



The State of Manufacturing Technology 2016

Connected Manufacturing at the Intersection of Cloud and IIoT

From wearables to business intelligence applications, technology can transform manufacturing, impacting everything from plant floor productivity to product quality and top-line growth. Where do you start? More importantly, how do you separate vendor hype from the practical, useful tools that can make your business better today? Each year, we survey hundreds of manufacturers to understand how and where they use technology to run their business operations.

Now in its second year, the State of Manufacturing Technology (SoMT) Report provides a look into manufacturers' use of technology to support business objectives, from the plant floor to the top floor. Manufacturing has always been an industry that drives innovation forward, from the early use of steam power and electricity to the first automated production lines, robotics, and computers. Today's manufacturing operations are precise, lean, and efficient. Modern manufacturers are leveraging every new advance—from autonomous vehicles to consumer mobile devices and cloud computing—to deliver quality, product innovation, and cost savings.

For this report, Plex surveyed nearly 200 manufacturers, from different sectors ranging from the automotive to the food and beverage industries, on the technologies they rely on and the tools they plan to incorporate in the coming years.

“At Plex, our team studies which technology trends are beneficial to manufacturing and works closely with our customers on how they are using new technologies. The industry has seen increasing technology adoption over the last few years with manufacturers leveraging inexpensive, powerful, elastic, cloud-scale computing to process big data and enable machine learning while enhancing their workforce with better mobility and access from the plant floor to the top floor.”

– JERRY FOSTER
CHIEF TECHNOLOGY OFFICER

197
manufacturers
surveyed

GLOBAL AND GROWING

Global operations, once the domain of only the largest corporations, are now essentially standard for mid-sized organizations. Of the companies surveyed, over three quarters operate multiple manufacturing facilities. In many cases, regional plants are in place to support specific local customers and original equipment manufacturers (OEMs), in other cases location can be based on favorable energy or labor costs. This survey is focused on U.S.-based, multinational organizations as well as manufacturers in Mexico. Top secondary locations include Mexico (34 percent of respondents), Asia (20 percent), Europe (20 percent), and Canada (16 percent).

Survey respondents are also growing, with nearly 90 percent achieving revenue growth over the past five years. And while the economic environment for manufacturing has been challenging over the past 18 months, more than 35 percent of respondents still report growth of 20 percent or better.

What are the factors driving that growth? Certainly consumer spending and general economic expansion are all factors in supporting manufacturing industries. Even slow growth creates opportunity, and in areas such as automotive manufacturing, OEMs are reporting historic performance. For most manufacturers, these are external influences. We asked manufacturers about the things they do to achieve growth, and nearly half of respondents directly attributed their company's growth to the use of technology. This report looks at the many ways technology is put into practice every day in areas that not only fuel growth, but also drive efficiency, improve quality, and support customer service.

According to the National Association of Manufacturers, workers in the manufacturing industry contributed \$2.17 trillion to the U.S. economy. With over 12 million manufacturing workers in the U.S., nearly 3.5 million manufacturing jobs will be needed over the next decade, and 2 million will go unfilled due to the talent skills gap. The industry has a critical need for highly skilled workers especially as the number of retiring baby boomers continue to increase and affect the manufacturing industry, which already has a higher average age per worker than most other industries.¹



¹<http://www.nam.org/Newsroom/Top-20-Facts-About-Manufacturing/>

FROM THE CLOUD TO CONNECTED MANUFACTURING

Manufacturers have long been known as early adopters of technology in order to reduce costs, innovate, and drive revenue. From the plant floor to the top floor, technology is used to expand worker mobility, gain real-time insights, and make data-driven decisions on everything from business operations to the supply chain to the development of new products. Last year's State of Manufacturing Technology report validated that the cloud is a primary catalyst for technology usage overall. Fundamentally, cloud reduces the IT cost and personnel burden for core systems and administration, opening up resources for greater innovation and much needed focus on higher-value technology projects. The core capabilities inherent in modern cloud solutions—mobility, ease of integration, configurability, and the elimination of upgrade cycles—also make it easier and less expensive for manufacturers to connect their people, equipment, materials, suppliers, and customers.

This year's survey uncovers an emerging trend: connected manufacturing. Organizations are building on the connectivity of the cloud and leveraging integration that extends from mobile devices to plant floor equipment, customers to suppliers, and people to materials. These capabilities provide a new application foundation for everything from agile process design to enterprise supply-chain management, innovation, and product quality.

Five Key Elements in Connected Manufacturing:

1. Technology starts with the workforce.
2. Industrial Internet of Things (IIoT) connects everything in the manufacturing environment.
3. Big data starts on the plant floor.
4. Consumer mobility puts pressure on industry-specific solutions.
5. Cloud continues to be the catalyst for manufacturers that want to leverage mobility, big data, and IIoT.

TECHNOLOGY STARTS WITH THE WORKFORCE

In 2016, manufacturers raised new concerns about the opportunity for growth in the coming year. Seventeen percent cited weak demand from U.S.-based customers, more than double the prior year. Worries about the impact of lower-cost competitors also rose slightly to 22 percent.

Still, for the second consecutive year, manufacturers listed the shortage of skilled workers as the number one obstacle to company growth in the coming year (28 percent of respondents).

Beyond the general statistics, manufacturers we've spoken to cite a number of challenges in recruitment. Manufacturing as a career has taken a multi-decade hit in North America. Both high school and college institutions have dramatically reduced the emphasis on skills education, often based on the cost of facilities and programs. At the same time, public perception of manufacturing careers has been tarnished by memories of recessions and layoffs, as well as an inaccurate perception that manufacturing is still dangerous, dirty, repetitive work. This couldn't be further from the truth.

Today's manufacturing plant floor is a vibrant network of people, materials, and equipment that moves with both precision and efficiency. The manufacturing worker profile is a unique blend of technologist, maker, and problem-solver. We asked manufacturers what skills are most important for their next-generation workforce:

Not surprisingly, skills related to lean manufacturing topped the list with 38 percent of respondents making it their number one priority. Since the connected nature of the modern plant floor is becoming more commonplace, the number two priority for new hires is data analysis. From materials and equipment to customers and quality, connected manufacturing environments are enabling the capture of huge quantities of data—making turning that data into insight a cornerstone for leading organizations.

Third on the list is mechanical engineering. It is no secret that today's factories are highly automated, from connected stamping machines to robotics and autonomous vehicles. Even mid-sized operations rely heavily on sophisticated equipment. Increasingly, those same mid-sized manufacturers are co-designing or re-purposing equipment to create breakthroughs in product design, performance, and cost. Engineering leadership spans from product innovation to plant floor production design.

1 in 5 manufacturers is looking for next-generation employees who have data analysis skills.

40% of manufacturers want to hire employees with lean manufacturing skills.

What's Next: As manufacturers like Tesla, GE, and Caterpillar continue to promote manufacturing jobs as high-tech careers, other organizations will benefit from designing more sophisticated career and talent management programs to attract a new generation of workers. GE's advertising campaign equating building trains with building software is a case in point: the next generation workforce wants to solve problems using technology and innovation. Manufacturers that design and promote these job opportunities will have a leg up in recruiting and retaining top talent.

IIOT CONNECTS EVERYTHING

IIoT has become standard vocabulary for vendors and pundits, with broad predictions for number of devices soon-to-be-connected and make a global economic impact. This report looks more at what is going on today and how are organizations actually deploying connected devices to improve processes and business outcomes.

Nearly a quarter of survey respondents, for example, already use smart thermostats or energy control devices. Coupled with cloud-based systems, not only can these smart devices improve safety, but they can also help reduce energy consumption. For example, lighting for a specific workcenter can be tied to activity, providing operations managers with a clear visual indication of activity in a given part of a facility.



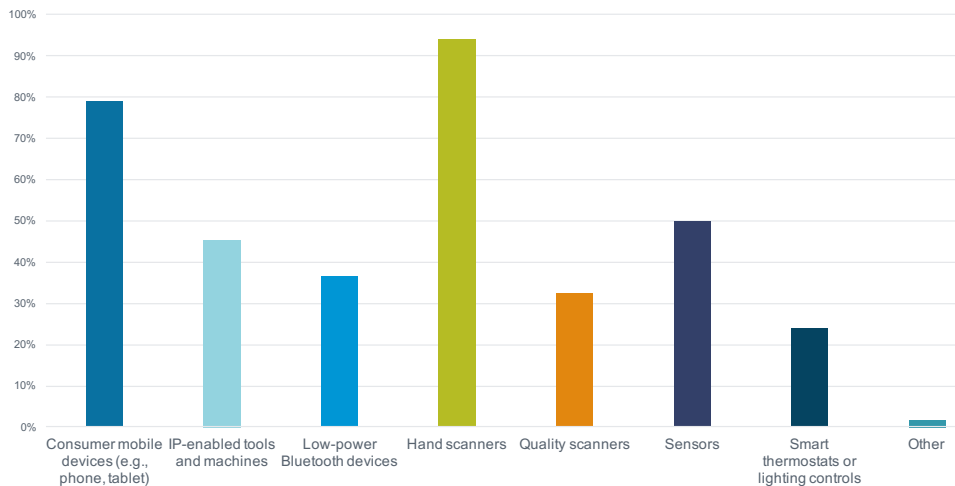
IP-enabled tools are another staple of the connected plant floor, providing two-way communication between systems and devices. Calipers send data directly to a quality system, eliminating operator input errors. Device calibration is recorded and enforced, requiring operators to complete quality-management activities and recording those actions in real time. This dramatically improves the value and speed of traceability.

As we noted last year, low-power Bluetooth and other inexpensive communication and identification devices continue to grab attention. Nearly 40 percent of organizations leverage Bluetooth devices, but 50 percent deploy smart sensors that may use wired or wireless connections to capture data. This extends from materials and product handling to quality management and equipment maintenance. Today's deployments primarily focus on real-time operations: pushing a non-compliant part out of a production line or tracking the performance of a machine. These same sensors are sending real-time data back to cloud-based systems, enabling leaders from the plant floor to supply chain planning to improve decision making, efficiency, and quality.

25% of manufacturers have
deployed smart thermostats
or lighting controls.

The use of low-power Bluetooth devices in manufacturing grew 40 percent year-over-year to enhance mobility and machine-to-machine communications.

What connected devices do you employ in your manufacturing operations today?



What's Next: IIoT continues to be part of an organic trend for connected manufacturing and an unquestionable priority for organizations. Ninety-eight percent of respondents noted that connectivity to systems, machines, suppliers, and customers is either somewhat or very valuable to their business today. Equipment and all forms of devices now include connectivity as a standard, and pervasive cloud solutions make it easy to not only capture data, but to also control, manage, and optimize equipment into agile processes. IIoT is also enabling big data approaches, even for smaller organizations, as the intersection of easy connectivity and embedded analytic applications allows plant floor and business users to tap data for insight, planning, and innovation.

Smart manufacturing, supported by IIoT, was ranked the third most important factor to a company's growth in the next five years.

1 in 5

manufacturers are planning to invest/deploy smart connected tools.

40%

of manufacturers have already built “smart” products, or are planning to in the next five years.

BIG DATA STARTS ON THE PLANT FLOOR

The intersection of IIoT and the cloud creates a new opportunity for manufacturers to leverage big data as a strategic asset. We asked manufacturers directly about their current use of data. Seventy-three percent (up from 66 percent in 2015) said that cloud solutions had improved their level of insight into their business, and 90 percent (up from 81 percent in 2015) noted improved mobile access to data.

We also looked at trends that support big data, where growing use of connected systems and equipment provides better access to real time data. More than 65 percent of respondents cite the cloud as a key factor in improving connectivity and communications with customers, with 64 percent noting similar improvement with suppliers. More than 40 percent claimed improved communication with transportation providers. As rich communication becomes simpler, more configurable and less expensive, organizations will gain access to even larger streams of data from across the supply and demand chain. Analytic applications that are becoming critical components of cloud ERP and CRM solutions can tap into those data streams to provide an even broader view for global enterprises.

It is this combination of device connectivity, ubiquitous cloud computing, and open analytic applications that will keep big data’s evolution at the forefront of new opportunities for manufacturers for many years to come.

Big data adoption by manufacturers is on the rise. By 2017, 40 percent of manufacturers expect to have deployed big data analytics or be deep in the planning stage.

Big Data Delivers Insight on Customer Demand

Manufacturer: Quatro Composites

Industry: Composite structures for aerospace, industrial, and medical markets.

The company relies on cloud ERP to collect “as much data as possible,” like parts specifications or materials information, and centralize that data so it is visible across the entire company. With greater visibility into customer trends, and even into individual customer’s buying patterns, the company can identify and address market trends as well as grow business opportunities with existing customers.



What’s Next: Starting on the plant floor, connected manufacturing will continue to expose new data to enterprise systems. Previously isolated equipment data, such as operating temperatures and energy consumption, will be available not only to production operators, but also to business planners as well. Imagine a supply chain planner looking at relative machine performance from two facilities when identifying how to source components or service a specific customer. Enterprise-wide visibility and ever-improving analytic applications will support more informed, data-driven decisions.

MOBILITY CONTINUES TO ADVANCE IN MANUFACTURING

Connected manufacturing isn’t just about machines and networks, much of it still revolves around people leveraging data for decisions, problem-solving, and managing quality. The informed plant floor technician is fundamental to a high-performing organization.

Historically, mobile devices on the plant floor were highly-tailored, ruggedized pieces of equipment. Hand-held scanners were often robust,

fully functional personal computers—the “brick on a stick”—with price tags to match.

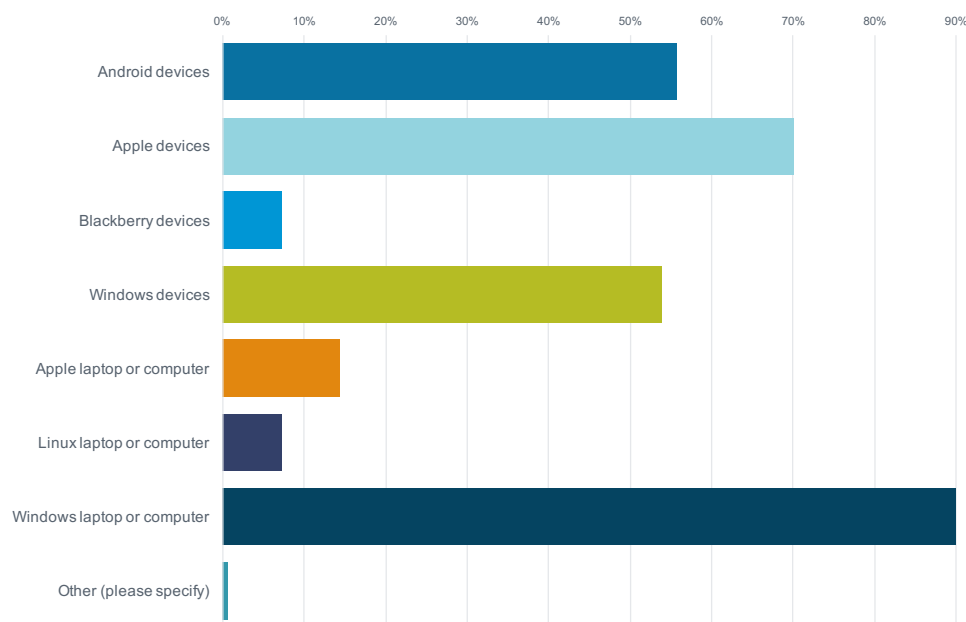
Consumer mobile devices are truly changing the game on the plant floor and across manufacturing organizations. Apple and Android-based smart phones are both cheap and reliable, and cloud applications are almost universally deployed on both platforms. Seventy percent to 56 percent of manufacturers report having deployed Apple and Android devices respectively, representing nine percent to 24 percent year-over-year growth. Sixty-four percent report using consumer tablets specifically, and as we spoke with manufacturers about these deployments it was very clear that the relative low cost of consumer devices, along with the ubiquity of networking, is making experimentation with new devices a big part of their innovation efforts. And those bricks on a stick are being replaced by sleek, modern scanners that incorporate the latest mobile applications and design.

We also saw this reflecting on the changing worker dynamic on the plant floor. As new products like the Microsoft Surface and Apple iPad Pro bring full-featured PC capabilities to portable, touch-driven devices, workers are opting for mobility. The cost of integrating new devices is almost zero, giving IT managers flexibility without sacrificing security and standards.

Finally, mobility extends beyond the four walls of the plant. Both mobile applications and browser-based software enable untethered workers to have full enterprise access from anywhere, over any device. This changes the way data is accessed, the way decisions are made, and the way work is done. Employees from industrial manufacturer Caltherm, for example, access and move inventory between locations over a smartphone.

10% decline in laptop use by manufacturers' workforce from 2015 to 2016.

What devices and platforms does your company currently provide to employees today?



Manufacturer: Caltherm

Industry: Thermostats and valves for heavy-duty diesel engines.

The company produces over 30,000 thermostats a week—1,560,000 per year. Relies on cloud ERP to serialize inventory for complete visibility and traceability. The company has 12 mobile tablets and 22 workstations on its plant floor. Material handlers can move inventory from one location to another as well as ship, receive, and check inventory from their mobile phones.



What's Next: Mobile workers are rapidly becoming the standard rather than the option. Cloud-based applications may become more specialized as a result, leveraging role-based configuration to deliver not only user- but also location-specific information and control. Worker-driven data will also inform the enterprise, from location data to performance and talent management to safety. Wearables, which

continue to be in the experimentation phase, will eventually take hold as costs and utility improve, much like we're now seeing 3D printers take hold (26 percent of respondents now using). Survey respondents rate connected devices as a seven out of 10 in importance for providing competitive advantage in their organizations over the next five years. Emerging technologies including drones, smart glasses, and smart watches, are just a bit behind at six out of 10. Expect to see increasing implementation over the next two to three years.

CLOUD REMAINS THE CATALYST FOR CONNECTED MANUFACTURING

Cloud continues to be the catalyst for connected manufacturing, as open integration and ubiquitous Internet make it increasingly easy and cost efficient to leverage mobility, big data, and IIoT. What's interesting is that in many cases, organizations did not set out with a transformational goal. Instead, pragmatic, short-term approaches using Internet and cloud-based solutions have formed a strategic backbone and foundation for more advanced applications. While manufacturers are focused on clear next steps, such as connecting to their customers and suppliers, connecting the plant floor, or improving quality and traceability, the end result is an open and connective fabric that enables new business approaches with extensibility beyond initial expectations.

65% of manufacturers said the cloud is enabling them to implement new initiatives to enhance quality and increase plant or enterprise integration.

50% of manufacturers attribute cloud solutions to making it easier to introduce new products.

Software technologies (e.g., cloud technologies, data analytics, ERP system, and plant connectivity systems) are the key focus area for manufacturers to strengthen their competitive edge in the next five years.

Cloud solutions enable manufacturers to better meet fluctuating customer demands and global supply chain management according to 65 percent and 55 percent of manufacturers.

Cloud ERP Connects Costing Data for Increased Accuracy

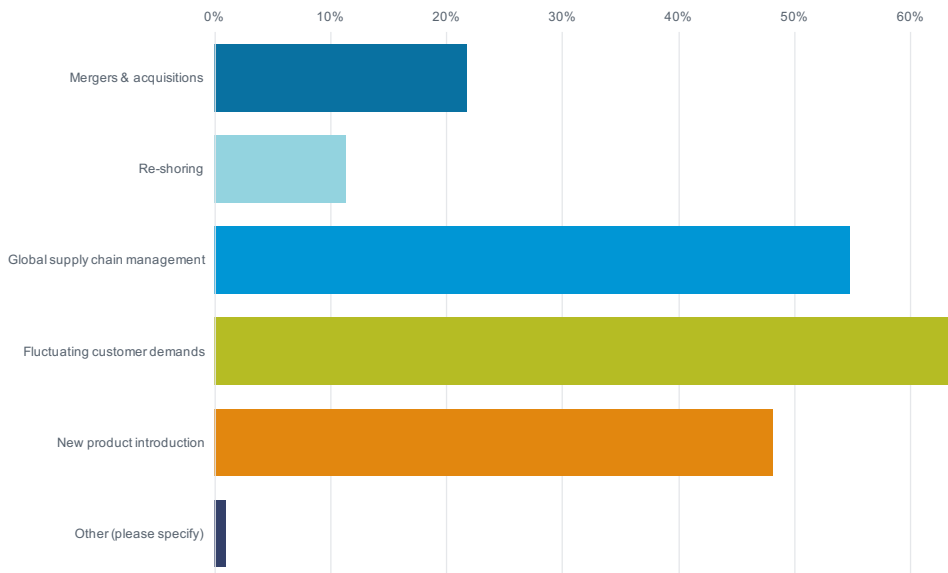
Manufacturer: FloraCraft

Industry: Floral foam products

The company has more than 3,500 active SKUs it kept track of through various reports but forecasting and planning was a nightmare trying to integrate all the data. With cloud ERP, the moment an order is entered into the system, everyone can see what is needed and what is missing. The company can also now capture variances for more accurate costing data that enables FloraCraft to pin costs down to one tenth of a cent.



Has your use of cloud solutions positively impacted your company's ability to manage any of the following business demands?



What's Next: The cloud enables limitless data collection, delivery, and scale, forming a fully connected manufacturing enterprise. The next steps are more deployment of sensors, connections, and continuous improvement of analytics, which will enable better quality capabilities, aid in more efficient equipment usage through deeper plant floor measurements, and deliver predictive maintenance for better uptime. Fortunately for manufacturers, this won't require massive investment as incremental or departmental improvements will continue to contribute to better enterprise performance.

THE FUTURE IS HERE: EMERGING TECHNOLOGIES ON THE PLANT FLOOR

Google Glass was a big story in 2015, and as Google quietly walks away from this technology use-cases were just beginning to take hold in manufacturing—the industry hasn't stopped. New entrants like DAQRI's Smart Glasses, coupled with the dropping costs of devices like 3D printers and drones will continue to open new options for organizations. A significant portion, 32 percent, of manufacturers still expect to leverage wearable glasses over the next five years, with nearly 40 percent considering wrist-based smart technologies like Apple Watch. Cloud continues to be a key enabler, making connected experimentation easy.



21% of manufacturers expect to deploy autonomous vehicles over the next five years.

25% have already deployed 3D printers.

48%

plan to deploy 3D printers or additive manufacturing technologies over the next five years.

40%

are considering location-aware communication devices including iBeacons.

What's Next: Innovation in the tech market occurs at a rapid pace, providing manufacturers with a steady pipeline of options to continually enhance their operations. Cloud and IIoT will continue to make adoption easy, promoting experimentation especially as consumer innovations drive costs down.

SUMMARY

Connected manufacturing, fueled by cloud computing and IIoT, enables manufacturers to build ecosystems that include suppliers, partners, and customers to enhance end-product usage and performance. This year's report highlights continued manufacturing focus on practical, pragmatic solutions for better plant floor automation, improved quality, and better connectivity to customers and suppliers. By addressing challenges in a pragmatic way using cloud and IIoT technologies, manufacturers are also establishing the foundations for connected manufacturing, which is imperative to their future success.

Connected manufacturing is not possible without a cloud backbone to leverage the power of elastic cloud-scale computing to process big data and enable machine-to-machine learning and communication. The cloud backbone also eliminates IT friction by shifting the management and responsibility to the cloud services provider, enabling company technical

resources to focus on high-value business process needs while also reducing the cost by using a shared tech infrastructure model.

As a result, manufacturers can freely explore and leverage new technologies to better compete, lead, and innovate. Cloud is the catalyst for innovation in manufacturing, and having a connected cloud ERP backbone enables manufacturers to more easily support IIoT, big data, mobility, and emerging technologies to enhance their operations and add to their bottom line. As manufacturing becomes more connected and expansive data is captured and shared, those companies ahead of the curve using the cloud are poised to separate themselves from the competition and lead the industry forward.

ABOUT PLEX

Plex is the Manufacturing Cloud, delivering industry-leading ERP and manufacturing automation to more than 500 companies across process and discrete industries. Plex pioneered Cloud solutions for the shop floor, connecting suppliers, machines, people, systems and customers with capabilities that are easy to configure, deliver continuous innovation and reduce IT costs. With insight that starts on the production line, Plex helps companies see and understand every aspect of their business ecosystems, enabling them to lead in an ever-changing market.