The Connected Enterprise Maturity Model

How ready is your company to connect people, processes, and technologies for bigger profits?
Manufacturing will change more radically in the next five years than it has in the last 20.

Are you ready?

In the “Internet of Things” (IoT), almost every object can use embedded technology to gather and transmit information. A pill might perform medical analysis, a concrete highway may offer traffic guidance, and machinery on a factory floor can manage quality control and energy usage.

The accelerated connection of operations technology (OT) to information technology (IT) enables unprecedented collaboration across the enterprise, linking processes and facilities to suppliers and customers in new ways. Manufacturers, industrial operators and Original Equipment Manufacturers (OEMs) can take advantage of real-time decision-making that drives profitability — but they also face new challenges in securing the data and infrastructure that underlies that opportunity.

A new path to improved productivity

The rapid convergence of OT and IT — thanks to the proliferation and affordability of plant-floor Ethernet and smart devices, powerful local computing solutions, and multiple network technologies merging into one — is transforming information into insight. This gives decision-makers across the enterprise new visibility into operations — and new opportunities to make them better in response to:

• **Internal measures:** Real-time monitoring and sharing of key performance indicators (KPIs) so that staff — senior executives down through frontline employees — can identify problems and resolve issues before they escalate or even occur. You cannot improve what you don’t measure.

• **External business activities:** Incorporate customer-demand information and/or supplier performance data (e.g., late deliveries, out-of-stocks) as they happen to trigger revised production scheduling, staffing changes, procurement alternatives, etc.

• **Market changes:** Supply-chain planners and purchasing managers now rely on an array of vendors from around the world, complicating management of lead times, quality, and cost control (e.g., additional staff time to work with distant suppliers, inventory carrying costs, obsolete materials due to overstocking, etc.).

The connection of people and processes via technology allows executives and their continuous-improvement (CI) teams to implement real-time decision-support tools that boost productivity and profits — often without direct intervention or additional staff.

"Making data the basis for automation and control," says the *McKinsey Quarterly*, "means converting the data and analysis collected through the Internet of Things into instructions that feed back through the network to actuators that in turn modify processes. Closing the loop from data to automated applications can raise productivity, as systems that adjust automatically to complex situations make many human interventions unnecessary." ¹

Intelligent networks also improve optimization of assets — including energy usage, equipment reliability and longevity, and expanded capacity from existing assets. The information delivered by the network also helps executives to plan strategically, scheduling production within their portfolio of facilities based on performance trends, logistics patterns, market demands, etc.
Lastly, when baby-boomer executives and experts throughout the organization — engineers, OT specialists, maintenance, etc. — retire, their lost knowledge becomes a significant danger to the organization. (Some 10,000 baby boomers will turn 65 every day until 2030.) Improved information flow and availability can help to mitigate this risk, especially in industries facing increased customer demands, regulatory requirements, and a decrease in skilled labor.

Making sure that information — and profits — are secure

Most industrial infrastructures today were not designed to take advantage of the Internet of Things. According to the 2013 Next Generation Manufacturing Study, surprisingly few manufacturing executives indicate that their business systems and equipment are state-of-the-art and able to provide long-term support for six key strategies that will drive organizations into the next generation (see chart).

<table>
<thead>
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<th>Quality of business systems and equipment to support world-class strategic performance</th>
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<td>Customer-focused innovation</td>
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<td>Process improvement</td>
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None | Inadequate for current requirements | Adequate but limited to current requirements | State-of-the-art and able to provide long-term support


A study of manufacturers conducted by *IndustryWeek* magazine and Rockwell Automation found surprisingly low levels of integration, both on the plant floor and throughout the enterprise:

- Only 14% of executives indicated that all plant-floor data is integrated with enterprise systems.
- About one-quarter of executives indicated that nearly half or more of their plant-floor machinery (not including computers) is Internet-enabled (Ethernet or Wi-Fi); 30% report none of their equipment is Ethernet-enabled.

The opportunity clearly exists for manufacturers to bring their equipment and systems into the modern information-enabled world. The American Society for Quality (ASQ) surveyed manufacturers about their use of smart manufacturing — defined as the integration of network-based data and information that provides real-time understanding, reasoning, planning, management and related decision making of all aspects of a manufacturing and
supply-chain enterprise. Only 13 percent said they use smart manufacturing within their organization. Of those organizations that claim to have implemented smart manufacturing, 82 percent say they have experienced increased efficiency, 49 percent experienced fewer product defects, and 45 percent experienced increased customer satisfaction.5

Attacks on enterprise networks can come from anywhere, anything, and anyone, including via legacy OT devices. As employees or contractors monitor production via wireless smartphones and tablets, these hand-held devices can become entry points for both intentional and unintentional internal attacks or, externally, through authorized or unauthorized remote access. Unauthorized access could indicate an attacker’s intent to capture proprietary data or information, or to fully stop production at a facility. More malicious actions could impair plants in ways that put public health and welfare in danger. Security policies must now reach from enterprise to end point — areas in which IT has not traditionally ventured and which require IT and OT collaboration to securely address the needs of the operation.

Aging systems connected to modern OT or modern systems connecting to aging OT also can pose significant risks, such as flawed transmissions that change processes and result in incorrect product specifications, poor quality, or equipment and work stoppages. A production stoppage in some industries, such as the automotive sector, can exceed $20,000 per minute.6 Networks also can incorrectly interpret data, building reports that misrepresent operations information for customers, stakeholders, regulators, and/or corporate reporting and planning. These older legacy systems also are increasingly becoming harder to integrate and maintain for improved efficiencies.

In contrast, state-of-the-art OT devices and controls from Rockwell Automation rely on open, industry-standard technologies, such as Ethernet Industrial Protocol (EtherNet/IP), which uses the Common Industrial Protocol, both managed and maintained by ODVA. The network connects devices (e.g., motor starters and sensors) to controllers, machine-operator interfaces, and the enterprise network, linking OT with IT and making the combined network more manageable and information available for better visibility and decision making.

Newer, more intelligent networks also minimize the financial risk of sudden total cost of ownership increases (TCO). Why? Because aging OT and IT systems and networks can trigger massive TCO spikes due to malfunctions that result in missed deliveries, scrap and rework, lost customers, and safety problems. State-of-the-art OT and IT offer both improved profitability now and cost certainty.

**Implementing a More Intelligent OT/IT Network**

Any major technology change offers excitement and opportunity — but also fear and danger. Fortunately, there’s the Connected Enterprise Maturity Model for implementing a more intelligent OT/IT network, pioneered by Rockwell Automation and proven with significant reductions in costs and improved capabilities. Rockwell Automation developed a five-stage maturity model that incorporates measures and best practices necessary to ensure effective change in both technologies and organizational cultures. It also has partnered with Cisco Systems®, Microsoft®, Panduit®, and others to establish an OT/IT knowledge bridge for manufacturers and industrial operators (see Rockwell Automation Partners).
The Assessment Stage of the Connected Enterprise Maturity Model evaluates all facets of an organization’s existing OT/IT network:

- Information infrastructure (hardware and software),
- Controls and devices (sensors, actuators, motor controls, switches, etc.) that feed and receive data,
- Networks that move all of this information, and
- Security policies (understanding, organization, enforcement).

Rockwell Automation Partners

Rockwell Automation has partnered with leading IT companies for joint solution development and integrated solutions and services. These collaborative efforts result in better asset optimization and broader risk management for industrial companies:

**Cisco:** Rockwell Automation and Cisco are committed to being the most valuable resources in the industry for helping manufacturers to improve business performance by bridging the technical and cultural gaps between plant-floor and higher-level information systems and the enterprise. Through collaboration on products, recommended architectures, services and educational resources, together we help manufacturers and machine builders converge, optimize, and future-ready their network architectures, and help customers create a secure and reliable network infrastructure using EtherNet/IP — the world’s leading open industrial Ethernet network.

**Microsoft:** Rockwell Automation and Microsoft are working together and aligning strategically to accelerate innovation for both operations and IT practitioners, empowering them to apply solutions in new and powerful ways. We are partnering to develop manufacturing information solutions that enable manufacturers to increase the value of ownership, and to lower the barriers of applying information technologies to optimize production. Today, we are developing solutions for our customers who want to leverage their existing technology investments and reduce cost of ownership more rapidly to differentiate themselves competitively.

**Panduit:** Together, Rockwell Automation and Panduit are driving integrated solutions that help you to reduce risk, improve reliability, simplify installation, and successfully implement EtherNet/IP solutions and architectures. Through collaboration on technology and physical network infrastructure solutions and services, the Rockwell Automation and Panduit strategic alliance helps customers develop a robust, secure, future-ready physical network infrastructure for industrial environments. Supporting the reference architectures work Rockwell Automation has done around the logical network framework, the focus for this strategic alliance provides users and machine builders the ability to seamlessly integrate the logical and physical deployment from initial design, maintenance, and operations throughout the entire enterprise.

Stage 1: Assessment

The Assessment Stage of the Connected Enterprise Maturity Model evaluates all facets of an organization’s existing OT/IT network:

- Information infrastructure (hardware and software),
- Controls and devices (sensors, actuators, motor controls, switches, etc.) that feed and receive data,
- Networks that move all of this information, and
- Security policies (understanding, organization, enforcement).
Especially critical is an examination of the people and processes that manage this framework — if a recognizable framework even exists.

“We assess the readiness of an industrial company to change its processes and information architecture to leverage timelier and more accurate information that is available in the enterprise today,” says Keith Nosbusch, chairman and CEO, Rockwell Automation. “We often find that less effective legacy processes are in place, and that those processes and work flows have not been designed to take advantage of the OT/IT convergence and the significant benefits available from the connected enterprise. We then help industrial companies establish a strategy that systematically, sequentially, and securely integrates the technologies, processes, and people.”

A major challenge during the Assessment Stage is potential hesitation to invest time in questioning practices that they have relied upon for years. Even more pressing, though, is to understand how to manage the transition to a more intelligent OT/IT network without disrupting operations or causing customer delays. That transition will depend, in large part, on the extent of the gap between the current state and the desire state — i.e., can the capability of the existing network be upgraded, or will it need replaced?

A thorough assessment identifies and catalogs problems with the existing OT/IT network, to help create a “wish list” for the new network and operations, laying the foundation for more advanced technologies, such as business intelligence software or cloud-computing capabilities. More than half of manufacturers (56%) report that none of their applications or systems use cloud computing; another 23% have just 1–10% of applications and systems in the cloud. On average, just 10% of applications and systems are in the cloud (see Cloud Computing), however, cloud computing falls among the top three technologies CIOs selected as a priority in 2013 as it is predicted to disrupt business fundamentally over the next 10 years. These statistics are likely driven as much by technology capabilities as by executive preference.

Just as important as understanding the ability to move to improved technologies, the assessment will uncover network security issues, allowing for risk-mitigation procedures to begin. Rick Esker, senior director of the Industry Solution Group at Cisco, told Control Magazine that industrial networks are multiplying and diversifying so rapidly that they leave manufacturers vulnerable to attack. “As a result, Cisco and Rockwell Automation
have been working on advanced security functionality appropriate for the industrial marketplace. We have a much more integrated approach, thanks to our enduring relationship, and this lets us successfully address the primary concerns of our users, help them become more aware and practice security as a habit, and protect them against threats in the future. 9

No two manufacturers are alike, and each will define the level of risk they are willing to accept — and the level of action they are willing to take on to get to that sense of security. The precise definition of those “consequences” is another outcome of the Assessment Stage.

Stage 2: Secure and upgraded network and controls

After gaps and weaknesses have been identified in the current OT/IT network and operations, upgrades begin with a long-term view that contemplates facility expansions and new technologies. During this stage the organization evolves and/or builds an OT/IT backbone that will deliver secure, adaptable connectivity from plant-floor operations to enterprise business systems.

It’s this phrase — “from plant floor to enterprise network” — that surfaces one of the largest challenges manufacturers face in designing more intelligent networks: who has responsibility for managing the new OT/IT network? Is it OT — or IT — or both? During Stage 2, upgrades to hardware begin, along with planning for how OT and IT engineers will collaborate. In a workshop environment, cross-functional teams assess new technology options, establish vendor roadmaps, and plot out future-ready, scalable design of the OT/IT network. The objective is to guide the intersection of OT and IT in a controlled, virtual environment, rather than wait and hit those problems in the real world, with real customer orders on the line. This process also allows companies to map out business processes and workflows that are acceptable to both sides of the house and appropriately distribute management of the intelligent network.

A frequent challenge, especially in larger organizations, is the sheer volume and variety of outdated controls and networks in place. Savvy executives plan for systematic replacements, with priorities determined by cross-functional teams that include representation by location, function, etc. It’s also not uncommon for an OT/IT upgrade to encounter hesitation from executives and engineers who feel that current systems remain viable. If a network cannot acknowledge equipment, it cannot secure it. Senior leadership will be responsible for the culture change that persuades or removes these obstacles to change.

Even as an organization moves through Stage 2, a more secure network emerges, providing accessible data with built-in security authorizations and authentications. For many companies, it will be the first time they've ever had an integrated OT/IT network — and the first opportunity to control equipment performance in real time (e.g., demand responsiveness). Developing a security policy to accompany the more secure, productive network also begins in Stage 2.

Stage 3: Defined and organized working data capital (WDC)

In Stage 3, teams organized for the OT/IT upgrade, define, and organize the company’s Working Data Capital (WDC) — i.e., all the available data for improving business processes and improvements — and determine how to leverage it for optimum gains. Note that none of the stages are completely separated from others, and this is especially
true with organizational changes in Stage 2 (new data capabilities emerging) and Stage 3 (identifying how to harness and leverage the data). In Stage 3, the team also “contextualizes” the data by scoping new workflows, schedules, and responsibilities. Data must be standardized and normalized between systems.

“The changes occurring during this time represent a famine-to-feast information evolution in the organization,” says John Nesi, vice president market development, Rockwell Automation. “You go from having no usable OT data in some instances to an overabundance. How will you evaluate what is now available and turn data into insight? How will you filter the important insights from the nice-to-know but not-actionable insights?”

A WDC plan prevents manufacturers and industrial operations from drowning in data while they starve for information. The plan helps companies establish systems that allow them to identify how to turn data into tangible triggers for change, and to evaluate how C-level strategic decisions benefit the bottom line. Even with the most basic of business strategies, few manufacturers can clearly see — as an entire organization — the return from their efforts. For example, just 14% of manufacturers describe their measurement systems for reviewing return from customer-focused innovation efforts as “regular monitoring and review of company-specific metrics by CEO and senior staff and transparency and clarity throughout the organization.” Many manufacturers have no systems to monitor returns from their strategic efforts (see Measure and Monitor Returns).

An effective OT/IT network incorporates data from OT devices across the enterprise to deliver performance-critical information (e.g., costs, downtime) that can be used for real-time decision-making, even as IT supports more locations via remote monitoring. Just as important, documentation also is being compiled in real-time necessary for customers, certification programs (e.g., ISO), and regulatory compliance programs.
Stage 4: Analytics

During Stage 4 the focus shifts from hardware, devices, software, and networks to continuous improvement. How best to leverage the newfound OT/IT capabilities? A changing culture within the company now recognizes the ability of the OT/IT network to surface problems and opportunities in real-time. At an operational level, analytics utilizing the WDC identified will help to pinpoint the greatest needs for real-time information (e.g., persistent problems by location, process, product, machine); authorized recipients of the information who have the ability to act on the information; and standardized protocols that the information will trigger (many proactive and automatic).

At the senior executive level, analytics inform asset management. “The OT/IT network has evolved into an ecosystem,” says Sujeet Chand, senior vice president and chief technical officer, Rockwell Automation. “It allows executives to optimize their global plant operations and achieve significant long-term savings via capital-avoidance. They can make better decisions on which plants produce which products, and when.” At Rockwell Automation, for example, approximately $3 million per year has been saved in capital avoidance alone due to improved capacity utilization and scheduling across its plant network.

During Stage 4, the challenge continues to be scope — and avoiding data overload. Some managers will want to capture and review all available data, even though there is little benefit in doing so. Others will fall victim to “data disbelief” — hesitant to accept data emerging from the plant floor because it contradicts long-held beliefs regarding how processes, lines, and equipment operate. Again, senior leadership will be responsible for culture change that persuades or removes these obstacles to change, furthering development of an organization focused on operational excellence.

Once cultural change begins to occur, built-in mechanisms will proactively respond to issues and problems as they arise, often based on lead metrics that minimize cost-draining losses. So rather than wait for lag measures that lead to an accumulation of wastes (inventory, resources, energy, etc.) and that typically spur short-lived firefighting improvements, WDC and analytics help the organization rapidly identify and prioritize continuous-improvement/kaizen projects before problems escalate. And through this progression of ongoing operational improvements — via lean, six sigma, and/or other improvement principles — productivity, efficiency, and quality improve in lockstep. Rockwell Automation achieved numerous operations improvements over multiple years of the company’s progression through the maturity model (see Rockwell Automation Operations Improvements).

### Rockwell Automation Operations Improvements

| Plant behavior          | • Inventory reduced from 120 days to 82 days.  
|                        | • Recorded $3 million per year capital-expenditure avoidance |
| Supply chain/lead times | • On-time supplier deliveries improved from mid-80% to 96%.  
|                        | • Lead times were reduced by 50%. |
| Customer service        | • Customer delivery performance (measured as on-time to customer request) increased from 82% to 98%.  
|                        | • Quality improved by reducing parts-per-million-rejects by 50%. |
| Productivity            | • Annual productivity improved from 4% to 5%. |
Stage 5: Collaboration

Stage 5 of the maturity model is creating an environment that anticipates activities throughout the enterprise and through the supply and demand chain.

Within the enterprise emerges predictive capabilities that make for more efficient production planning and asset management; timely and leveled order execution; improved quality; and streamlined plant-to-plant performances. Real-time information brings the ability to sense and manipulate plant processes on the fly.

The external objectives are to develop responsiveness to external events — supplier and customer activities, business trends, markets, political events, and even weather patterns — to minimize losses from negative events (e.g., foreign currency collapse and its impact on inventories in the country) and leverage new opportunities (e.g., effect of a heat wave on product demand). The OT/IT network begins to coordinate activities from furthest suppliers to end customers.

Although the opportunity to improve supplier and customer relationships is available to all manufacturers, only 21% have developed “partnership” relationships with customers, and only 13% describe their supplier relationships as “partnerships” (see Supply-Chain Relationships).

During Stage 5 improvement continues internally, but focuses on advanced performance targets with innovative methods to reach once-unrealistic goals. One major challenge during this stage is tempering the belief that the organization can now “do anything,” which can unnecessarily burden staff.

Limitations of OT/IT networks at suppliers and customers also can prevent optimum collaboration and performance. Supplier criteria can be established to “encourage” vendors to move forward with their own maturity models, but customers may remain resistant until they understand how collaboration can improve products and prices. For suppliers, customers, and business units capturing or contributing data to the OT/IT network, access should be scoped, both for network-security reasons and to protect proprietary processes.
The benefits from being able to react rapidly and accurately to emerging supply-chain and market conditions drive operational excellence and cost savings in countless ways:

- Improvement of supplier performances in delivery, quality, and costs, as well as improved vendor documentation for regulatory compliance.
- Integrated production with the enterprise via manufacturing execution systems that drive and track consistent workflows, materials consumption, inventories, etc.
- New partnering opportunities, such as collaboration tools in use across an extended OT/IT technology framework (e.g. remote access, instant messaging, video chat, file sharing, etc.) that unleash unprecedented innovation.
- Centrally located domain experts that can be leveraged across countries and companies, instantly sharing best practices and enlisting the knowledge base of an entire supply chain to address challenges.

For Rockwell Automation, collaboration with the supply chain, both component and parts suppliers and downstream OEMs, resulted in innovation breakthroughs and significantly improved operational forecasting and efficiency.

**Conclusion**

Every manufacturer will enter and progress through the stages of the Connected Enterprise Maturity Model that is most appropriate for it, at a pace determined by its own needs, infrastructure, readiness, and resources. At Rockwell Automation we have worked with organizations that are in relatively advanced positions (as identified by the assessment), already leveraging their WDC and collaborating with suppliers; we also have worked with companies at the beginning of their OT/IT intelligence journeys. There are significant opportunities — and profits — for both.

At Rockwell Automation, with operations in 80 countries and 22,000 employees, it took several years to make the full progression through the model and to utilize information from the intelligent OT/IT operation effectively. This progression required commitment from senior leadership, strategic investments, and collaboration with numerous stakeholders. Based on that experience and codification of the five stages, manufacturers with which Rockwell Automation now works experience accelerated advancement via the Connected Enterprise Maturity Model.

To discuss how a connected enterprise can benefit your operations, call a Rockwell Automation sales office or visit: [http://www.rockwellautomation.com/connectedenterprise](http://www.rockwellautomation.com/connectedenterprise).

Rockwell Automation, Inc. (NYSE:ROK), the world’s largest company dedicated to industrial automation and information, makes its customers more productive and the world more sustainable. Headquartered in Milwaukee, WI, Rockwell Automation employs about 22,000 people serving customers in more than 80 countries.