The Internet of Things: Finding the Path to Value

How U.S. Manufacturing Is Responding to the Business Challenges and Opportunities Being Unleashed by the Internet of Things and Advanced Analytics.
RESEARCH PREFACE
Rise Above the Data Deluge

This is an exciting time for manufacturers as the barriers come down between operational technology—the industrial hardware and software that monitors and controls machines—and the ERP systems and other information technology used to operate and support the business. New opportunities for improving productivity and innovating new sources of customer value are emerging every day, as are the challenges.

Manufacturers were awash in data long before the “Internet of Things” or “big data” terms were coined. They've been collecting and analyzing machine data for decades. Today, as they replace legacy equipment and systems, the quantity and accessibility of machine data continues to grow with wider network connectivity and deeper data collection capabilities.

At the same time the Internet of Things is ramping up the flow of data on the customer side. As networked products tighten the connection between manufacturers and their customers, service capabilities are expanding and creating entirely new revenue models.

Amidst this accelerating rush of 1s and 0s, there's a growing feeling among some manufacturing leaders that they're missing opportunities. They have all of this data, but aren't sure exactly what to do with it, or even where to start. It is clear their analysis capabilities are not keeping up with the times. This is where advanced analytics comes in.

Advanced analytics generally refers to sophisticated statistical and quantitative analysis, data mining and predictive simulations, executed as close to real time as necessary. In practical terms, advanced analytics predict, forecast, optimize and prescribe the best action to take, versus traditional analysis and reporting that reveal what happened. Yes, there's a shortage of people with these analytical skills. But every year the analytical and visualization tools become more accessible and easier for everyone to use.

Taking full advantage of the opportunities presented by the Internet of Things and advanced analytics is largely a matter of having a plan and allocating resources. That's probably the biggest takeaway for manufacturers from this special IndustryWeek research study. The time for dipping your toe in at the edge of the pool is over. It's time to create an IoT strategy for your business and take the plunge.

Best of luck,

Patricia Panchak
Editor-in-Chief, IndustryWeek
Executive Summary

The number of network-connected sensors and devices could triple to 21 billion by 2020. This explosion of Internet of Things (IoT) technology, coupled with advanced analytics capabilities, is changing how manufacturers make business decisions. The 2015 IndustryWeek Industrial Internet of Things Analytics Research Study gauges the current and planned usage of IoT technology and analytics by U.S. manufacturers.

More than half of U.S. manufacturers report that they are currently using IoT technology to collect machine data, and a significant but smaller percentage (44%) are collecting data from sensors embedded in their products.

Despite the fact that they’re already collecting such data, and two-thirds believe the Internet of Things technology will be critical to their future success, only one third of manufacturers report that they have a specific IoT technology strategy. Those that do have a strategy are being pushed by leaders to become more data driven, and they’re applying analytics more widely across their organizations.

Network security and data privacy are manufacturers’ top concerns about IoT technology. They are also concerned about their internal capabilities for data collection and analysis. The leading IoT applications and benefits include monitoring machine performance and product quality, improving equipment uptime, and gaining new market insights.

On the analytics side, while manufacturers are becoming more analytical, two out of three say they rely more on management experience when addressing key business issues. Roughly a quarter (28%) of manufacturing leaders believe they are outpacing their competitors when it comes to the use of analytics. Those that believe they are ahead are collaborating much more widely both internally and externally.

Looking forward at future technology needs and capabilities, manufacturers’ top desire is more training on using current analytical tools. They also want more data storage and processing power, as well as mobile interfaces. Of course, as more products and machines are connected, and analytical capabilities deepen, exciting new applications for Internet of Things technology will continue to emerge.

Research Methodology

This report highlights the findings of the 2015 IndustryWeek Internet of Things Analytics Research Study underwritten by SAS. The purpose of the study is to explore the current adoption levels and implementation plans for Internet of Things technology and the analytical capabilities in U.S. industry. In October 2015 IW Custom Research e-mailed invitations to participate in the online survey to a selection of our subscribers. That invitation was followed by two reminders to non-respondents. We received and tabulated 478 completed surveys. Response percentages do not always add up to 100 percent due to rounding and the allowance for multiple responses on some questions.
Introduction

Welcome to the New Era of Decision Making

Successful leaders in every era are judged by their ability to make good decisions with limited information. As U.S. President Theodore Roosevelt said, “In any moment of decision, the best thing you can do is the right thing, the next best thing is the wrong thing, and the worst thing you can do is nothing.”

The Internet of Things (IoT) is changing management decision making in ways that are often overlooked in all of the hype around the billions upon billions of things that will be networked someday. Connected devices, coupled with advances in data collection and analytics, are giving business managers at all levels more relevant information when they need it than they’ve ever had before. How that affects the decisions they’re making is having a deep and lasting impact on operational and business performance.

The Internet of Things spans a broad range of mature and early stage technology from RFID tags and remote monitoring to autonomous robots and microscopic sensors dubbed smart dust. For the record Gartner predicts that there will be 6.4 billion connected IoT devices in use worldwide in 2016, and 21 billion units by 2020. That means the number of internet-connected things could triple over the next five years.

With this explosive growth in mind, we developed the 2015 IndustryWeek Industrial Internet of Things Analytics Research Study to gauge the current and future state of IoT technology usage by U.S. manufacturers. Because the Internet of Things is less about the things themselves, and more about the ability to collect, analyze and use the massive amounts of data generated by such devices, we included a special focus on data collection and analytics.

For the purposes of this research, we define the Internet of Things as the products and machines that contain embedded electronics, software, sensors, and network connectivity, which enables remote data collection and control. Analytics refers to the process of leveraging raw data into insights that enable better decision making.

More than half of manufacturers report that they’re currently using IoT technology to collect machine data. A significant but smaller percentage of companies (44%) are collecting data from sensors embedded in their products. This machine and product data is primarily being used to generate management reports and perform root cause analysis when problems crop up.

Less than one out of four respondents are using IoT data for more proactive purposes. This includes developing optimization models or data mining in order to improve business decision making. All of which points to a huge opportunity and potential source of competitive advantage.
What’s Your IoT Strategy? Do You Have One?

To gauge the seriousness of their investments, we asked manufacturing leaders if they have an explicit Internet of Things strategy. Roughly one third said they do have such a strategy. Not surprisingly, these manufacturers are more likely to report that senior leaders are driving their organizations to become more data driven and analytical. Reflecting their familiarity with the technology’s potential capabilities, they are also more likely to have been collecting sensor data for a longer period of time.

Comparing manufacturers that have an IoT strategy to those that don’t reveals some other interesting differences. Manufacturers with an IoT strategy are more concerned about everything relating to such technology, starting with network security and data privacy. They are also applying analytics more widely (at the individual level and across the organization as a whole), and they’re more likely to be collaborating in use of analytics with suppliers, customers and other internal functions.

In this report we explore these and more observations from our research in detail, and offer a general overview of their implications for U.S. manufacturers.
1. PERCEPTIONS AND STRATEGIES

Finding the Right Balance Between IoT Priorities and Resources

As noted above, only one third of manufacturers report that their company has a comprehensive and specific Internet of Things strategy. At the same time almost nine out of ten say that the Internet of Things is an important technology trend, and two-thirds believe it will be critical to their company’s future success.

So the Internet of Things is a clear priority and opportunity, but most manufacturers don’t yet have a strategy for capitalizing on it. How do we explain the disconnect?

One of the more enduring management theories is that effective business strategies arise from two very different sources.* The first are the opportunities and threats that executives can foresee which inform their annual strategic plans. The second are the opportunities and challenges they do not anticipate that emerge and demand attention as the year unfolds. A company’s success hinges on how well management is able to balance resources between these deliberate and emergent priorities.

The business and profit opportunities presented by advanced sensor networks and analytics are still emerging for many industries. The challenge for manufacturing leaders today is to stay current and informed so that their companies are ready when the technology matures and the return on investment calculations make sense for their businesses. But they can’t wait too long.

With any new technology experience and familiarity will reveal the capabilities and opportunities. This is borne out by our research. Manufacturing companies that have used IoT technology to collect machine and product sensor data for a year or longer are much more likely to believe that such technology will be critical to their future success. Manufacturers reporting that they have a deliberate strategy for capitalizing on such opportunities share the same point of view.

To uncover these opportunities manufacturers are looking both within their organizations and externally. Almost equal proportions report that cost savings (45%) and revenue growth (44%) are the primary drivers of their IoT strategy.

There’s very little difference in the internal or external IoT focus by company size. But there are some differences by industry. Aerospace and consumer packaged goods manufacturers, for example, are more likely to be focused on revenue growth. In contrast, automotive and consumer durables tend to be targeting productivity and efficiency improvements.

*Professor Henry Mintzberg, Desautels Faculty of Management at McGill University, Montreal, Quebec, Canada.
2. IoT CONCERNS AND BENEFITS

Are the Risks Worth the Rewards?

Widely publicized hacks of everything from HVAC systems to baby monitors and vehicles have heightened public awareness of the security vulnerabilities of IoT technology. It’s no surprise therefore that network security and data privacy top the concerns of our survey respondents. As billions of new connected consumer and commercial devices come online, it will create ever more opportunities for system infiltration and data breaches by cybercriminals.

As leaders begin to recognize the business risks, manufacturers are stepping up their security investments. They are making security issues a higher priority during design, development and manufacturing, in addition to when equipment and products are sold and installed.

Manufacturers’ other concerns about IoT technologies are more inwardly directed around their data analysis and collection capabilities. That makes perfect sense. For it to be useful, all of the data being captured by embedded product and machine sensors has to be organized and placed into context. And then it has to be analyzed to extract any valuable and actionable intelligence. It’s no wonder almost every manufacturing leader you talk to is struggling to find talented people with proven analytical skills and experience.

As important as concerns over device and data security are, the biggest risk for manufacturers when it comes to Internet of Things technology could be not making any investments at all. The number one internal application for all manufacturers is improving equipment uptime and availability. But priorities vary somewhat by sector. Automakers, for example, are more focused on quality and improving yield rates than manufacturers as a whole.

On the customer side, the number one IoT application by a wide margin is monitoring product quality and performance. This is especially true for chemical, oil, gas and other process manufacturers, many of which have been using such technology for over a decade.
3. IoT DATA COLLECTION

Quality In, Value Out

When it comes to the Internet of Things, manufacturers are struggling to squeeze value from all of the data that they already have coming in. The big question is how they’re going to handle the deluge when all of the new IoT devices come online and the quantity of data explodes at double-digit annual rates.

Take cars, for example. Today less than 10% of vehicles—mostly luxury cars—are connected to the Internet. With the technology moving into mid-market models, it’s predicted that there could be anywhere from 150 million to 250 million wirelessly connected vehicles by 2020. Fully packed with sensors, each of these cars could collect and report up to 350 megabytes of data per second, or 30 terabytes per day.

Just to be clear, the objective with such technology is to provide some form of value, make better decisions and improve business results. To do that, the traditional analytics lifecycle from data storage, aggregation, cleansing and analysis is being upended. Analysis begins in real time, when the data is collected, and continues through aggregation and cleansing.

According to our research, more and more manufacturers are experimenting with collecting both machine (52%), and product (44%) sensor data, although a significant proportion have only been collecting such data for less than one year. Operations, customers and sales data top manufacturers’ wish list of areas where they’d like to have more detailed and actionable intelligence. To expand their analytical capabilities, a significant number of firms have begun integrating and supplementing IoT information with product quality (45%) and production data (43%).

IoT experience seems to build an awareness of both the opportunities and challenges. Manufacturers that have been collecting machine and product data for a year or more are much more likely than those that haven’t to believe the Internet of Things will be critical to their future success. Those manufacturers that have been collecting IoT data for longer are much more concerned about data collection and analysis capabilities, and report that they have a clear IoT strategy.
**Data Used to Supplement IoT Data**

- Product quality/testing: 45%
- Operations/production performance and planning: 43%
- Work/repair order history: 28%
- Environmental factors (e.g., ambient temperature, humidity, etc): 22%
- Sales plan and performance: 22%
- Worker/technician skill sets and staffing schedules: 18%
- Warranty information: 16%
- Call center and/or CRM: 13%
- Demand signals (indicators): 12%
- Social media data: 9%
- Other relevant sources: 1%
- We do not use supplemental data with IoT data: 13%

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**IoT Haves Vs. Have Nots**

Manufacturers that have collected machine and product sensor data for one year or longer compared to those that have not been collecting data as long.

**Machine Sensor Data**

- IoT is critical to my company's future success (agree strongly or somewhat): 80%
- Concerned about data collection capabilities (4 or 5 on 5 point scale): 54%
- Concerned about analysis capabilities (4 or 5 on 5 point scale): 53%
- Have a specific and comprehensive IoT strategy (agree strongly or somewhat): 20%

**Product Sensor Data**

- IoT is critical to my company's future success (agree strongly or somewhat): 84%
- Concerned about data collection capabilities (4 or 5 on 5 point scale): 56%
- Concerned about analysis capabilities (4 or 5 on 5 point scale): 54%
- Have a specific and comprehensive IoT strategy (agree strongly or somewhat): 24%
4. ADVANCED ANALYTICS: STRATEGY AND COLLABORATION

Cutting Big Data Down to Size

While the hype around “big data” has abated, the volume of data being collected on a global level continues to grow exponentially. As business leaders are finding out, capturing and storing the data is the easy part.

Only a fraction of the data that’s collected is ever analyzed or used. There are several reasons why. First and foremost, it’s a resource-consuming task to link, match and cleanse so much data coming in from multiple sources. Then there is the shortage of people with the analytical skills required to glean useful business insights.

It comes as no surprise then that data analysis capabilities are a significant concern for two-thirds of manufacturing managers. A similar percentage report that senior leaders are pushing their organizations to become more data driven. And three out of four believe their organizations need to step up the use of analytics to improve decision making.

As the capabilities for applying advanced analytics to decision-making emerge, part of the challenge is cultural. Two out of three respondents report that their companies rely more on management experience than data analysis when addressing key business issues.

When asked to rate their company’s analytical capabilities in comparison to key competitors, roughly a third of respondents believe they are on the same level. Senior executives have a tendency to believe their organizations are more advanced than lower level managers.

Looking at the internal use of IoT applications, those who believe their analytical capabilities are more advanced do in fact report that they are reaping more of the benefits. That technology familiarity is supported no doubt by the evolving ability of analytics solutions to provide useful intelligence to people other than data scientists.

The departmental and functional silos that exist in most organizations frequently prevent data collection and sharing, which hinders analytical capabilities. It follows then, based on our research, that manufacturers who believe they are more advanced tend to be collaborating more across their organizations.

Manufacturing Leaders’ Perceptions of Analytics

- 75% It is important for my organization to step up its use of analytics to make better decisions
- 64% My organization relies more on management experience than data analysis when addressing key business issues
- 57% There is pressure from senior management for the organization to become more data driven and analytical
- 25% Actionable analytics is not timely enough to enable better decision making
- 16% The benefits of using analytics are over-hyped and dubious for most organizations

How Manufacturers Rate Their Use of Analytics Compared to Competitors

- 31% About the same as competitors
- 22% More advanced
- 42% Less advanced
- 18% Don’t know

Internal IoT Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>More advanced</th>
<th>Other</th>
</tr>
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<tbody>
<tr>
<td>To improve operational equipment (asset) uptime and availability</td>
<td>54%</td>
<td>42%</td>
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<tr>
<td>(e.g., predictive maintenance)</td>
<td></td>
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<tr>
<td>To monitor machine performance, quality and reliability</td>
<td>50%</td>
<td>39%</td>
</tr>
<tr>
<td>(e.g., warranty, safety or regulatory requirements)</td>
<td></td>
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</tr>
<tr>
<td>To improve production quality/yield rates</td>
<td>49%</td>
<td>38%</td>
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<tr>
<td>To build an overall manufacturing/operations KPI dashboard</td>
<td>37%</td>
<td>27%</td>
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<tr>
<td>Remote diagnostics and troubleshooting of our production technology</td>
<td>41%</td>
<td>23%</td>
</tr>
<tr>
<td>To improve supply chain logistics</td>
<td>26%</td>
<td>26%</td>
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5. ADVANCED ANALYTICS: USAGE, METHODS AND TOOLS

The Right Tool for the Job

The “law of the instrument” describes the human tendency to view and attack problems with the tools at hand. Paraphrasing, if the only tool you have is a hammer, you approach everything as if it is a nail.

It should come as no surprise then that well over half (57%) of manufacturers report that they are using spreadsheets to analyze sensor data. It’s the analytical tool with which most people are familiar. But it’s a rudimentary approach for extracting insights from the massive amounts of data being reported by Internet of Things devices. And spreadsheets are completely incapable of processing IoT data in real time.

Some of the more powerful tools that manufacturers are using include specialized analytical and business intelligence software, ERP modules and applications developed by equipment manufacturers. They are primarily using this software to generate management reports and dashboards, perform root-cause analysis, and plot data for visualization purposes. As you would expect, those manufacturers that consider their analytical capabilities more advanced than their competitors are doing more of every type of data analysis.

Of course every CIO has a list of what they could do if and when their company can justify the investment. Interestingly, when it comes to analytics, the top investment priority for users isn’t the software itself (although that is a close second). What manufacturing managers want most is more training on using the analytical tools.

More advanced analytics users report similar training and functionality priorities. They also want more data storage and processing power, as well as mobile interfaces. Such investments will enable true situational awareness based on continuous analytics and traditional data cleansing techniques applied to data in real time before its stored.

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**IoT Analytical Methods**

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<tr>
<th>Method</th>
<th>Other</th>
<th>More advanced</th>
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</thead>
<tbody>
<tr>
<td>We summarize the data in management reports and/or dashboards to inform decisions</td>
<td>37%</td>
<td>66%</td>
</tr>
<tr>
<td>We perform data-driven root cause analysis</td>
<td>30%</td>
<td>56%</td>
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<tr>
<td>We plot the data for visualization</td>
<td>26%</td>
<td>44%</td>
</tr>
<tr>
<td>We develop forecasting and optimization models to drive decisions</td>
<td>17%</td>
<td>36%</td>
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<tr>
<td>We mine the data (data mining) to find new data patterns of interest</td>
<td>15%</td>
<td>39%</td>
</tr>
<tr>
<td>We develop analytics models to predict issues and alert us to new issues</td>
<td>8%</td>
<td>29%</td>
</tr>
<tr>
<td>We integrate other data sources with IoT data for contextual analysis</td>
<td>8%</td>
<td>20%</td>
</tr>
</tbody>
</table>


**Analytics Investment Priorities**

<table>
<thead>
<tr>
<th>Priority</th>
<th>Other</th>
<th>More advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>More training on using business analytics tools</td>
<td></td>
<td>65%</td>
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<tr>
<td>More functionality (business analytics software tools)</td>
<td></td>
<td>58%</td>
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<tr>
<td>More mobility (devices such as smart phones and tablets)</td>
<td></td>
<td>24%</td>
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<tr>
<td>More computing power to analyze data (hardware, such as new computers)</td>
<td></td>
<td>23%</td>
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<tr>
<td>More capacity to store data (hardware, such as servers or server space)</td>
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<td>19%</td>
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Conclusion

Building the Business Case

The first Internet-connected, smart refrigerator hit the market 15 years ago. (It was released by LG in 2000.) Since then countless IoT applications with more clear user and business benefits have been piloted across a range of industries. Some industries are further down the road than others.

Utilities and airlines, for example, have been leveraging machine sensor data for diagnostic and repair purposes for decades now. Mining operations are using fleets of 2,000-hp driverless trucks tracked by satellite. Process manufacturers of everything from food products to plastic parts routinely monitor real-time performance and receive alerts when temperatures drift outside of optimal ranges, production rates slow down or product quality starts to slide.

Data availability and modeling capabilities now make it possible to test different scenarios, and then optimize operational and financial performance as circumstances change. These and more enhanced decision-making capabilities simply weren’t possible a decade ago. Still, in many respects, the so-called IoT revolution is really an evolution. Industry is doing what it always strives to do: Reduce costs and increase revenues. The Internet of Things is just creating more opportunities to do so in innovative ways.

Technology challenges and user concerns, like network security and data privacy risks, will have to be addressed and managed. But as more products and machines become connected, and analytical capabilities deepen, new and profitable applications for Internet of Things technology will emerge, and industry will continue to evolve.