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BUILDING THE DIGITAL FACTORY VALUE CHAIN:

How to Maximize the Value of IIoT and IoT Strategy

Mike Harmon and Jim Routzong

ISG WHITE PAPER

Over the past half-decade, companies in manufacturing-related industries have begun to tap the potential of the digital factory value chain – and, in so doing, have begun to reinvent and transform their operations and the larger value chain. By championing digital connectivity, these enterprises have created digital transformation initiatives that allow them to measure and optimize their processes via quantitative means rather than just qualitative means.

Today's manufacturers need a pragmatic top-down and bottoms-up approach to improve value delivery and realize the full potential of digital factory value chain business cases.

The digital factory value chain has shown to generate tremendous gains in efficiency and output along with improved health and safety on the manufacturing floor. Many manufacturers and enterprises in other industries that rely on operational connectivity have invested heavily in digital factory initiatives over the past five years. This trend is clearly visible in the introduction of Industrie 4.0 in Europe. In fact, digital factory initiatives across industries are projected to contribute significantly to the global GDP over the next two decades.

However, recent research shows some slowing in investment related to digital factory value chain and industrial internet of things (IIoT) project initiatives in the manufacturing and connected industry segments when compared to other segments. Why? ISG finds that many manufacturers struggle to get started with digital factory value chain initiatives. Others find it difficult to maximize business case projections or scale their use cases across the enterprise. Investing in the capabilities needed to optimize the digital factory value chain is expensive, and manufacturers must work to overcome the challenges and maximize their return on investment.

Today's manufacturers need a pragmatic top-down and bottoms-up approach to improve value delivery and realize the full potential of digital factory value chain business cases. Such an approach includes three distinct phases:

1. Define the digital factory value chain vision and strategy from the top down
2. Identify and justify digital factory value chain opportunities
3. Implement transformational digital factory value chain initiatives and measure performance from the bottom up, working the details from the individual use cases and business case justifications specific to each use case.

The Growth of IIoT/IoT Opportunities

Digital transformation initiatives that allow manufacturers and other enterprises to measure and optimize their processes via quantitative means rather than just qualitative means depend heavily on the internet of things (IoT) and the IIoT.

The IoT is a "system of systems" in which people, machines, devices, sensors and businesses are connected and interactive. This creates new modes of collaboration, intelligence and business value. The IIoT is the application of IoT capabilities in industrial, manufacturing and agricultural environments.

Combining connectivity, sensing capabilities and advanced analytics enables manufacturers to evolve their legacy plant floor control systems and integrate enterprise-wide systems to increase value across their manufacturing operations. These capabilities allow enterprises to do two revolutionary things:

1. **Significantly improve and optimize the way they manufacture and distribute products.** Digital connectivity drives the order-to-delivery value chain to optimize its cost of goods sold. By connecting and integrating manufacturing and engineering systems to IT systems and deploying the analytics and governance to optimize production and distribution, a manufacturer can automate feedback loops that were previously manual. This automation serves not only to speed up the predictive and prescriptive use of data but also to eliminate opportunities for human error that have often plagued these processes.

2. **Significantly improve the products' performance and service for the end user.** If a manufacturer builds mining trucks, for example, it can build sensors into the trucks to predict system failures and schedule maintenance. In this way, IoT becomes a core component of the product and a key differentiator for survival of any product manufacturer. IoT extends the value of products by listening to what they have to say over the lifecycle of their use in the field.

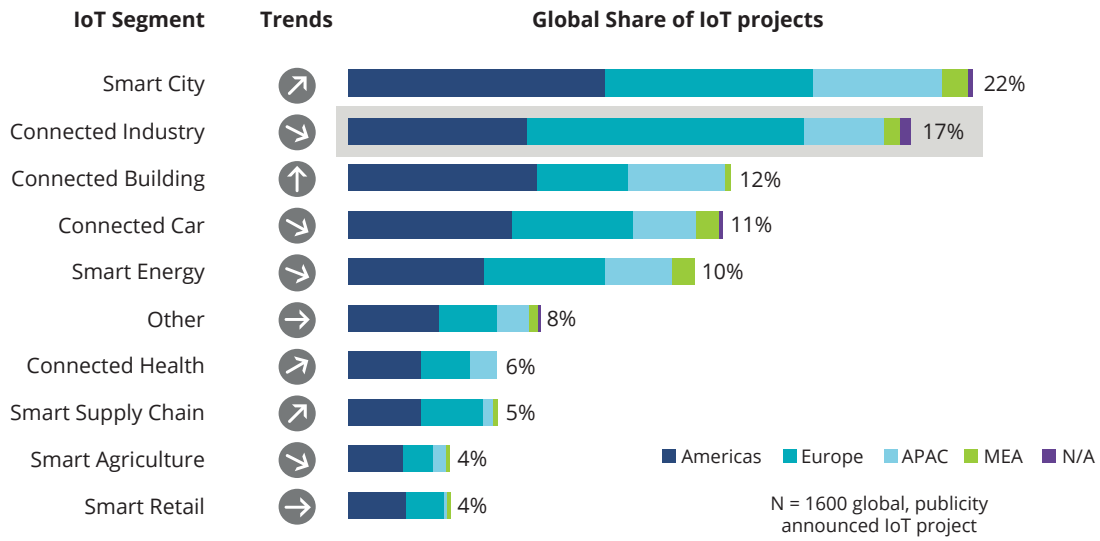
Many manufacturers have attempted to implement digital factory value chain capabilities with disparate and limited use cases that are sub-optimal and without a top-down digital factory value chain vision – an approach that threatens the success of their investments.

Though many call the IoT and IIoT transformation the "fourth Industrial Revolution" – and the adoption of digital technologies in creating smart cities and connected buildings is strong – IoT/IIoT growth trends are beginning to slow in the manufacturing and industrial segments. Because the IIoT is a network of intelligent computers, devices and objects that collect and share a huge volume of data, configuring interoperability and integration between devices and machines with different architectures and protocols can be challenging. Some manufacturers have struggled to achieve the return on investment and long-term value they expected. Many manufacturers have attempted to implement digital factory value chain capabilities with disparate and limited use cases that are sub-optimal and without a top-down digital factory value chain vision – an approach that threatens the success of their investments.

Figure 1 below uses data from IoT-Analytics.com to depict the global share of IoT/IIoT projects by segment. The segment defined as connected industry is made up of manufacturing industries that are embracing IIoT both inside and outside the digital factory. Equipment and asset monitoring are the most common IoT initiatives in this segment, allowing manufacturers to monitor and remotely control machinery, such as forklifts, cranes, valves, motors and other plant assets. Condition monitoring, which is made possible by IIoT initiatives such as these, allows enterprises to leverage predictive maintenance to improve overall operations.

The majority of enterprises today are still operating at the lowest level of IIoT/IoT maturity despite strong growth objectives for their digital factory value chain and IIoT initiatives.

Figure 1: Global Share of Enterprise IoT Projects and Connected Industry IIoT



For the past few years, the connected industry segment has been the fastest growing IoT segment. In 2016, IoT projects in this segment accounted for 22 percent of all global IoT projects. As of 2018, connected industry IoT projects account for just 17 percent of global IoT projects. Although these initiatives continue to grow, they are not growing as fast as other leading segments. This trend is believed to be driven by a variety of causes, including the mixed results when comparing actual value to projected value and the very real struggles companies face when rolling out digital factory value chain initiatives.

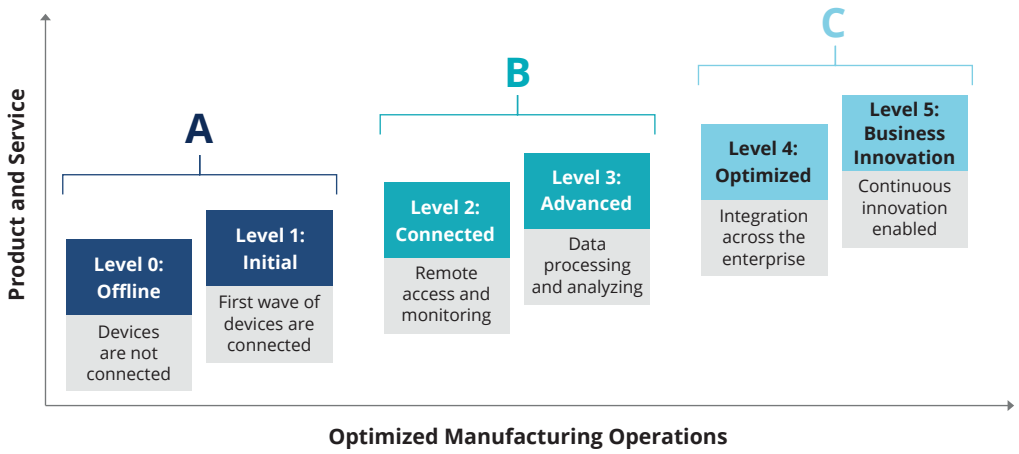
What Enterprises Are Saying about the Digital Factory Value Chain and Associated Challenges

Although data show some recent slowing, studies still project rapid growth in IIoT/IoT adoption across the manufacturing industry over the coming years. Some experts say up to two-thirds of manufacturers will be fully connected across operations by 2022. But getting there will not be without its challenges. The majority of enterprises today are still operating at the lowest level of IIoT/IoT maturity despite strong growth objectives for their digital factory value chain and IIoT initiatives.

Enterprises that pilot initiatives with smaller-scope use cases and suboptimal analysis can dampen the acceleration of their digital factory value chain vision and strategy.

Figure 2 below depicts six levels of enterprise readiness and maturity. Today, the vast majority of the manufacturing market falls in the first three levels, Levels 0-2. The market is seeing growth in Level 3, where IIoT/IoT connectivity, real-time analysis and value delivery are beginning to achieve projected returns.

Figure 2: IIoT/IoT Readiness and Maturity Check



Readiness and maturity for IoT and IIoT can be determined by the kinds of questions enterprises are asking. The levels and associated questions follow:

A. Level 0 "Offline" – Level 1 "Initial"

Enterprises that are in Level 0 have not yet established connectivity for devices or machines, they have traditional processes and high service costs. Enterprises in Level 1 have tethered heterogeneous devices, limited monitoring, limited data transmission and a high error rate. Enterprises with low maturity tend to ask the following questions:

1. How do we get started with digital factory value chain and IIoT/IoT initiatives?
2. How do we move from developing a digital strategy to implementing digital factory value chain initiatives?
3. Should we use proofs of concept or pilot initiatives, and how?
4. How do we transform our brown-field factories into digital factories?
5. How do we incorporate digital factory value chain initiatives into our new green-field initiatives?
6. How do we develop a digital factory value chain foundational architecture for both technical and business?
7. How do we understand and maintain our knowledge of IIoT/IoT products, solutions, vendors and service provider capabilities?
8. Traditional sourcing approaches don't appear to work well for IIoT/IoT initiatives due to market dynamics. What fast-track sourcing approaches can we leverage?

The more processes and systems that can be monitored, analyzed and integrated with others, the greater the value of optimizing them.

B. Level 2 "Connected" – Level 3 "Advanced"

Enterprises that fall in Level 2 have created some remote access, online connection, monitoring, transmission of sensor data and errors and monitoring-as-a-service. Enterprises in Level 3 have completely connected devices, time series transmission, mathematical predictive methods in place and KPI analysis such as overall equipment effectiveness (OEE) reporting. Enterprises in these levels ask the following questions:

1. How do we realize projected value and gains represented in the business cases?
2. How do we improve the actual results of IIoT projects as compared to the projected results?
3. How do we apply security from a traditional air-lock plant environment to the open ecosystems across our suppliers, partners and clients?
4. How should we apply IIoT/IoT to our aftermarket services across the value chain?
5. How do we know what solutions and service providers to engage over time?
6. How do we build high-quality analytics into our digital factory value chain operations?
7. What does our target operating model need to include and how do we implement it?
8. How do we transform our culture for digital factory value chain?

C. Level 4 "Optimized" – Level 5 "Business Innovation"

Companies that fall in level four have optimized the integration of processes including interaction with enterprise systems (e.g. SCM, CRM) and optimized processes (e.g. inventory level). Enterprises that fall in Level 5 have completely integrated the business, follow a pay-per-usage (e.g. provisioning of compressed air by fixed price with SLAs) and a pay-per-performance model (improper usage of a machine is identified leading to expensive charges). Organizations in these levels ask the following questions:

Implementing a digital factory value chain requires taking into account both information technology (IT) and operational technology (OT).

1. How do we integrate processes (e.g. operations and business processes) with technology to significantly improve value delivery?
2. How do we integrate new and evolving digital technologies with the integrated processes?
3. How do we integrate enterprise IT systems with manufacturing and plant floor operational technology?
4. How do we evolve security to cover the advanced integration of IT systems with operational technology?
5. How do we optimize and continuously improve processes?
6. How do we evolve by completely integrating with business operations?
7. What advanced units of measure and pricing metrics can we evolve and apply?
8. What SLAs makes sense at the advanced levels?
9. How do we define, negotiate and implement pay-for-performance models?

These questions reflect the challenges and struggles enterprises are facing in their quest for achieving projected value and ROI – and, when they remain unanswered, have contributed to the slowdown of the connected industry segment. Enterprises that pilot initiatives with smaller-scope use cases and suboptimal analysis can dampen the acceleration of their digital factory value chain vision and strategy.

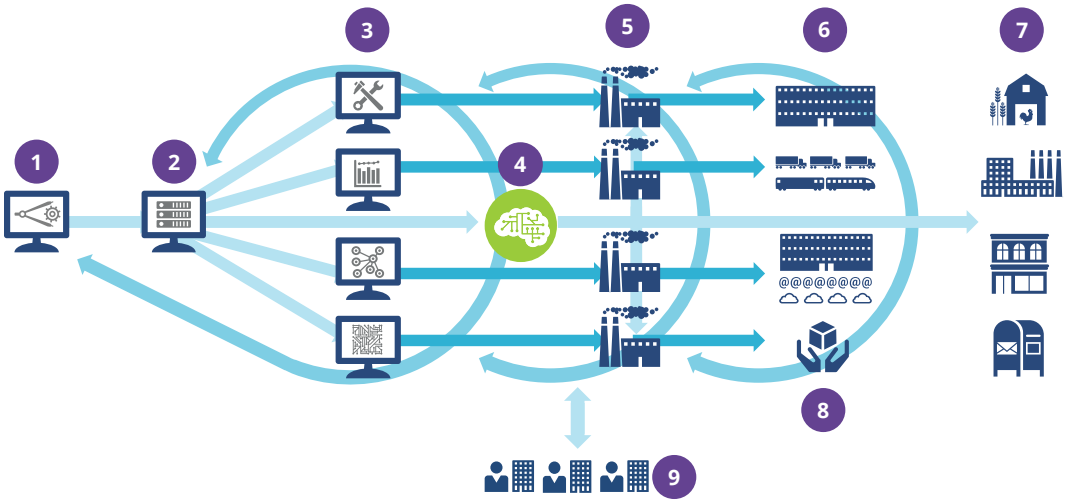
Building a Foundation for Digital Factory Value Chain and IIoT/IoT

Enterprises that are in the initial steps of a digital factory value chain transformation must develop a vision and strategy that will evolve over time as they justify and implement new initiatives. A vision and strategy should include the enterprise's portfolio of manufacturing operations, supply chain, distribution and aftermarket services. The intent is to develop a top-down vision and strategy that can be measured through bottom-up analysis and constantly balance between the two to continuously validate the integrity of the overall value.

In the digital age, companies must identify all that is possible, but they also must determine how all that is possible will facilitate operational excellence and growth.

Figure 3 below illustrates an optimal IIoT initiative in action across the value chain. Thinking of it this way helps enterprises jumpstart their vision and strategy development, so they can then tailor it to their existing operations, including manufacturing, supply chain and distribution channels.

Figure 3: The Digital Factory Value Chain



Key

1. R&D
2. Data Systems
3. Operational Systems
4. Big Data Analytics
5. Factories
6. Distribution
7. Customers
8. After-market Services
9. Suppliers

As products move through the order-to-delivery process from R&D on the far left to end customers on the far right, there are a significant number of use case opportunities for IIoT. By digitally interconnecting these use cases, an enterprise can discover and enable its full potential.

In traditional product engineering and manufacturing, it is common to view the numbered sections above – IT, manufacturing operations, assembly, logistics and distribution – as silos that operate separately across the enterprise. A critical success factor for a digital factory value chain is the integration of the complex components of the internal manufacturing process, suppliers, distribution and aftermarket services. As depicted by the blue arrows in the graphic above, connectivity and continuous feedback loops tie together upstream to downstream operations and processes, suppliers to and from the manufacturer's plant operations, and manufacturers to and from their customers. This way an enterprise builds in the capability for continuous monitoring and enhanced data generation and analysis. Therefore, it can look at how it might optimize individual manufacturing processes in a plant and at how to combine and optimize a series of processes from end to end across the value chain. Ultimately, the more processes and systems that can be monitored, analyzed and integrated with others, the greater the value of optimizing them.

When a manufacturer using IIoT creates a digital product idea in R&D, for example, it can be virtualized and simulated as a "digital twin" from the IT environment to manufacturing operations, final assembly configurations and distribution to end customers. This means functions of R&D for virtual product development, such as virtual validation and analytics, can be coupled with other digital elements downstream in the value chain to accelerate transformation. The promise of the IIoT in warehousing, distribution and logistics includes smart packaging, higher fleet efficiency, real-time visibility into warehouse operations and blockchain technology that enables traceability and smart contracts. Combine these with augmented reality, advanced automation, predictive maintenance and e-commerce platforms that improve the customer experience, and the value multiplies exponentially.

The Digital Factory Value Chain Operating Model is an Integrated Model

As graphic 3 illustrates, the value across the digital factory value chain potential is bigger than the sum of its parts. At the highest level of an enterprise's operating model, there is the corporate structure and at the lowest level, a warehouse or system in a factory. Making the most of individual opportunities to optimize is not merely streamlining varied digital initiatives inside the enterprise. It is the opportunity to create prescriptive insights that will continue to elevate the performance of those functions and systems over time.

Let's take, for example, a Tier I supplier that has connected various systems in its manufacturing environment to reveal insights about its entire operation. Having completed its digital value chain from levels 0-5 as defined in Figure 2: IIoT/IoT Readiness and Maturity Check, this organization can now monetize the data it generates in number four in Figure 3: The Digital Factory Value Chain, by becoming part of the connected supply chain of the OEM to which it sells parts. It has not only optimized operations, but it also has differentiated itself from its competitors and grown its revenue.

The target operating model for digital factory value chain should drive individual operational projects inside the plant and connect them to the overall enterprise ecosystem. This stands in contrast to what has existed for a long time in manufacturing, in which far too many disparate operations and systems run concurrently with little integration. Implementing a digital factory value chain requires taking into account both information technology (IT) and operational technology (OT). Converging IT and OT has a number of implications, challenges and opportunities. These initiatives often create horizontal opportunities across the entire value chain and, in so doing, transcend the digital factory ecosystem to increase value for the enterprise as a whole. These initiatives include:

Digital Factory: The opportunity to integrate technology, data, processes, people and organizations across the five layers of automation integration as defined by ISA 95: 1) business planning and logistics; 2) manufacturing operations management; 3) monitoring, supervisory control and automated control of the production processes; 4) sensing the production process, manipulating the production process; and 5) the plant floor and actual production process.

IIoT: IIoT is a subset of IoT and focuses on industrial applications in manufacturing, agriculture, oil and gas, mining, transportation and healthcare. If implemented correctly, it can increase efficiency and improve health and safety. IoT includes all of IIoT, including the consumer side of things like smart wearables and mobile devices. IoT also provides the same value of IIoT along with additional value by creating better end-user experiences, collaboration, intelligence and business value.

Accelerators: The factors that accelerate and improve the probability of delivering the projected value of digital factory value chain initiatives and use cases in a timely manner. Examples of such accelerators may consist of any of the following:

a. Proof of concepts (POCs) or pilots

b. Open framework architectures for machines and manufacturing systems

c. Commercial and open platforms for manufacturing systems

d. Specific and unique or innovative applications across manufacturing operations targeted at challenging use cases

IT/OT: The ongoing convergence of IT for data-centric computing and processing and OT for monitoring manufacturing events, processes and devices and making adjustments in enterprise and industrial operations within manufacturing operations.

Product Development: The design and development across the lifecycle of both digital and physical products or products that are a combination of digital and physical components.

Analytics Intelligence: The use of data to provide business intelligence and decision support and improve intelligent automation and process monitoring to help manage and optimize manufacturing operations and energy and increase health and safety.

Digital Twin: A virtual design approach in product development that helps maintain digital product data across the entire process and proactively address design issues.

Additive Manufacturing: A way to eliminate changes in production schedule and discontinuities in supporting demand with the use of 3D printing during production.

Applying and integrating these initiatives into a comprehensive IT-OT end solution will improve the value and ROI of the digital factory value chain.

Critical Steps to Jumpstarting and Accelerating Your Digital Factory Value Chain

Combining a top-down and bottom-up approach is critical to developing the big-picture vision, strategy and objectives. From the beginning, identify, define and justify the digital factory value chain use cases that align with the overall strategy and objectives. This is accomplished by creating a transformation roadmap that is flexible enough to change as the digital factory value chain vision and strategy evolve over time. The key steps to developing the transformation roadmap are as follows:

1. Define digital factory value chain vision and strategy
    - Develop digital factory value chain strategy
    - Design your digital factory value chain foundational vision
    - Develop your framework architecture for business and technology
    - Research the IIoT product and service provider market and capabilities
    - Develop and implement an IIoT sourcing framework

2. Identify and justify digital factory value chain opportunities
    - Identify and define IIoT use cases
    - Build a business case model to justify IIoT use cases
    - Build financial models to ensure return on investment
    - Develop IIoT deployment roadmap
3. Implement digital factory value chain transformational initiatives
    - Develop or evolve the cybersecurity strategy for IIoT
    - Develop digital factory value chain target operating model
    - Develop plan to transform to target operating model and manage organizational and cultural change
    - Develop the transformation team
    - Execute digital factory value chain transformational initiatives
    - Continue to identify digital factory value chain opportunities and justify alignment with evolving digital factory value chain strategy and vision
    - Continue to update transformation roadmap and plans with evolving digital factory value chain justified use cases and changing technology

Conclusion

In the digital age, companies must identify all that is possible, but they also must determine how all that is possible will facilitate operational excellence and growth. The IIoT holds great promise for enterprises in manufacturing, retail and other industries, but the keys to the digital world are found in how we enable federated business functions to act in concert across the connected digital value chain. To take full advantage of this, companies must create a vision and strategy that can evolve as use cases and technologies evolve and as industry delivery models and market demands change. A key component will be leveraging product and service providers to design, build, support and sustain an integrated IIoT ecosystem. It is only through these pragmatic steps and careful considerations that enterprises can achieve the full potential of the digital factory value chain.

ABOUT THE AUTHORS

BUILDING THE DIGITAL FACTORY VALUE CHAIN: How to Maximize the Value of IIoT and IoT

MIKE HARMON

Mike leads ISG's engineering service practice in the Americas and has over twenty years of leadership experience. He offers ISG clients considerable expertise in engineering services, IoT and manufacturing and has a diverse background working in virtually all discrete and process manufacturing segments with a wide range of clients from leading technology companies to heavy equipment manufacturers, railways, aerospace and industrial products. He has crafted solutions and managed the relationship and overall delivery of consulting and outsourcing services for each of his clients.

JIM ROUTZONG

Jim Routzong is an expert in engineering services sourcing, application development and maintenance (ADM) outsourcing, IT infrastructure outsourcing (ITO), restructuring/ renegotiations, and business process outsourcing (BPO). Jim led the engineering services global market analysis and business case development that justified ISG's market entry with the Engineering Solutions Service Line. Jim was instrumental with the start-up and establishment of its Engineering Solutions Service Line with the design and establishment of multiple solutions and services including successful client service delivery, IP development, engineering services conferences, and white papers. Jim is ISG's Engineering Solutions Service Line Knowledge Manager. He has led or participated in numerous ISG engagements over the past decade and a half across many diversified clients and global industries from vehicle to high-tech and heavy equipment manufacturing, aerospace and defense, retail, energy, financial services and insurance, biotechnology, and media and entertainment. Jim is ITIL Foundation v3 certified.

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