Connecting Physical and Digital Worlds to Power the Industrial IoT

By gathering IoT data at the network’s edge, analyzing it and integrating it with operational information in enterprise IT systems, manufacturers can better optimize production, address customization requirements, generate customer insights and more intelligently manage their businesses.
EXECUTIVE SUMMARY

Today’s manufacturers are on the cusp of a “Fourth Industrial Revolution” — so-called smart manufacturing, based on the Internet of Things (IoT) and an understanding of the rich data residing at the network’s edge. To realize the promise of the industrial IoT, companies must integrate operational technology with enterprise IT. They must collect and analyze data across the organization – from customer orders and production on the shop floor, to supply chain and delivery – to generate actionable insights and foresights.

By doing so, manufacturers can better manage production, address customization requirements and generate customer insights. In turn, they can more intelligently manage their businesses, improve response time, promote innovation, reduce costs and boost revenues. The industrial IoT is best understood as a “system of systems” made up of many different elements and dependent on end-to-end systems integration.

This white paper addresses how the industrial IoT (IIoT) is changing the competitive landscape for manufacturers, and suggests a strategic roadmap to guide leading organizations for their implementation journey to IIoT at scale.
FROM POWER TO POWERING SERVICE: A CHANGED MODEL FOR MANUFACTURING

Rolls-Royce has built engines since 1915. Now, the company sells “power by the hour,” on a model that offers maintenance services based on flying hours to airlines that use its engines. Its success now depends on connecting its expertise in complex power plants with digital information to manage operational performance — integrating hundreds of sensors on its engines to systems that monitor and optimize fuel usage, anticipate service needs and schedule service.

In an industry where fuel savings can add up to millions each year, Rolls-Royce provides airlines with information to help optimize routes, altitude and airspeed, weight and freight. Along the way, its engineers learn how its engines perform in a range of conditions, thus informing the design of its next generation of engines and enabling increasing customization based on market needs.

Rolls-Royce exemplifies the opportunities and benefits of the industrial IoT. And this iconic company is not alone. Shell Oil is pioneering simulation technology — so-called digital twins — to help oil and gas operators manage offshore assets, improve worker safety and predict maintenance. Also, from a digital innovation hub in Atlanta, Stanley Black & Decker is driving digital technologies throughout its businesses — from customer tools, hydraulics and fasteners to electronic security services to healthcare. The company is developing technology to improve patient and customer experiences, amplify safety and security, and optimize workflows.

The list is long and diverse, covering equipment manufacturing and pharmaceuticals development and delivery, medical device manufacturing and healthcare products. Today’s leading manufacturers are transforming the way products and services are developed and delivered, powered by the growing number of sensors that monitor performance.

According to the 2016 MPI Manufacturing IoT Study, which surveyed 350 manufacturing companies, almost two-thirds (63%) believe IoT will have measurable impact on their business in the next five years. The same percentage of respondents believe that applying IoT to their products will increase profitability over the next five years.
IDC predicts that by 2020, 50% of the Global 2000 will see the majority of their business depend on their ability to create digitally enhanced products, services and experiences. Innovation accelerators, including those for enabling IoT, will see rapid adoption in the next three to four years.⁷

**DRIVING THE NEW REVOLUTION: INDUSTRIAL IOT**

Until recently, operating technologies have predominated in manufacturing environments, while enterprise IT remained in its own domain. Now, those domains must merge.

Historically, enterprise IT focused on processing information to run the business; it relied on supporting technologies and networks for openness, speed and agility for users. In industry, operational technologies monitored devices, processes and events, and managed assets for safety and sustainability. And operational technology systems, which largely depend on foundational technologies and IT infrastructure, are highly fragmented.

Each domain generates massive amounts of data. Yet, each remains isolated from the others. To optimize performance, manufacturers must close this gap, integrating these previously separate domains of information to upgrade processes and make more valuable products.

This is the industrial IIoT, which connects people and the physical world of places and machines with the digital world of software, cloud platforms, automation, augmented reality, artificial intelligence and data. IIoT offers the opportunity to maintain a single view of analytical data, and thus operate with real-time agility and respond to adverse events within the plant or across the supply chain. This requires integrating and consolidating enterprise and operational applications, infrastructure and systems.

The ongoing rapid evolution of microprocessor technology and computing power allows such functional integration. Operations engineers can create increasingly complex control systems and implement increasing levels of automation on the factory floor. Growth in operational technologies built on manufacturing execution systems (MES) and open standards creates the foundation for integrated shop-floor systems. System-on-a-chip (SoC) and micro-electromechanical systems (MEMS) enable micron-scale integration of system functionality while reducing power use, footprint and cost.

At the same time, high-bandwidth networks, virtualized hardware and open IP standards have fundamentally changed the feasibility of building an IIoT platform by reducing the required resources and costs. Cloud systems provide increasingly reliable, secure networks
IDC predicts that by 2020, 50% of the Global 2000 will see the majority of their business depend on their ability to create digitally enhanced products, services and experiences. Innovation accelerators, including those for enabling IoT, will see rapid adoption in the next three to four years.
Beyond connecting devices to a network where they interact and exchange information, the IIoT’s real value lies in the data generated from relationships between devices and their environment, data analytics at the network’s edge, and insights into efficiency, yields and maintenance.
that deliver results faster, scale as needs dictate, and integrate new applications and services that analyze data and provide insights. Enterprises need pay only for the services they use, as they use them.

In the IIoT, devices become smart and connected. Data, understood in context and properly conditioned, is at the heart of every IIoT system. Beyond connecting devices to a network where they interact and exchange information, the IIoT’s real value lies in the data generated from relationships between devices and their environment, data analytics at the network's edge, and insights into efficiency, yields and maintenance.

According to research conducted by the Cognizant Center for the Future of Work, sensors and IoT will stand as the preeminent digital technologies by 2025, affecting the entire manufacturing sector (see Figure 1). New, integrated sensor data, combined with advances in connectivity, security, interoperability and analytics, will create immense potential.

**Technologies Driving Change in the Manufacturing Organization**

Between now and 2025, digital technologies focused on the Internet of Things – as well as big data/analytics, cybersecurity and collaboration – are projected to have a maximum impact on manufacturing companies.

<table>
<thead>
<tr>
<th>Technology Category</th>
<th>2015</th>
<th>2025 (projected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Data/Analytics</td>
<td>137%</td>
<td></td>
</tr>
<tr>
<td>Cybersecurity</td>
<td>137%</td>
<td></td>
</tr>
<tr>
<td>Artificial Intelligence</td>
<td>137%</td>
<td></td>
</tr>
<tr>
<td>Mobile Technology</td>
<td>147%</td>
<td></td>
</tr>
<tr>
<td>Internet of Things</td>
<td>242%</td>
<td></td>
</tr>
<tr>
<td>Process Automation Software</td>
<td>326%</td>
<td></td>
</tr>
<tr>
<td>Biotechnology</td>
<td>326%</td>
<td></td>
</tr>
<tr>
<td>Social Media</td>
<td>248%</td>
<td></td>
</tr>
<tr>
<td>Collaboration Technology</td>
<td>356%</td>
<td></td>
</tr>
<tr>
<td>Cloud (public)</td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>Wearable Technology</td>
<td>262%</td>
<td></td>
</tr>
<tr>
<td>Telepresence Devices</td>
<td>298%</td>
<td></td>
</tr>
<tr>
<td>Robots that manipulate physical things</td>
<td>357%</td>
<td></td>
</tr>
<tr>
<td>Telepresence Devices</td>
<td>298%</td>
<td></td>
</tr>
</tbody>
</table>

Source: 2016 Cognizant Center for the Future of Work’s Work Ahead Study

Figure 1
Unlike traditional software applications, the IIoT is rooted in physical space, integrating data from digital devices and systems in factories and supply chains with enterprise assets. It enables enhanced monitoring, data gathering and integration, role-based information presentation and situational awareness for operators.

The integration of IoT, components and cloud-based analytics results enables organizations to sense and contextualize real-time data from IT or operations technologies (OTs). This information can be normalized through an array of analytical methods, using machine learning and AI. It can be converted into actionable insights that help maximize efficiencies across all aspects of the business – design, production, sourcing, supply chain, delivery, product monitoring, etc. The objective is to convert operational data into insights that inform decision-making, drive innovation and realize efficiencies at scale (see Figure 2).

Creating the Digitally Connected Manufacturing Enterprise

**Information Transparency**
Real-time information availability.
Common model of the physical world.
Situation-aware system.
Historical information.

**Intelligent Devices**
Connected machines, smart sensors and connected systems.
Self diagnostic, auto-configurations.

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Figure 2
The IIoT offers a profound long-term opportunity: integrating information across the extended enterprise with the OTs that drive production, warehouse and transportation operations.

INTEGRATING DATA: FROM ENTERPRISE, OPERATIONS & CUSTOMERS

The IIoT is best understood as a *system of systems* comprising different elements and dependent on end-to-end systems integration. It offers a profound long-term opportunity: integrating information across the extended enterprise with the OTs that drive production, warehouse and transportation operations (see Figure 3). The IIoT creates synergy across the enterprise, integrating key attributes of intelligent devices: the capability to dynamically anticipate problems, auto-diagnose solutions and adjust relevant operations to maintain optimum productivity. This synergy ultimately provides informational agility for the enterprise, from order to cash.

Change Drivers for Today’s Industrial Manufacturers

<table>
<thead>
<tr>
<th>Industrial IoT</th>
<th>User Interface</th>
<th>Analytics</th>
<th>Robotics</th>
<th>Cyber Physical Systems</th>
<th>Mobility</th>
<th>Additive Manufacturing</th>
<th>Big Data</th>
<th>Augmented Reality &amp; Virtualization</th>
<th>Digital Twins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Chain, Vendors, CMO</td>
<td>ERP, CRM, Dashboards, KMS</td>
<td>MES, EAM, LIMS, OMS, MIS, Serialization, EHS, GIS, SOC</td>
<td>Social Feed</td>
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</tr>
<tr>
<td>PLM, Engineering Drawings, PFD’s, P&amp;ID’s</td>
<td>DCS, SCADA, PLC, Historian, Logs, Advanced Controllers, Simulators, EMS</td>
<td>Sensors, Vehicles, Machines, Actuators</td>
<td>Service Management, Maintenance Logs</td>
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<tr>
<td>Horizontal Integration</td>
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Such integration can address the needs of stakeholders inside the organization, across the vendor ecosystem and supply chain, and externally to customers – through sales and service to product monitoring and feedback for design. Manufacturers can gather information more effectively, then apply insights from instrumented and networked devices to identify ways to increase efficiency and contain costs. This extends to systems that monetize data to enhance revenues.⁹

The inherent advantages of the IIoT are inexpensive processing, nearly infinite storage capacity and analytics technologies that automate traditional processes. Multiple applications and processes work together seamlessly, creating a digital replica of physical assets, processes and systems. Using such a digital twin, companies can remotely monitor performance, make changes in real time to improve efficiency, predict and meet service needs, upload updates, and increase precision and quality in engineering and production. Organizations will benefit from better yields, more productive assets, improved safety and lower costs.

This is the true opportunity of the industrial IoT. Industrial leaders understand they must dynamically evolve their business models and leverage emerging technologies to stay in the vanguard – integrating their enterprise, engineering and manufacturing processes to better manage every aspect of the supply chain right to the customer’s doorstep.

**TRANSFORMING THE MANUFACTURING ENTERPRISE: GETTING STARTED**

Many leaders recognize the need to transform their business with the IIoT. However, they struggle with the complex, siloed landscape of their manufacturing processes, IT and OT. As a result, some have adopted a technology-first approach for IIoT transformation.

Given the systems complexity experienced by many manufacturers, implementing the IIoT should be directed from the enterprise level. This is because when there is no centralized owner, multiple experiments or initiatives are undertaken in discrete business units, or in engineering and/or manufacturing operations. Such initiatives are rarely aligned, resulting in only incremental success or lackluster outcomes, thus limiting benefits and impeding continued investment.
Business leaders need to conduct a self-assessment, along with a review of organizational readiness, by answering the following questions:

- Where can our organization benefit most from a deeper understanding of operations and efficiency? What insights do we need?
- How can we assess our readiness for an IIoT transformation?
- How should we benchmark to our peers?
- What data should we concentrate on? How should we process it?
- What will be the cost for computational and storage capabilities for internal, cloud and hybrid alternatives?
- What is preventing us from a transformation? Legacy systems? Cost pressures?
- Besides cost, what internal barriers do we need to overcome? How do we manage change?
- Has our organization carried out a threat assessment to clearly understand cybersecurity requirements?

Leadership should compare approaches, examine the readiness of its technical architecture, understand the organization’s capacity to change and adapt on various technical maturity models and review available case studies. Engaging partners with the required domain expertise as well as hands-on experience with integrating IoT technologies can streamline planning and implementation.

Decision-makers should first identify opportunities to realize business value in their existing operations where they have identified the inefficiencies that impede their ability to respond to market opportunities. Two key questions at this point are: “What changes do we need in our business processes, operations, people and business models to respond to rapid market changes, new developments and emerging technologies?” and “What kind of talent do we need?”

BUILDING THE ROADMAP: ASKING THE RIGHT QUESTIONS

To drive transformation, leaders will want to build a multidisciplinary team. Our experience with digital initiatives suggests that organizations should conduct workshops to generate buy-in across stakeholder groups; identify a team across business, IT and manufacturing operations; and create a roadmap that reimagines their business processes. This helps ensure that the right technology foundation is in place to convert insights into action, and provides the governance, change management and design of a unified smart manufacturing operation.
Successful journeys take manageable steps such as designing and installing advanced sensor technology; implementing faster and more efficient interconnectivity between the enterprise, business units and production facilities; developing analytics; and piloting use cases that not only demonstrate the promise of the industrial IoT but also realize its value at scale. In proceeding this way, manufacturers develop and grow the talent, skills and tool-sets necessary to build a connected ecosystem that seamlessly integrates digital, operational and information technology.

Industrial companies can learn from one another about forming a unified view of integrating people, processes, assets and technology by using these leading practices for implementing smart manufacturing powered by the IIoT:

• **Define the business problem**, developing viable use cases to guide the approach and defining desired outcomes which could include cost reduction; process, product or efficiency improvement; new business models; monetization strategies; and/or service models aligned to strategy.

• **Define the organization's goals.** Stakeholders in OT, IT and other affected business disciplines should collaboratively assess the requirements and the economics of the organization and define benchmarks to measure results.

• **Choose the right partners**, including technology providers and business and systems integrators with the right set of industry domain and digital capabilities.

• **Build a multidisciplinary team structure around business, IT and manufacturing operations experts** who can align stakeholder requirements, ensure internal buy-in, make decisions, and provide governance and change management.

• **Cultivate talent.** The IIoT requires new technologies, processes and business models. Organizations must leverage talent to advise, instrument, integrate, engineer, analyze and manage programs. Resources should include strategists, digital technologists, data scientists, user experience designers, technical architects, security experts, and hardware and software developers and engineers. These resources can be sourced internally or from a partner.

• **Design the right end-to-end architecture**, from digital technologies including sensors and hardware to the cloud and analytics, while making sure to address operational technology and cybersecurity needs.

• **Conduct pilot projects to accelerate innovation.** To validate the case for change, organizations can pilot programs with short timeframes that, if successful, can be implemented at scale. Manufacturers garner increased support when they pilot a use case and convert data to insight in discrete projects and operational areas, providing hands-on experience to prospective end-users with new processes and IoT technology.
Successful journeys take manageable steps such as designing and installing advanced sensor technology; implementing faster and more efficient interconnectivity between the enterprise, business units and production facilities; developing analytics; and piloting use cases that not only demonstrate the promise of the industrial IoT but also realize its value at scale.
A maturity framework to assess the state of a manufacturer’s processes will help decision-makers develop an organized and systematic approach and quantify value. This smart manufacturing strategy addresses the opportunities and challenges that need to be solved near-, mid- and long-term.

Creating Value Across the Enterprise

- **Enhanced Efficiency**
  - Data-stacked decision making

- **Improved Energy Efficiency**
  - Energy consumption optimization

- **Better Quality**
  - Reduced product and process defects

- **New Product & Processes**
  - Quick and improved development process

- **Decreased Downtime**
  - Optimized maintenance
  - Predictive maintenance

- **Increased Safety**
  - Workforce monitoring & compliance
  - Sustainable & safe operations

- **Connected Supply Chain**
  - Real-time visibility of material movement in and outbound

- **Real Time Operational Changes**
  - Cater to last-minute changes & requirements

- **Quicker & Better Reporting**
  - Improved data collection & management

- **Inventory Visibility**
  - Cross-channel visibility to both upstream and downstream partners

- **Product/Process Improvement**
  - Aggregate product data, customer sentiment and other third-party data

- **Improved Transparency**
  - With better & real-time monitoring & visualization

Figure 4
REALIZING THE BENEFITS: SMART FROM START TO FINISH

Manufacturers that migrate to IIoT-enabled processes and systems enterprise-wide realize a range of benefits:

- Improved efficiencies.
- Reduced operational disruption.
- Lower annual operating costs.
- Improved operator and asset productivity through self-monitoring and predictive maintenance.
- HR gains such as improved skillsets, better employment opportunities, greater employee satisfaction and higher retention of employees working in a new technology paradigm.
- Improved ability to address fluctuating customer demands, identify and exploit market opportunities, and develop new products and services – based on expanded information networks.
- Higher margins through customization and demand-driven product strategies.
- Greater monetization through understanding customer and stakeholder needs from cost-containment and revenue-generation initiatives.
QUICK TAKE

Top Floor to Shop Floor: The IIoT in Action

The IIoT is beginning to take shape across the industrial landscape. Here are some examples of IIoT engagements we are working on with clients:

• A leading manufacturer of packaging equipment now remotely monitors thousands of its machines at customer locations, which has prevented service bottlenecks and increased its service parts revenue by 12%. With a new business model – leasing and equipment sharing options – the company now delivers a more personalized service to customers.

• Relying on a comprehensive implementation of sensors, a farm equipment manufacturer now can visualize all aspects of its production assembly line, predict start-to-finish time of orders and address problems in real time, thereby accelerating production of new products by nearly 50% per machine.
• A global retail conglomerate retrofitted and IoT-enabled its refrigeration assets to remotely monitor equipment usage, predict component failure and reduce service call times. This resulted in a 10% reduction in product waste, and cut response times from five hours to 20 minutes.

• A construction equipment manufacturer has improved its ability to scale telemetry data in the field from 15 GB to 6,000 TB per day using an enterprise IoT platform. This has greatly improved visibility into the performance of its two million connected assets and enhanced performance and productivity.

• An aftermarket transportation services provider has been using assets, devices and APIs to apply real-time analytics to improve driver experience and fuel economy, reduce fleet liabilities and lower operational expenses by an estimated 10%.
Organizations that align IT and OT to create a system of systems, instrumenting every device in the extended manufacturing ecosystem, will be best positioned to harvest meaningful data at every touchpoint.

VALUE THROUGH IIOT AWARENESS & AGILITY

IIoT adoption will continue to grow, for the analytical capabilities of affordable processing and storage capacities in new software solutions are just beginning to be tapped. Even in today’s increasingly connected environment, many industrial organizations still rely on a minimal set of vendor-supplied analytics, often related to machine-specific solutions. However, manufacturing leaders that embrace IIoT will be better positioned to remove structural barriers that undermine technological progress.

Leading companies are embarking on digital integration to reinvent products faster, get the most out of new assets and ideas, and monetize insights from data insights. Manufacturers that have undertaken this journey are continually disrupting themselves: They are looking to understand the data they generate, to develop insights and to leverage real-time information to drive efficiencies from the top floor to the shop floor.

Organizations that align IT and OT to create a system of systems, instrumenting every device in the extended manufacturing ecosystem, will be best positioned to harvest meaningful data at every touchpoint. Manufacturers can operate processes, data, applications, assets and devices seamlessly. This will provide the business better accuracy, increased control, cost savings, and new business models and revenue opportunities. Only then will they have fully embraced the IIoT, running agile operations fueled by data and realizing the corresponding boost to performance that validates a complete business makeover.
FOOTNOTES


ABOUT THE AUTHOR

Phani Bhushan Sistu leads Strategy and Consulting Services within Cognizant’s Intelligent Products and Solutions business unit, helping companies transform their businesses in the digital era by optimizing processes and operations with IoT, Industry 4.0 and IoT analytics solutions. In his 28-year career, Dr. Sistu has worked extensively with automotive, pharmaceuticals and process manufacturers, and has published in international journals. A chemical engineer, he earned his Ph.D. at the Rensselaer Polytechnic Institute in Troy, NY. Dr. Sistu can be reached at Phanibhushan.Sistu@cognizant.com | LinkedIn: www.linkedin.com/in/phanibhushan-sistu-4103a93/.
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