internet of manufacturing.

Business Conference

IoT / SECURITY / DATA ANALYTICS
IoT: A New Age for Manufacturing

The Internet of Things (IoT) offers transformative rather than incremental change, with the ability to reshape whole industries. According to Accenture, IoT will add trillions of dollars to the global economy over the next fifteen years. A recent study by Cisco also found that the manufacturing sector will drive 34% of total IoT value in the overall economy over the next ten years.

Yet gains are already being realised: a survey by TATA Consultancy Services indicated that manufacturing companies that have invested in IoT technologies saw an average of a 28.5% increase in revenues between 2013 and 2014. The study also revealed that the same companies expect a 27.1% increase in revenues over the next three years.

Behind the numbers, the reasons for these gains are that IoT enables business transformation through connectivity to IP networks and resources. It offers a way to change the basis of competition, allow companies to innovate, realise gains in productivity and efficiency, and grow revenues. In the new age of industry, customers expect more than an end product that is not customizable to their needs, or does not improve over time. IoT allows companies to offer intelligent products that learn over time, and adapt to their customers’ needs. It also enables them to offer services to generate new revenue flows and surpass customer expectation. Businesses ignoring the full impact of IoT therefore do so at their peril.

“The businesses ignoring the full impact of IoT therefore do so at their peril.”

Differentiate IoT from remote monitoring; data analytics and intelligent platforms. By some accounts, the value derived from IoT devices and sensors account for just a third of the total opportunity, with the remaining two-thirds being derived from the platforms and the analytics.

Today’s data analysis methods are capable of processing vast quantities of data in real or near real time and returning actionable insights, forming the basis of new business services. For example, developing predictive analytics solutions that allow companies to foresee breakdowns or the need for parts replacement. This not only results in reduced downtimes for user operations, which are often costly, but also lower service costs for their suppliers as routine services checks can be eliminated.

Towards Smart Manufacturing through the Encounter of OT and IT

In order to capitalise on these benefits suppliers have developed intelligent, broadly based platforms that are able to capture this information and either automate the next step in the process or alert relevant personnel for action. In such a case, the system can alert the nearest engineer to the machine with predicted service issues, giving them comprehensive details of the location, machine, any spare parts re-
quired and how to fix the problem. With such platforms, companies are also able to automatically push software updates and make iterative amendments to processes to optimize them.

In the past the focus in manufacturing has been on factory automation – typically, automating manual work processes. IoT takes this much further, utilising advances in software and data analytics to allow companies to make faster, smarter decisions that optimize processes, and pass these benefits onto their customers. Thus, the IoT becomes the essential enabler of the smart manufacturing vision. This vision – also known as intelligent factory or smart factory – envisages a new way of organising manufacturing processes in which different parts, from suppliers to logistics to the entire life cycle of the product and material, become closely and intelligently connected within the corporate boundaries. The factory becomes a system of systems glued together by the data gathered in the various stages, integrated in different moments, and used for reaching the key strategic objectives of the business.

All this is created by the converging of operational technology (OT) with information technology (IT). Historically, these have been developed as two separate domains – OT operating in real (or near real) time providing process control physically close to machines, with IT then operating on a batch update basis at a central location. IoT provides the basis for bringing these two domains together, enriching both in the process. The IT domain gains detailed new information on machine performance and utilisation which can then be shared widely throughout the enterprise – in product design, customer service, finance and contract control to name a few. OT gains from data analytics used for diagnostic (why something happened), predictive (what will happen) and even prescriptive (how to prevent it happening) purposes. In this way IoT promises to optimize business processes, enhance information for better decision making and shorten project times by unifying these two key domains.

“ IoT promises to optimize business processes, enhance information for better decision making and shorten project times by unifying the two key domains of OT and IT.”

Exploring the Internet of Manufacturing

To identify the ways that IoT may enhance activities in the Manufacturing sector, Beecham Research has divided the Manufacturing sector into 6 key sub-sectors, as follows:

- Heavy Equipment
- Materials
- Precision/High-Tech
- Agriculture/Mining
- Consumables
- Construction

Activities within each sub-sector typically utilise similar manufacturing processes and are therefore likely to use similar IoT
solutions. These sub-sectors are used as the basis for the inner section of the Sector chart shown below. In the chart, the middle section then provides examples of typical products produced within each sub-sector. The outer section features examples of those IoT Solutions or “touch points” that can and in many cases have already provided benefits to those using manufacturing processes in those sub-sectors.

THE INTERNET OF MANUFACTURING IoT / SECURITY / DATA ANALYTICS

Source: Beecham Research

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This sector brief will initially explore the impact of the Internet of Things on the six sub-sectors. Consequently, it will provide readers with insights on the key elements of the Internet of Things such as data management services, connectivity solutions, and IoT security. The brief will also discuss the increasing role of emerging technologies into smart manufacturing such as Augmented Reality (AR), Virtual Reality (VR) and a combination of these - called Mixed Reality. It will also address how relevant the emerging convergence between robotics and the Internet of Things could be in the manufacturing sector. Finally, the sector brief will discuss the different initiatives in place to promote the smart manufacturing vision, including public-led initiatives (such as Industry 4.0 in Germany) and private consortia (such as the Industrial Internet Consortium).

Heavy Equipment

The heavy equipment manufacturing lines will also see an increasing use of robotics, seen as intelligent and connected devices, able to substitute the humans or to collaborate with humans. Robotics will optimize production, but also increasing the safety within the plant. In addition to robotics arms, there will be an increasing use of collaborative robots. Those will enable collaboration between robots and people to work together. Companies can utilize the tirelessness and the repeatability of the robot with the intelligence, creativity, and flexibility of the human enabling more efficient manufacturing processes.

The data that flows from all the sensors and devices described above can then be integrated with existent IT systems. The combination of machine-generated...
data and enterprise IT data can enable an unprecedented horizontal view of the company from the production plant to the distribution of the final product though the activities in warehousing activities. The role of data analytics as an essential tool of operation assessment analysis becomes critical. Predictive analytics is particularly relevant here. For example, elevator manufacturer Schindler has reduced elevator wait times by up to 50% by predicting elevator demand patterns, calculating the fastest time to its destination floor and assigning the appropriate elevator to move passengers quickly and efficiently. Finally, data visualization tools available in the form of apps for tablets, ruggedized tablets, and wearable devices will be important tools for different types of employees.

There will also be an increasing need of intelligence embedded in devices or used for optimizing various steps of the processes. Head mounted displays embedded with workflow management software, in the future enriched with context-aware applications, are an example of the importance of intelligence at device level. With the convergence with robotics and autonomous systems, the use of Artificial Intelligence will enable sophisticated machine intelligence along the production lines. The use of Augmented Reality and Virtual Reality will also be used in areas like rapid prototyping techniques, for testing products and processes, and also for educating employees in new manufacturing techniques.

"IoT will transform heavy equipment manufacturing into a system of systems."

Imagining all this under a unique umbrella, the Internet of Things will transform heavy equipment manufacturing into a system of systems heavily automated and integrated with other parts of the company operations. The vision of this is moving towards almost autonomous lines with the effortless presence of intelligent devices of any sort, together with the creativity and flexibility of humans. All of this will run on horizontal software platforms, also known as industrial internet platforms, that will be briefly explored in this sector brief.

**Materials**

Materials production involves turning a raw material into an intermediary good for use in other manufacturing processes, or finished good for sale. Plastics and petrochemicals are refined from crude oil for instance, fabrics are made from cotton plants or sheep wool, and medicines are a concoction of other chemicals and elements.

"Materials production is frequently dangerous, IoT can therefore have a positive impact through the automating and remote monitoring of manual tasks."

Materials production is frequently dangerous – utilising hazardous materials and employing medium to high risk methods. IoT can therefore have a positive impact on the materials production industry through the automating and remote monitoring of manual tasks. For example, employees at Marathon Oil refineries wear a wireless multi-gas detector that continuously tracks exposure to harmful gases, and also tracks his or her location. In the event of an emergency, individuals can press a panic button to trigger an alarm and call for help from a central control centre.

Production also requires accurate mixing of materials and chemicals, which if mixed...
wrongly can have serious adverse effects, such as in medicine formulation. The supervisory control and data acquisition (SCADA) systems used to manage the manufacturing process can be integrated into IT systems so as to provide stricter controls and provide an audit trail for regulation and governance protocols, such as the EU Restriction of Hazardous Substances (RoHS) directive. These systems can in turn be linked to other systems requiring the same treatment such as environmental impact monitoring, for example emissions control and proper disposal of waste materials.

“Devices will be able to automatically shut down or slow down processes quickly to prevent or significantly reduce major accidents.”

Furthermore, by bringing intelligence to sensors either locally or by utilising cloud computing technologies, devices will be able to automatically shut down or slow down processes as soon as possible to prevent or significantly reduce major accidents. These systems can reassure governments, local residents and investors, resulting in stronger support for ongoing operations. This is particularly the case in perceived environmentally unfriendly industries such as oil refinery or steel manufacturing.

**Precision and High-Tech**

The methods used in manufacturing precision and high-tech goods are predominantly discrete based, but it also includes some process manufacturing techniques, for example in the forging of precision instruments. Some elements are mass produced, while others are made in batches. It differs from heavy equipment in that there are typically fewer assembly levels.

“**The Internet of Things can help manufacturers work to the accuracy needed, whilst keeping pace with changing designs and assembly methods utilised.**”

The industry is characterized by the need for almost zero error tolerances and fast moving research and development cycles. Through the use of reprogrammable, intelligent machines and robots, the Internet of Things can help manufacturers work to the level of accuracy needed, whilst keeping pace with changing designs and assembly methods utilised. Computer aided manufacturing (CAM) systems will not only integrate with assembly machines, but also research and development systems, allowing on-the-fly alterations to designs. In turn, adjustments are tested using automated test equipment (ATE) at crucial stages so as to allow ongoing, valuable feedback. This system, known as process development execution, integrates data, legal, business and information and knowledge processes, and is optimized through the increasing data input generated by IoT.

The demands for data processing in everyday operations and in Research and Development in this industry are higher than in most others. Consequently, there is also a need for high speed computing and specialist industrial control systems such as the Experimental Physics and Industrial Control System (EPICS) used in some laboratories. Previously these technologies were considered too costly to implemented for many businesses. However, through its greater connectivity and access to cloud computing, IoT will help many companies transform these critical elements of their business.
Agriculture and Mining

In contrast to Materials manufacture, the agriculture and mining industries are in the business of extracting raw materials for use or refinement in other industries. The farming and fishing sectors provide the raw produce for food for instance, while the mining industry extracts metal ores to be turned into rolled steel or stone to be used in construction.

The use of Internet of Things technologies in farming has grown dramatically over the past few years, and growing and rearing food has become reliant on technologies in ever more steps in the production process. Some milking parlours for example have become more like industrial assembly lines, with cows being fed and milked automatically in their sheds. Large combine harvesters use GPS technology to automatically manage their movements, and even measure crop yield maps that farmers can examine on their terminals. Combine harvesters are increasingly becoming connected – using different forms of connectivity – and intelligently using data analytics solutions and software applications. As agriculture vehicles are becoming increasingly autonomous, robotics has also entered other parts of the farm. A robotic machine can selectively destroy weeds in between the rows of crops, reducing the need to apply costly weed killers, at the same time addressing public disquiet about the use of chemicals on food. Autonomous milking systems are an essential part of livestock farming. UAV or drones are becoming common ways of monitoring soil, operations and security of the farm.

“Sensor based technologies are making inroads in the food delivery chain.”

Sensors can in theory be built to detect almost any parameter, e.g. temperature, humidity, pressure, even specific chemical substances, and examples of their use are abundant. For example, sensors using imaging technology are being used in the intelligent irrigation and ‘fertigation’ of valuable berry crops. Likewise, the application of sensor based technologies is making inroads in the food delivery chain, where the food leaves the farm gate to be processed, packed and transported on its way to the retailer. An example is the case of cold chain logistics and refrigerated vehicle monitoring. Here M2M based systems not only capture real time remote data from temperature monitoring devices and raise alarms if temperatures deviate from set limits, but also provide proof to customers of compliance to the strict rules that govern the supply of foodstuffs to consumers.

“The ultimate IoT aim is to enable data collected to be integrated and shared, affording greater insight and enriching decision making.”

Data analytics and management software represent the governing layer of all the devices and sensors described above. Farm data management systems collect large amounts of data, much of which has still to find a use. Complementary to this data, sensor based precision technologies have been finding uses in several areas of farming – arable, livestock, even fish farming.
At the back office end, clever analytics must make sense of all the data collected from different sources. The ultimate IoT aim is to enable data collected to be integrated and shared, affording greater insight and enriching decision making. IoT developments in other ‘smart’ industries could supply lessons and propose solutions for the industry.

“The use of sensors for monitoring mine conditions also in terms of working safety is a common practice in the mining sector.”

As per the agricultural sector, the convergence of the Internet of Things and robotics has a strong potential in the mining sector. Autonomous vehicles are largely used to perform difficult and tiring tasks for humans. The use of sensors for monitoring mine conditions also in terms of working safety is a common practice in the mining sector. The sector is also adopting head-mounted displays supported by work flow management applications. There is also the adoption of wearable devices for security and wearable cameras for providing real-time view of an operational situation to the centre. Outside the mining activity itself, monitoring trucks remains an important part of the entire mining process. It is also important to highlight that the type of connectivity in the mining sector is diverse, often with a cellular-satellite dual mode.

“Connected sensors and other IoT technologies will bring bigger changes in supply chain management and marketing.”

Many companies have long experimented with RFID technology in factories to monitor the flow of goods, as well as looked to increase automation in the production line. However, connected sensors and other IoT technologies will bring bigger changes in supply chain management and marketing. For example, Coca-Cola Enterprises, has installed sensors on its products and vending machines to monitor supply and buying trends.

“The real value is the ability to link production with distribution and retail in order to have a complete picture on the product life cycle.”

As in other subsectors, data gathering and data analytics can be used for having a detailed view of the production, but also for enabling predictive maintenance on machines and identifying potentially defective goods. However, the real value for consumable manufacturing companies is the ability to link production with distribution and retail in order to have a complete picture on the product life cycle. This implies the use of monitoring solutions during distribution. As a result, fleet management solutions have become very important and, in the case of food and sanitary products, cold chain solutions.

Consumables

The fabrication of consumables involves turning materials into finished goods that are used by consumers. The manufacturing of food and beverages, clothing, sanitary products, sporting goods and crockery are included. However, the category can expand to any other additional goods used by consumers such as DIY tools, toys, and accessories.
are critical. The ability then to incorporate product reviews and suggestions from customers into the entire product lifecycle can also enable interactive forms of product design between customers and the manufacturing process.

“Product tags and intelligent shelving solutions can optimize the activities.”

Warehouse and stock management solutions are also very important for this sector. Here, product tags and intelligent shelving solutions can optimize the activities. There is also an increasing role for wearable devices in warehouses that enable workers to gather the information on the status of the warehouse, send the information to the operation centre real-time, and receive the necessary information on the next steps through the work flow management software embedded in the wearable device. Additionally, safety and surveillance connected systems are present in the warehouses to safeguard products and assets.

“3D printing robots are now used in the design and prototyping phase.”

The role of robotics is also important in this sector. 3D printing robots are now used in the design and prototyping phase, but also for printing raw parts, adding parts to existing moulds or for repairing existing parts. Robot arms are also used for packaging and in warehousing activities.

Construction

The construction industry is characterized by the production of one-off engineering construction projects. Most of the time, the construction process is unique. It depends on a specific design and the environment in which it is built. Having said that, there are buildings which are developed in a modular way and the same approach is used for different buildings.

High speed computing for simulation and environmental monitoring systems, therefore, are critical technologies. However, IoT will become particularly relevant with the unique data produced in construction. Firstly, it will help streamline and optimise the supply chain as suppliers and contractors have better insight into the current stage of building work and when the material is required. Secondly the data generated, including daily construction reports and the myriad of sensors connected to buildings and their sites, is often stored in isolated data sets. Data analytics technologies can bring this data together with large historical data sets from similar buildings to give better prediction of timescales, failure points or material shortages. For example, SITESENSR, a hosted internet application, tracks and monitors critical assets, tools equipment, vehicles and inventories across multiple work sites. It can use this information to provide information on where an asset is and what it is being used for, as well as site noise and vibration levels so as to ensure compliance with local regulations.

“IoT will help streamline and optimise the supply chain giving suppliers and contractors better insight into the current stage of building work.”

Considering the large amount of mobile and immobile assets used in construction sites, asset monitoring and vehicle tracking solutions are very important. In additional to that, site monitoring and control for security and environmental reasons are important.
to ensure a safe and healthy working environments. In order to improve safety and productivity, large construction companies are starting to adopt wearable devices such as connected helmets, head-up displays and wearable security systems in addition to ruggedized tablets and devices that have been used already for some time.

Consideration on Key Technologies for Smart Manufacturing

Within the Internet of Things umbrella, there are a set of technologies that will strongly impact the move towards smart manufacturing. We have explored them during the analysis of the sub-sectors, but some of them deserve some additional insights.

- Data management and analytics solutions are an essential building block.
- Security is the essential feature of smart manufacturing. Without security, the Internet of Things will never develop to its full potential.
- Smart manufacturing is a connectivity-agnostic environment where different connectivity solutions have a role, from cellular to satellite, from fixed to short range wireless.
- Smart manufacturing highlights the need of convergence between robotics and the Internet of Things.
- The smart manufacturing vision can be realised efficiently using a horizontal management layer, known as an Industrial IoT Platform, that govern all the IoT connected devices and machines in the manufacturing process.
- There are then a set of emerging technologies that will be increasingly relevant for the manufacturing process, from AR/VR to 3D printing.

Data Management and Analytics Solutions
Collecting large amounts of data from all operations must be matched by effective processing of the data collected in order to make sound decisions. The more granular the data, the more precise will be the understanding of what is happening on the manufacturing floor and hence, the better decisions taken from that data, be they manual or automated.

“Today’s manufacturing plants utilise multiple smart systems that aim to give both predictive and prescriptive insights.”

As mentioned earlier, today's manufacturing plants utilise multiple smart systems that bring together different data sets and aim to give useful insights, both predictive and prescriptive, typically through an MES. However, communication streams are still broadly focused on an individual machine basis, with that information feeding into a simple reporting system that at most offers alerts at prescribed trigger points. The Internet of Things offers a wider dimension to this process. It brings together very large sets of data from all machines and processes, offering greater insight to how certain decisions made at one point may affect other connected systems. The objective is to optimise the decision making process in near real time in ways that were not previously possible. Here the datasets are derived from sensors embedded in all areas of manufacturing operations, as described above.

“Large global companies, like Siemens, GE and Bosch, will have valuable historical data to make use of and differentiate on.”

In parallel to the availability of new types of data, data management technologies have progressed so as to allow the handling of any type of data, structured or not, from
any number of sources. Whilst early M2M implementations had to make the data from devices match a proprietary format, IoT systems incorporate the Internet Protocol and layers of hardware, software and networks with technologies from different vendors.

"Considerable IT system design skills will be needed in building a unifying IoT system of systems for a manufacturing installation."

IoT systems also combine sensor collected data with other data such as publicly available and reference data from governments and other sources, including satellite imagery and other research data. Large global companies, like Siemens, GE and Bosch, will have valuable historical data to make use of and differentiate on, but will need the tools and data scientists to unlock that information.

Therefore, the different sensor and data types that will be collected will reside in different silos; an additional step will be needed to connect these diverse data sources into a standard format that can be input into the analytics platform of choice. Notably, these data volumes will be large which could result in time delays when processing. Considerable IT system design skills, together with subject matter expertise, will be needed in building a unifying IoT system of systems for a manufacturing installation.

"Once correctly handled there are valuable opportunities for data owners to cross sell to other partners in the supply chain."

It is worth noting that data ownership and sovereignty is expected to become the subject of increasing management attention. At its simplest, the entity that collects the data owns it. Once this data is shared between partners and contractors, however, the matter of who owns what and who has right of access to it becomes more complex. Such agreements need carefully consideration. Nevertheless, once correctly handled there are valuable opportunities for data owners to cross sell to other partners in the supply chain.

Security

"IoT security must be included in solutions from the ground up – it cannot be added retrospectively."

There is much to be gained from the IoT and it represents an essential way forward for Manufacturing. However, network security threats are also increasing. This is best viewed as ‘noise’ that needs to be filtered out and that security requirements have become an essential new part of the specification for IoT solutions. IoT security must be included in solutions from the ground up – it cannot be added retrospectively.

To gain real value from the IoT, systems must be capable of inter-operating. However, once anything connects to the Internet to do this, it opens the risk of being hacked, corrupted or leveraged as part of a Denial of Service attack. Hence it will be even more important to ensure data quality and integrity as well as establishing well architected security structures to mitigate the increasing risks. Manufacturing is highly competitive and of high value, particularly across sub-sectors like pharmaceuticals and chipset manufacturers, so the potential for significant disruption if systems are breached is real and will inspire many to invest in advanced security systems.

According to Beecham Research, security in the Internet of Things is significantly more complex than in existing M2M applications or traditional enterprise networks. The IoT
ecosystem is composed of layers involving platforms, networks, sensors, system and users and the multiple vectors of threats from external and internal actors. Significant effort is therefore required in the identification, authentication and authorisation of all these components, as well as their users.

Connectivity Options
The manufacturing sector represents one of the largest adoption of fixed M2M connectivity solutions. This is particularly the case for machines on the shop floor, although the use of wireless is also growing quickly as it offers a way to by-pass legacy IT systems. Fixed connectivity is also often used for security and surveillance purposes. However, with the introduction of head-up displays and other wearable devices on the shop floor, there will be an increasing role for short-range wireless solutions. Wireless mesh networking is also increasingly being used in manufacturing operations. In addition, emerging solutions such as LPWAN (Low Power Wide Area Network) may also become viable options for creating plant-focused network for low data rate applications.

“The nature of robots is becoming more refined.”

Robotics arms are not new on the assembly line, but as technology evolves the nature of robots is becoming more refined. They are able to run different tasks and embedded with high levels of intelligence. Robots become then intelligent devices on the assembly line monitored and controlled, but with a high degree of independence. The rise of robotics in manufacturing has been also highlighted by The International Federation of Robotics. The organisation predicts the number of industrial robots in use will rise to just under 2 million by 2017, up from 1.4 million in 2014. Commonly seen on assembly lines, robotic technology is expanding its applications beyond pick and place PCB assembly machines. These machines are becoming more agile, and able to do a multitude of tasks. They are lighter and able to be moved to different locations for different purposes. Robot manufacturers are also taking advantage of machine learning programs and even some artificial intelligence technologies to make robots more human friendly in the workplace. Companies like Universal Robots AS of Denmark are making robots that are able to sense the proximity of humans and slow down or pause production so as not to endanger them with flailing arms or hazardous methods that human would need protective gear on for, such as welding or cutting metal.

“The nature of robots is becoming more refined.”

From this it is clear that IoT solutions for Manufacturing must be able to cater for multiple forms of connectivity. It is unlikely that any one connectivity type will be sufficient for an overall IoT solution.

The Convergence of Robotics and the Internet of Things in Smart Manufacturing

“The nature of robots is becoming more refined.”

Human-robot collaboration and robot-robot collaboration on the assembly line are areas of key developments.”
Robotics is a fast-evolving area. Human-robot collaboration and robot-robot collaboration on the assembly line are areas of key developments. But, robotics and autonomous systems - here referring to driverless machines mainly - will impact all the areas of manufacturing and agriculture. There will also be a role in prototyping through the use of 3D printing robots.

“ This type of platform becomes a sort of operating system on which the smart manufacture structured as a system of systems will run.”

**Industrial IoT Platforms**

The area of Industrial IoT Platforms is evolving, and an essential area for the development of smart manufacturing. This type of platform becomes a sort of operating system on which the smart manufacture structured as a system of systems will run. The platform will enable the monitoring and control of the machines and devices. It will enable the gathering, storage, integration and analysis of the data and further the development of applications running on different devices. The platform will also be the security brain of the entire system. It will also ensure interoperability between systems through extensive API management. As the reader can imagine, this is a complex area on which several organisations are working, such as GE, Bosch, SAP and Siemens and many others. It is also important to highlight the effort to offer such complex platforms for small and medium enterprises. Given its importance, Industrial IoT Platform development is supported by several public and private initiatives that are briefly introduced later in this paper.

**Relevant Emerging Technologies**

Virtual and Augmented Reality technologies have advanced immeasurably in recent years with the rise of such products as Oculus Rift, now within Facebook, Sony’s Project Morpheus and the Samsung Gear VR. Its application in IoT, and specifically Manufacturing, is increasing. The aim of virtual reality technology is to immerse the user in a virtual world. This can have benefits for the manufacturing sector as it helps with data visualization, task training, product design and prototyping. enabling engineers to experience their designs in a virtual environment allows them to better understand how a consumer will interact with their designs. This results in lower costs of prototyping and field testing, in turn shortening time to market. Indeed, companies such as ESI are offering solutions that enable companies such as BMW, Ford, Caterpillar and Trumpf to do exactly that; to perform collaborative and immersive design reviews, and optimize assembly and disassembly sequences that consequently help in training also.

Similarly, augmented reality is also growing in importance in IoT, as indicated by PTC’s recent acquisition of Vuforia from Qualcomm. Augmented reality aims to connect the user to the user’s environment which can enable employees to view relevant information regarding a particular machine or part they are working on, and show specialist engineers or perhaps original manufacturers the problem in front of them. This will speed up completion of tasks and improve accuracy as well as direct real time collaboration that can help to realise synergies on disparate global teams, saving money and allowing resources to be distributed more effectively.

“ AR and VR technologies offer real-time management information and provide an audit trail that ensures accountability and traceability.”

Crucially, both technologies can solve real business problems such as big data collection and analysis, inventory reduction and experiential communications. Additionally,
both technologies offer real-time management information and provide an audit trail that ensures accountability and traceability.

“Both wearables and additive manufacturing (3D printing) are key examples.”

Beyond AR/VR there are many other emerging technologies that are helping to speed up the manufacturing process, and make everything even more connected. Both wearables and additive manufacturing (3D printing) are key examples. Wearable devices represent the interface between the industry practitioner and the environment on the one hand, and between the wearer and the back office IT system and IoT on the other.

Over the long term, these wearable devices will become smaller and less obtrusive, so as to “melt” into the background. They could include items worn on the wrists, glasses and even integrated into clothing. As well as signalling an alarm if the wearer is in danger, such objects may help wearers in affording a greater understanding of their complex environments, with the help of tools such as assisted reality and context aware applications.

“Additive manufacturing has enabled a new method of rapid prototyping.”

Additive manufacturing has enabled a new method of rapid prototyping and even fabrication of the final product itself. Indeed, various Formula 1 racing teams have used the technology for both uses for some years now. Integration with embedded intelligence however would allow a machine to identify a faulty part, or identify when a well-worn part needs replacing and automatically print a new part to minimise down time.

Partnerships and Consortia

The move towards smart manufacturing is highly complex and the task of connecting these intricate systems can prove challenging. Many industries are keen to capitalise on the many advantages this may bring, but lack the expertise of how to do it. Adding to this complexity issue are numerous solutions all apparently promising the same thing, but often using different technologies and standards. There have been several partnerships and consortia born out of this exact issue, all with the common goal of helping companies achieve this connected industry goal. These organizations include private establishments such as the Industrial Internet Consortium (IIC), and public-private partnerships like Industry 4.0, as well as standards boards, such as the Object Management Group (OMG).

“The IIC was founded by AT&T, Cisco, GE, IBM and Intel in March 2014 to “bring together the organizations and technologies necessary to accelerate the growth of the Industrial Internet by identifying, assembling and promoting best practices.” Members include vertical market leaders and universities as well as small and large tech firms. It does include government organizations, however they are merely members, in contrast to public-private partnerships like Industry 4.0 which is led by the German government. The IIC is not a standards body. However, it works closely with the OMG, which it is related to, and aims to help define standards that best fit leading applications and technology advances relevant to the industry.

Industry 4.0 originates from the high-tech strategy of the German government, which set out to promote what it called the computerization of manufacturing.
It supports companies, in particular its famous Mittelstand, in implementing connected manufacturing systems in the hope they will become more competitive in the global market place. It does this by outlining six key design principles:

- Interoperability
- Virtualization
- Decentralization
- Real-time capability
- Service orientation
- Modularity.

It aims to help SMEs adopt big data and analytics applications, an area they have traditionally been slow to use. There are similar projects around the globe, including China’s Made in China 2025, France’s Industrie du Futur, and more widely, the EU’s Factories of the Future (FoF). Within those initiatives, there are also specific government-led activities. Those focus on specific sub-sectors such as Farming 4.0 in Germany for the agricultural sector. Other activities they look at promote the concept of smart manufacturing for SMEs, which represent the core of manufacturing economies, particularly in Europe.

Conclusions

“IoT will change the basis of competition and create a new wave of disruptive companies similar to what Uber has achieved in the taxi business.”

The advantage for many in the manufacturing sector is that M2M systems have been in use for decades, and therefore the concept of expanding these networks should not be met with hesitation. This is, however, also its greatest barrier. The technology must be brought up to speed as must attitudes and skillsets.

Beecham Research believes that a major step in understanding must accompany developments and applications of M2M and IoT technologies, so as to identify the new opportunities and benefits that near universal connectivity will make possible in this and other industries.

In the above sections, we have identified the many benefits of combining information technology with operational technology to create IoT environments across separate manufacturing industries that transform businesses and generate new revenues. Indeed, numerous studies and use cases have demonstrated the possible revenue growth opportunities that IoT brings to the manufacturing sector. GE, for example, announced more than $1 billion in incremental revenues in 2014 as a direct result of increased IoT investment. However, it is important to stress the transformative ability of IoT. It will change the basis of competition and create a new wave of disruptive companies similar to what Uber has achieved in the taxi business. Therefore, companies viewing the technology as merely incremental do so at their peril.
**Internet of Manufacturing Business Conference**

**IoT / SECURITY / DATA ANALYTICS**

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www.beechamresearch.com
info@beechamresearch.com
@BeechamResearch

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