BECOMING A SMARTER MANUFACTURER

HOW THE INTERNET OF THINGS WILL CHANGE INDUSTRY

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SCM World

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Pierfrancesco has over 20 years of industry experience in manufacturing operations and supply chain strategy research, consulting and IT solutions, with a strong focus on the business value of technology in manufacturing. Prior to joining SCM World, he served as Head of EMEA at IDC Manufacturing Insights, where he led the EMEA research practice and was the global lead for the Operations Technology Strategies advisory service.

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EXECUTIVE SUMMARY

This report discusses the emergence of the "internet of things" as a set of technologies expected to transform the way manufacturing organisations run their businesses. The research focuses specifically on the application of the internet of things on the manufacturing plant floor and along the supply chain, often called "smart manufacturing" or "industry 4.0".

Supported by the results of SCM World's "Smart manufacturing and the internet of things" survey, this report addresses the following issues:

- Why manufacturers have to change the way they operate and become smarter.
- Why agility and responsiveness are the way to success – and why a lack of visibility is the key barrier.
- How the internet of things, connectivity technologies and big data analytics will change industry forever.
- The expected business outcomes of smart manufacturing.

The report also provides a number of case studies from companies that have already made progress on their smart manufacturing journeys, including Harley-Davidson, Fiat Chrysler Automobiles and Cisco Systems.

Among the key findings of our field survey:

- **Agility and responsiveness** are expected to become the undisputed metrics used to measure manufacturing success going forward – much more so than the ability to keep operational costs down. Lack of visibility across the supply chain and from within production facilities is considered the major barrier to performance improvement for manufacturers.
- **Smart manufacturing** is emerging as the right approach to solving today's manufacturing challenges. This is about creating an environment where all available information – from the plant floor and across the supply chain – is captured in real time, made visible and turned into actionable insights. The journey begins with manufacturers connecting the factory, machines and other assets, but the ultimate objective is to orchestrate the supply chain.
- Smart manufacturing requires a healthy dose of technology to make sure machines collaborate with each other, material flow is visible in real time and teams of knowledge workers orchestrate the entire process. The majority of manufacturers believe that smart manufacturing and its foundational technology platform, the **internet of things**, are ready and that now is the right time to invest. Priority investments to enable this transformation include analytics, connectivity, automation and mobility.
- The most important finding of this research is the significant **business benefits** that smart manufacturing and the internet of things can offer. Smart manufacturing is expected to increase OEE (original equipment effectiveness) by 16 percentage points, improve quality and unplanned downtime by nearly 50%, increase inventory turns by nearly 35%, reduce new product introduction cycle times by over 23% and reduce energy costs by 17.5%.

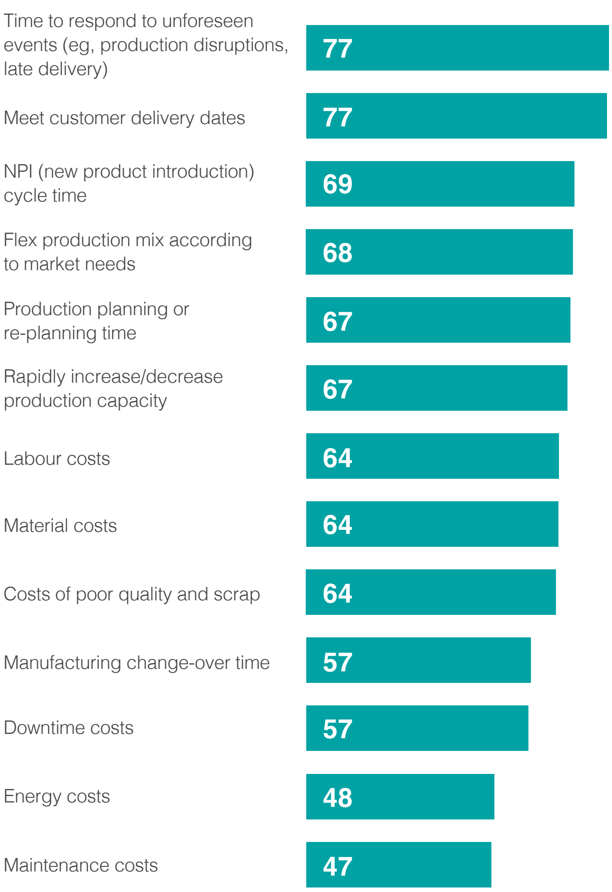
INTRODUCTION

Response times for unforeseen events, meeting customer delivery dates, new product introduction cycle times, flexing production mix… these are the most pressing challenges for today's manufacturing organisations, according to new data gathered by SCM World. The vast majority of the 400-plus respondents to our "Smart manufacturing and the internet of things" survey consider addressing these agility-related challenges more critical than traditional cost-related challenges (Figure 1).

Labour and material costs, and costs associated with poor quality and wastage continue to challenge the majority of manufacturers. However, they are not comparable with the percentage of companies picking agility-related challenges, accounting for nearly 80% of preferences.

1 | Today's key manufacturing challenges

% of respondents rating challenges as "extremely/somewhat serious"



Source: SCM World survey, June 2015 n=416

This revolution has been triggered by dramatic changes taking place in the manufacturing marketplace. The extensive availability and rapid diffusion of information in today's digital economy has completely changed the way customers purchase goods. They are well informed, can easily compare, select and discard multiple products, have extensive choice, are impatient and expect customised products at affordable prices.

Consistent with the findings of last year's SCM World report *The Future of Manufacturing: Maximum Flexibility at Competitive Prices*[1], agility and responsiveness in meeting customer fulfilment needs are expected to become the undisputed metrics used to measure plant-floor success – much more so than the ability to keep operational costs down. Agility relates to the ability of a manufacturer to respond to both changes in the marketplace and unforeseen events (such as production disruptions or late delivery) efficiently and effectively. Responsiveness is the speed at which a company can make decisions to meet customer needs. The combination of the two determines how an organisation is able to embrace market change: understand it, adapt to it and leverage it – all very rapidly.

What emerges from our research is that the traditional approach to manufacturing – efficient production plants and permanent cost-containment initiatives – cannot respond adequately to the changes companies are facing today. Manufacturers have spent years squeezing costs out of their supply chains and manufacturing operations, and many are now at the point where further cost cuts will only lead to reduced flexibility and poor customer experience.

With customers looking for speed, personalisation and value, manufacturers have to learn how to prosper again. They need to find a better balance between cost to serve and higher levels of agility and responsiveness. In short, it is time for manufacturing industry to reinvent itself.

MANUFACTURING AND SUPPLY CHAIN VISIBILITY

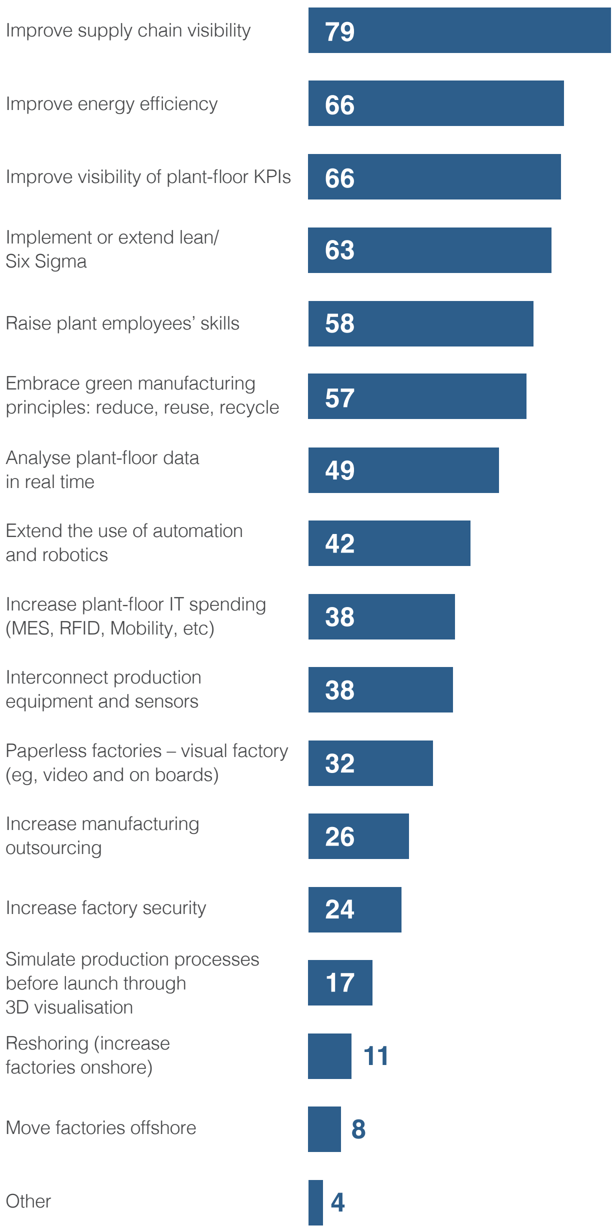
An important finding of this research is the lack of visibility across the supply chain and from within production facilities as the fundamental barrier to further performance improvements in manufacturing. The ability to collect, analyse and use information in real time is critical for manufacturers that wish to achieve higher levels of agility and responsiveness.

Unfortunately, the vast majority of manufacturers today do not feel they have adequate visibility. Improving plant-floor KPIs and visibility along the supply chain are therefore among the top initiatives that manufacturers are planning to undertake over the next five years (Figure 2). With the latter initiative accounting for nearly 80% of preferences, supply chain visibility is emerging as the weak link in performance improvement in manufacturing.

To shed some light on today's visibility levels and what is expected in the future, we asked our survey respondents to consider four progressively deeper levels of visibility, ranging from no visibility to full supply chain visibility, as follows:

- **Offline** – Little or no ability to gather real-time data from the plant floor.
- **Factory-level insights and control** – Able to gather real-time data from some production equipment, sensors and devices in each factory, in isolation.
- **Enterprise-level insights and control** – Able to integrate plant-floor data across multiple factories and compare common KPIs.
- **Supply chain real-time orchestration** – A "control tower" that enables informed decisions in real time and orchestration of the entire supply chain.

2 | Key manufacturing initiatives in the next five years



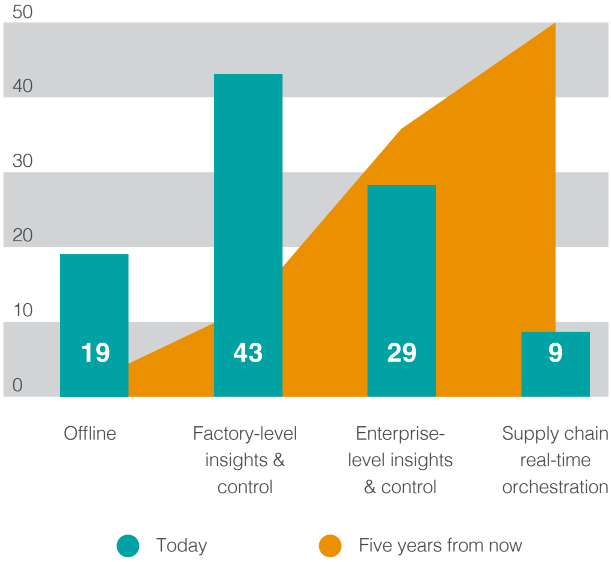
Source: SCM World survey, June 2015 n=415

The findings reveal that the largest share of manufacturers (43%) today have visibility of single factories in isolation, while almost a fifth have little or no ability to gather real-time data from their facilities. Others are in better shape: 28% say they are able to integrate plant-floor data across multiple factories and compare common KPIs, while 9% have a control tower that provides real-time visibility and orchestration of the entire supply chain. Over the next five years, however, the situation is set to improve significantly, with half of our respondents planning to achieve this (Figure 3).

Cisco Systems is one company that has significantly accelerated its progress along the visibility maturity model. With a fully outsourced manufacturing footprint, the company adopts modern technologies such as cloud, big data analytics and the internet of things to improve visibility across its entire supply chain and orchestrate predictive quality throughout (see company spotlight for more on this).

3 | The four stages of visibility maturity

Level and depth of visibility today and in five years' time



Source: SCM World survey, June 2015

% of respondents
n=418

COMPANY SPOTLIGHT

How Cisco gets real-time visibility across its outsourced manufacturing network

To better orchestrate its global network of outsourced production plants, Cisco developed a secure “virtual” MES (manufacturing execution system) platform, or VMES, which provides real-time visibility of production operations. The VMES covers three fundamental aspects:

- **Traceability.** End-to-end traceability at the component, board and system level, enabling capabilities such as serial number and pallet genealogy, substance and trade compliance.
- **Transformation.** Tracking of software that is “injected” into products at the time of manufacturing. This software transforms a base product into a finished product, determining in large part the product’s functionalities (including custom configuration, licensing and anti-counterfeit mechanisms).
- **Quality.** The VMES provides a networked test platform – for both structural/functional tests and repair capabilities – where automated test procedures are developed and made available to contract manufacturers.

Phase 1: cloud and big data analytics

Through the VMES, which is accessible in the cloud from every plant in its network, Cisco collects terabytes of quality data every day. In order to analyse this, Cisco recently developed big data analytics capabilities, which is in the process of moving into production.

Using big data analytics, Cisco expects to move from ex-post quality tests to predictive quality. Previously, pallets of finished products had to be opened and each unit inspected in order to get enough quality data. Now a product can be tracked in real time throughout the end-to-end supply chain as it is being built.

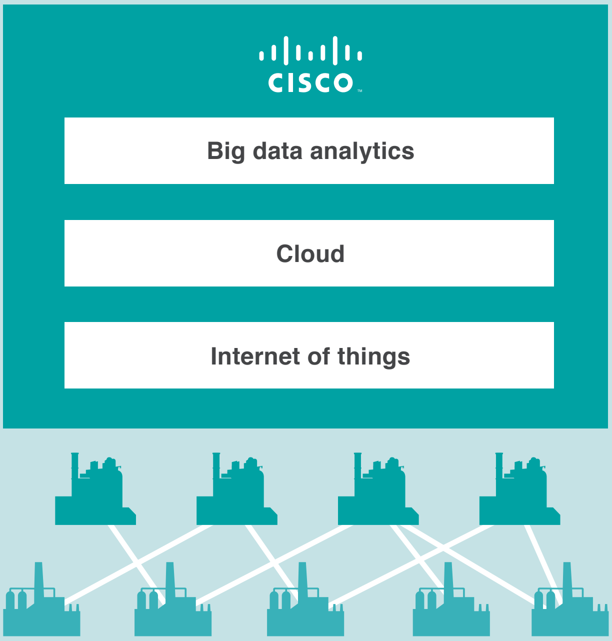
Using this real-time information, Cisco can create “adaptive test” procedures that can be scaled up or down according to certain parameters. If quality indicators are low, then the VMES can automatically change the test procedure and make it more compelling.

Phase 2: the internet of things, connected machines and assets

Cloud and big data are strategic technologies at Cisco. They enable a step forward in test and factory automation compared to the past, when data was local to each factory and there was no common communication protocol to connect and gather data from different equipment. Cloud and big data are also instrumental for the planned extension of the VMES with the internet of things.

Cisco is currently developing the internet of things fabric that will make it possible to pull data automatically either from production and test equipment across the supply chain or from finished products during their lifecycle. Connecting machines with embedded switching, compute and security will enable plant-floor edge analytics for predictive maintenance and reduced downtime.

With the internet of things, more data will be gathered in the future. The quicker Cisco staff can get access to production, quality and product data, the quicker they can get to the root causes of problems and prevent faults from spreading across the customer base.



SMART MANUFACTURING

For decades, manufacturing has been painted as grim, risky, unhealthy and uncool. Journalists, educationalists and politicians alike paid little attention to it. Making things wasn't considered strategic for the most advanced economies, and as such was neglected by government, shunned by the media and abandoned by manufacturers themselves. Today, things have changed. With a better understanding that an economy purely based on services cannot survive in the longer run, manufacturing is getting smarter.

The term "smart" is common in consumer technology, but is still relatively new in manufacturing. A few years ago, a group of manufacturers, academics and technology vendors in the US started a conversation on how to make the industry smarter. With that in mind, they created the Smart Manufacturing Leadership Coalition (SMLC). Around the same time, in Europe, the Industrie 4.0 Working Group was formed and sponsored by the German government as a strategic initiative to ensure industry competitiveness in the future. Different names, same goal: making the industry smarter.

Today, the tireless work of these entities is producing tangible results. Recently, US Senator Jeanne Shaheen introduced the Smart Manufacturing Leadership Act, outlining a national plan to assist US manufacturers to improve productivity and energy efficiency through smart manufacturing technologies. While not yet law, such legislation shows how the prospect of smarter manufacturing industry is, after years of oblivion, grabbing the interest of policy makers.

What is smart manufacturing exactly? A possible definition, blended from several descriptions currently in use, is as follows:

"Smart manufacturing is the notion of intelligently optimising supply and demand through the integration of real-time data with process expertise to enable manufacturing and supply chain real-time visibility, speed and proactive decision-making capabilities."

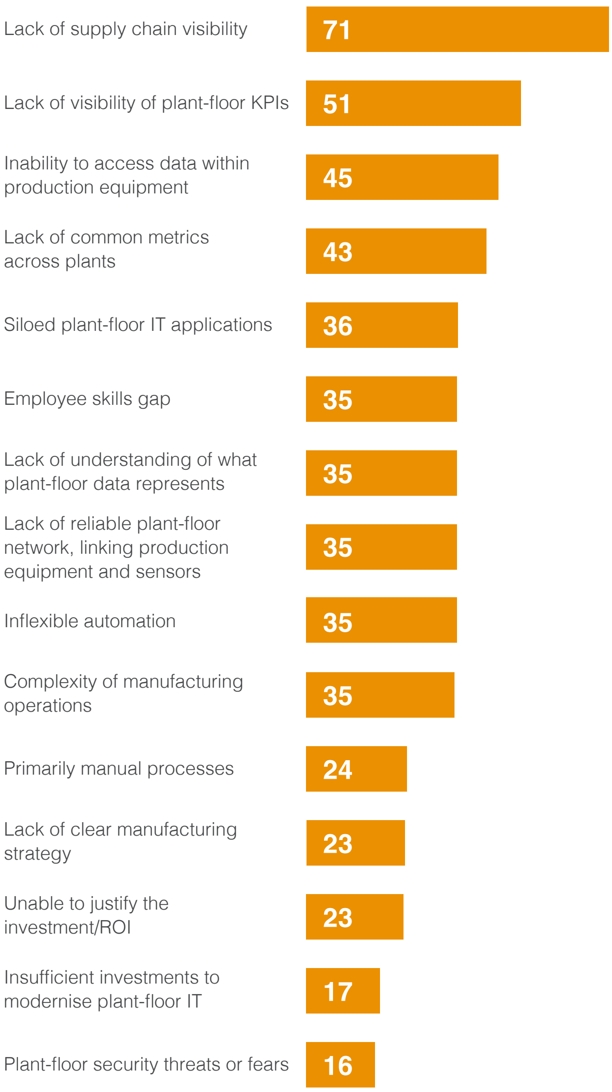
Smart manufacturing is therefore about creating an environment where all available information – from within the plant-floor and from along the supply chain – is captured in real-time, made visible and turned into actionable insights. Smart manufacturing comprises all aspects of business, blurring the boundaries between plant operations, supply chain, product design and demand management. Enabling virtual tracking of capital assets, processes, resources and products, smart manufacturing gives enterprises full visibility, which in turns supports the streamlining of business processes and optimising supply and demand.

In essence, smart manufacturing is a decision-making environment that enables firms to take faster, better informed decisions about their supply chain and manufacturing operations. It includes proactive analytics capabilities that enable automated actions driven by previously inaccessible insights from the physical world – predicting and fixing potentially disruptive issues, evolving operations, delighting customers and increasing the bottom line.

Our survey participants strongly believe in the opportunity to become smarter manufacturers. A key finding of the research is that the expected benefits of embracing smart manufacturing (see Figure 4) are closely aligned with the key challenges described above. Smart manufacturing, therefore, emerges as the key tool to support manufacturing industry in improving performance. Over 70% of respondents believe they can gain more supply chain visibility with smart manufacturing. Visibility of plant-floor KPIs, access to production equipment data and collection of common KPIs across multiple production facilities are also expected to be benefits.

4 | How smart manufacturing is better

Barriers that smart manufacturing will be able to overcome more effectively



Source: SCM World survey, June 2015

% of respondents
n=265

A number of leading global manufacturers – including the likes of Bosch, Cisco, Fiat Chrysler Automobiles, GE, General Mills and Harley-Davidson – are early adopters of smart manufacturing or Industrie 4.0 in their plants. Interesting examples include:

- **General Electric.** At GE's Durathon battery plant, more than 10,000 sensors measure temperature, humidity, air pressure and machine operating data in real time. This not only affords an opportunity to monitor production and adjust processes, but also to trace battery performance back to specific batches of powder and at every step along the process.

- **Harley-Davidson.** Much of the turnaround that Harley-Davidson achieved in rebuilding its production facility in York, Pennsylvania, is due to a dramatic increase in visibility. Every asset on the plant floor is connected and every step in the production process is tracked and incorporated in a real-time performance management system (see company spotlight for more details).

Smart manufacturing requires a healthy dose of technology to ensure that machines collaborate with one another, that material flow is visible in real time, and that teams of knowledge workers orchestrate the entire process. Industry has to become more digitised; this is not up for debate. The question is: what are the technologies that manufacturers need to invest in to make this digitisation happen? The answer points to the internet of things, which represents the technology environment necessary to implement smart manufacturing.

COMPANY SPOTLIGHT

A connected factory environment makes Harley-Davidson more agile

As the global economic slump hit in 2008, Harley-Davidson lost 40% of its business and was facing the prospect of having to shut down its major motorcycle manufacturing operation – the York Vehicle Operations facility, which accounts for more than 60% of annual production.

The York factory was designed on Henry Ford's mass production principles and was highly inefficient and extremely inflexible in meeting customer fulfilment needs. Each motorcycle model was assembled on a dedicated assembly line and the process flow was heavily constrained by the physical space and shape of the buildings. Large batches of make-to-stock bikes often didn't meet customer demand either in terms of volume or model mix.

The company embarked on a profound transformation of the York facility aimed at making it an agile and responsive factory, driven by customer demand. Among the key activities implemented:

- **Single digital chain.** Harley-Davidson got rid of multiple physical assembly lines, where motorcycles rigidly move along a predetermined path, to one single, multiple-model, digital chain where bikes move on AGVs (automated guide vehicles) driven by planning needs, software and automation.

- **Plant-floor visibility.** The factory environment is connected via the use of wireless networks. Every step of production is tracked and incorporated into a real-time performance management system available on digital signage and large screens around the plant, on desktops and on mobile devices. Management has full visibility of plant-floor performance and can make informed decisions in real time. Cameras placed around the manufacturing floor also enable managers to monitor production processes remotely wherever they are.

- **Production planning.** Thanks to the digital chain and the greater visibility, the planning cycle has moved from a 21-day fixed plan to a six-hour horizon. This has not only significantly impacted inventory on hand – which is now just three hours compared with 8-10 days in the past – but also added a greater degree of flexibility and real-time rescheduling capabilities.

- **Fewer people, higher skills.** The new factory has about half the number of employees it had previously, as a result of better visibility, automation, outsourcing and the use of flexible workers during seasonal periods. At the same time, workers are more engaged and highly skilled to manage a digital factory.

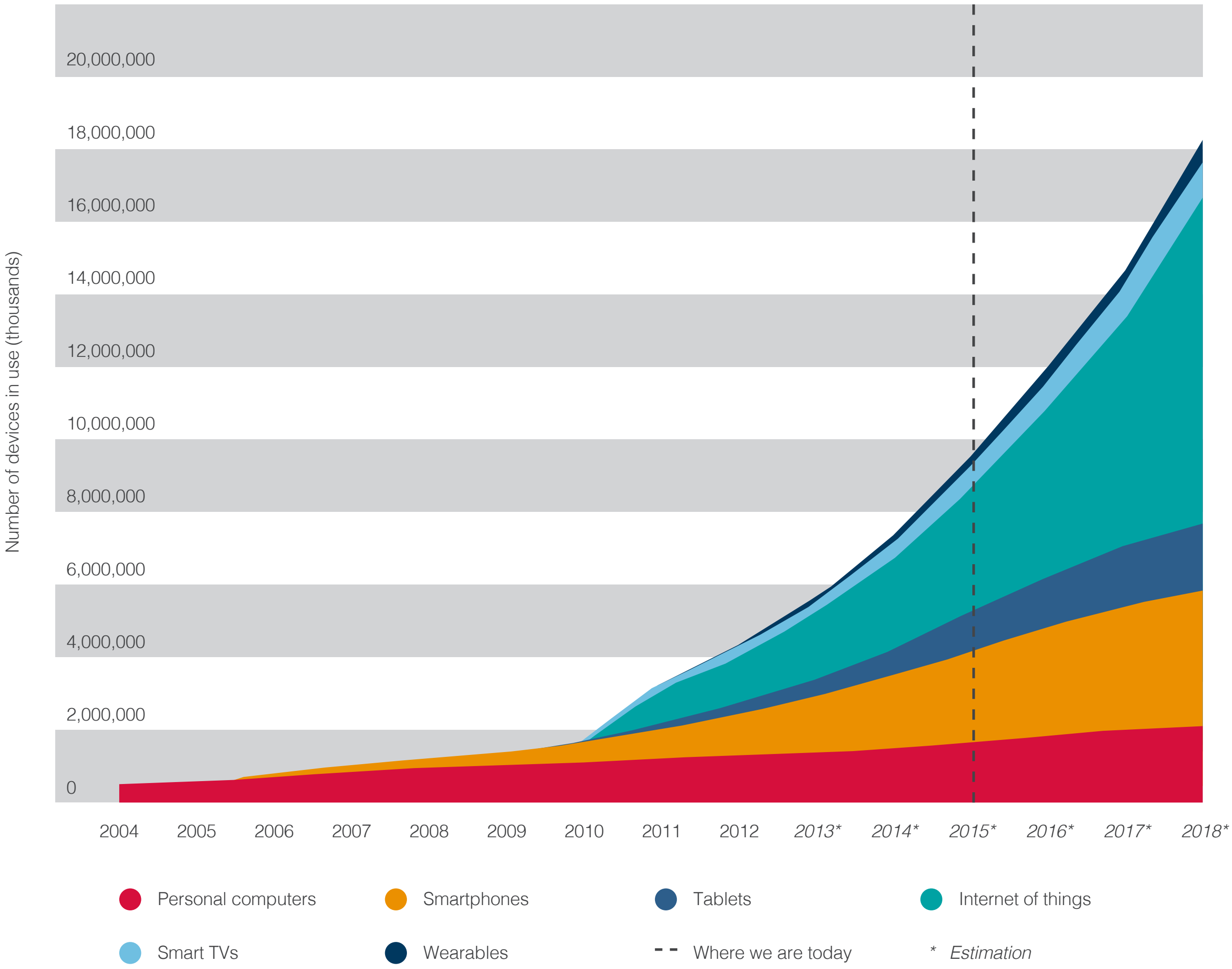
The transformation of Harley-Davidson's York factory is a great example of a company dramatically increasing manufacturing visibility to achieve a higher level of agility and responsiveness in meeting customer needs. This transformation drove down costs by 7%, increased productivity by 2.4% and boosted the net margin by 19%[2].

THE INTERNET OF THINGS

The internet of things represents the next evolution of the internet, taking a huge leap in its ability to gather and distribute data from a growing number of devices. The advent of the internet around the mid-1990s significantly accelerated productivity in manufacturing, because it provided an opportunity to go beyond the four walls of an enterprise and integrate the supply chain. The development of the internet of things is expected to further improve productivity in the coming years.

Estimates of internet of things growth are massive. Combining the estimates from several technology research firms, Business Insider[3] calculated that "the internet of things will account for an increasingly huge number of connections: 1.9 billion devices today, and 9 billion by 2018. That year, it will be roughly equal to the number of smartphones, smart TVs, tablets, wearable computers and PCs combined." (Figure 5).

5 | Growth of global connected devices



Source: Business Insider (BI Intelligence) on data from Gartner, IDC, Strategic Analytics, Machina Research et al.

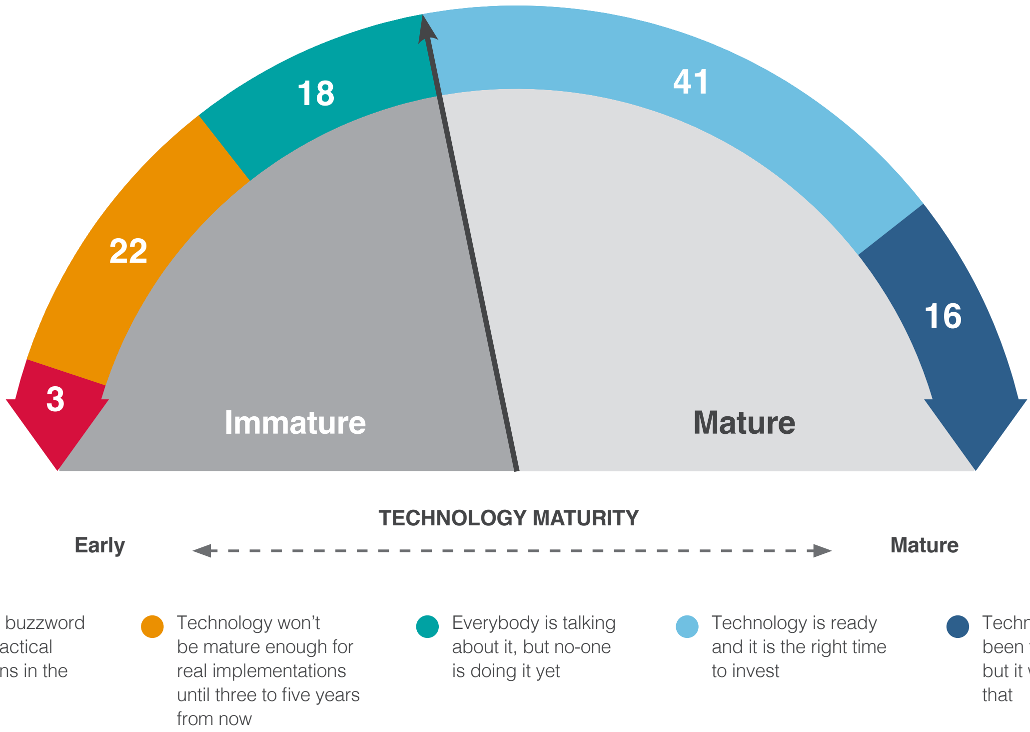
The internet of things offers the opportunity to integrate billions of physical objects – from automobiles to home appliances, from sensors to cameras – to the virtual world of the internet. The data generated is set to increase dramatically during the next few years, not only as a result of a big increase in the number of connected devices, but also thanks to the timing, accuracy and granularity of the events being recorded.

With respect to smart manufacturing applications, the internet of things can create a network securely linking together a range of assets from production equipment to parts being produced, from sensor-embedded automation controls to energy meters, from trucks and lorries to warehouse smart shelves. Manufacturers will be able to give each of their physical assets a digital identity that enables them to know the exact location and condition of those assets in real time.

Unlike traditional industrial automation, the internet of things is ubiquitous and standard, allowing assets to be visible not only within the four walls of production facilities, but also throughout the supply chain. It therefore offers manufacturers the potential for real-time, end-to-end manufacturing and supply chain visibility and remote control of their physical assets, wherever they are around the world.

Manufacturers are excited by the idea of adopting the internet of things on the plant floor. Four out of 10 respondents to our survey believe that the technology is proven and that now is the right time to invest (Figure 6). Just 3% believe that smart manufacturing and the internet of things are buzzwords with no practical application.

6 | Ready to deploy
Views on smart manufacturing and the internet of things



Source: SCM World survey, June 2015

% of respondents
n=277

THE ESSENTIAL TECHNOLOGY STACK

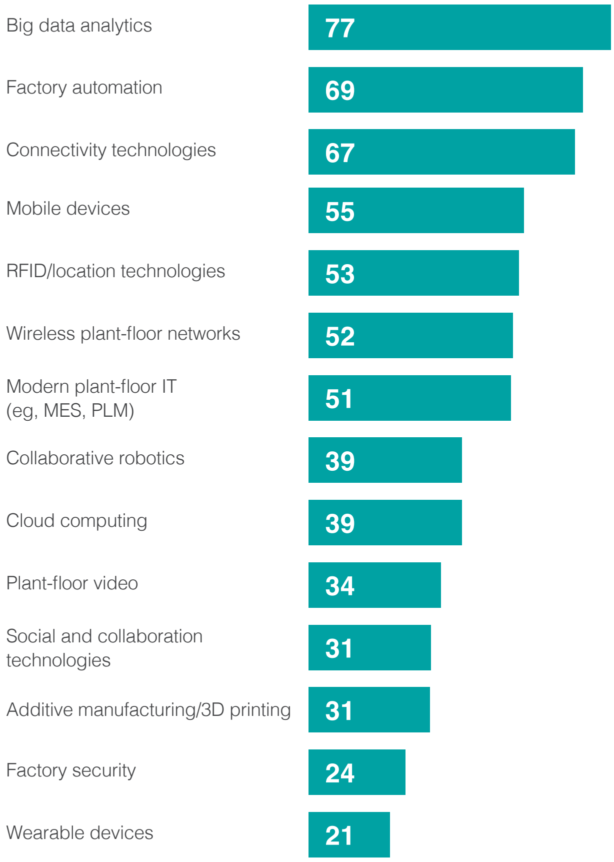
In his 2011 book *The Third Industrial Revolution*[4], Jeremy Rifkin paints a vivid picture of how the internet of thing is expected to support every aspect of economic and social life. "The intelligent TIR (third industrial revolution) infrastructure – the internet of things – will connect everyone and everything in a seamless network. People, machines, natural resources, production lines, logistics networks, consumption habits, recycling flows, and virtually every other aspect of economic and social life will be connected via sensors and software to the TIR platform, continually feeding big data to every node – businesses, homes, vehicles, etc – moment to moment in real time. The big data, in turn, will be analysed with advanced analytics, transformed into predictive algorithms, and programmed into automated systems, to improve thermodynamic efficiencies, dramatically increase productivity, and reduce the marginal cost of producing and delivering a full range of goods and services to near zero across the entire economy."

Rifkin talks about the internet of things as the platform for smart manufacturing, around which a number of devices are interconnected and where big data analytics orchestrates the behaviour of the entire system. Our survey findings confirm his intuition and provide an essential technology stack for the internet of things for smart manufacturing applications.

Essentially, the internet of things on the plant floor links factory automation assets to big data analytics (Figure 7). Indeed, the internet of things is not a technology per se; it is the combination of several technologies such as IP-based connectivity (the network that enables things to connect to the internet), cloud (the computing and storage environment where assets can communicate) and big data analytics (the intelligence of the system that is able to analyse data and provide insights on the fly). Mobile devices, RFID, wireless networks and plant-floor IT applications such as MES (manufacturing execution systems) or PLM (product lifecycle management) are also considered to be at the heart of the internet of things and smart manufacturing by the majority of practitioners we surveyed.

The essential technology stack for the internet of things for smart manufacturing applications is represented in Figure 8:

7 | Internet of things technologies that support smart manufacturing



Source: SCM World survey, June 2015

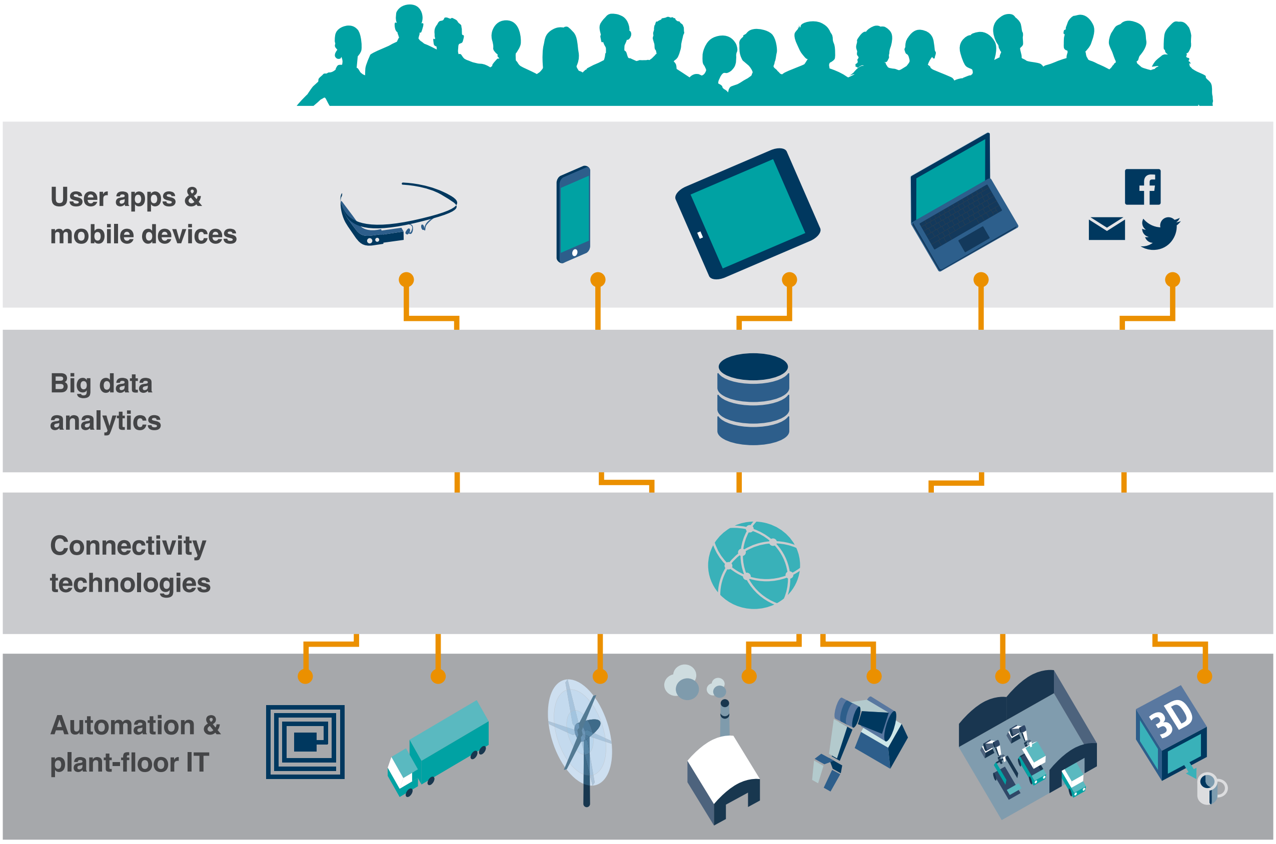
% of respondents n=396

- **User apps and mobile devices** – These are essential to deliver plant-floor and supply chain information anywhere, in real time. They are the end-point technology connecting knowledge workers with operational processes, and are the means to create plant-floor visibility for critical resources 24/7.

- **Big data analytics** – The intelligence tool that is able to automatically analyse huge volumes of unstructured and variable data, gathered in real time from the supply chain and from within production facilities. Big data analytics provides insights to users automatically and doesn't require them to endlessly search transactions for possible problems. It creates an event-based, self-healing system that can intelligently take decisions, while making operational processes more visible.

- **Connectivity technologies** – Interconnecting any asset and device throughout the supply chain and within the plant floor, connectivity technologies are the essential gateway through which data is collected and stored from billions of devices in

8 | The essential internet of things technology stack for smart manufacturing



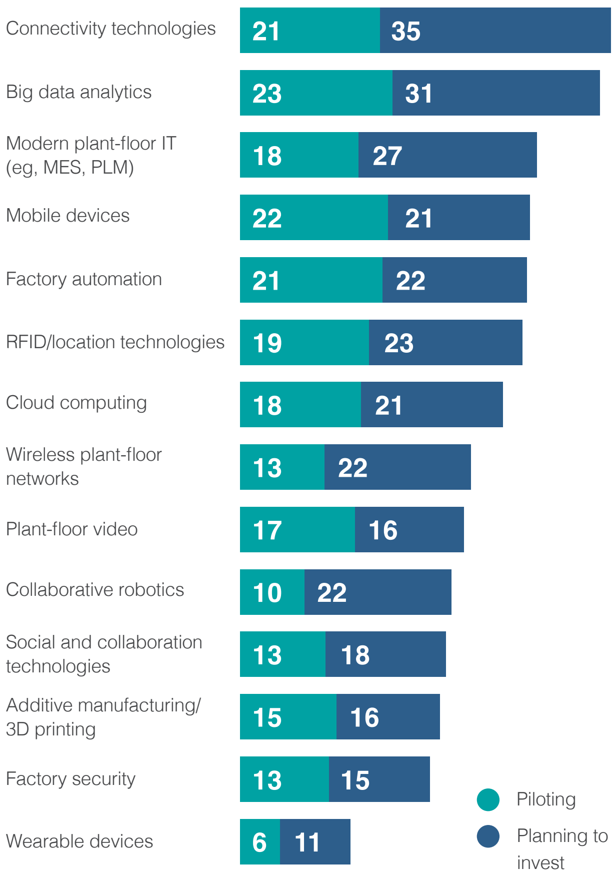
Source: SCM World

real time. This includes a secure, converged and wireless-enabled network with integrated edge compute to provide low-cost transformation of data embedded in the network or machine. The survey showed that many manufacturers view secure connectivity as an essential foundation for enabling smart manufacturing and the internet of things.

- **Automation and plant-floor IT** – Factory automation, industrial robots, plant-floor IT applications and a range of interconnected assets and devices within the plant floor and along the supply chain are equipped with an ability to connect to the internet, share their status and engage in dialogue with other devices.

Our survey data indicates that many manufacturers are currently piloting or planning to invest in these technologies (Figure 9). In particular, more than half of respondents are piloting or planning to invest in connectivity technologies and big data analytics. The next two sections look at the most critical use cases and examples for these two technologies.

9 | Adoption of plant-floor technologies



Source: SCM World survey, June 2015

% of respondents
n=365

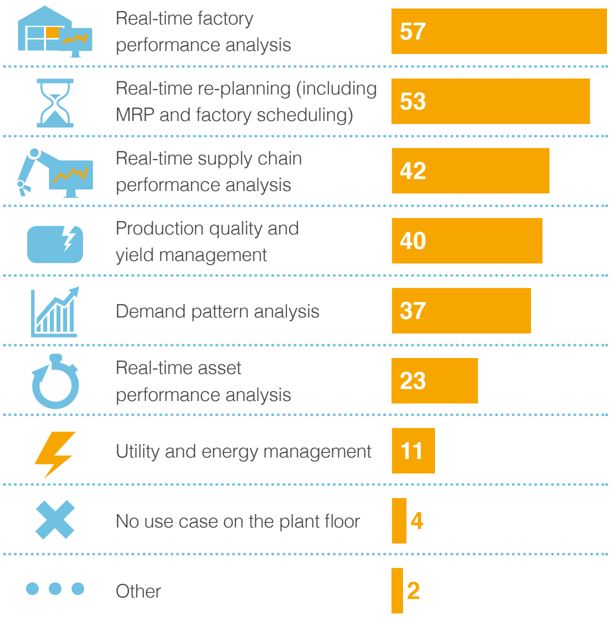
BIG DATA ANALYTICS

In SCM World's "Future of manufacturing" survey last year, respondents shared their enthusiasm regarding the use of big data analytics on the plant floor (Figure 10). With only 4% believing it has no use case, big data analytics is rapidly and powerfully entering the enclave of manufacturing operations.

Real-time factory performance analysis emerges as the most relevant use case for big data analytics (57%), along with real-time supply chain performance analysis (ranked third at 42%). Not only do companies want to have real-time control and supervision of their production facilities and supply chains, but they also want to plan and re-plan their production capacities in real time (53%). These two capabilities go hand in hand in a virtuous circle, where continuous factory and supply chain planning is triggered by real-time trending and variances in performance.

Production quality and yield management (40%) is another relevant area of application for big data analytics on the plant floor. It is, perhaps, the best developed area today, particularly in the hi-tech industry.

10 | Big data analytics use cases



Source: SCM World The Digital Factory report

% of respondents
n=158

TECHNOLOGY IN ACTION

Like many companies, Intel's raw data is growing exponentially. In an effort to manage this, it developed a big data analytics platform to mine volumes of information. One area of intense use of big data is the plant floor, where Intel aims to improve yield and lower unit costs. The company has identified a number of data-intensive production processes and uses big data analytics for each one to log information, find anomalies and predict future behaviour and trends.

By analysing this data, Intel can detect failures in its manufacturing lines and determine when a specific step starts to deviate from normal tolerances. For example, the company uses big data analytics to assess the quality of silicon wafers and how they are cut. The end goal is to have less waste and more processors for better yields. In 2012, Intel saved $3 million in manufacturing costs by implementing predictive analytics on a single line, and is now planning to extend the process to more chip lines and save an additional $30 million over the next few years.

Sharing similar objectives, Cisco uses big data to enable predictive quality in a fully outsourced manufacturing environment. Other firms are no different in term of quality requirements. GE Aviation is profiting from advanced quality techniques – involving infrared sensors, cameras and pyrometers – to monitor the quality of metal production processes, particularly when involving brand-new methods such as laser sintering. As this additive manufacturing process builds layer upon layer of melted metal, there are plenty of opportunities for quality faults. As the terabytes of quality data accumulate, the trick is to have a sophisticated analytics program to sift out the useful information. GE Aviation has estimated that using big data analytics to enable "in-process" inspection could increase production speeds by 25%, while cutting down on inspection after the building process is complete by another 25%.

CONNECTIVITY TECHNOLOGIES

At the heart of the internet of things there is data: visible, comprehensible and actionable. Manufacturers need to gather data to know exactly what's happening on the plant floor and across their supply chains. To this end, they need to create a network of connected assets – from production equipment to robots, and from smart shelves to trucks – that can share data in real time.

Six out of 10 manufacturers who participated in our "Future of manufacturing" survey in 2014 see connectivity technologies as a way to track production and remotely monitor their factories, while almost half (46%) would use it to track items in the supply chain (Figure 11). Real-time asset performance and machine-to-machine (M2M) communication are also seen as attractive by a significant minority. Indeed, only 6% of respondents see no use case.

TECHNOLOGY IN ACTION

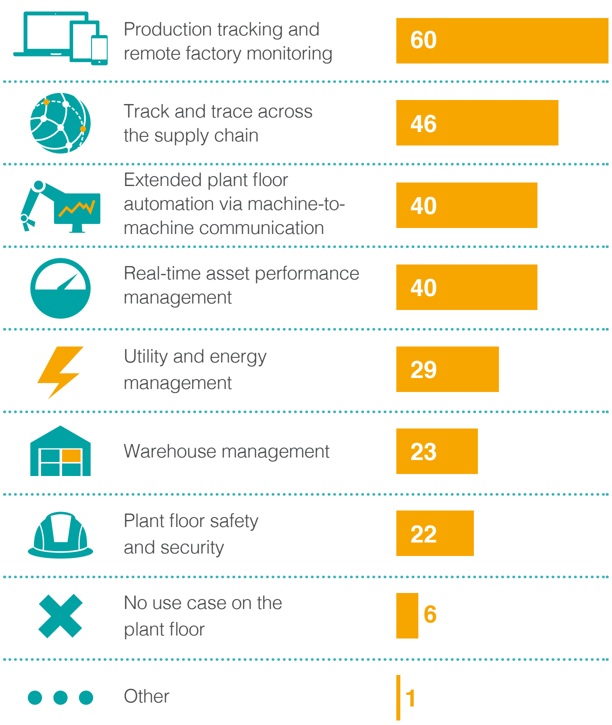
Fiat Chrysler Automobiles and its supplier KUKA Systems leverage connectivity technologies to link 60,000 devices – including welders, sealers and 245 robots – to a central repository that provides full plant-floor visibility at its Toledo factory (see company spotlight for more information).

Bosch is currently implementing a new approach to logistics at its manufacturing sites. The goal is to completely virtualise the physical flow of goods and track it in real time. Today, RFID tags are already common information and data carriers. In the future, web-enabled sensors will also transmit status information about objects. As a result, the quantity and quality of data will continue to increase. Intelligent software solutions and high-performance algorithms will evaluate data, and this will open up new potential for improvement. During a pilot project at Bosch's Homburg site in Germany, the efficiency of logistics processes was improved by 10%, by transitioning from RFID to web-enabled sensors connected to the internet of things.

Connectivity technologies and the internet of things also enable new business models. Michelin has launched a new service – dubbed Effifuel – that helps truck fleet managers to reduce fuel consumption, saving up to 2.5 litres per 100 kilometres driven. To supply the service, Michelin outfits each truck with sensors attached to the vehicle's engine and embedded in its tyres. These sensors collect data on fuel consumption, tyre pressure, temperature, speed and location. This data is then transmitted to a cloud service, where Michelin analyses it and makes recommendations to the fleet manager.

Rolls-Royce has embedded its jet engines with sensors that transmit information about their condition and maintenance needs. The company can ensure that replacement parts are available at the right airport to service them when they arrive. Connectivity technologies have allowed Rolls-Royce to introduce new service-based costing to its customers. Engine usage can be metered on a thrust-per-second basis and sold using a subscription-based pricing model, turning a physical product into a connected information service.

11 | Connectivity technologies and the internet of things use cases



Source: SCM World The Digital Factory report

% of respondents n=156

COMPANY SPOTLIGHT

FCA pioneers the internet of things to achieve maximum production agility and quality

FIAT CHRYSLER AUTOMOBILES

FCA's Toledo assembly complex in Ohio is one of the largest automotive factories in North America, with an annual production capacity of half a million vehicles. Sections of the facility have operated as an automobile assembly plant since 1910, although most of today's plant was reconstructed in 2006-07. The plant is made up of two facilities: final assembly operated by FCA and a supplier park, where on-site suppliers make different parts and subassemblies on a just-in-time basis.

KUKA Systems – a subsidiary of KUKA, a manufacturer of industrial robots and solutions for factory automation – is FCA's supplier of the Jeep Wrangler model's "body in white" (the initial welding of a car body's sheet metal component), as well as the chassis assembly and painting operations. Work-in-progress vehicles rolling off KUKA's production line are purchased by FCA, which then addresses trim, validation and shipping directly in its finishing plant next door.

KUKA Systems built a brand new 342,000 square foot production facility in 2007. The company understood that the new facility would have to be equipped with cutting-edge plant-floor technologies to open lines of communication with FCA and other firms at the Toledo Supplier Park, maximise flexibility in producing multiple car models and configurations on the same assembly line, and ensure an outstanding level of quality.

To achieve these goals, KUKA pioneered use of the internet of things. The company's highly automated plant interconnects a central data repository to as many as 60,000 devices, such as welders and sealers, and 245 KUKA robots – 68 used for material handling, 166 used for welding and 11 used for roller hemming operations. The data repository of real-time production gives KUKA's managers visibility of huge amounts of data and an unprecedented insight into factory operations and performance. By gathering and analysing real-time information from the plant floor, KUKA Systems has achieved a high degree of visibility that supports a faster production line with a greater agility to adapt to changes in business requirements.

Better traceability

Other than speed and agility, the other key objective was creating better traceability as vehicles move along the assembly line and into FCA's facility. With the internet of things in place, all production information related to each vehicle is automatically gathered and stored in real time as the vehicle is being produced. KUKA Systems can retrieve a detailed genealogy and traceability of each vehicle at any time, including "where-used" parts and a number of relevant details for quality purposes such as geometries, the "fit and finish" dimensions and pictures of the vehicle.

These efforts have paid off handsomely. Today, the Toledo Supplier Park can build a vehicle with less labour than any other North American assembly plant of any auto maker. In ratings published by the Harbour Report (an annual competitive analysis tool that benchmarks the performance and strategies of auto makers), it takes 13.57 labour hours to build a Jeep Wrangler – 1.5 hours less than the next most productive North American plant.

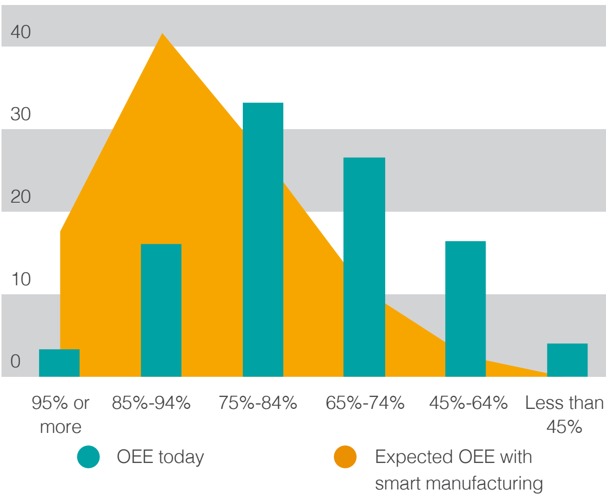
BUSINESS OUTCOMES

The most important question about smart manufacturing and the internet of things is the business impact. In our recent survey, we asked respondents to share their views on the most critical manufacturing metrics, ranging from percentage defect rate and inventory turns, to OEE (original equipment effectiveness) and NPI (new product introduction) cycle time. We also asked them to say how they expect metrics to be used when they are fully smart manufacturers.

Particular emphasis was given to OEE, as the most comprehensive and significant metric in manufacturing. Originally designed to measure maintenance effectiveness on individual equipment, OEE has today become widely used to measure the performance of entire factories. It's a taught metric because it comprises the multiple of three key underlying metrics: performance, quality and availability. World-class OEE is generally viewed as 85%, although the largest group of our respondents reports OEE of between 75% and 84% (Figure 12). Less than a fifth have an OEE of 85% or more, while almost half are struggling with OEE performance levels below 75%.

Smart manufacturing is expected to significantly impact business outcomes. As far as OEE is concerned, more than 40% of respondents expect smart manufacturing to help them exceed the world-class OEE target, with readings between 85% and 94%. At the same time, the share of those with a poor OEE reading lower than 75% is set to drop to less than a fifth. On average, the improvement in OEE is expected to be as much as 16 percentage points.

12 | OEE is set to improve with smart manufacturing



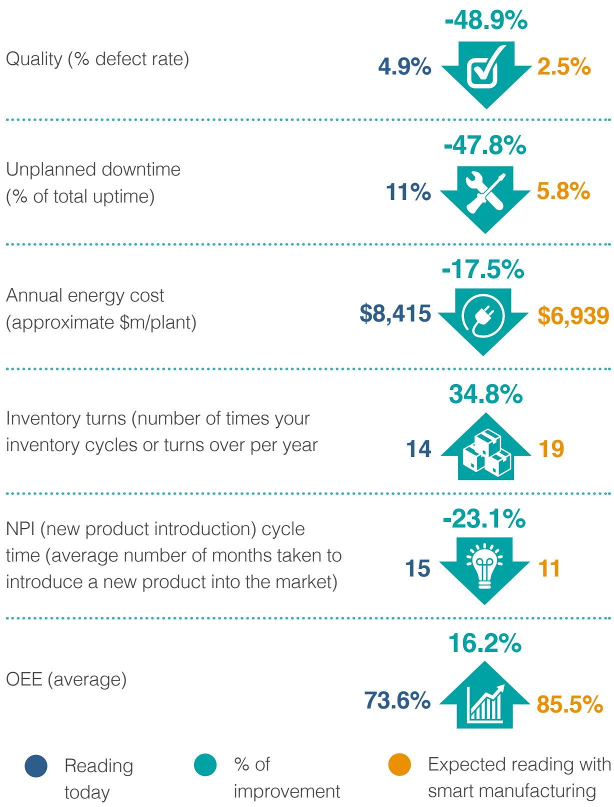
Source: SCM World survey, June 2015

% of respondents n=415

All other critical metrics are expected to see large improvements as a result of smart manufacturing (Figure 13). Quality and unplanned downtime will improve by nearly 50% compared to today's situation. Manufacturers expect to cut inventory turns by nearly 35%, while lead times for getting new products to market will shrink from 15 months (the average figure across all industries) to 11 months – an improvement of over 23%. Last, but not least, energy costs for running production facilities will fall by 17.5% – an average of almost $1.5 million in savings per annum, per plant.

So there is no doubt whatsoever about why manufacturers are so excited about smart manufacturing.

13 | Most critical metrics are set to improve with smart manufacturing



Source: SCM World survey, June 2015

CONCLUSIONS & RECOMMENDATIONS

There is a revolution happening in manufacturing today – a revolution that calls for companies to become more agile and responsive, not just more productive. This revolution is triggered by dramatic changes in the marketplace, with customers looking for speed, personalisation and value for money.

Manufacturers have to move away from an exclusive focus on efficiency, which tends to be inward-looking and risks distracting attention from the essential goal of fulfilling customer needs. What's the point of having super-efficient factories if they can't meet customer needs for speed, innovation and personalisation? Efficiency continues to be important, of course, but meeting customer fulfilment needs with higher levels of flexibility is much more so.

Smart manufacturing – and its foundational technologies: the internet of things and big data analytics – can give manufacturers access to real-time information on factory operations, supply chains, warehousing and logistics through an ability to connect virtually all assets within their factories and along their supply chains.

Companies expect that adopting smart manufacturing will give them more visibility and, through that, more agility and responsiveness. This will enable them to better manage their businesses, since visibility empowers manufacturers to orchestrate the supply chain, make their factories more agile and responsive, cut operational costs and reduce defects.

Manufacturers will become more responsive, more flexible and more able to meet customer fulfilment needs. They will be able to ramp up and scale down production according to dynamic marketplace needs, and in much shorter timeframes. Operations will be smaller and located closer to end markets, lead times will be shorter, and products will be more modular and ready to be customised to fulfil the requirements of smaller sub-groups of customers.

The following are SCM World's key recommendations to navigate through this period of manufacturing transformation:

- **It's about time to change.** The traditional approach to manufacturing, associated with efficient production plants and permanent cost-containment initiatives, can't respond adequately to changes in the marketplace today. With customers looking for speed, personalisation and value for money, be brave and embrace a business model that is more about agility and responsiveness rather than just efficiency.

- **Increase visibility.** Use the visibility maturity model included in this report (Figure 3) to benchmark your company's current level of visibility against your peers'. Your transformation journey should start by creating a higher level of visibility within your factories and along your supply chain.

- **Be smart about manufacturing.** Get acquainted with the work of associations such as the Smart Manufacturing Leadership Coalition and the German Industrie 4.0 working group, in order to plan your journey towards smart manufacturing.

- **The internet of things is ready.** There is no reason to be afraid of modern technologies like the internet of things. Many of your peers consider the technology to be ready and that now is the right time to invest. At the core of the internet of things platform for smart manufacturing are connectivity technologies and big data analytics. Lay out your investment plans considering they are two critical sides of the same coin to capture data in real time, make it visible and turn it into actionable insights.

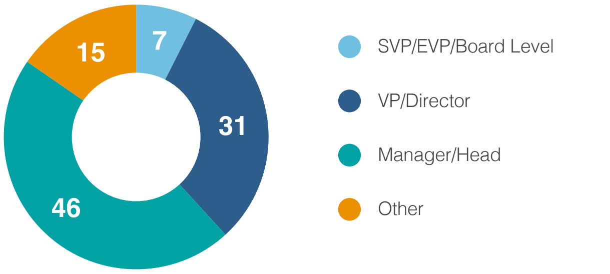
- **Benchmark your critical metrics.** This report provides average values for the most important manufacturing metrics as measured today, and expected with smart manufacturing fully implemented (Figures 12 and 13). Benchmark you current metrics against those of your peers and calculate the impact of smart manufacturing on your bottom line.

ABOUT THE RESEARCH

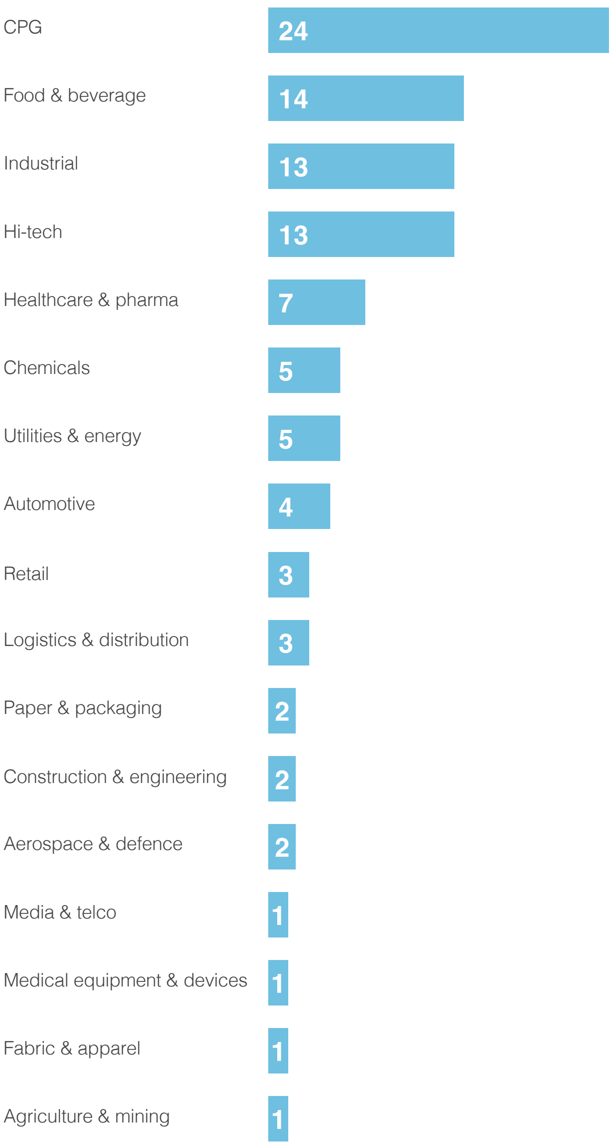
In June 2015, invitations to complete an online survey were sent to members of SCM World and to a wider group of practitioners in supply chain and other functions globally. In total, 418 completed responses were received during the survey period.

Key demographics are as follows (all figures represent % of respondents):

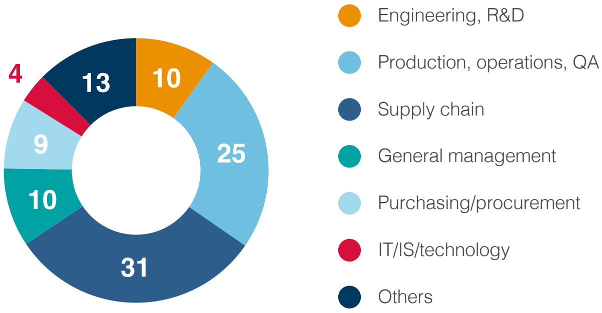
Job level



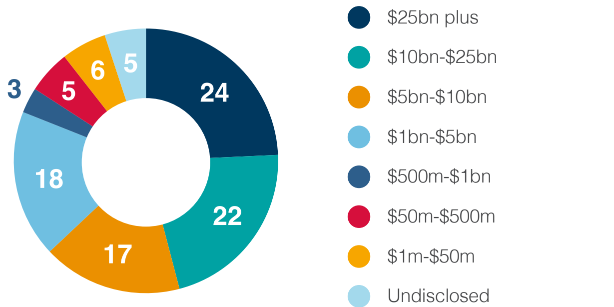
Industry sector



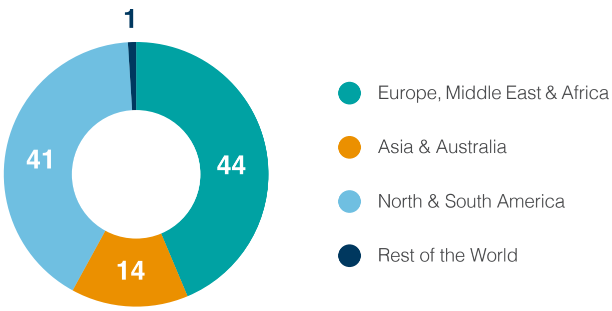
Job function



Company size



Location



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ABOUT SCM WORLD

SCM World is the supply chain talent development partner for the world's leading companies, empowering professionals with the capability, commitment and confidence to drive greater positive impact on business performance and help solve three of the world's fundamental challenges: health, hunger and environmental sustainability.

The SCM World community accelerates collective learning and performance by harnessing the knowledge of the most forward-thinking supply chain practitioners, shared through industry-leading research, best-practice exchanges, peer networking and events. Over 150 companies participate in and contribute to the SCM World community, including P&G, Unilever, Nestlé, Samsung, Lenovo, Cisco, Merck, Caterpillar, Nike, Raytheon, Chevron, Shell and BASF.

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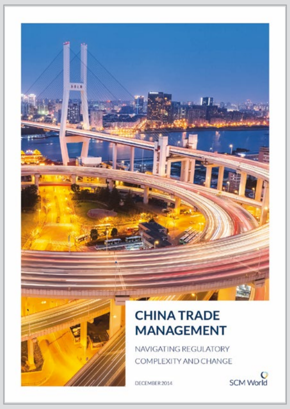

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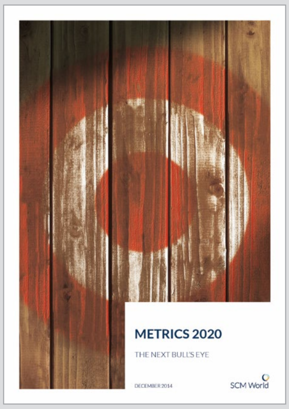

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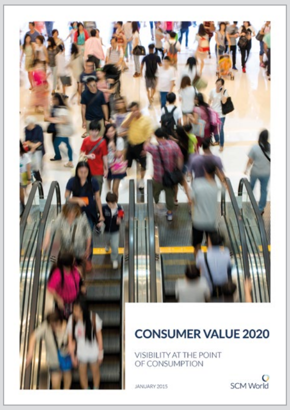

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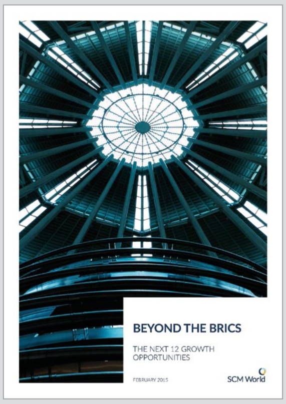

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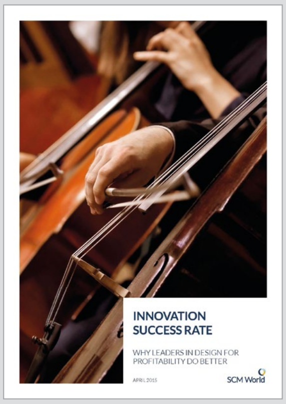

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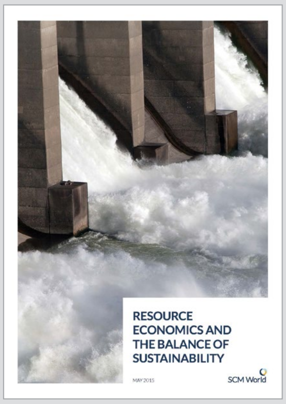

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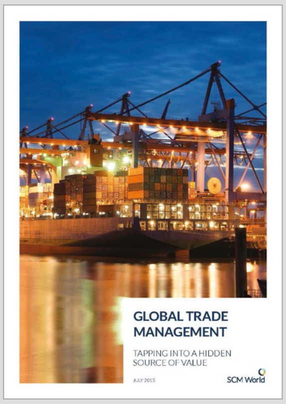

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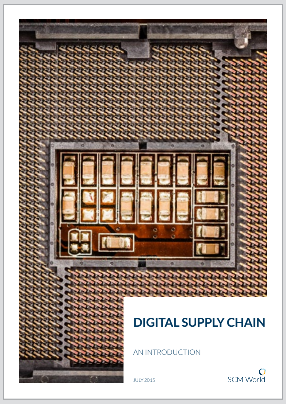

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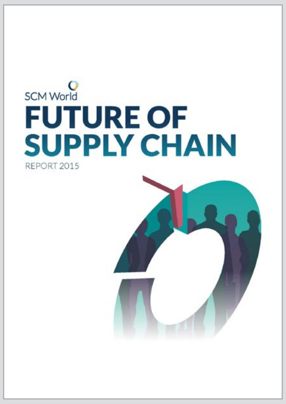

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