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 demand for speed, cost reductions and product innovations. This is driving many manufacturers to search for new, innovative ways to differentiate themselves in areas such as aftermarket services and product personalization.

Meeting these challenges is no easy feat. Many organizations are saddled with aging, siloed systems that make it difficult to collaborate across products, geographies and suppliers.

With most manufacturing sectors focused on lowering production costs in recent years, little time has been spent on addressing major technology-driven opportunities made possible by the Internet of Things (IoT) — the capacity for machines, systems, assets and people to be interconnected through the Internet via 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 2009.1 This increasingly interconnected world is giving customers unprecedented power over the products they buy. For the first time, manufacturers have the ability to collect and mine massive amounts of data for real-time insights into product design and performance and give customers the products they want.

On next-generation factory floors, IoT is helping manufacturers replace islands of automation with connected, self-healing systems that collaborate to drive quality, efficiency and cost savings to new levels. Imagine networked machines that can automatically predict failure, produce alerts or even auto-correct the problem. Gartner forecasts that the total economic value added by IoT across industries will reach $1.9 trillion worldwide in 2020 — more than six times the return on projected investment of $309 billion for the same period.2

Despite these rapidly emerging trends, the manufacturing industry, as a whole, has been slow to adopt IoT 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 IoT program 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.3

Similarly, according to IDC’s 2013 CloudTrack Survey and IDC’s Cloud MaturityScape, manufacturers have made significant progress on cloud, with 32.6 percent of applications projected to launch in the cloud in 2014, but only a small number of manufacturers (6.7 percent) reported reaching an optimized stage of cloud deployment.4

Technology is driving other disruptive forces:

• Additive manufacturing, 3D printing and more agile operations are enabling new players to change the competitive landscape.

• Low-cost sensors, with some form of embedded intelligence and emerging smart materials, are creating huge volumes of valuable data that can be analyzed for business insights.

• Emerging power-by-the-hour business models deliver services on a pay-as-you-go basis — requiring better analytics tools to understand and manage service-delivery quality and costs.

• Augmented reality tools enable maintenance and repair workers to visualize equipment and remote infrastructure to streamline maintenance, repair and overhaul (MRO) and increase first-time fix rates. Other wearable devices can monitor productivity, protect employee safety and health, and support new ways of connecting products with customers.

• Increasingly sophisticated threats to intellectual property, connected manufacturing cyber and physical systems, and connected products require more sophisticated cybersecurity strategies.

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These disruptions not only pose technology challenges, but in some cases, could put individual companies and entire business sectors at risk of becoming obsolete. However, these same disruptions can create new opportunities for fast-moving organizations in the new era of manufacturing — the fourth 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. All agree that few companies today are prepared to compete and survive in this new revolutionary phase.

The U.S. Dow Jones index of companies 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 four companies — GE, DuPont, 3M and United Technologies Corp. — were still listed in 2014. Disruptive forces caused once-leading players, such as Eastman Kodak, American Can, American Tobacco, U.S. Steel and Woolworth, to fall off the list years ago.5

How can manufacturers in high labor-cost economies such as Germany and the United States survive with lower-cost competitors thriving in emerging economies? The answer, in part, is by embracing technology innovation to offer differentiated products, services and processes.
Necessity, the mother of invention, has long powered the innovations that have advanced human civilization.

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 making goods by hand, were soon displaced by mechanized mills that could produce the same goods at significantly lower cost.

The next great revolution began in the early 20th century in the United States. The introduction of electricity enabled moving assembly lines, division of labor and mass production. Many manufacturers still using outdated processes could not compete.

Advances in electronics and information technology (IT) over the past 40 years powered the third Industrial Revolution. IT automated and improved production, distribution and maintenance. Enterprise resource planning systems transformed business processes through digitization, dramatically simplifying and reducing the costs of production, operations, inventory management and logistics. Companies could no longer use manual, paper-based processes and remain competitive.

Today, a combination of technologies is converging in the fourth Industrial Revolution. Manufacturers are harnessing the Internet, mobility, cloud, big data and a new generation of smart software algorithms and operational technologies, such as SCADA, PLCs, intelligent sensors and actuators, to create smart manufacturing systems and processes that support real-time context awareness and autonomic interactions between machines, systems, assets, people and things.

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

- **Consumerization.** Customers, enabled by smart devices, are demanding easy access to goods and services that are tailored to their individual needs. Manufacturers must design products and services to be flexible and adjust rapidly to changing customer demands for personalization related to software and connectivity.

- **Skills.** A shortage of technology resources and talent is driving globalization, as companies search more broadly for new skills to support programs such as mobility, embedded systems and data science. Mature companies face the added challenge of finding legacy IT maintenance skills to replace baby boomers, who are retiring from IT departments at record rates. An estimated 4 million U.S. workers are retiring each year, with 48 percent of the supervisors working in 2011 expected to retire by 2015.6

- **Commoditization.** As industrial manufacturing has been moving to low-cost labor markets, such as China, India and Chile, industrial products are becoming commoditized and prices are decreasing, putting pressure on traditional players in high-cost labor markets.

- **Urbanization.** The number of people living in urban areas is expected to grow from 54 percent of the world’s population in 2014 to 66 percent by 2050 — an additional 2.5 billion people. The world’s megacities (with 10 million or more inhabitants) grew from 10 cities in 1990 to 28 in 2010. By 2030, the number of megacities is expected to reach 41, with most located in Asia.7 In many cases, manufacturers will be forced to replace centrally located factories with more distributed operations that use efficient, environmentally sustainable processes suited to urban areas.

**KEY ENABLERS FOR THE NEW ERA**

Unlike in previous eras, manufacturers have access to a variety of technological advancements that can enable rapid changes in operations and business models — but with a smaller window of time to exploit these advantages. 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 technology and algorithms can integrate these silos. Only with integrated operations systems and processes will organizations be able to gain real-time insights into products and processes and leverage the potential of orchestrated manufacturing.

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

• **Cyber-Physical Systems.** A major driver for innovation is the growing proliferation of tightly integrated cyber-physical systems, which collaborate with other systems to collect and process information, make intelligent decisions and execute tasks in changing environments. In manufacturing, cyber-physical systems are taking various forms, such as intelligent control systems, fully integrated assembly lines or safe, fully integrated human-robotics assembly lines.

• **Intelligent Materials.** Design and development teams have historically been limited to using materials with mass and structure only. Today, more materials gather and store relevant information and actively respond to external input — creating many new opportunities to connect products. The combination of intelligent materials with new technologies, such as 3D and 4D printing, will result in major disruptions across many industries.

These technology innovations are the keys 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.\textsuperscript{8}

**FRAMEWORK FOR ORCHESTRATING THE MANUFACTURING VALUE CHAIN**

As smart manufacturing systems and processes are orchestrated through preconfigured, digital interactions and cyber-physical production systems, traditional organizational barriers and stovepipes are being eliminated — opening up new opportunities to connect with customers, rapidly design innovative products, transform operations and compete more effectively for innovative aftermarket services.

To guide manufacturing organizations toward this future state, CSC established an Orchestrated Manufacturing framework, which focuses on four core components of the manufacturing value chain: Make, Move, Support and Synchronize.

**MAKE**

**DESIGN, DEVELOPMENT AND PRODUCTION**

Manufacturers are increasing speed and efficiency by integrating design, development and production systems and making real-time information available across all involved systems and processes. Collaborative CAD/CAM tools and technologies, such as additive manufacturing and 3D printing, are transforming the way products are designed, prototyped and manufactured.

Collaboration is the key to improving the value chain and driving efficiency and innovation. For instance, suppliers can contribute ideas that improve time to market, provide a deeper understanding of customer needs and wants, and improve product designs.

The emergence of additive manufacturing and 3D printing also has the potential to transform processes — and enable manufacturers to replace mass production with mass customization. 3D printing gives manufacturers the ability to conduct rapid prototyping of designs by reading CAD/CAM design data and then laying down layers of liquid, powder or sheet material to produce a physical model. Digital designs can be customized with a few clicks of a mouse, depending on the customer’s need.

This technique minimizes waste, significantly improves efficiency, and enables model-based digital product design, testing and crowdsourcing. As prices fall and 3D printers become ubiquitous, a whole new generation of do-it-yourselfers could become both suppliers and competitors.

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

Another key trend is related to a boom of more than 1.7 million industrial robots worldwide.\textsuperscript{9} A new generation of environment and context-aware intelligent robotics systems are exchanging relevant information and making intelligent autonomous decisions with limited human intervention.

Operations managers are able to rely on such self-adjusting systems to control production processes and generate data for predictive and prescriptive analytics to increase overall efficiency and reduce, or even eliminate, unexpected downtime.

Other key trends:

**Accelerating product development and reducing engineering costs.** Current product development processes must be adapted to the increasing need for improved hardware...
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and software integration and the need for more virtualized, collaborative, multi-enterprise product lifecycle management (PLM) 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, enterprise systems such as supply chain management, customer relationship management and PLM.

Mastering data analytics to streamline production. Connected sensors, smart products and cyber-physical systems are generating massive amounts of data. To improve products and production schedules, machine maintenance and downtime, manufacturers must be able to collect, manage and analyze large volumes of new sets of master, transactional and operational data in structured and unstructured formats within different contexts. Then organizations can mine that data for business insights that drive improvements.

Securing IP-based manufacturing systems from emerging threats. As hardwired systems in closed local area networks are opened up to stakeholders across the value chain, proven cybersecurity frameworks and tools are essential to securing connected systems and protecting 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. This trend is generating intense competition among retailers, resulting in Amazon’s announcement in 2014 of same-day delivery options — a service made possible by orchestrating supply chain and logistics systems.10 The company believes that using smart autonomous machines, such as drones, in the supply chain could soon make same-hour delivery a reality.

To compete in this environment, manufacturers need real-time supply chain integration, location mapping and the ability to leverage cloud infrastructure to rapidly introduce new infrastructure and applications.

Key trends include:
Improving collaboration with suppliers. To provide customers with faster delivery, more options for customization and real-time visibility into their order status, manufacturers must implement appropriate levels of integration between their global suppliers’ systems and their logistics, transportation management systems (TMS), warehouse management systems (WMS) and, in some cases, even manufacturing execution systems (MES).

Analyzing real-time data to support decision making. 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 teams to effectively sell complex solution bundles that can be delivered on time.

Expanding into new geographies. Growth opportunities require manufacturers to seek new customers and grow in emerging markets across the globe — fast, dynamic expansion of production, distribution and sales capabilities that is being simplified, at reduced costs, through the cloud and software-as-a-service (SaaS) applications.

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 typically spent weeks in a cumbersome, manual effort to provide customers with product reliability data.

The company needed a way to quickly analyze massive volumes of data generated from multiple factory operations in Asia. CSC designed and delivered a data analytics platform in the cloud. Now data on the entire production history of a drive is accessible at any time, enabling representatives to immediately respond to inquiries from customers and operations managers to identify potential quality issues.
Figure 3: Orchestrated Manufacturing Infographic, Part 1
CSC’s Orchestrated Manufacturing provides the framework for designing, implementing and managing complex ecosystems that provide real-time awareness and autonomic interactions between machines, systems, assets, people and things.
### SUPPORT

**AFTERSALES SERVICES, MAINTENANCE AND SUPPORT, INFRASTRUCTURE**

Many manufacturers face intense competition for aftersales services and parts sales. To compete more effectively, manufacturers must take better advantage of sensor data and connected products to connect with consumers, grow cross- and up-selling, and provide needed support on time.

Digitized systems are providing self-healing mechanisms and autonomic service capabilities that minimize unplanned downtime and reduce the need for onsite service visits through remote diagnostics and potentially remote repair capabilities.

Supporting products with next-gen aftermarket services allows manufacturers to overcome many common challenges:

- Collecting and analyzing real-time product sensor data to improve quality and performance
- Dynamically pricing spare parts to generate additional top-line growth
- Inspiring new transformative business models, such as power-by-the-hour, usage-based leasing — helping organizations define themselves as services companies vs. products companies
- Modernizing outdated IT infrastructures and applications to enable smart products and services and new business models

### SYNCHRONIZE

**HOW TO SURVIVE IN THE NEW ERA OF MANUFACTURING**

**PHARMACEUTICAL MANUFACTURER TRACKS RISKS — FROM NATURAL TO MANMADE EVENTS**

A global pharmaceutical company with operations in more than 30 countries faced repeated challenges to meet demand for its products, which are prescribed by millions of doctors worldwide.

CSC’s OmniLocation team mapped and analyzed the company’s business footprint of dozens of products across hundreds of locations and developed a Visual Risk Management System that combines, analyzes and reports on risks from nine sources across 11 data feeds to all types of operations including manufacturing, R&D, suppliers, distributors, warehouses, packaging, planning and sales.

A dynamic visual display alerts these stakeholders of events that could disrupt supply chains, distribution and operations, including earthquakes, severe weather, power outages, political instability, travel alerts and security threats.

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**Distributed Locations**

*Figure 4: Synchronizing Processes and Technologies*
ENTERPRISE DATA AND COLLABORATION
By synchronizing people, processes, 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 includes the monitoring and analysis of internal and external data sources to help manufacturers:

• 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 crowdsourcing

TIPS FOR GETTING STARTED
With most manufacturers focused on productivity gains, few are able to adequately plan for ways to incorporate technology innovations into existing operations. Even fewer organizations have adopted consistent, repeatable processes. Tips for getting started include:

ACTION 1: DEFINE YOUR UNIQUE SELLING PROPOSITION
The first order of business is to answer the following: What is your core competency? How are you different from and better than your competitors? Where do you want your business to go in the future? What is the key value you have to offer your customers now and in the future?

To properly answer these questions, enterprises must define a unique selling proposition (USP), including differentiators related to product design, materials, user configurability and other factors. Knowing your USP will help provide a clear path to technology innovation and improved competitiveness.

ACTION 2: MOVE FROM INSIDE-OUT TO OUTSIDE-IN
While the IT 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 organizations and even other industries.

Historically, innovation came solely from internal teams in design, production, services, sales and marketing. But the days of self-containment are over.

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

Customers, too, are becoming key drivers of innovation. IoT offers companies numerous ways to capture customer preferences and insights to drive improvements across R&D, engineering and production. Today’s business executives must look outside to identify breakthrough technologies that can deliver maximum value back to the business.

ACTION 3: CREATE A ROADMAP, BEGIN WITH QUICK WINS
Regardless of how you begin embracing IoT and other innovations, it’s essential that you first produce a roadmap to examine all areas of your manufacturing operation, including people, processes, systems and technology; clarify strategic goals and objectives, both business and technology; and define the end state you wish to achieve.

MINING COMPANY TAPS IOT TO MANAGE REMOTE EQUIPMENT, TOOLS AND PEOPLE
In the mining industry, it’s widely recognized that 40 percent of the workday for maintenance personnel is spent searching for tools and equipment.

In order to increase “wrench time” for its maintenance crews at one of its largest mines, one leading company talked to CSC about using IoT technologies to track the location of equipment and tools, including 40 remote lighting towers and numerous generators, pumps, compressors, welding units and tool kits. Personnel tags that include messaging and fall-detection capabilities were provided to onsite employees.

The new system is remotely turning equipment on and off and collecting machine sensor data to improve predictive maintenance. The company has dramatically reduced the time needed to locate industrial lighting equipment and keep it up and running, avoiding an estimated $200,000 in downtime costs per lighting failure.
As you dynamically create this roadmap, you’ll be able to identify quick wins that bring instant value to the business and help you maintain the support of your executive sponsors and managers and ensure funding for future projects.

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

There are so many directions manufacturers can go to begin embracing IoT, many are not certain where to begin. We recommend that you start small with connected internal machines and processes.

The manufacturing equipment you use today is fitted with sensors that generate reams of data on every aspect of its operation. Few businesses make full use of that information, but those that do have a big advantage. They’re able to optimize production to the highest degree, minimizing maintenance expenses and downtime while reducing energy usage and environmental impact.

The key is to create new data models to capture data from existing machines and bring it back to a central repository where it can be analyzed and mined for broad business insight. The first step in tearing down barriers and information silos is to make this data transparent to all stakeholders. Then start making this data available to relevant processes and systems.

Begin with small projects that have the greatest impact on internal users or customers, but think big. This is a good time to begin assessing new business models. IoT will offer many new opportunities for companies to target new markets and compete more effectively for aftermarket revenues.

ACTION 5: ASSESS YOUR TECHNOLOGY READINESS

Collecting data is never the ultimate goal. The ultimate goal is to make good use of data to gain business insights. Operational technology (OT) systems, then, must have access to this data and be able to understand and act on it.

Therefore, IoT programs require complex integration between internal and external systems, as well as cyber-physical systems. Many manufacturers will need to modernize and retrofit both their applications and infrastructure. A technology-readiness assessment is a must for evaluating the ability of your IT and OT systems to fulfill the requirements of your IoT initiatives and roadmaps.

This assessment should include a software technology assessment, application functional assessment and network assessment. At the same time, companies must implement enterprise strategies and platforms for cloud, mobility, big data and cybersecurity.

ACTION 6: MAKE SURE YOU HAVE INDUSTRIAL-GRADE CYBERSECURITY

As manufacturers move from hardwired systems to distributed, connected cyber-physical systems over the cloud, information will stretch across multiple systems, applications, companies and countries – increasing cyberthreats to intellectual property, operational data and physical systems that could put the whole business at risk.

In the modern era of advanced persistent threats and sophisticated state-sponsored adversaries, manufacturers must take aggressive steps to secure their systems and protect their mission-critical data and systems.

Before rolling out IoT-related programs, be sure to have plans in place for industrial-grade cybersecurity frameworks for connected products and services, advanced intrusion detection, and rapid incident response protocols.
NEXT STEPS
Many organizations have already started projects related to mobility, IoT and predictive analytics. However, few have created an enterprise strategy for managing all these disruptions.

The key to success is a pragmatic approach that continually questions traditional assumptions about processes, products, suppliers and customer demands. Leaders in this new era will successfully manage disruptions, introduce new business models and adeptly make information and technology part of the company value proposition.

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LEARN MORE ABOUT ORCHESTRATED MANUFACTURING
Orchestrated Manufacturing 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.

It’s how we help manufacturers take full advantage of IoT, 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.

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