HOW TO SURVIVE IN THE ERA OF ORCHESTRATED MANUFACTURING

Tips for Harnessing Disruptive Technologies for Smart Products, Operations and Services
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OVERCOMING DISRUPTIVE FORCES IN MANUFACTURING

Manufacturers face numerous challenges in today’s economy — low growth forecasts, hyper-competition and increasing demands for speed, low cost and product innovation. Many organizations struggle with collaboration across products, geographies and suppliers. Others are searching for ways to differentiate their aftermarket services and increase revenues.

With most manufacturing sectors focused on lowering production costs in recent years, little has been spent on addressing major technology-driven disruptions made possible by the Internet of Things — the capacity for machines, systems, assets and people to be interconnected through the Internet via hard-wired and wireless networks.

According to Gartner, the installed base of “things,” excluding PCs, tablets and smartphones, will grow to 26 billion units in 2020 — an almost 30-fold increase from 0.9 billion units in 2009. This increasingly interconnected world is giving consumers unprecedented power over the products they use. For the first time, manufacturers have the ability to mine massive amounts of data for real-time insights for predictive maintenance programs and design and development.

On next-generation factory floors, the Internet of Things is helping manufacturers replace islands of automation with connected, self-healing systems to drive levels of quality, efficiency and cost savings. Gartner forecasts the total economic value-add across industries from Internet of Things will reach $1.9 trillion worldwide in 2020.

Despite the trends, the manufacturing industry as a whole has been slow to adopt the Internet of Things and other disruptive technologies such as cloud computing, mobile apps, data analytics and cybersecurity.

A recent Forrester survey of 646 global enterprises found that only 15 percent have an Internet of Things solution in place. About half of the companies (53 percent) are planning to implement a strategy in the next 24 months, but about half (52 percent) are concerned about implementation complexity and cost.

Similarly, according to IDC’s 2013 CloudTrack Survey and IDC’s Cloud MaturityScape, manufacturers have made significant progress with cloud — 32.6 percent of applications are projected to launch in the cloud in 2014 — but only a small number of manufacturers (6.7%) reported reaching an optimized stage of cloud deployment.

Technology is also driving other disruptive forces:

• New players in manufacturing that could potentially change the competitive landscape with techniques such as additive manufacturing and 3D printing, and more agile operations

• The growing usage of low-cost sensor and emerging smart materials that can both collect data and respond to external inputs, creating huge volumes of data for storage and analysis

• Improvements in tools to analyze data in real time to monitor operations, supply chains, connected products and numerous external data sources, enabling better decision making

• Emerging power-by-the-hour business models that combine product and services costs on a pay-as-you-go basis — requiring higher levels of services, more data and predictive analytics

• Augmented reality tools that enable maintenance and repair workers to visualize equipment and remote infrastructure to increase productivity and first-time fix rates

• Increasingly sophisticated threats to the cybersecurity of intellectual property, connected products and operations
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All of these disruptions pose technology challenges, such as integrating hard-wired legacy manufacturing execution systems with open, connected systems, or storing and analyzing massive amounts of sensor data. However, these disruptions also mean new opportunities for fast-moving organizations that are preparing for the new industrial revolution.

SEIZING NEW OPPORTUNITIES IN THE FOURTH INDUSTRIAL REVOLUTION

Welcome to the Fourth Industrial Revolution, or Industry 4.0, a term coined in 2011 by a working group of public and private organizations brought together by Germany’s Federal Ministry of Education and Research. It refers to the four distinct phases of the Industrial Revolution – from steam-driven machines to today’s cyber-physical systems.

Since Germany initiated Industry 4.0, other public and private organizations, including CSC, Siemens and Cisco, have advanced the concept in the manufacturing industry, which has seen many winners and losers over the past three industrial eras.

The U.S. Dow Jones Index is a good indicator of the impact. None of the original companies listed in 1885 is on the Dow today. General Electric, added in 1896, is the only manufacturer to remain on the Dow since the turn of the 20th century and the second Industrial Revolution. Of the 21 manufacturers listed in 1976 at the onset of the third Industrial Revolution, only 4 companies — GE, DuPont, 3M and United Technologies Corp. — were still listed in 2014. Once-leading players such as Eastman Kodak, American Can, American Tobacco, U.S. Steel and Woolworth fell off the list years ago due to disruptive forces.

How can manufacturers remain competitive in an increasingly competitive global marketplace, with lower-cost competitors thriving in emerging economies? The answer, in part, is embracing the next level of technology innovation.

Necessity, the mother of invention, has long powered the innovations that have advanced human civilization. Germany and other developed countries

First Industrial Revolution. The first Industrial Revolution began in Britain in the 18th century. It was enabled by the steam engine, powered mills and manufacturing plants, as well as the trains and ships that transported manufactured items. Craftsmen, who made their living hand-making goods one item at a time, were soon displaced by mechanized mills that could mass produce the same goods at significantly reduced cost.

Second Industrial Revolution. The next great revolution began in the early 20th century in the United States. The invention of electricity enabled moving assembly lines, the division of labor, and production on a mass scale. Manufacturers still using manual processes soon found themselves out of business.

Third Industrial Revolution. Advances in electronics and information technology over the past 40 years powered the third industrial revolution to dramatically automate and improve production, distribution and maintenance. Enterprise resource planning systems transformed business processes through digitization, dramatically simplifying and reducing operation, inventory, logistics and manufacturing costs. Companies could no longer use manual, paper-based processes and remain competitive.

Fourth Industrial Revolution. Today, a combination of existing technologies such as the Internet, mobility, the cloud and big data are converging under the Fourth Industrial Revolution to create intelligent manufacturing operations that could drive unprecedented levels of efficiency, quality improvement, customer satisfaction and cost savings.
Doing so requires a global system of IP, connected computer networks and advanced sensors, actuators, machines and devices — only recently have the processing power, sensor capabilities, smart software algorithms and high-speed communication networks become sophisticated enough to support smart, orchestrated manufacturing.

From information silos and disconnected players
To real-time insights into the complexities of product and process information

Smart Operations

From mass and structure only
To materials that gather and keep relevant information and actively respond to external input

Intelligent Materials

From Islands of automation
To a network of location-aware intelligent devices interchanging relevant information and insights and making autonomous decisions

Connected Devices

From Islands of automation
To a network of location-aware intelligent devices interchanging relevant information and insights and making autonomous decisions

Cyber-Physical Systems

From independent and disconnected islands of decision making
To IT systems able to cope with volumes of data and turn them into intelligent decisions

Software-Driven

Personalization

Globalization

Digitization

Operations

Serviceability

Connectivity

Figure 1: Orchestrated Manufacturing: Taking Operations to the Next Level

From the long-term business perspective, these changes in the industry are being driven by several key megatrends:

• Industry must find efficient and environmentally sustainable ways to feed, house and provide industrial products to a rapidly growing global population (9 billion people, and counting).

• A shortage of technology skills and talent is driving globalization, as companies search the globe for the technology expertise they need to produce high-quality goods and services.

• By 2020, 80 percent of the world’s population will live in urban centers. Manufacturers will need to locate within these urban centers to both access the skills they need to produce high-quality goods and to be near the customers who will purchase their industrial products. They will need to replace large, distantly located manufacturing centers with smaller manufacturing units across multiple urban areas.

• Consumerization will increase as customers, enabled by smart devices, demand easy access to goods and services that are tailored to their individual needs. Manufacturers need to better design products and services around these needs and be flexible to adjust rapidly as customer needs change — or their customers will go to a manufacturer that gives them the individualized products and services they demand.
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Commoditization continues to drive down the price of industrial products, which have been moving to low-cost labor markets, such as China, India and Chile. Mature industrialized nations require new manufacturing efficiencies in order to remain competitive.

Unlike in previous eras, manufacturers today have access to a variety of technological advancements that can enable rapid changes in operations and business models. There are four key enablers for manufacturers to address these trends:

- **Smart Operations.** Typically, operations today have too many information silos and disconnected players. Improved data analytics can give organizations real-time insights into products and processes.

- **Connected Devices.** While most companies have invested heavily in automation, many machines still lack real-time integration with other systems and processes. To achieve higher levels of efficiency, manufacturers can create networks of location-aware intelligent devices that interchange relevant information and insights with one another and make autonomous decisions.

- **Cyber-Physical Systems.** Organizations are often challenged by independent and disconnected islands of decision making, related to limitations in both systems and organizational structure. Cyber-physical systems enable management teams to get complete information and insight from throughout the enterprise.

- **Intelligent Materials.** Design and development teams have historically been limited to using materials with mass and structure only. Today, a growing range of materials will gather and store relevant information and actively respond to external input — creating many new opportunities to connected products.

These technology innovations are key to survival in the era of Industry 4.0, according to a recent German Federal Ministry of Education and Research report:

“Driven by the Internet, the real and virtual worlds are growing closer and closer together to form the Internet of Things. Industrial production of the future will be characterized by the strong individualization of products under the conditions of highly flexible (large series) production, the extensive integration of customers and business partners in business and value-added processes, and the linking of production and high-quality services leading to so-called hybrid products.”

**FRAMEWORK FOR ORCHESTRATING THE MANUFACTURING VALUE CHAIN**

As smart manufacturing devices and processes are orchestrated through digital interactions and cyber-physical production systems, traditional organizational barriers and stovepipes are being eliminated — opening up unlimited opportunities to connect more deeply with customers, design more innovative products, improve operational efficiencies and predictive maintenance, and compete more effectively for profitable aftermarket services.

Manufacturers that fail to embrace these opportunities will suffer the consequences of the coming disruptions — but manufacturers that begin to act now face the opportunity of a lifetime.

To guide manufacturing organizations toward this future state, we established an Orchestrated Manufacturing framework. It focuses on four core components of the manufacturing value chain: make, move, synchronize and support.
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ORCHESTRATED MANUFACTURING

**FAST, CUSTOMIZABLE DESIGN**
Engineers rapidly design customizable and highly individualized products using configurable, connected systems. Integrated manufacturing and production controlled ecosystems enable real-time, flexible operations.

**AGILE, CONNECTED SYSTEMS**
As-a-service applications and infrastructure enable organizations to quickly add new suppliers and expand into new geographies.

**SUPPLY CHAIN INTEGRATION**
Real-time supply chain integration enables manufacturers to digitally adjust production processes to meet the dynamic shifts in customer demand and respond to catastrophic breaks in the supply chain.

**PRODUCT LIFECYCLE MANAGEMENT**
Multi-enterprise product design and development drive innovation, lower cost and meet customer demand.

**REAL-TIME OPERATIONAL INTELLIGENCE**
Production line managers use real-time intelligence from systems and external sources to make proactive judgments affecting the manufacturing value chain.

*Figure 2: Orchestrated Manufacturing Infographic, part 1*
Figure 2: Orchestrated Manufacturing Infographic, part 2
MAKE (DESIGN AND DEVELOPMENT AND PRODUCTION)

In the era of the Industry 4.0, manufacturers are increasing speed and efficiency by connecting design, development and production systems to the Internet of Things. Collaborative tools and merging technologies, such as additive manufacturing and 3D printing, are transforming manufacturing processes.

Collaboration is key to improvements across the value chain to drive efficiency and innovation. For instance, suppliers can contribute ideas to improve time-to-market, and a deeper understanding of customer needs and wants will improve product designs.

Just as the factory and mass production replaced manual, one-item-at-time production processes during the first Industrial Revolution, new technologies are making it viable to replace mass production with mass customization.

The emergence of additive manufacturing and 3D printing has the potential to transform processes. Computer-controlled printers are printing 3D parts from advanced polymers, metals and composites through a 3D layering process. The digital design can be customized with a few clicks of a mouse, depending on the customer’s need. It can produce spare parts for aging devices or new parts that support new products far more efficiently than traditional processes.

3D printing offers manufacturers the ability to conduct realistic product simulations — crash test an automobile, for instance, or engineer lighter jet engines with fewer parts — virtually without having to produce and test physical prototypes. The use of this technique is rapidly spreading across various industries (automotive, aerospace, construction and prosthetics). It is also being used increasingly by do-it-yourselfers as desktop 3D printers become more affordable — allowing small, distributed manufacturing operations to create innovative products and compete with global suppliers.

Researchers are also beginning to explore 4D printing, which combines 3D printing techniques with smart materials that change when exposed to water, temperature changes or air, or self-assemble into predetermined shapes. 4D printing has a potentially wide range of applications, from organ printing in the medical industry to innovative products in the construction, furniture, sportswear, automotive, aerospace and marine industries.

Another key trend: A new generation of location-aware intelligent devices are exchanging relevant information and making intelligent autonomous decisions on the factory floor, with limited human intervention. Operations managers are able to rely on sensors and machine-to-machine integration to control self-adjusting systems and generate data for predictive analytics to reduce and manage downtime. For instance, networked machines can automatically predict failure, produce alerts for maintenance to correct problems before they impact production, and, in some cases auto-correct the problem.

Other key trends:

Accelerating product development and reducing engineering costs. Current product development processes must be adapted to the increasing need for integrated hardware and software solutions. This includes meeting demands for more collaborative, multi-enterprise product lifecycle management programs.

Integrating systems, people and things to drive efficiency. The cost of creating individualized and customized products must be reduced by connecting smart products with smart assembly lines.

Mastering data analytics to streamline production. Sensor data, analytics and self-adjusting systems are generating massive amounts of data. To improve product and production schedules, machine maintenance and downtime, manufacturers must be able to manage and analyze this data and to mine it for business insights that drive improvement.
Securing IP and production control systems from emerging threats. As closed, hard-wired networks are opened up to stakeholders across the value chain, proven cybersecurity frameworks and tools are essential to securing connected systems and proprietary information in a rapidly changing threat environment.

MOVE (SUPPLY CHAIN, DISTRIBUTION, AND SALES)

With the emergence of smart devices in the early to mid-2000s came the emergence of the well-informed, highly demanding customer. Intense competition among retailers has resulted in companies such as Amazon initiating “same-day” delivery options — made possible by orchestrated supply chain and logistics systems.

This is driving the need for real-time supply chain integration that enables manufacturers to digitally adjust production processes to meet the dynamic shifts in demand or in response to supply chain changes. It also requires location mapping and logistics to track assets, locate people, monitor operations, remotely visualize complex or extended infrastructure, and optimize service support.

By orchestrating production and supply chain systems, manufacturers can gain the ability to digitally adjust production processes to meet the dynamic shifts in consumer demand — or respond to catastrophic breaks in the supply chain.

Key trends include:

**Strengthening relationships with suppliers.** In order to provide customers with real-time visibility into their order status, manufacturers must integrate their global suppliers into their logistics systems — to improve the customer experience through rapid delivery and more customized and individualized products.

**Enabling real-time supply chain integration.** Real-time integration between supply chain and production systems enables organizations to respond to supply disruptions and digitally adjust production processes, automatically alert maintenance personnel about major equipment breaks, and notify production managers of potential impacts to schedules. Real-time insight is increasing the accuracy of demand planning processes as it decreases inventory costs.

**Improving location mapping and logistics.** Location mapping and logistics technologies are helping manufacturers track assets, locate people, monitor operations, remotely visualize complex or extended infrastructure, and optimize service support — allowing their sales team to effectively sell complex solution bundles that will be delivered to the customer on time.

**Expanding into new geographies.** Growth opportunities require manufacturers to seek new customers in emerging markets across the globe — expansion that is being simplified, at reduced costs, through cloud-based networks and Software as a Service applications.

SUPPORT (AFTERSALES SERVICES, MAINTENANCE AND SUPPORT, INFRASTRUCTURE)

Many manufacturers face intense competition for aftersales services and parts. To compete more effectively, manufacturers must take better advantage of sensor data and connected products to take support services to the next level. Digitized systems are providing self-healing mechanisms and autonomic service capabilities that minimize unplanned downtime and reduce the need for onsite service visits.

The Internet of Things is giving manufacturers unprecedented insights into the way their products perform in the field. Aftermarket sensors produce information that is driving advancements in predictive maintenance — and opening up opportunities for manufacturers to compete with third-party providers to provide aftermarket services and adopt new sales and business models.

LEADING ELECTRONICS MANUFACTURER IMPROVES QUALITY ACROSS MULTIPLE FACTORIES

A leading computer and electronics manufacturer needed to respond to customer requests to validate the quality of its products. After a hard drive failure, the company would typically spend weeks in a cumbersome, manual effort to provide customers with reliability data for all hard drives, for purposes of comparison.

Needing a way to quickly analyze massive volumes of data generated from multiple factory operations in Asia, the company talked to CSC about deploying big data in the cloud with its sophisticated machine data analytics engine. Now the entire production history of a drive is available for access at any time, enabling company representatives to immediately respond to customer inquiries and operations managers to identify potential quality issues in production.
Supporting products through next-gen aftermarket services allows manufacturers to overcome these common challenges:

- Analyze product sensor data to improve quality and performance
- Dynamically price spare parts to generate additional top-line growth
- Use predictive analytics to minimize unplanned downtime, reduce onsite service calls and support new sales and services models, such as power-by-the-hour leasing

The key to providing agile support programs for many companies is the modernization of IT infrastructures and applications. Cloud and Infrastructure as a Service give IT departments the ability to right-size infrastructure and applications – and a platform for rapid provision and testing for new apps. With an estimated 45 percent of applications expected to move to SaaS deployment by 2020, the cloud is a key enabler for the emerging as a service economy.

This increasing reliance on cloud, mobile apps and connected devices makes securing the enterprise even more challenging, as criminals and nations devise innovative, sophisticated ways to damage others’ critical infrastructure and steal intellectual property and customer data.

The key to success is elevating cybersecurity and addressing it as an enterprise-wide business strategy, instead of as a responsibility that falls solely to the IT department. Together, with the business, the cybersecurity can develop approaches that can even outmaneuver and block human-in-the-loop software attacks.

**SYNCHRONIZE (ENTERPRISE DATA AND COLLABORATION)**

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<th>Network</th>
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Figure 3: Orchestrated Manufacturing Drivers and Influencers
By synchronizing people, systems, machines and assets, teams throughout the organization are able to collaborate closely to test and implement disruptive technologies and increase efficiencies in production and services. Synchronizing is the key to capturing and mining the data that will produce real business insights.

By capturing and analyzing sensor data from a manufacturing environment, manufacturers can identify unique trends and:
• See what their equipment is doing in real time
• Get early warning signs from external data that could affect operations
• Harvest data from social media, consumer discussion forums and weather services
• Monitor energy usage and commodity prices
• Enhance knowledge management, collaboration and crowd-sourcing

TIPS FOR GETTING STARTED
With so many manufacturers focused on productivity gains, few organizations are able to adequately plan for ways to incorporate technology innovations into existing operations. Even fewer organizations have adopted consistent, repeatable processes across the enterprise. Here are five tips for getting started:

ACTION #1: DEFINE YOUR UNIQUE SELLING PROPOSITION
The first order of business is to define where you want your manufacturing business to go. What is your core competency? How are you different from and better than your competitors? What is the key value-add you offer your customers now and in the future?

To properly answer these questions, you need to define your Unique Selling Proposition (USP). This requires thorough research, but it will help you affirm the key factors or benefits that make your product different from, and better than, other equivalent products on the market. Without it, you will be selling just another commodity — and be woefully unprepared for the disruptions ahead.

Once you define your USP, only then can you commence embracing the industrial Internet of Things and the innovations and opportunities that will give you true competitive advantage in a competitive marketplace.

ACTION #2: MOVE FROM “INSIDE-OUT” TO “OUTSIDE-IN”
Whereas the information technology revolution, was driven by large organizations that built large staffs of IT experts to produce custom business solutions, the Fourth Industrial Revolution is being driven by innovations from outside the organization and even from other industries.

Increasingly, innovation, information and value will come from outside your organization’s own four walls. Until recently, these were created internally by organizations’ design, production, sales and marketing, and support teams. But the days of self-containment are over.

Many of today’s top IT technologies and techniques — including cloud, everything as a service, post-PC mobility, the consumerization of IT, social media, crowd-sourcing and community content — are happening outside the organization.

Today’s business executives must look outside the organization to identify the breakthrough technologies that will make or break their success. They must partner with the most creative individuals and resources that can deliver maximum value back to the business.

MINING COMPANY TAPS INTERNET OF THINGS TO MANAGE REMOTE EQUIPMENT, TOOLS AND PEOPLE
In the mining industry, it is widely recognized that maintenance personnel spend about 40 percent of their workday looking and asking for tooling and equipment. One leading natural resources company estimated that workers were spending two hours of each shift driving around for these reasons.

In order to increase “wrench time” for its maintenance crews at one of its largest mines, the company talked to CSC about rolling out Internet of Things technology that would enable the organization to track the location of equipment and tools, including 40 remote lighting towers, plus numerous generators, pumps, compressors, welding units and tool kits. Personnel tags that include messaging and fall-detection capabilities were provided to a limited number of employees on site.

The new system is remotely turning equipment on and off and collecting the machine’s sensor data to support predictive maintenance. The company has dramatically reduced the time spent locating and accessing lighting equipment and keeping it up and running. This program saved more than $200,000 in downtime costs associated with each occurrence of a lighting system failure.

MINING COMPANY TAPS INTERNET OF THINGS TO MANAGE REMOTE EQUIPMENT, TOOLS AND PEOPLE
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LEARN MORE ABOUT ORCHESTRATED MANUFACTURING

Orchestrated Manufacturing (OM) is CSC’s revolutionary framework for designing, implementing and managing complex ecosystems to provide real-time awareness and autonomic interactions between machines, systems, assets and things.

OM is how we help manufacturers take full advantage of the Internet of Things, cloud, data analytics, next-gen applications and cybersecurity across the manufacturing value chain. Learn more at csc.com/om. Contact us at manufacturing@csc.com.

ACTION #3: CREATE A ROADMAP, BUT START WHEREVER YOU WANT

The Internet of Things is rife with a wide range of options and opportunities. Regardless of how you begin embracing its innovations, it is essential that you first produce a roadmap to (1) examine all areas of your manufacturing operation — people, processes and technology — and (2) clarify strategic goals and objectives — both business and technical — to define the end state you wish to achieve.

ACTION #4: START SMALL WITH CONNECTED PROJECTS, BUT THINK BIG

There are so many directions manufacturers can go to begin embracing the industrial Internet of Things that many are not certain where to begin. We recommend that you start small with connected internal machines and processes.

Data management is a good place to begin. Begin capturing machine data and bring it back to a central repository where you can begin to analyze it and mine it for broad business insights.

If you don’t have a cloud strategy, now is a good time to begin. The cloud will be central to everything manufacturers do in the future.

Application integration and modernization is also something you can begin now. The first step in tearing down barriers and information silos is to make your applications transparent to stakeholders across the value chain.

These are smaller-ticket projects that can help you begin your journey. As you begin to deliver smart-connected components and services, you can gradually enhance them and begin testing your customer base. Starting small, you can begin to develop the model and processes that will guide you to ever greater innovations.

ACTION #5: MAKE SURE YOU HAVE INDUSTRIAL-STRENGTH CYBERSECURITY

As your enterprise becomes fully integrated and you connect to smart devices, to the cloud and even to the machines on your factory floor, cybersecurity provides the trust needed to launch connected products and share data and infrastructure with partners, customers and suppliers.

Testing and protecting internal systems and connected products requires specialized tools, expertise in hacking and intrusion prevention and a framework for connecting all devices to networks. The first step is understanding what thieves might attempt to accomplish in the real world.

NEXT STEPS

Many organizations have already started projects related to mobility, the Internet of Things and predictive analytics. However, few have created an enterprise strategy for managing all of these disruptions.

The key to success is a pragmatic approach that continually questions traditional assumptions about processes, products, suppliers and customer demands. Manufacturers that can successfully manage disruptions and embrace new business models will be positioned as leaders in this new era.
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