INTRODUCTION

In April, Automation.com released our first eBook sharing several real instances where IIoT is delivering tangible value in factories and plants all over the world. The reader response was such that we are bringing you a 2nd edition of Advancing Automation to share still other ways that the digital transformation is delivering economic growth throughout several industries.

This edition, sponsored by Sciemetric Instruments, will discuss how IoT is driving manufacturing, how digital technologies are generating mountains of previously unseen data to enhance decision making, the current evolution of digital business models as seen in the modern enterprise, where IIoT will take us in the future, and much more. Whether you focus on process control, manufacturing, energy conservation, or are just interested IIoT innovation, this eBook has the latest stories and studies of how industrial organizations are currently using digital technologies and the IIoT to advance innovation and the bottom line.

This ebook includes:

Sciemetric’s detailed guide on big data and how organizations can bridge the gap from theory to execution

If you have piles of data, but are not sure where to begin, then this is exactly the guide to help you get started. Sciemetric’s guide shares specific examples of how organizations are finding tangible benefits with the implementation of effective data-driven practices and the IIoT.

Automation.com’s in-depth look at how manufacturers are bringing connectivity to the plant floor with impressive results

If you’re looking to help your manufacturing company embrace the digital transformation, you won’t want to skip this read, which will share several of the latest innovations which can be installed with existing equipment to make your factory ‘smart’ and eliminate costly downtime.

Automation.com’s analysis on how IIoT is bringing stunning changes to manufacturing business models

Manufacturing managers and executives can’t afford to miss this Bill Lydon piece. This article discusses how technological advancement, already causing massive overhauls in countless industries, has marked manufacturing as it’s next target, and what your organization can do to prepare.

Automation.com explores automation architectures, and how to deal with the increasing pace of equipment obsolescence

This forward-looking article by Bill Lydon, takes a look at how digital connectivity has permanently altered the way organizations communicate at all levels, and how organizations can take steps to avoid obsolescence while streamlining architectures and driving enhanced productivity.
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Introduction
If your team struggles to understand how the Industrial Internet of Things (IIoT) applies to your plant, it can be summed up in one word — data.

Discrete manufacturers have been collecting data from their production line processes and equipment for decades. But not all data is the same, nor is it useful in the same way. The challenge is to get all the data flowing in an integrated and organized way, so people can understand it and gain quick insight to take timely action.

This requires “smart” machines that can capture and communicate data in production real time (within one cycle of completion of each process or test cycle) to quickly diagnose the inefficiencies and problems that waste resources and lead to costly recalls and warranty claims.

In other words, IIoT is about mastering data to drive profitability and competitiveness. By data, we mean all the data on the line, be it scalars, digital process signatures or machine vision images with their datasets.

Part 1: The Data Gap
Many plants still face a gap between theory and execution. Part data is often not collected and organized cohesively to drive quality and efficiency. Instead, it is trapped in silos up and down the line, neglected, or even discarded after it has been used for basic pass/fail determinations for a process or test.

Signs that you have gaps to address
Consider these questions:
Are you overwhelmed with data you can’t use?

Despite understanding the value of production data, many manufacturers lack the tools to retrieve and analyze data to quickly trace the root cause of production issues. Without these tools, tracing root cause can take days or even weeks.

Do you have databases with different data types scattered across the production floor, making it difficult to review the data?

Many manufacturers suffer with a hodge-podge of database systems sourced from different vendors or built in-house. They lack the tools to parse this data into a standardized format and flow it into a centralized database for rapid analysis.

Is setting up test stations a matter of guesswork or trial and error?

Setting up a test station, or even commissioning a whole new product line, can be executed in a fraction of the time using data analytics software that can automatically calculate statistically based limits and the correct processing algorithms.

Does your team struggle to make the right tradeoff between cycle time and repeatability?

Modern data analytics can mine stored data to conduct a range of tests and simulations without running additional parts through a process to validate parameters. Review that historic data and run those simulations to see where and how a test cycle can be shortened without impacting quality assurance. This boosts productivity and can reduce the number of test stations.
Are any test stations plagued by false passes or false failures?

Many quality engineers don’t know the Gage Repeatability and Reproducibility, or Gage R&R, of their test stations. Many don’t want to know because they fear it may be poor. We encourage our customers to focus on the first R: repeatability.

By focusing on repeatability first, you can exclude all controllable variables that can impact the test regardless of the equipment — sealing variations, operator behaviors and so forth. The goal is to determine what the test system, including parts and connectors, is capable of in the absence of these external variables. Once you have confidence in your equipment, you can systematically tackle the controllable variables to improve the second R, reproducibility.

The key to mastering Gage R&R lies with data — you must collect and analyze the part data generated by the system through each test cycle, just as you would for any process on the line.

Did you say yes to any of these issues?

A single yes is a sign that there is something missing in the plant’s approach to data management.

Part 2: Turn Big Data into Better Data

Production parts data often isn’t used to its full potential. When integrated into a single birth history record for each part by serial number, the datasets from each assembly process, test station or other critical operation provide the means to identify a problem and quickly address its root cause.

Modern digital data management and analytics platforms make this possible. Traditional systems and methodologies can feed their datasets into a single platform and be supported by the integrated data analysis that is possible with that platform. Every quality management, monitoring and reporting system in the smart factory is more reliable, efficient and interconnected as a result of creating these feedback loops.

This level of digitization with feedback loops allows for specifications to be rapidly adjusted to minimize costly product quality issues, reduce unnecessarily tight product specifications, improve customer perception and loyalty and quickly introduce product enhancements.

But it all relies on the completeness and reliability of your data.

Best practices to consider

Use as much of your production part data as possible: Every cycle of every process and test station on the line generates data from parts being produced or tested, including scalar, digital process signatures and images.

The more data you collect, the more insight you have into what has happened to that part at every assembly step. Anything that happens upstream can have a bearing on a problem that arises further downstream.

Take an engine assembly that fails a leak test. What is the cause of the failure — a faulty gasket due to improper dispensing, bolts that didn’t tighten down correctly, poorly machined surfaces due to excessive vibration at a machining center? How many different gaskets and bolts are we talking about?

Getting to the root cause could require investigation of a dozen or more machining, dispensing, fitting and rundown operations, each with its own dataset. By having all of part’s relevant datasets collected into a single birth history record and indexed by serial number, tracing root cause won’t be a nightmare.

Consolidate the data: Bring all of the data together and consolidate it into an accessible structure. Modern data management and analytics platforms are flexible, and have the capability to ingest data from disparate sources. This eliminates data silos and allows you to scale down the various types of software and hardware on the production floor.

Standardize the data reporting model: Having a standard data model for your plant floor systems greatly simplifies implementation and assures project success by using standard off-the-shelf reporting. For instance, if your data model standard identifies traceability to a specific part by serial number (highly recommended), this will ensure all tooling suppliers...
program their logic controllers accordingly, or have the appropriate barcode readers/scanners or part-marking systems in place.

Part 3: Put that Data to Work
Data that can’t be retrieved, correlated and analyzed on demand is of limited value, regardless of how much is collected.

When evaluating a modern digital data management and analysis platform to standardize quality assurance and process improvement in your factory, seek the following:

**Accessible data:** All data related to a specific part, assembly or finished product can be quickly pulled by serial number. This is referred to as the full birth history.

**Web-based, real-time access:** Quality and production staff should have access to web-based tools for analysis — data is not trapped in silos or accessible only through specific workstations.

**Quick reporting and dashboarding:** Dashboards and smart alerting systems quickly give notification if processes are drifting out of control.

**Easy visualization for overlay comparisons and trending:** Many systems capture and store digital process signatures as flat image files and lack on-demand visualization tools. Data must be exported into spreadsheets, in which each test or part has its own tab with its signature’s waveform image. There is no way to overlay and correlate these images. Making any sense of this pile is time consuming and frustrating.

With the right data management tools, signatures can be converted into histograms that can be correlated with other data types to illustrate the profile of a good part and the range of acceptable deviation. This makes it easy to create and visualize a baseline against which to compare all parts.

**Ability to determine your top priorities:** With this kind of insight, plant staff can apply the 80/20 rule to determine which adjustments or refinements on the production line will improve quality most.

This is called the Pareto Principle. In Figure 1, production problems are organized from left to right in order of importance or occurrence with a Pareto chart. The old 80/20 rule — that 20 percent of the effort can fix 80 percent of the issues — is usually true of most processes. The chart helps to understand this quickly.

When applied to managing quality, this exercise helps quality practitioners focus their attention on the issues that will have the greatest return.

**What organized and correlated data allows you to do**

Here are some of the day-to-day benefits you can expect:

**Set up new test systems quickly with objective data for limit setting and management:** At one component company, it took weeks to find the correct test limits for an automotive sensor — it even took days for a simple calibration. By adding signature analysis capability to the test system already installed on the line, the scalar data and associated signatures could be collected and analyzed together. The data analytics software did the work to automatically calculate statistically based limits and the correct processing algorithms within 30 minutes.

**Test “what-if” using historical data without affecting production:** It is easy to review such historic data and run simulations to see where and how a test cycle can
be shortened without impacting quality assurance. This boosts productivity and can reduce the number of test stations.

In Figure 2, a manufacturer was only looking for peak breakaway torque as part of a torque to turn test. Analysis showed that ending the test cycle sooner would have no impact on quality. By adding a new test and terminating the cycle based upon this result, a seven-cycle savings per eight-hour shift could be achieved. For this plant, that amounted to a production increase of 132 parts per month.

**Troubleshoot and run off new equipment and lines faster:** This is particularly valuable for large manufacturers that may be launching lines with 50, 100, or even 500 machines strung together. One weak link will hold up the entire line.

Bottlenecks can be identified immediately. Root causes can be diagnosed and eliminated systematically. New control limits can be verified and easily adjusted. Process signatures from the new line can be matched against existing ones to give a strong indication of conformance.

**Compare, manage performance for parallel stations or like stations anywhere:** Innovations in one plant can be reliably applied to other plants, providing a repeated increase in yield. We worked with one customer that could launch new lines around the world an average of four times faster, for estimated average savings of US$4 million per plant, using its data in this way.

In addition, don’t suffer the consequences of the same problem occurring twice. Once the root cause of a production or quality issue has been identified, the comparable process, test or machine on other lines or at other plants can be adjusted before they can suffer the same problem.

**Visualize the problem and fix it:** For example, a fuel rail leak was detected at an automaker’s plant. This slowed production and caused a quarantine for thousands of vehicles. Analyzing the test data revealed that all failures had just barely passed the quality tests. In this case, the limits being used on the test stand were those originally supplied by the part designer and had not been monitored after production startup.

The quality manager used one week of manufacturing test data to assess the impact of applying statistically-based limits. It was determined that tightening the test limits would have caught the faulty fuel rails with very minor impact on throughput. Two months’ worth of part data was retested, applying the new limits to identify other suspect parts.

Three additional suspect parts were found and their serial numbers forwarded to the assembly plant. Production resumed at full speed since confidence in the parts had been restored. Not only was this urgent bottleneck addressed, but the potential recall situation by end customers was entirely averted.

**In conclusion**

With the falling cost of sensors and data acquisition systems, network topology and throughput and multi-terabyte class storage, it is now feasible and economical for any discrete manufacturer to achieve the master data and prosper in the Industrial Internet of Things.

Powerful and advanced off-the-shelf analytical tools make it easy to integrate, correlate and analyze all data together for rapid trending and root cause analysis. Quality engineers can then find trends and patterns that reveal the reasons behind decreases in yield. This applies to any controlled process — from press fitting and leak testing to rundown, crimping, welding and dispensing. With these insights, manufacturers can increase their productivity, yield and cost savings.
The adoption of the Internet of Things (IoT) concepts and technology is providing the basis for dramatic manufacturing industry improvements. The core concept of Industry 4.0 and Industrial Internet of Things is to use IoT technologies to link business information and manufacturing in order to improve results with the application of communications and computing, including analytics, optimization, and production coordination. The broader scope view predicts that the digitization and integration of all aspects of production and commerce, across company boundaries, will eventually lead to even greater productivity and efficiency.

The application of IoT creates a holistic system, enabling manufacturing companies to be more efficient and responsive to changes including customer orders, work-in-process flows, raw material costs, and energy prices. The resulting productivity and efficiency boosts then result in higher return on investment returns. There is a bonanza of other possible benefits as well, including:

- Lower Work In Process (WIP) Time
- Faster time to market
- Improved Supply Chain Efficiency
- Greater Asset Utilization
- Minimizes Unplanned Downtime

**Smart Machines**

Data accumulates at multiple levels a manufacturing enterprise and that data can be used to perform advanced analysis and system-level optimization. Today’s smart machines have the ability to collect information locally, analyze that information, and optimize the local machine while passing that information on to other systems. Connected machines and network infrastructure equipment are incorporating computing and communications capabilities in order to achieve these functions.

**Retrofit**

There is an extremely large installed base of manufacturing machines and equipment that will be productive assets for years. Owners and operators of this equipment now have the ability to take advantage of new technologies, in the form of IoT computing and networking appliances, and make their machines and equipment intelligent. A good example is Mazak Corporation’s **SmartBox**. Part of the Mazak iSMART initiative to improve manufacturing, the unit captures machine information and performs analytics, integrating with the user’s manufacturing cells and overall systems to improve production performance. Mazak Corporation is a leading machine tool supplier providing a wide range of machines, including 5-axis, milling, turning, CNC controls, and automation.

The Mazak SmartBox is built with a CISCO hardware and software solution to connect machines. The solution collects sensor data, synthesizes information within a local fog application, performs real-time analysis for process optimization and predictive maintenance. The unit communicates data to other equipment and systems, including enterprise systems, in order to accomplish plant level analytics using the **MTConnect** open standard. The MTConnect open standard enables manufacturing equipment to provide data in structured XML (rather than proprietary formats) that can be used by any controllers and systems.
This uniform information from production equipment, sensors, and other hardware provides the foundation for a trove of applications that can actively increase efficiency of production.

Mazak actively supports the MTConnect standard as a way to provide complete manufacturing solutions. This support includes having more than 200 of its machine models prepared to accept the MTConnect adapter before they leave the factory, as well as offering moderately priced MTConnect adapters for existing Mazak equipment in the field. The Mazak SmartBox works with any machine regardless of make, model or age and Mazak will offer it in various configurations/kits based on the scenarios and challenges in which the units will be used. The device physically mounts to the side of machines, without having to integrate into a machine’s electrical cabinet. With several standard input/output connecting ports, Mazak SmartBox lets users quickly and easily connect any standard off-the-shelf sensors to the system for machine data gathering and condition monitoring. One Mazak SmartBox may service several machine tools along with other associated manufacturing equipment, depending on the application.

At the heart of Mazak’s SmartBox is Cisco’s Connected Machine solution using the IOx enabled fog application. Fog extends computing to the network edge, in order to perform local control, data transformation and communications with other systems. The MTConnect fog application runs directly on the ruggedized Cisco Industrial Ethernet (IE) 4000 switch equipped with the IOx application framework. Analytics are performed to optimize machine performance, within the manufacturing cell, providing real time visibility and insight into data right on the factory floor. The unit communicates data, in the MTConnect open format, to enterprise systems thereby optimizing overall operations and business decisions.

The underlying Cisco networking platform helps ensure that IT technicians will be familiar with Mazak SmartBox’s operation and can easily control and manage network security. Further, the hardware allows manufacturers to accomplish reliable machine communications through secure access and identity policy mechanisms. Third parties, such as equipment suppliers, can then gain secure remote access when necessary for service procedures.

**Make to Order**
Industry 4.0 is highly focused on leveraging IoT to achieve make-to-order manufacturing, building association between parts and processes. Applied to machined parts, for example, the part carries with it associated cutting tool paths and control points, which are then matched to a manufacturing process. The information, carried with the part, controls the machine tools and the production process making it, rather than the other way around.

**Predictive Maintenance**
Unplanned machine, and other production equipment, failures are highly disruptive to manufacturing, and create significant downtime that directly impacts productivity upstream and downstream in the production process. Capturing detailed machine data provides the basis for the application of analytics software to perform predictive maintenance. This predictive maintenance eliminates potential surprises and allows for orderly maintenance, prior any projected failure, keeping production running smoothly. This also increases the efficiency of maintenance workers and avoids disruptive repair emergencies.

**New Business Models**
These new technologies are enabling suppliers to provide more value-added services, improving manufacturing uptime and efficiency. Subject matter experts are becoming increasingly hard to find, yet today’s machines, enabled with processing and communications, allow experts to analyze problems and abnormal situations and find ways to improve and optimize operations, without traveling to the site.
This capability can deliver significant results by avoiding the economically-infeasible need for users to employ high level subject-matter experts for all functions, while still having experts, and analytic software, continuously monitor controllers and/or systems for abnormal situations, identify current problems or predict of future problems.

**Cyber Security**
These technological advancements do bring a new set of issues to the table. Cyber security has become an important issue with the installation of new and existing plant networks. Cyber security concerns are prevalent throughout the industry, but this cannot be a reason to avoid taking advantage of new technology that can improve operations. These systems and solutions can be deployed using sound protective methods. The International Electrotechnical Commission IEC 62443: INDUSTRIAL NETWORK AND SYSTEM SECURITY standard provides the basis for a cyber security program, built from the International Society of Automation ISA99 standard. The International Society of Automation provides multiple resources and training opportunities for industrial companies looking to leverage the new technologies. Another excellent cybersecurity resource is the ISC-CERT - Industrial Control Systems Cyber Emergency Response Team. Fortunately, while cybersecurity resources are prevalent, products in the industry are already being built that incorporate solid cyber security. For example, the ruggedized Cisco Industrial Security Appliance 3000 provides specific access control, threat detection, and application visibility for the most harsh and demanding of environments with four high-performance Ethernet data links in a DIN rail or rack-mount form factor. This appliance has visibility and control of industrial protocols including CIP (EtherNet/IP), DNP3, Modbus, IEC 61850, and PROFINET.

**Network Foundation**
In order to achieve the greatest value from these new technologies, manufacturing plants must ensure a cyber secure and high performance network infrastructure. Certainly a great deal can be done using existing installed networks but to completely leverage these technologies as they grow, strong consideration needs to be made to improve network bandwidth, performance, cyber security, and resiliency, when retrofitting and upgrading manufacturing plant networks.

This also includes the need for infrastructure to manage the growing number of wireless applications within a plant, including traditional 802.11 and sensor networks based on 802.15.4 standards - IPv6.

**IPv6 Network**
The importance of moving to an IPv6 network infrastructure is important for a number reasons, most importantly as a way to ‘future proof’ your investments. IPv6 increases the number of unique TCP/IP address identifiers to accommodate the rapid expansion of connected devices throughout the world. Further, IPv6 provides greater security, scalability, and seamless connectivity. Implementing IPv6 should be strongly considered for any upgrades, additions, and new network installations, because it provides the infrastructure necessary to fully take advantage of Internet of Things manufacturing technologies.

**Competitive Investment**
In a global economy, the need to remain competitive is of utmost importance for manufacturers, which is a large reason why we’ve seen such a rise in adoption of Industry 4.0 and IIoT technologies. Manufacturers who are able to productively digitize data and information, from machines, personnel, and enterprise systems, set themselves up to improve productivity, efficiency, and business results. Investment in new technologies, and ensuring an optimized, secure operating environment for the new technologies, is extremely important to maintain manufacturing competitiveness, and in this digital age, may be necessary for operation survival.
Want faster issue resolution?
Turn your data into action.

Everyone is talking about collecting assembly data but it still takes too long to solve issues that occur every day on the line.

Sciemetric’s Data Management and Manufacturing Analytics solution puts the right data and tools in the hands of the people who need to fix these problems quickly. Find root cause by tracing parts down to the serial number, identify station performance issues, set the right test limits and tweak cycle times in hours—not days or weeks.

We consolidate data from across the production line, eliminating silos and helping you resolve problems faster.

See how we’re changing the way you put data to work
sciemetric.com/makedatawork
A key mantra, repeated in virtually every presentation about the impact of the Internet of Things (IoT), Industrial Internet of Things (IIoT), and Industry 4.0 always exclaims “These will change business models!” They’re right to do so. Business models are undergoing change in multiple industries, including manufacturing, and manufacturers that don’t change with the times will see their competitiveness dwindle. That said, typically coupled with these messages from automation suppliers are calls to action to make technology investments, usually in their specific product. While there may be a great deal of truth in many of these statements, automation professionals have a responsibility to be mindful of their employer’s best interests. While new technologies are opening new levels of productivity, making major investments in these new technologies, without rethinking your entire manufacturing processes, could lead to rash, costly purchasing decisions that negatively impact your business.

IoT concepts have already impacting services in other industries in a big way. These advances have connected users directly with the individual supplier, creating new business models, and many new businesses that have taken market-share from those operating on more traditional models. Oft-cited examples include:

- **Uber**—An on-demand car service
- **Zipcar**—A rental car service
- **Airbnb**—A hotel alternative, many times using private homes

The fundamental concept behind all three of these businesses is the effortless connection of the user, directly with suppliers, at a lower transaction cost.

### A New Evolution to Lean Manufacturing

In the manufacturing world, the application of IoT is primarily used to achieve efficient, make-to-order manufacturing, linking the buyer directly with the manufacturing process and all related stakeholders. This evolution to fully automated and connected lean manufacturing, is leading the effort with goals of achieving greater customer satisfaction and highly efficient production.

### The Building Blocks of Our Manufacturing Future

The availability of many new technologies has provided the building blocks for dramatic changes in the manufacturing industry. These efforts include:

#### 3D/Additive Manufacturing

Plastic, 3D-printed parts were among the first applications of this additive manufacturing technology, which has now been extended to create metal parts as well. Jet engine manufacturers, for example, have been using additive manufacturing to create metal replacement parts for their engines. In one such effort, **GE Aviation** recently tested a demonstrator engine with 35% additive manufactured parts. The engine was made to validate 3D-printed parts for the clean-sheet design Advanced Turboprop (ATP) engine, which will power the new Cessna Denali single-engine turboprop aircraft. The FAA **cleared the first 3d 3D-printed part to fly** in a commercial jet engine from GE in 2015. This 3D metal printing capability was demonstrated in the **KUKA Robotics** booth, at the 2016 IMTS show, by **Midwest Engineered Systems**. They built stainless steel boat propellers using a laser welding additive manufacturing method.

#### Product Lifecycle Management (PLM) Software

Product lifecycle management (PLM) software integrates data, processes, business systems and people, in order to manage information throughout the entire lifecycle of a product, from conceptual design, design implementation, manufacturing, service, and end of life disposal. Designed to be cheaper and more efficient, PLM software continues to be refined dramatically to make it easier to use.

#### Collaborative Robots

A new breed of light-weight and inexpensive robots are working cooperatively with people in production environments, providing a means for companies to implement flexible manufacturing. Human collaboration is possible because these robots are inherently safe sensing. They note when humans and other obstacles
are in their path, and automatically stop to avoid causing harm or destruction. Surprisingly, the typical cost of one of these robots is less than $40,000, and their simplified programming means they can be deployed without hiring specialized engineers.

Pervasive Communications
The cost and performance of machine-to-machine communications has improved dramatically with IoT applications, making it possible to create holistic and responsive manufacturing, linked to customers and all the pieces of the manufacturing process.

Orchestrating New Business Models
I had a very interesting discussion with SAP’s Gil Perez, Senior Vice President Digital Assets & IoT about how SAP is changing their business model, through IoT. Gil Perez is a member of the SAP SE Product & Innovations executive team responsible for developing and commercializing a range of SAP solutions enabling digital transformation. The solutions comprise SAP Vehicles Networks, SAP Connected Parking, SAP IoT Security, Robotics and extended Warehouse Management, as well as SAP Direct Manufacturing (3D printing and On-Demand Manufacturing).

In September of 2016, SAP committed to invest €2 billion in IoT over five years as well as to continually expand their IoT portfolio. In January 2017, the company announced the SAP Leonardo IoT Portfolio as part of this commitment. Further, SAP just announced the opening of the early access program for the SAP Distributed Manufacturing application to new customers. This application was created in joint collaboration with UPS in order to make 3D printing and on-demand manufacturing an integral part of the digital manufacturing landscape. This, and other offerings, have been built on an SAP technology foundation that enables SAP customers to build IoT solutions, leveraging a consistent framework, featuring:

- SAP Cloud Platform- A Platform-as-a-Service infrastructure provides the framework for SAP Leonardo. SAP Cloud Platform provides end-to-end micro services for machine learning, analytics, Big Data, security, user experience, user management, and backend integration application program interfaces.

- SAP Leonardo Business Services- These enable users to rapidly build Internet of Things applications, allowing them to develop digital twins, create reusable application services, and apply predictive algorithms. These is designed to help users process a high velocity of data, with the ability to stream analytics and run predictive scenarios. This is all delivered on an SAP Cloud Platform, which is connected to millions of devices.

- SAP Leonardo for Edge Computing- Ingests data regardless of connectivity, latency, or device protocol concerns, all while delivering intelligent edge applications.

As Gil Perez explained, a key part of the 3D printing and on-demand manufacturing use case is the digital “manufacturing instruction” framework which contains all the specifications, requirements, and electronic design files transmitted to potential suppliers to quote.

SAP’s approach is one example of how new business models are leveraging platform-as-a-service and creating an ecosystem of suppliers for manufacturers. To this end, SAP has created relationships with a number of partners, including GE, Siemens, Bosch and PTC, to help provide solutions for customers.

Approaches like this have the potential to create more efficient manufacturing outsourcing with higher quality at a lower transaction cost.

What should manufacturers do first?
Before making major investments in any of these new technologies, manufacturers may do well to rethink their entire manufacturing processes to see how these new possibilities could help.
These technologies will continue to evolve current manufacturing processes, directly linking the producer with customers and suppliers, driving responsiveness and efficiency.

Industry 4.0, Industrial Internet of Things, and Smart Manufacturing are still in the early stages of development, and the effectiveness of new approaches is not yet clear. Small, incremental investments in pilot programs might be the best way to help learn in a constructive, productive environment, and could save a lot of time and agony, when major investments are made down the road.
It is not news that the industrial automation industry is in the midst of sweeping, fundamental change. I have been writing for years about the coming changes to industrial automation system architecture and now we’re finally seeing that evolution starting to occur. The application of revolutionary new concepts and technologies, including the Internet of Things (IoT), sensor advances, embedded controllers, and other technology improvements, are rapidly driving this evolution. 5 years ago, I wrote the article: Simplifying Automation System Hierarchies, which discussed the looming changes in industrial automation architecture, due to the dramatic growth and influx of the system concepts and technology advancements, that were then in their infancy. The article further discussed the pending collapse of the Purdue five-layer architecture model, a model that has been reflected in most traditional industrial automation systems configurations. The latest automation innovations have enabled users to create more responsive system architectures, which have been driving increased reliability and performance, in addition to lower software maintenance costs. Each new innovation provides even more building blocks to further evolve system architectures and spawn nearly exponential innovation in industrial automation. This article will further discuss the ramifications of these changing system architectures as well as links to other articles describing some of the products and developments that have resulted from and are spawning more of these changes.

What does this evolution mean for users?

Existing Systems Will Slowly Fade
This isn’t an overnight process. Installed systems will certainly be kept in place as long as they are productive, financially viable investments just as mainframe computers and minicomputers remained in place when they were still sensible. Yet, the newer innovations can definitely help extend and improve these systems, as add-ons which increase functionality and value. Many established suppliers have a tendency to view new technology additions as unattractive, for a range of reasons, until they come out with their own version. We saw this trend recently as well, through the initial resistance of traditional suppliers to replacing proprietary HMI hardware and software with PCs and Windows-based software.

Shortening Lifecycle Curves
The influx of new technology also has the capability to shorten the lifecycle curves of existing systems significantly, if they add value and lower the ongoing cost of ownership. When this tipping point is reached, it will accelerate the adoption of new technology and decrease the lifecycle of existing installed solutions. Again, the computing industry provides a viable example. The old model of enterprise computing required programmers to write computer code for reports and analysis based on the user’s requirements, a process which was labor-intensive and took far too long to achieve results. End users who performed analysis on PCs using spreadsheets, were able to significantly lower the cost of accomplishing these tasks while also providing immediate actionable results. The impact of this decreased cost, in both time and money for the business community, signaled the end of large data processing departments. You can even find a prominent example in your own home. How many people no longer use cameras, given the convenience of today’s smartphone camera technology and instantaneous sharing ability?
Big Data, Analytics, Edge & Fog Computing
Big data & analytics have served as one of the largest areas of potential to improve the operations of discrete manufacturing and process plants. Yet these advancements also require new computing models.

Servers
Applications that do not need to be synchronized with plant operations in real-time can reside in on-site servers and/or cloud services delivering new operational insights and predictive maintenance. This function can be value-added easily to existing systems.

Edge & Fog Computing
We are just starting to scratch the potential gains in efficiency and profitability for discrete manufacturing and process plants, through the application of big data and analytics, synchronized in real time with operations. This application is accomplished by using edge computing at the sensors and actuators, in order to perform the real-time analysis and make decisions that change operating parameters. Another building block for these architectures is fog computing, which is between the edge devices and the cloud. Fog computing is designed to bring the high-performance application of big data and analytics closer to the edge. Today, these functions are starting to be performed in newer, more powerful industrial controllers and PCs, in harsher environments, delivering further insights into operations. This has only been possible through high-performance embedded computing and low-cost high-speed communications.

Communications to Everything
The new industrial automation architectures are enabling edge devices to communicate to any level in the hierarchy. The sensors and controllers, at the edge, are able to communicate information to all levels directly using the appropriate methods and protocols. Yet, today’s multilevel hierarchical computing model still requires field data to pass through multiple computers, and layers of middleware software before reaching the enterprise and remote experts. This creates complicated brittle architectures, which can lead to significant increases in cost, risk, ongoing configuration control, and lifecycle investment. In contrast, the new distributed model brings computing to the point-of-use, streamlining the system architecture at a significantly lower lifecycle cost.

Holistic & Adaptive
Industry 4.0 and related initiatives create holistic and adaptive manufacturing, delivering a logical next step for industrial automation systems to achieve more responsive and efficient production.

Organizational Competitiveness is at Stake
Companies that do not research and take advantage of the appropriate disruptive innovations are likely to become stagnant and see themselves leapfrogged by more advanced competitors. Conversely, companies that leverage disruptive innovations are positioning themselves to become leaders in their industry. There are numerous historical examples that saw people and companies take the risk to leverage innovative thinking and technology and revolutionize not only their business but the industry at large. These examples include:

- Henry Ford - Ford dominated the early automotive industry with the world’s first moving assembly line.
- Andrew Carnegie - Producing steel more efficiently using technology including the Bessemer process and innovative material handling systems.
- Federal Express - Leveraged bar code and computer technology to achieve dramatic growth.

Change Agents
This is NOT a no-brainer. Automation professionals need to be change agents, do the research and understand the new technologies to determine if they can be effectively used to improve results in their companies. We at Automation.com are constantly working to bring you the latest and best information for automation professionals to be able to make the best decisions for your future.
Disruptive Technologies Make or Break Your Business

Automation Controllers & Word Processors – Embrace the Technological Shift or Die

Embedded IEC 61131 is Enabling Industry 4.0 & Industrial Internet of Things

Industry 4.0 for Process Automation – Process Sensors 4.0 Roadmap

The Open Group Open Process Automation Forum Launched

Worldwide Manufacturing Technology Changes

InTech - IoT impact on manufacturing

InTech: Manufacturing at a crossroads?

CISCO Live 2016: Disruption, Data Communications to Drive Industrial Success

Internet of Things Driven Manufacturing

Industry 4.0: Intelligent and flexible production