

# *The Internet of Things: what it means for US manufacturing*

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**pwc**

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## Executive summary

The world is hurtling into an era of deep data inter-connectivity. From collars with microchips that map a pet's wanderings to jet engines alerting manufacturers of imminent maintenance needs, the Internet is getting hit with conversations from one device to another. This is the Internet of Things (IoT), and it's creating mountains of data, much of which has yet to be fully put to use. What's enabling the IoT is a massive instrumentalization of the world, with literally billions of devices equipped with unique IP addresses—whether it be a smart phone, a camera on an oil-drilling rig or an optical sensor in a steel mill—that collect and send data. This isn't just a vision of the future. The installed base for Internet-connected devices already exceeded 14 billion by early 2015, and is forecast to mushroom to nearly 50 billion by 2020 according to one estimate.<sup>1</sup>

### Changing America's factory floors

Connected devices and new data flows have already made impressive headway in manufacturing. We expect to see roll-outs accelerate, especially as the cost of the infrastructure (e.g., sensors, computing power and data storage) declines, and new IoT-related software makes analysis of the data from the devices easier to use. And, in a positive feedback loop, information technologies are in turn giving rise to entirely new kinds of data—and data flows—that can be acquired in real or near-real time. Over the next decade, manufacturers could stand to capture about \$4 trillion of value from the IoT through increased revenues and lower costs, according to one estimate.<sup>2</sup>

How is all this connectivity applied? Here's an example: Through the deployment of data-collecting storage and analysis technology (e.g., sensors, controllers, analytics software, telemetry, Big Data and cloud computing), manufacturers are predicting maintenance needs before a piece of equipment malfunctions without gumming up production. Parts can be inspected with optical sensors or cameras, then tagged and followed digitally throughout the supply chain and even while in use by the customer. In doing so, new machine-to-machine and machine-to-human connections are being forged.

Manufacturers are moving to leverage IoT technologies and data analytics as a part of running their businesses and staying competitive. Consider that 57% of global manufacturing executives have, in the last two years, changed the way they approach big decision making as a result of Big Data or analytics, according to PwC's latest *Global Data & Analytics Survey*.<sup>3</sup> These changes included relying on data simulation, training executives to interpret data analysis techniques and hiring a dedicated data insights team.

Clearly, some manufacturers are further along the IoT trajectory than others. To get a closer look, PwC surveyed US manufacturers to learn more about what they are doing (or not doing) and what plans are afoot toward building more sophisticated data-driven businesses.<sup>4</sup> We found that manufacturers fall roughly into one of

three groups: early adopters, sideliners (doing little or nothing), and waders (those beginning or planning to begin to adopt). This suggests that we may still be several years away from seeing widespread adoption of IoT technology and systems deployed by US manufacturers. Our survey findings illustrate this:

- *Thirty-five percent of manufacturers are currently collecting and using data generated by smart sensors to enhance manufacturing/operating processes; 17% plan to do so in the next three years, with another 24% with plans, but no timeline.*
- *Thirty-four percent of manufacturers believe it is "extremely critical" that US manufacturers adopt an Internet of Things (IoT) strategy in their operations; 60% believe it's "moderately or slightly critical."*
- *Thirty-eight percent of manufacturers currently embed sensors in products that enable end-users/customers to collect sensor-generated data; 31% have no plans to do so, and the balance plan to do so in the future.*

In some ways, the ascent toward high operational intelligence through data-driven technologies can mean climbing up rungs—from deciding what data is to be collected—to using data to automate operational decisions in near- or real time and to even inform long-term business strategies. This report endeavors to look at how US manufacturers are faring on these fronts.

1 Karen Tillman, Cisco Systems blog and Cisco System's live Internet of Everything Connections Counter, which estimates number of connected devices reached 14.7 billion as of February 6, 2015). Retrieved on February 6, 2015, from <http://blogs.cisco.com/news/cisco-connections-counter>.

2 ARC Advisory Group, *Internet of Things (IoT) Could Enable \$3.88 Trillion in Potential Value to Manufacturers*, March 2014.

3 *PwC Global Data & Analytics Survey*, PwC, 2014.

4 PwC and Zpryme survey and analysis, *2014 Disruptive Manufacturing Innovations Survey*, conducted in 2014.

## Data hunting and gathering

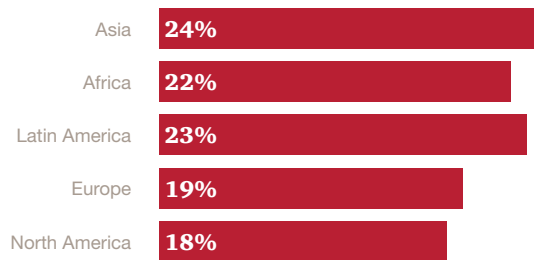
To get any value out of data, that data first needs to be gathered. Manufacturers are deploying instruments such as sensors and controllers or even smart, networked cameras or RFID readers to measure a wide range of operational processes.

These are as varied as: ascertaining the amount of voltage used to produce a product, or inspecting parts with greater speed and accuracy, or testing the performance of equipment. In such ways, they are receiving data previously unknown, unseen, and unused.

Building out the infrastructure that makes this possible—deploying devices that measure data and the tools to analyze it—will likely become more of a requisite for manufacturers attempting to keep up with competitors who have already done so. Consider that, by 2025, the number of Internet-connected devices industrial automation sector is forecast to represent about three-quarters of all connected devices, and grow by a factor of 50 from 2012–2025.<sup>5</sup>

### North America lags in sensor adoption

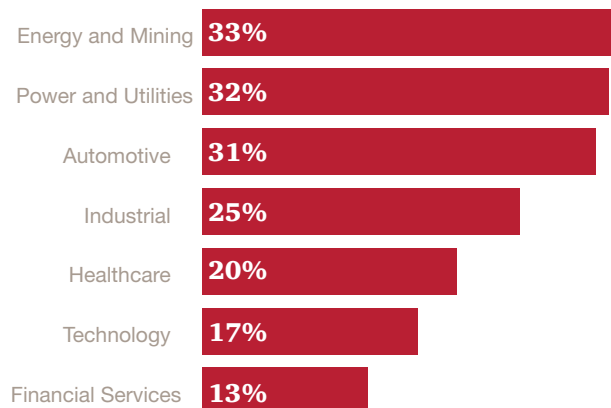
Percentage of companies by region investing in sensor technology



Source: PwC 6th Annual Digital IQ, 2014

### Sensor adoption by industries

Percentage of companies by industry investing in sensor technology



Source: PwC 6th Annual Digital IQ, 2014

### Manufacturing IoT in a nutshell

The Internet of Things is the growing skein of connectivity between objects equipped with the ability to gather, store, process, and send data either through communication protocols to the Internet, or directly to other things or to an Internet gateway. These objects could be as varied as a camera sending an image or a sensor on a wind turbine capturing data on temperature and turbine performance. Sensors collect numerous types of data—including pressure, humidity, optics, speed of a moving part, sound, etc. For manufacturers, the IoT becomes a full ecosystem when software, cloud computing (or in-house servers), and analytics tools combine to turn raw data into meaningful information or predictions—and when it's presented on easy-to-use interfaces (such as dashboards or mobile Apps) enabling users to monitor, and in some cases, automate response actions or remotely control equipment or systems.

5 *The Internet of Things Explodes*, IHS Quarterly, 1Q 2014.

## ***Sensing change in how manufacturers gather data***

The mind-boggling pace of real-time monitoring can obscure the reality that not all manufacturers have the capabilities and resources—and, in some cases, even the immediate need—to build out platforms that seamlessly connect data throughout the organization.

To be sure, large multinationals are making major investments in leveraging data to squeeze out more productivity, deliver higher quality products and to even track those products for performance long after they leave the factory floor. General Electric, in 2012, announced it would invest \$1.5 billion to advance the “Industrial Internet” in its manufacturing and product service operations. As part of that effort, the company has, to take one example, installed over 10,000 sensors in its 180,000-square foot plant in Schenectady, New York, which produces advanced sodium-nickel batteries. The sensors are connected to an internal Ethernet, and track materials usage, the temperatures used to bake high-tech ceramics that are used in the batteries, and ambient air pressure. The data are readily available to factory floor employees’ iPads through the factory’s Wi-Fi.<sup>6</sup> To take another example, GE’s wind turbines contain some 20,000 sensors that produce 400 data points per second, which is analyzed in near-real time to optimize turbine performance. The data is stored and used for predictive analytics to improve maintenance and parts replacement.<sup>7</sup>

But not all manufacturers can launch a multi-billion dollar program to dive into the industrial Internet. Small and mid-sized manufacturers are looking for ways to wade in despite more limited financial and talent resources.

One way companies can enter the IoT at the ground floor is by gaining a real-time situational awareness of how one’s assets are performing. Cloud computing has lowered computer processing and storage costs, while hardware costs are also coming down for certain devices; MEMS accelerators, for example, which once cost in the hundreds of dollars, now cost in the tens.<sup>8</sup> “The technology is getting so much cheaper and easier to use that barriers to entry are coming down all the time,” said Betsy Page Sigman, Distinguished Teaching Professor, Georgetown University, McDonough School of Business, in an interview with PwC. “Setting up sensors and doing the configuration can require expertise,” she said, but once it’s in place, small and middle sized manufacturers “can use warnings, alerts, and data visualizations to get a lot out of the data from such a system,” she added.

Digital situational awareness is being applied to simpler problems, such as pin pointing energy waste. Consider the experience of an Indiana-based meat packing plant, which installed an energy monitoring system to find the culprits behind its electricity costs. The company retro-fitted its plant’s machinery and equipment and electric meters to collect energy use data through a wireless

Ethernet network for analysis, ultimately revealing that one of its refrigeration units was using far more energy than necessary. Fixing the (70-year-old) refrigerator saved the company about \$250,000 a year.<sup>9</sup> Real-time energy-use data can also help plants reschedule the running of energy-intensive assets to avoid peak energy costs and get a more precise picture of how much energy costs account for the total cost of a product. “Once you can determine how much energy is being used on a granular level, manufacturers can account for energy costs and build them into the total cost of manufacturing,” said Arun Sinha, engineer and leader on energy management business at Opto 22, a maker of products for industrial automation, remote monitoring, and data acquisition. “One of our manufacturing clients had been sending an employee around the plant checking energy meters on equipment and writing the readings down on a clipboard. We helped them build an energy monitoring system that polled the meters and sent data to their ERP. Ultimately, what you want is to get this detailed operations data pulled from the plant floor and delivered to the boardroom in a way that’s easy to analyze and understand. You’d be surprised how many companies—even large ones—still are doing things old-school,” Sinha said. He added that manufacturers are especially interested in having real-time operational data accessed via mobile Apps for remote monitoring (and, in some cases, control) of systems and equipment.

6 *An Internet for manufacturing*, MIT Technology Review, January 28, 2013.

7 *G.E. Makes the Machine, and Then Uses Sensors to Listen to It*, Quentin Hardy, The New York Times, June 19, 2013.

8 *The Internet of Things can Drive Innovation—If you understand sensors*, Altera website, <http://www.altera.com/technology/system-design/articles/2014/internet-things-drive-innovation.html>.

9 Case study from Opto 22 website, [http://www.opto22.com/site/documents/doc\\_drilldown.aspx?aid=4038](http://www.opto22.com/site/documents/doc_drilldown.aspx?aid=4038). Retrieved on November 15, 2014.

Sensors are also being employed beyond efforts to cut costs, as manufacturers seek to ensure product quality and even product safety. Take, for example, the pharmaceutical industry's use of optical sensors to measure optical characteristics for product inspection, with individual packages measured for the correct level of opacity (packaging is included in FDA drug approvals). That's a big leap from the previous method of inspection through statistical sampling. Optical sensors are also deployed in harsh environments, such as in mines, on oil rigs, with robotic welders, or in steel mills.<sup>10</sup> The oil and gas industry deploys sensors to measure conditions such as pressure, and can communicate with valves for their opening or closure to help prevent leaks.<sup>11</sup>

Despite the overall growth of smart sensor deployment, only a third of US manufacturers are currently leveraging it, but about a quarter look to adopt the technology. According to our survey, 35% of US manufacturers are collecting and using data generated by smart sensors to enhance their manufacturing and operating processes. Many are just beginning to deploy devices to gain a greater situational awareness of their operations. However, the survey also found that 24% of manufacturers have no plans at all to implement and another 24% plan to do so but have no timeline (see chart).

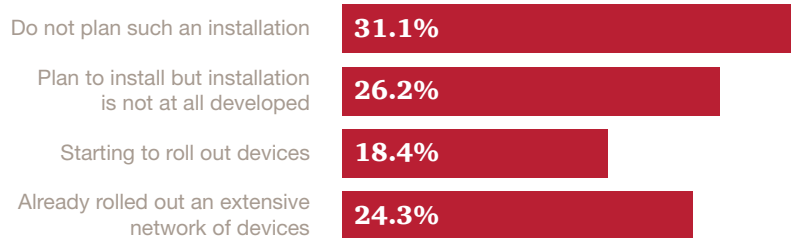
And, when asked, more broadly, about whether they have deployed any IP-enabled devices to improve connectivity in their manufacturing ecosystems, the responses were also split among adopters and sideliners. One in four manufacturers has already rolled out an extensive network of IP-enabled devices, while 31% say they have no plans. The balance of respondents is in the process, with 18% beginning a roll out and 26% with plans in place.

<sup>10</sup> *Optical Sensors Speed Up Production Lines*, Europhotonics, Autumn 2013.

<sup>11</sup> *Sensor Insights*, Sensorsmagazine.com, November 14, 2014.

## One-third of manufacturers are deploying Internet Protocol connectivity

**Q. How developed is your company's installation of IP-connected devices that improve connectivity in your manufacturing ecosystem?**

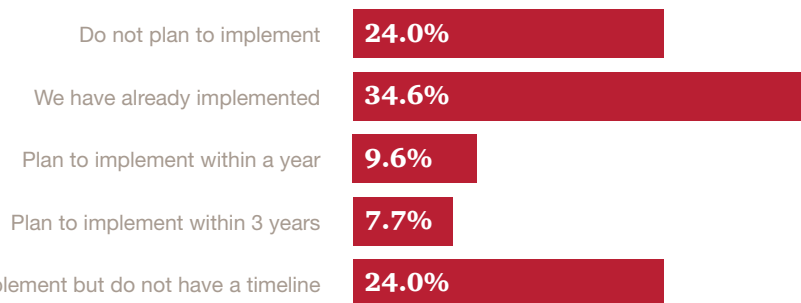


Number of respondents: 103.

Source: PwC and Zpryme survey and analysis, *2014 Disruptive Manufacturing Innovations Survey*, conducted in February 2014.

## Smart sensors gaining traction

**Q. What is your company's timeline for collecting and using data generated by smart sensors to enhance manufacturing/operating processes?**



Number of respondents: 104.

Source: PwC and Zpryme survey and analysis, *2014 Disruptive Manufacturing Innovations Survey*, conducted in February 2014.

## Building an IoT ecosystem: when data works harder

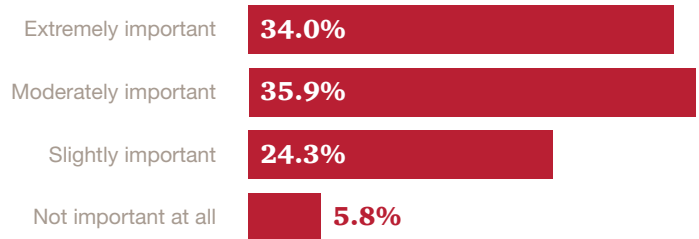
Given the hype around IoT in the last several years, it is somewhat surprising that there seem to be a number of manufacturers who do not see its relevance. According to our survey, about 30% say that it is “slightly important” or “not important at all” for US manufacturers to adopt an Internet of Things strategy in their operations. However, our findings again reveal a gap between believers and sideliners; 34% of respondents believe that adopting an IoT strategy is “extremely important” (see chart).

Gathering operational data is nothing new. What’s changing is a rapid proliferation of IP-enabled, data-gathering devices, and that more precise insights are being eked out.

But, clearly, while manufacturers cannot do everything at once, they are nonetheless evolving their IoT strategies. Manufacturers are at different stages of their IoT evolution or on different rungs of the ladder (see sidebar) toward creating a ubiquitous IoT.

### Not all US manufacturers think an Internet of Things strategy is critical

**Q. How critical is it that US manufacturers adopt an Internet of Things (IoT) strategy in their operations?**



Number of respondents: 103.

Source: PwC and Zpryme survey and analysis, 2014 *Disruptive Manufacturing Innovations Survey*, conducted in February 2014.

### Climbing the IoT ladder

#### Rung 1: Data hunting

Determining what data needs to be captured. Deployment of data collectors (Internet-connected sensors, controllers, cameras, gauges, smart phones, tablets, etc.). Data connectivity through wired and wireless (e.g., ZigBee), Wi-Fi, mobile phone, local networks, and Internet.

#### Rung 2: Data gathering and analysis

Collection, storage, and organization of data, using software, cloud servers—private, public or hybrid. Real-time performance monitoring and analysis of plant equipment, materials and processes, and energy use on granular level.

#### Rung 3: Actionable data delivered to decision makers

Data consolidated through gateway platforms in an App for all relevant employees to act upon (e.g., to alert via email possible machine failures), scalable, can pull data from external sources (e.g., weather information).

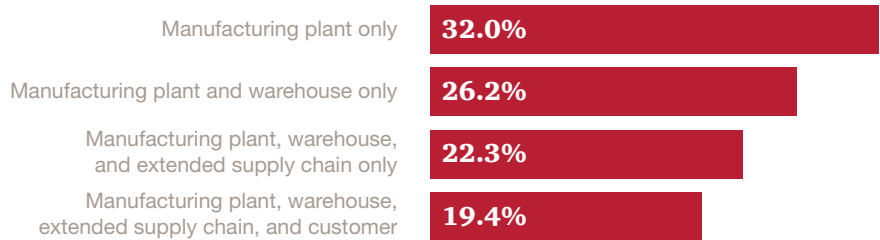
#### Rung 4: Data ubiquity now... and in the future

Data collection/analytics pervades operations and into supply chain and distribution further spreading the IoT network. New technologies adopted for greater connectivity (e.g., 3-D sensors, collaborative and social software, augmented reality, location awareness, 3-D data visualizations, wearable technology to monitor conditions for worker safety. Increased machine-to-machine (M2M) data exchange between advanced manufacturing equipment such as industrial robots, 3-D printers, etc. Increased adoption of product-monitoring service business models.

For manufacturers already investing in initiatives that could end up being IoT-related, there seems to be impressive commitments on numerous fronts to enhance their operations and/or products by connecting devices. Investments include smart IP-enabled and connected sensors and telematics, mobile workforce connectivity, digitally tracking parts and products, and networking of Internet-based manufacturing and operational processes. In fact, only 13% of manufacturers said they were not implementing any of these technologies (see chart).

### Where are manufacturers deploying data-driven technology?

**Q. In your manufacturing ecosystem, which best describes your deployment of data-driven manufacturing (digital business models, use of smart sensors, machine-to-human and machine-to-machine communication, big data, etc.)?**



Number of respondents: 103.

Source: PwC and Zpryme survey and analysis, 2014 *Disruptive Manufacturing Innovations Survey*, conducted in February 2014.

### Enterprise-wide data driven manufacturing

As more manufacturers adopt IoT technologies to make their factories smarter, they're also applying technologies across their organization's value chain and even looking into the possibilities of new services-based business models through remote monitoring of assets as part of operations and maintenance services. To get a glimpse of how extensive IoT technology has been deployed across manufacturers' ecosystem we asked manufacturers where they have deployed technologies including use of smart sensors, machine-to-machine and machine-to-human communication and Big Data, etc.). Of those that have deployed such technology, one in three manufacturers use data-driven technology in the manufacturing plant only, with about one in four deploying it in their plant and warehouse. The survey also found that about 20% of manufacturers have

deployed data-driven technologies across their value chains—in the plant, warehouse, extended supply chain, and the customer.

### The big retrofit

Building the infrastructure to create machine-to-machine data flows and analysis could be a tall order for some manufacturers. "One problem is that a lot of plants and machines are purpose built, and so linking all systems together in a way to gather data and make it useful can in some cases be trying," said David Dornfeld, professor of mechanical engineering, University of California, Berkeley, in an interview with PwC. Older machines need to be retro-fitted, adding time and expense. But most of the new machines are equipped with data portals that are plug-and-play for most data monitoring platforms, he noted. "Once you get the data and analyze it, you start to understand the DNA of your equipment—and assign, for example, a likely cause for

a problem when you see a deviation in performance—whether it be that a tool is wearing out, or even a connection between the temperature of the plant and certain problems with certain processes. One can more accurately anticipate issues and can fix them before they cause a real problem," he said.

Makers of industrial equipment are moving to smooth the transition for their customers who are keen on leveraging IoT advancements. Mazak Corporation, a maker of machine tool and advanced manufacturing technology, for example, announced in 2013 that it converted its Florence, Kentucky, factory to MTConnect—the open-source communications protocol enabling the monitoring and data analysis of manufacturing equipment through the exchange of data between shop floor equipment and software applications—developed by the MTConnect Institute,



a non-profit group. The company uses MTConnect to monitor equipment efficiency and to receive texts or email alerts on operational issues. Mazak also builds MTConnect compatibility in the machines it produces, with over 100 Mazak customers integrating MTConnect in their own manufacturing facilities.<sup>12</sup>

“Existing enterprise applications, business processes, customer interactions and data are functionally isolated and fragmented, difficult to use other than by experts, and hard to change due to their complexity. As a result, people are not aware of bottlenecks. It is really hard to sense and predict the downstream consequences of decisions. Smart, connected devices coupled with elastically scalable services in the cloud where product, customer interaction and other relevant data and metrics are stored and analyzed will offer exponentially expanding opportunities for new functionality and capabilities. The first thing many companies can do, without investing too much or ripping and replacing their existing technologies, is simply connect their equipment utilizing standards like MTConnect, MQTT, and analyze base-line characteristics to see if they’re running at optimal levels or at industry standards,” said Surendra Reddy CEO of Quantiplay, in an interview with PwC. “For example, does a machine perform at a low or high through-put? Or, even something as basic as machine availability—is it up and running or not? Some companies are still collecting this data manually and do it in silos,” he added.

### ***New data connectivity opens window to augmented reality***

Taken one step further, manufacturers who have already established an IoT ecosystem are looking for ways to squeeze even more productivity and connectivity through next-generation augmented reality tools, such as 3D-simulated environments. Take, for example, Indiana Technology and Manufacturing Companies, a machinery parts maker that has coalesced MTConnect with Google Glass in a shop data-management application it dubs MTConnect + Google Glass. The device helps machine operators by streaming in MTConnect-generated data on machines such as power status, path feed-rate, and machine location. In the event of a need for repairs or maintenance, the user of the device calls up information on parts—or even views a training video.<sup>13</sup>

### ***Lightening the data load on the cloud***

As manufacturers gather more and more data, they will likely encounter limitations in their computing ability to sift through and interpret that data with dedicated servers. Cloud-based computing and tailored Apps that harness that data are giving such companies greater bandwidth, scalability, and customized data—both for their operations and external data such as weather information. “There will come a point where pretty much every manufacturer who collects data will need to start using the cloud—it simply will not be feasible for them to do otherwise—there’s

simply too much data to be reckoned with,” said Surendra Reddy, CEO of Quantiplay.

Manufacturers are also taking advantage of the cloud to save time and streamline operations. Take DP Technology, based in Camarillo, California, which developed a cloud-based computer-aided manufacturing (CAM) software for a full range of machine tool applications. Its ESPRIT Machining Cloud Connection gives programmers access to a library of up-to-date tooling product data, which the company says reduces hours of manually programming tool creation (e.g., for milling, turning) by offering suggested lists of recommended cutting tools.<sup>14</sup>

<sup>12</sup> *Manufacturing factory floor the first of its kind in the machine tool OEM industry*, Industrial Machinery Digest, July 17, 2013.

<sup>13</sup> *Shop Projects Better Machine Vision with MTConnect + Google Glass*, Americanmachinist.com, July 12, 2013.

<sup>14</sup> DP Technology company website, retrieved on January 27, 2015, <https://www.dptechnology.com/>

**Q&A with Dennis Little, Vice President of Production, Lockheed Martin Space Systems Company, a division of Lockheed Martin Corporation**

**PwC:** How is digital manufacturing changing the design and manufacturing ecosystem at Lockheed?

**DL:** We are pushing the limits of how information technologies and advanced manufacturing intersect. We're applying a gamut of innovations across our business—such as digital modeling, Big Data, 3D printing, computer simulation and automated inspection acceptance—in countless ways, from developing innovative designs and products to improving factory design. We call our adoption of model-based designs and IT-based technologies the Digital Tapestry, and our vision is to use only digital tools throughout the product lifecycle to increase our agility and functionality. Another way of looking at it is that we turn data into things and things into data. We are weaving all aspects of our digital strategy together seamlessly, from conceptualization to engineering to production and sustainment. The days of stove-piped organizations in research and development are long gone.

**PwC:** Which data-driven technologies are already gaining significant traction?

**DL:** First, our success with virtual reality has proven transformative. All new product design begins in a virtual environment, which we call the CHIL [Collaborative Human Immersive Laboratory]. The CHIL is a virtual reality and simulation laboratory that offers a smarter, cheaper and lower risk opportunity in building space systems, including satellites, exploration spacecraft, launch vehicles and missile defense systems. The facility enables virtual creation before the physical creation to improve the affordability of our products and associated processes, while fostering a culture of collaboration and excellence.

In the CHIL, design engineers and manufacturing technicians use 3D models, 3D glasses, motion tracking and virtual reality technology to create a unique collaborative environment for exploring and solving problems quickly. They are hooked up with motion sensors to create a virtual experience using 3D

models to develop products or to improve on existing ones. Teams of design and manufacturing engineers, suppliers and even customers can virtually walk around their creation, look at it from every angle, virtually add parts to it and interact with it as if it were physically in the room. The CHIL creates a unique, virtual and collaborative environment for exploring and solving problems quickly, where hardware designs and manufacturing processes can be fine-tuned in the virtual world, before production or development begins. Engineers and technicians are able to validate, test and understand products and processes early in program development, when the cost, risk and time associated with making modifications are low. Now, we place virtual hands on a virtual product before physical hands touch a physical product.

But we're finding all sorts of other applications, such as designing an entire factory virtually. We're even using it to virtually simulate transportation of our products. We've modeled a journey to simulate the delivery of a satellite system traveling from Colorado to Florida's Cape Canaveral—virtually dry-running the entire route and following it over bridges and under tunnels along the way to ensure success. Even jet plane maintenance has been virtually simulated. In this these ways, the Digital Tapestry has unleashed the creativity of our engineers.

Another technology we're ramping up is additive manufacturing, or 3D printing. Lockheed Martin has been developing this technology for a decade, and now we have a battery of 3D printers for prototyping parts in polymer and printing flight-ready parts in titanium and aluminum and polymer inks. Small polymer printers are becoming as common as inkjet paper printers on the desks of our design engineers. We're continuously considering whether final flight-ready parts can be 3D-printed. In fact, some 300 parts on the Orion were 3D printed (NASA's unmanned spacecraft which made a successful test flight in December 2014 and for which Lockheed

Martin was a contractor). Our satellite propulsion tanks once could take up to 21 months through traditional manufacturing, such as titanium forging. Now, by leveraging additive manufacturing technology, we can manufacture a tank in less than six months, and with a cost savings of over 50 percent.

**PwC:** How are these technologies changing the landscape of manufacturing in general?

With all these advancements, we want to be able to accelerate the design and production of a satellite from as many as 48 months down to 18. That's a pretty ambitious goal, but we think it's achievable. The digital technologies are also unleashing creativity, enabling altogether novel geometries in product design that reduce mass of a product by one-tenth of a conventional design while maintaining the same degree of strength and integrity. Shrinking weight or mass pays off enormous dividends in our satellite systems.

**PwC:** What does the future of manufacturing look like?

**DL:** The next home run in advanced manufacturing will be the development of new materials. We've been stuck inside the periodic table of elements, and we need to go beyond that to what we call "materials by design." Another big change will be how other manufacturers adopt digital technologies. We're evolving from sending paper drawings to suppliers—now, we're sending 3D CAD files. So, we likewise expect all our suppliers to advance in the digital world, to be as digitally advanced as we are. Going forward, suppliers will have to keep up with this technology, or they won't be competitive. We are trying to bring them along with us on the road to keeping everything digital and based on 3D models. The talent landscape is changing, too. We're working with a generation of manufacturing engineers that don't know how to draft on paper. Our new engineers have grown up on a steady diet of 3D models, and they are not about to regress to 2D drawings. But as we leave that 2D world, IT, I suppose, is the new T-square.

### Smart products: a path to new customer service

While this report focuses primarily on the adoption of data-driven technologies by US manufacturers within their operations, one of the disruptions the IoT is ushering in is the growing potential for manufacturers to produce more “smart” products that communicate data. Shipments of IP-addressable devices, for example, reached 4.3 billion in 2012 and will grow to 13.7 billion by 2025, according to one estimate.<sup>15</sup>

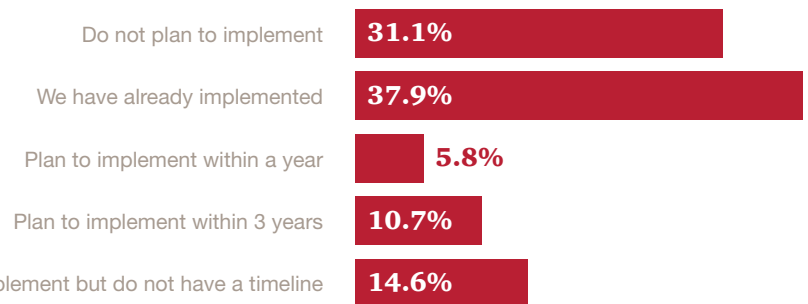
Indeed, manufacturers, according to our survey, are well on their way toward embedding intelligence into their products. Nearly 40% of respondents report they are already embedding sensors in products to enable end-users or customers to collect sensor-generated data. Manufacturers are adding intelligence to existing product portfolios as well to altogether new products.

### Smart products to create new service opportunities

With IP-enabled products that can gather, digest, and organize diagnostic and prognostic data, manufacturers are unlocking doors to new “product-as-service” models. Consider, for example, products such as tractors or engines equipped with sensors that feed performance and other types of data to the manufacturer who, in turn, analyze that data for their customers, and deliver--on a near-real time basis-- actionable information on dashboards accessible through smart phones.

### Nearly 40% of manufacturers are already embedding sensors in their products

**Q. What is your company’s timeline for embedding sensors in products that enable end users/customers to collect sensor-generated data?**



Number of respondents: 103.

Source: PwC and Zpryme survey and analysis, 2014 Disruptive Manufacturing Innovations Survey, conducted in February 2014.

Such customer-service business models extend revenue beyond the initial point of sale and beyond traditional MRO contracts. By being able to remotely diagnose a problem with a product, manufacturers can streamline servicing, for instance by identifying the right parts needed for a repair before a service technician even sees the product. Better yet, if a manufacturer spots an imminent problem with a product and carries out predictive maintenance before a product breaks down, the manufacturer not only saves the customer and itself time and expense, may also build customer loyalty.

### Mining data-savvy talent

Going forward, many manufacturers will likely need to up their game to attract the talent needed to get the most out of the IoT. Training staff or hiring from the outside to expand IoT capabilities is not an easy task considering that manufacturers compete with other industries for talent with sought-after specialties. New job titles are entering the manufacturing employee lexicon and show the scale of the change underway: digital-mechanical engineers (connect machines with software

<sup>15</sup> *The Internet of Things Explodes*, IHS Quarterly, 1Q 2014.

and sensors); data scientists (develop algorithm and models to optimize machine performance); business operations data analytics (increase performance, mitigate risk, and cuts costs through operational data); or user interface experts (human-machine, machine-machine connectivity), to name a few.

According to PwC's recent *Global Data & Analytics Survey*, 25% of global manufacturing executives said the lack of skills and expertise among senior management was the principle reason preventing them from making wider use of data and data analysis when "making big decisions."<sup>16</sup> Yet skill gaps are not only at the executive level, but include mid-level employees as well. A cursory look at LinkedIn job listings for manufacturing engineers, for example, revealed over 17,376 openings as of January 2015; data science engineer jobs numbered 34,841; and manufacturing systems engineers yielded 12,333.<sup>17</sup>

*"There will be an increasing need for techs who are trained in the relevant information technology tools and who can apply them in a manufacturing context... Some of these jobs, of course will require highly educated engineers and data scientists, but a good number can surely be filled by techs with university degrees, but with specialized training."*

— from Manpower's *The Future of The Manufacturing Workforce* report<sup>18</sup>

<sup>16</sup> PwC's *Global Data & Analytics Survey* 2014.

<sup>17</sup> LinkedIn website, retrieved on January 7, 2015 (results of searches in the website's jobs category search tool, using the following terms: manufacturing engineer, data science engineer and manufacturing systems engineer.

<sup>18</sup> *The Future of the Manufacturing Workforce*, Manpower, 2013.

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## Are you ready for the manufacturing Internet of Things?

Manufacturing is undergoing a sea change. With increasing options available to exploit the opportunities that data-driven technologies present, manufacturers are under increasing pressure to decide what IoT technologies will give them the greatest benefits on their investments in time, capital—and the talent required to carry out such initiatives.

As our survey of US manufacturers found, manufacturers are, indeed, making impressive strides in leveraging more data in their operations. They're also responding to customer needs by embedding intelligence into their products to increase functionality. Furthermore, manufacturers are connecting products to the IoT to track the performance of products over their life cycles to satisfy customer expectations for smarter products and to overlay services upon those products.

For manufacturers looking to initiate an IoT strategy—or to expand upon one already in place—there are some questions they might want to consider, including the following:

- Have you taken stock of processes, machines, and equipment that are not being monitored for performance in real-time that ought to be?
- Is your organization getting the most out of its operational data (e.g., leaving any data unused or not optimally exploited)? Is your organization continually improving how the data is presented (on a mobile App) to ensure that the right data is available for people to act on?
- Is your organization providing employees with access to real-time operational data across the organization (e.g., not only to factory workers and technicians, but also to procurement, R&D, and even board members)?
- Do any products in your portfolio that are IP-enabled potentially lend themselves to a value-added service attached to that product?
- If you are able to track performance data on products, can you use that data towards product improvements or even to altogether new product development?
- Are there more data and analysis you can share with others outside your organization (e.g., from suppliers, distributors to end users) to improve operations and strengthen customer relationships?
- Have you explored cloud-based platforms for computing, Big Data storage and analytics?
- Have you identified employees that should receive specialized training to help build and oversee your IoT strategy?
- Which elements of your IoT strategy ought to be done in-house, and which ones might be better done by a third-party vendor?
- Is your organization mulling hiring candidates with specialized skills in data science and analytics to help carry out your IoT strategy?
- Has your organization assessed whether it can benefit by applying its operational data in next-generation augmented reality technology?



### ***About Zpryme Research Survey***

The survey findings in this report were generated by Zpryme, which conducted an online survey of 120 US manufacturing professionals in February of 2014.

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