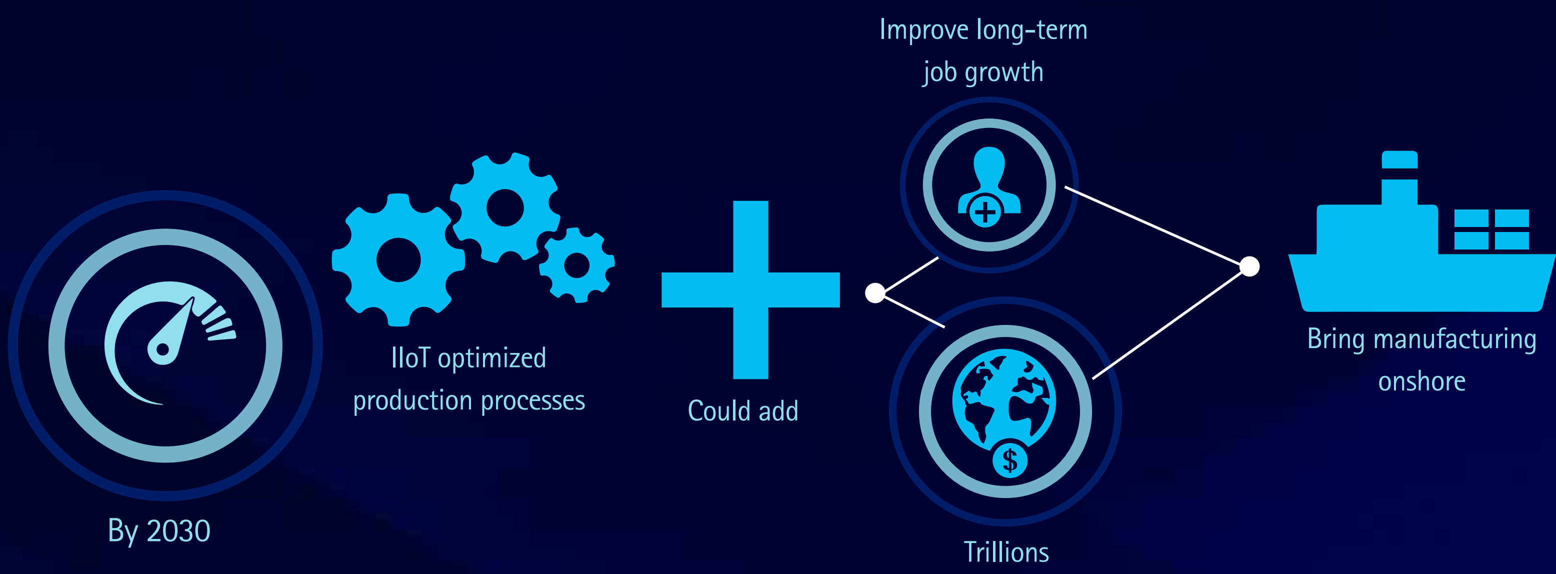
Finding a way forward:

how manufacturers can make the most of the Industrial Internet of Things

The Promise

A universe of intelligent products, processes and services that communicate with each other and with people over the Internet.

That's how Accenture defines the Industrial Internet of Things (IIoT), which promises to be the most transformative industrial revolution yet for manufacturers, changing the way they think about resource allocation, production processes, materials handling, and the workforce.



Thanks to the greater visibility, more efficient data utilization, and tighter integration of underlying systems that the IIoT delivers, manufacturers will be able to boost production efficiency and increase both workforce flexibility and product quality. In time, the IIoT will also facilitate the creation of entirely new functionalities: products, processes and services that open new revenue streams, transform business models and drive measurably better outcomes for customers.

Indeed, we believe the IIoT will enable industries that collectively account for almost two-thirds of global output[1] to benefit as much from digital transformation as the media and software sectors already have done. By 2030, the optimized production processes that the IIoT heralds could add trillions of dollars to the global economy and significantly improve long-term job growth[2]—in part by bringing manufacturing back onshore.

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All this will, of course, take time. When Accenture recently surveyed more than 1,400 global business leaders, 84 percent confidently asserted that they could create new income streams from the IIoT. Yet 73 percent still hadn't made concrete plans to do so, and only seven percent had developed a comprehensive strategy backed by matching investments.[3]

Furthermore, the pace at which manufacturers progress towards smart production will vary greatly, though careful planning can accelerate it (see *The Pace of Progress,* page 5). And in our experience, companies that successfully extract value from *any* new technology are not only detailed forward planners. They also follow a roadmap flexible enough to allow them to change course when circumstances require it and pursue alternative routes to their ultimate destination.

Smart factories on a large scale—distributed, self-organizing, highly automated, and demand-driven—are still years away. But some basic building blocks of smart production are already here. Embedded sensors and control mechanisms now power most shop-floor machinery. And thanks to the convergence of Operational Technology (OT) with Information Technology (IT), these machines are increasingly connected with production management, manufacturing execution, logistics and enterprise planning systems. As a result, manufacturers have timely and continuous visibility into the production process. By applying advanced analytics to the data their systems generate, they can also identify and predict performance bottlenecks and make smarter decisions about how to improve factory operations, manage workforce and supply chain risks, and enhance the product design process.

In the future, manufacturers will reap even greater rewards from the highly automated, end-to-end integration of production that the IIoT enables. Incoming parts and materials will interact automatically with intelligent machines, driving the cost-effective assembly of customized products. New product and service offerings that augment physical products with services will tap into new revenue streams. And enhanced connectivity will significantly strengthen customer relationships.

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7%

have developed a comprehensive strategy

The Pace of Progress

The rate at which manufacturers progress towards smart production can be accelerated by considering the following key factors:

Level of investment

All these transformations come at a price. Modernizing and retrofitting equipment can be a costly proposition. And so too, of course, can the new facilities that some manufacturers may opt for. The key to success will be solid business cases, based on a set of use cases, so that the return on investments can be easily identified and measured.

Ability to align OT and IT

Manufacturers that have started the alignment process will be better positioned to take full advantage of intelligent technologies. But some may organize operations, planning and engineering separately, which will make it difficult to integrate processes even if they've already adopted technologies that make it easier to integrate supporting IT systems. Many traditional OT systems are proprietary and closed so significant investment will be needed to facilitate their participation in a larger, open IT ecosystem. It will also be critical to define governance between OT and IT (especially on security policy) early in the process.

Affinity for technology change

Manufacturers will have to embrace new technologies and change their processes in order to reap the benefits of the IIoT. They will require infrastructure that enables them to commit both people and equipment. Cloud services can accelerate delivery of new types of applications and add-on services. Connected equipment, devices and wearables can help people interact with their machines and work together in new and different ways. Manufacturers who embrace these new technologies quickly and easily will be better positioned to compete.

Speed to reskill workforce

More complex skills such as equipment development, maintenance and repair will be more in demand. New technologies will, of course, allow manufacturers to harvest talent globally and round the clock. But their ability to manage the re-skilling and retraining of their workforce will be a critical determinant of how swiftly they adopt these technologies.

And the use of workforce enablement devices such as wearables, which guide workers remotely based on their experience level, will gain traction.

Agility in deploying industrial security solutions

As industrial environments move to open protocols, wireless sensors and connected operators, and as OT and IT systems integrate, security issues will be amplified. What's more, resolving them can't wait for the next software patch. Traditional field devices will need replacing with more sophisticated solutions. And increased vigilance around security will be paramount.

The Journey

Our research suggests that the evolution of the IIoT will follow four distinct phases.

Figure 1.

1. Operational Efficiency

- Asset Utilization
- Operational cost reductions
- Worker productivity

2. New Product & Services

- New business models
- Software-based services
- Data Monetization

3. Outcome-based Economy

- Pay-per-outcome
- New connected ecosystem
- Platinum-enabled market place

4. Autonomous Pull Economy

- Continuous demand sensing
- End-to-end automation
- Resource optimization and waste reduction

Operational efficiency very often lays the foundational business case for IIoT adoption. Increasing efficiency by just one percent a year could add trillions of dollars to global GDP over the next 20 years.[4]

And early adopters are already realizing quick wins in terms of higher productivity, lower operating costs, better working conditions, and effective machine utilization.

Case in point: ThyssenKrupp AG, uses networked equipment sensors to identify and predict maintenance issues, which reduces unscheduled down time and helps prevent unnecessary elevator repair trips.[5]

Predictive asset maintenance can:

Save up to

12%

in scheduled repair costs

Reduce overall maintenance costs by up to

30%

Result in up to

70%

fewer breakdowns

The immediate returns on investment in such capabilities are easily measureable, making the business case easier to justify. Predictive asset maintenance, for example, can save up to 12 percent in scheduled repair costs, reduce overall maintenance costs by up to 30 percent, and result in up to 70 percent fewer breakdowns.[6] Furthermore, operational efficiency builds the underlying infrastructure that enables manufacturers to advance in their IIoT journey, adapting their offerings and driving new revenue opportunities.

Ultimately, as the IIoT becomes more ingrained in production processes, and new product and services business models (Phase 2) morph into the delivery of measureable outcomes (Phase 3), a pull-based economy characterized by real-time demand sensing enabled by intelligent machines, and highly automated and flexible production and fulfillment networks will emerge.

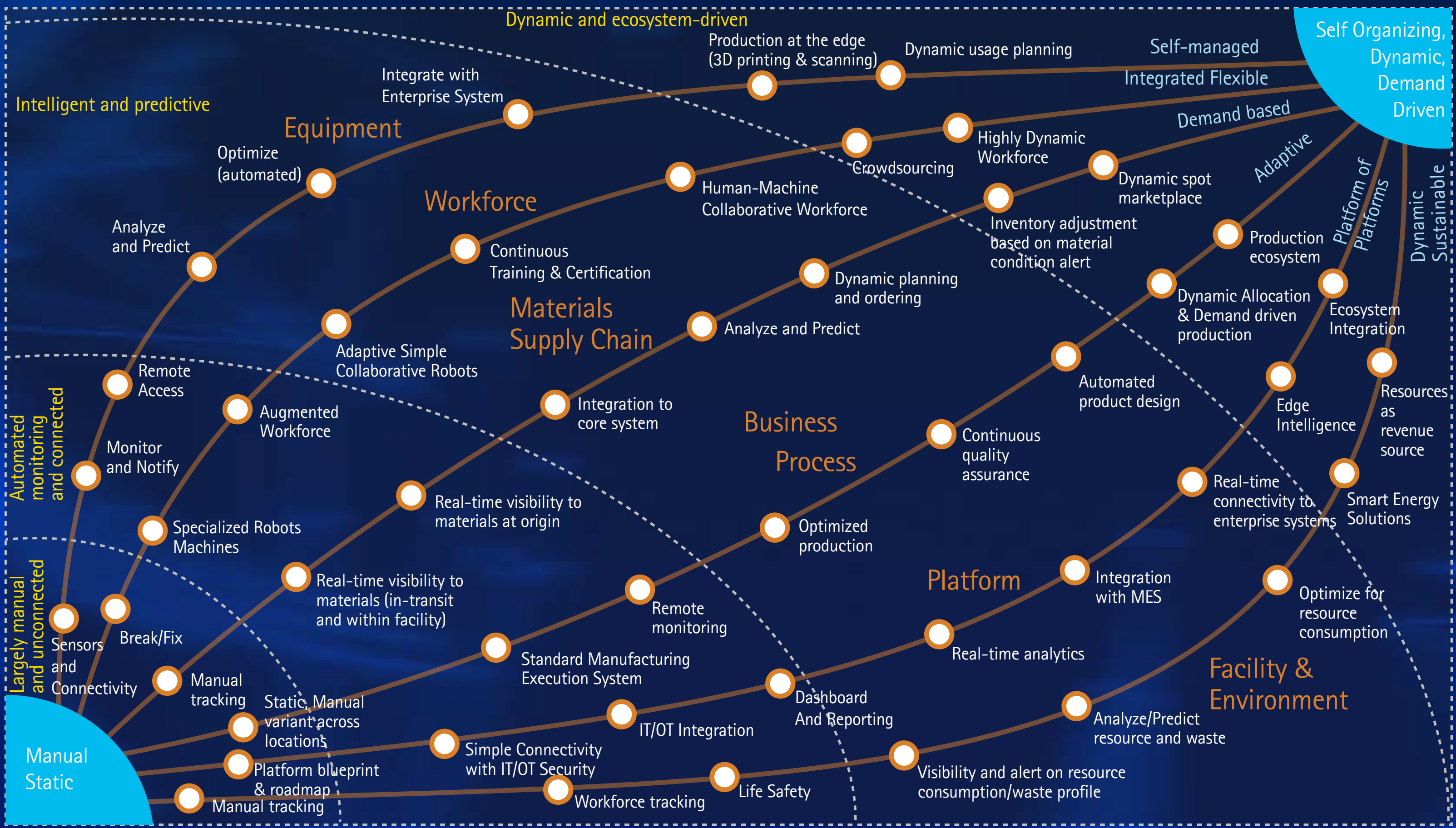
As products become more intelligent, so too will factory floors. Automation will accelerate, dramatically changing the face of the manufacturing workforce, along with the skill sets required to succeed in a significantly more automated economy. Consider, for example, how Rio Tinto is optimizing the use of critical expertise by using control towers to deal with exception management and execution deviations in its production processes. Skilled equipment operators sitting in the mining maven's remote command center in Perth, Australia, can work alongside data analysts and engineers to orchestrate the actions of drills, excavators, earthmovers and dump trucks across multiple mining sites.[7]

"Operational efficiency builds the underlying infrastructure that enables manufacturers to advance in their IIoT journey, adapting their offerings and driving new revenue opportunities."

The Adoption Pattern

Each organization will chart its own path toward the smart factories of the future. But in Figure 2 below we identify six key dimensions that many might consider.

Figure 2.



1. Equipment

The journey starts in factories where equipment is still unconnected, fixed only when it breaks, and where maintenance is scheduled regardless of load. Such unpredictable assets are costly—both financially and in terms of reputation. But by making equipment intelligent enough to self-manage and collaborate with the rest of the manufacturing system, manufacturers can drive overall reliability, predictability and optimization. This multi-step journey includes:

Monitor and notify

Retrofitting existing equipment with sensors to increase visibility into its condition and identify threshold violations so maintenance can be scheduled pro-actively. Vibration measurement and analysis, infrared thermography, oil analysis and tribology, ultrasonic and motor current analysis can all be applied to rotating equipment and other moveable machine parts, though interviews with workers responsible for maintenance can also help identify some conditions. Sensors can then be connected to a larger network to allow remote monitoring, thus enabling manufacturers to predict problems, whilst optimizing resources beyond the immediate facility.

Analyze and predict

The baselines created by condition monitoring, combined with analytical techniques, can help manufacturers correlate current and historical data to predict potential equipment failure, and begin a mitigation process. In Europe, for example, a large utility company is using sensors and analytics to anticipate pipeline leakage in real-time. Maintenance work can be scheduled at the appropriate time, not only significantly reducing unscheduled down time, but also the costs associated with ordering replacement parts urgently and bringing in unscheduled maintenance workers at short notice, which is typically charged at a much higher rate.

Optimize

By integrating predictive maintenance data with Enterprise Resource Planning (ERP) systems to optimize workflow scheduling, manufacturers can help ensure that the impact of equipment unavailability is minimized by dynamically adjusting production run. For example, Taleris uses this technology to predict aircraft maintenance faults and thus minimize flight delays.[8]

Production at the edge

By helping create spare parts Just In Time (JIT) and on-demand at the equipment edge, 3D printing helps eliminate both outages and the need to maintain a spare parts inventory. GE's oil and gas division is poised to pilot production of 3D printed metal fuel nozzles for its gas turbines, for example.[9] While Ford Motor Company's use of 3D printing to make prototypes of such auto parts as cylinder heads, brake rotors, shift knobs, and vents shows how this digital technology also enables mass customization and ultra-postponement (delaying the manufacture of the finished product until the customer is ready to purchase).[10]

"By making equipment intelligent enough to self-manage and collaborate with the rest of the manufacturing system, manufacturers can drive overall reliability, predictability and optimization."

2. Workforce

Rising wages, even in traditionally low cost countries, have led manufacturers to focus on efficiency in processes and workforce through automation, augmentation and collaboration (including automated manufacturing and next-generation robotics). Assigning tasks manually with workers operating on a fixed schedule independent of production needs is slow, expensive and quickly outdated because it limits flexibility. But creating a blended workforce that comprises humans and machines working collaboratively and dynamically can deliver outcomes that neither could produce alone. This journey includes:

Augmented workforce

Giving the workforce mobile and wearable technologies such as Daqri's helmet or Apple's Watch can boost employee efficiency on the factory floor by providing real-time access to such data as status, alarms and instructions, while freeing the hands to hold tools or equipment. These technologies also provide a powerful new level of video collaboration as more experienced colleagues can see exactly what shop-floor technicians are seeing and provide guidance. Manufacturers can assign new tasks to their employees quickly and dynamically and deliver JIT training.

Human-machine collaborative workforce

Designed to be easily trained (i.e. to learn by observation) and to mingle and work collaboratively with humans, next-generation robots have been used for elder care, hospitality, and concierge services. But they can also perform simple and repetitive tasks on the factory floor. What's more, their price continues to drop. Rethink Robotics' Baxter robot, for example, which helps Vanguard Plastics with sort-and-pick-type applications, now costs around US$25,000.[11] There are also several thousand robotic workers in Amazon's warehouses, moving shelves and bringing them to human-operated packing stations.[12]

Highly dynamic workforce

Manufacturers with a blended workforce will need to become much more dynamic and agile. Integrating the human and machine workforce with the rest of the enterprise will further optimize resource allocation. Dynamic scheduling systems will help manufacturers avoid underutilized assets, missed deadlines, unplanned shutdowns in safety critical operations, and even reduced profits. Moreover, by enabling them to schedule and dispatch operations in real-time and respond to sudden changes, such systems will deliver significant competitive advantage.

3. Materials Supply Chain

Manufacturers already use JIT inventory and supply-chain management techniques to reduce the costs and waste associated with maintaining a huge backlog of inventory. By leveraging the IIoT to enhance materials management, not only across the factory floor but also between supply chain partners, they can gain additional efficiencies. An optimized system requires an integrated, agile and efficient materials handling process that can provide materials in real-time and on-demand. There are three key stages in achieving such a needs-based system:

Real-time visibility to materials

RFID tags have been used to help connect partners and move goods from a logistics and supply chain management perspective across organizational boundaries. But they can also be used on the factory floor to track work-in-progress materials, route those materials efficiently, enable parts requirements, handle JIT replenishments, and manage the availability and utilization of assets. When coupled with other data regarding materials as they flow through the factory and eventually to target customers, RFID tags and other tracking mechanisms can provide plant operators with insights that enable them to process raw materials efficiently, right through to the finished product.

Integration to core system

Integrating the data obtained by real-time visibility into the availability of materials across the entire supply chain with Enterprise Resource Planning (ERP) systems will allow manufacturers to schedule the appropriate production run with the right set of configurations and workforce. Further changes to materials availability can be quickly reflected to minimize unnecessary interruption and delay.

Analyze and predict

Armed with additional external data such as weather conditions, price volatility, traffic conditions, and potential strikes, manufacturers will be able to identify and predict what materials they need at the right time, based on the anticipated production run.

4. Business Process

Manufacturers have also been improving the efficiency and quality of their business processes by abandoning static manual management and tracking people, materials, tasks and products in favor of highly integrated, optimized systems that are dynamically planned and executed in real-time. Manufacturing Execution Systems (MES), for example, help streamline factory-floor operations by managing and monitoring all work-in-process. They provide real-time visibility, enable traceability of both materials and products throughout their lifecycles, optimize workflow to ensure lower lead times, facilitate corrective actions for defective products, and optimize plant operations for effective use of resources and assets.

By integrating MES with ERP systems, manufacturers can also orchestrate work orders and other resource needs. The factories of the future, however, will need to be even more agile, adjusting swiftly and effectively to changes in customer demand while still controlling costs and quality. The following three steps show how manufacturers can go beyond MES:

Continuous quality assurance

By enabling cross-correlation of multiple data streams, new technologies promise to make quality assurance much less time consuming and expensive. Sight Machines, for example, integrates visual image inspection with statistical process control (SPC) of plant processes and other data to deliver a real-time solution. Its vision tests can be written in a matter of hours and updated remotely; the resultant data run through a variety of reports, and trends measured against industry best practice.[13] As a result, quality issues can be addressed immediately, rather than waiting for the completion of the batch.

Automated product design

The smart factory extends well beyond its floor. Intelligent products can tell designers how customers are using them and thus enable improvements. Automated design software promises to accelerate this product development process. Autodesk Inc., for example, is working on a system called Dreamcatcher, which allows designers to input specific functional requirements, leverages evolutionary algorithms to recommend the best-performing option for their needs, and permits them to test it before creating a physical prototype.[14] In combination with 3D printing, intelligent, goal-directed design will enable manufacturers to bring new and highly customized products to market at an unprecedented rate.

> "The smart factory extends well beyond its floor. Intelligent products can tell designers how customers are using them and thus enable improvements."

Dynamic allocation and demand driven production

Adjusting to changes in product demand requires investment in agile processes that can scale up or down, as needed. Real-time automation and process integration across the supply chain enables the necessary responsiveness. Coupled with processes that support mass customization, it can help manufacturers meet the highly specialized build-to-order demands of their customers.

5. Platform

A manufacturer's ability to deploy a platform that facilitates the integration of IT and OT will determine how quickly it achieves IIoT transformation. The platform will facilitate the transfer of IIoT data from sensors and devices for centralized data analysis, decision-making and use by enterprise applications in the cloud. In time, however, it will evolve to support distributed decision-making at the level of IIoT devices at the edge, and enterprise applications in the cloud. The platform journey includes the following steps:

Simple connectivity with IT/OT security

Today's business operators have no comprehensive visibility into operational risks across their infrastructure. Such traditional security solutions as Security Information and Event Management (SIEM) and Intrusion Detection Systems (IDS) operate in a single domain (IT or OT) and require signatures and rules to detect malicious activity, making it extremely difficult to monitor a converging infrastructure that is becoming a target of increasingly sophisticated attacks: witness the STUXNET and BlackEnergy campaigns. Addressing such threats effectively requires a platform that can efficiently deploy, authenticate and manage a large number of sensors and devices, enhance the visualization of events and the relationships of incidents, establish event or alert correlation across domains and heterogeneous infrastructures, and develop real-time detection and response algorithms to adhere to the mission-critical constraints of the IIoT systems.

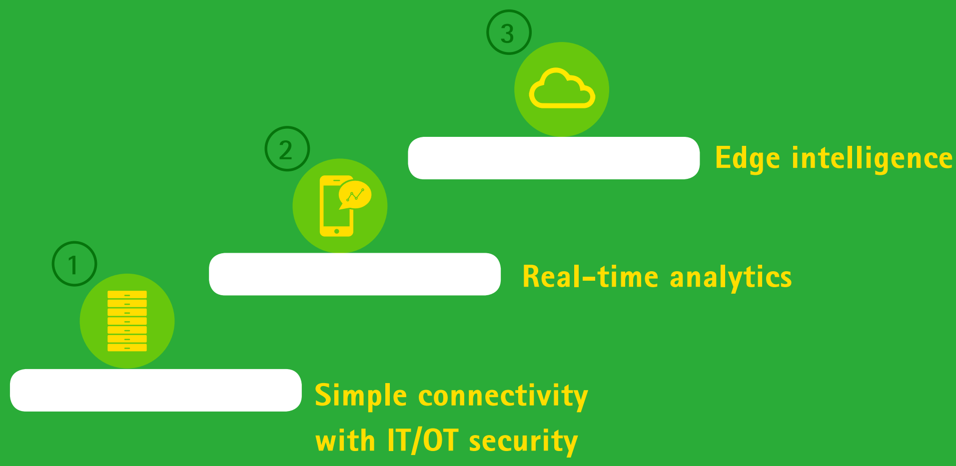
Real-time analytics

With millions of intelligent devices streaming huge volumes of data continuously, it's imperative that the IIoT platform, which must deal with data ingestion, processing, storage and predictive analytics in order to provide meaningful and actionable insights in a timely manner, operates in near real-time. Indeed, such sophisticated analytics as a real-time pipeline leakage capability requires a streaming analytics platform that delivers meaningful and actionable insights from processed data in a matter of seconds.

Edge intelligence

Initially, IT/OT integration will involve the movement of IIoT data to the cloud for further processing and analytics. But limited network bandwidth, energy availability, and security considerations may necessitate a decentralized distribution model, which, by delegating analytics, intelligence, and decision-making capabilities to edge devices with the contextual ability to process and analyze data independently, and communicate with other devices to accomplish tasks, could deliver better accuracy, improved performance and timeliness. Edge computing will allow systems to degrade gracefully, work autonomously and deliver information to decision-makers faster and more efficiently. Manufacturers will be able to put intelligence where it makes the most sense: in the field area network, in the edge device itself, or at the enterprise level. Analytics and decision-making will no longer always take place in the back office.

The platform journey



6. Environment and Facilities

Environmentally conscious manufacturing facilities strive to make the most efficient and productive use of raw materials and natural resources, as well as to minimize the adverse impacts on workers and the natural environment. Plant operators' first priority is to ensure employee safety, but they can also take steps towards understanding resource consumption in the manufacturing process. And as they become more aware, they can optimize the production process to minimize its impact on the environment, and even generate revenue from their procedures.

Life safety is a top priority

Digital technologies that tell plant operators where their employees are at all times, alert them when they are being exposed to hazardous environments, facilitate safe evacuations, and deliver efficient response to emergencies are critical components of plant solutions. Accenture, for example, together with AeroScout, Cisco and Industrial Scientific, has developed an innovative new technology to detect gas exposure and alert plant managers to remote safety incidents.[15]

To a degree, however, a facility can be considered a sophisticated piece of Equipment and therefore undertakes a similar journey.

Visibility into resource consumption

Visibility into plant-level energy consumption, waste production and the associated costs can enable plant managers to adjust production and optimize energy use. Such smart solutions as measurement systems, advanced modeling and scheduling tools, and automated environmental controls can all help forecast energy usage and avoid peak periods. A significant amount of energy is wasted when machines are idle. But when one vehicle assembly line using laser-welding technology systematically powered down inactive parts, it cut energy consumption by 90 percent during production breaks and achieved an overall reduction of 12 percent.[16] Such approaches can also be applied to resources like water, as well as to waste management.

Optimizing for resource consumption

The ability to respond to resource consumption alerts and change consumption patterns requires highly agile manufacturing processes. It also requires collaboration with utilities providers to conduct what-if analyses that forecast resource usage and thus help avoid periods of peak use by shutting down equipment and dynamically rescheduling workflows. By integrating energy use into the resource supply value chain a manufacturer can even become a "prosumer" of energy: generating revenues by giving back to the grid.

Seizing the Opportunity

Plainly speaking, making the most of the IIoT poses major challenges. And right now, few manufacturers are ready for them. But in this point of view we have endeavored to explain the promise of the IIoT, and how it facilitates smart production. We have also suggested six key dimensions for consideration, and identified the factors that can accelerate progress. Manufacturers will confront some difficult choices about which process options to pursue. But the time to start considering them is now.

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