

*Manufacturing 4.0:
A Playbook for Navigating the Journey to IT Modernization & Transformation*

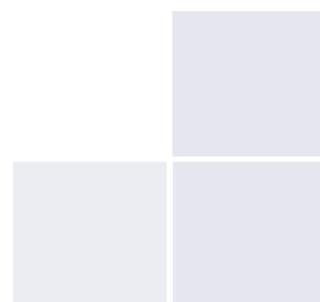
F R O S T  S U L L I V A N

A Frost & Sullivan White Paper

Digital Industrial Group

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“The manufacturing transformation will be more and more influenced by the IT technologies and by the advances in IT on the positive side as well as on the negative side. On the positive side, because we have these wonderful possibilities of really exchanging data and collecting data; on the negative side, these systems are still quite open to nearly anyone wanting to intrude. Therefore, we also have to do a lot of work in keeping up the security of these systems on a very high level, especially if you talk about process or discrete manufacturing. You have to prepare and train your people so that they know how to integrate all these new elements into the engineering process. Security must be an integrated part of the engineering process, otherwise it will not work.” Industry 4.0 Pioneer, Chairman, SmartFactoryKL Technology Initiative, Germany

INTRODUCTION

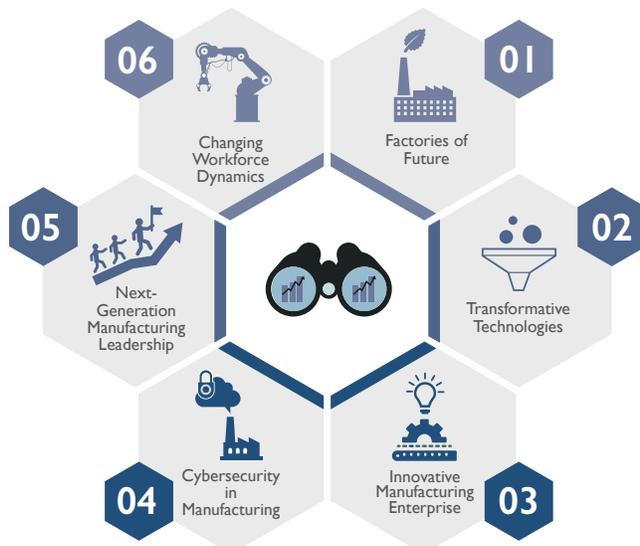
The manufacturing industry has entered an era of radical transformation where the promise of new levels of agility, flexibility, and actionable knowledge through the convergence of operational technologies and new digital technologies appears to raise the expectations—and doubts—of manufacturing executives around the globe. Mentioning Manufacturing or Industry 4.0 can lead to polarizing conversations as it is a mystery to some and the latest marketing buzzword to others. Still most will admit that the application of technologies that predict equipment failures, enable remote monitoring, control and maintenance, provide real-time yield optimization and a host of other benefits is compelling and can have a very positive impact on the business.

Manufacturing 4.0 is the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of Things and cloud computing to create “smart factories” and is often referred to as Industry 4.0.

This paper is designed to help manufacturing organizations understand the most critical issues in manufacturing transformation today. It includes an analysis of new value propositions that can help manufacturers attain and sustain competitive advantage. The following tools and insights are outlined to help manufacturers continue progress in their transformational journey:

- A benchmark tool: Self-assess your relative position in the industry
- An explanation of the strategic importance of IT modernization
- A selection of vital best practices to minimize risks in transformation
- A roadmap to help identify critical attributes of solution suppliers to help you achieve a smarter, faster, simpler and networked ecosystem

CRITICAL ISSUES IN TODAY’S MANUFACTURING ECOSYSTEMS



Frost & Sullivan’s Manufacturing Leadership Council, the member-driven global business network for senior industrial executives, has identified a set of six critical issues facing the manufacturing industry in its journey to transformation. Understanding these critical issues can help manufacturers align internal practices and processes as they start their journey to Manufacturing 4.0. Manufacturing executives will need this roadmap to transform their operations and business in the digital era.

Critical Issue #1: Factories of the Future

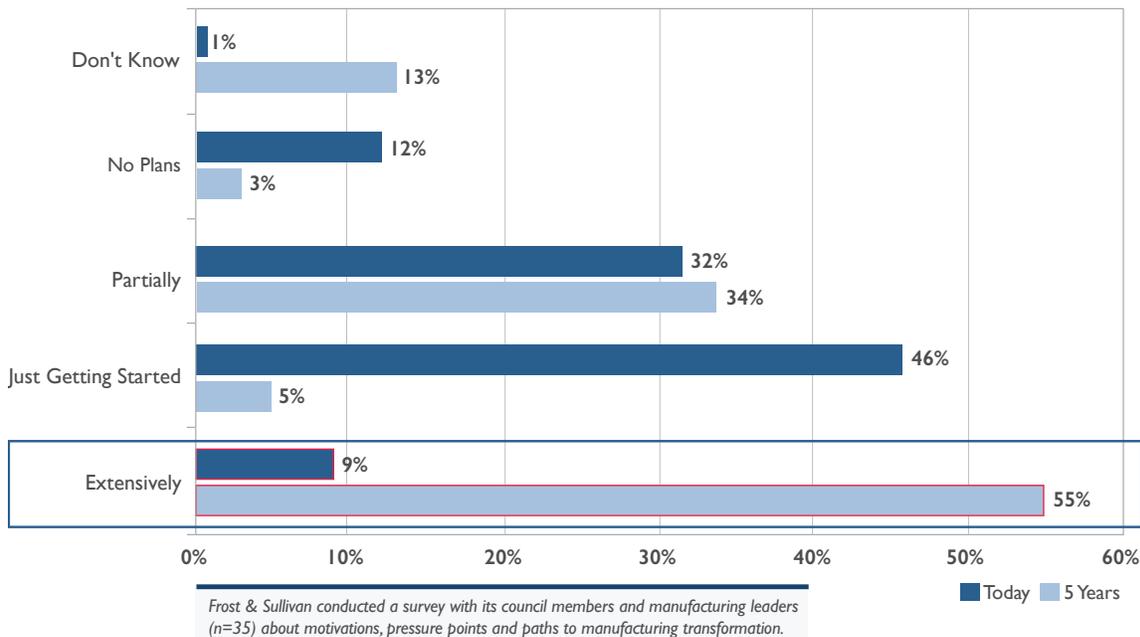
Manufacturers must understand the power of embracing new and evolving production models and technologies that allow them to digitize from the design phase and throughout the product lifecycle. Key strategies for managing the factories of the future include:

- **Migration paths toward Manufacturing 4.0:** Most manufacturing plants operate in a heterogeneous environment with a variety of equipment from different vendors and different models. To enable scalability and remain competitive, manufacturers should apply their scarce resources to modernizing aging assets, which will allow them to connect their embedded system production technologies with smart production processes.
- **End-to-end digitization of manufacturing processes:** This means interconnecting the manufacturing process from design to prototyping to manufacturing, production and after-market services, and enabling the processes to share a common data fabric that enables seamless exchange of information at every stage. This helps gain real-time traceability of quality issues, closed-loop feedback on design principles, reduced cost of poor quality (COPQ) and customer-centric innovation. For example, if a specific complaint about a product’s after-market service arises, feedback is provided in real-time to the product design team, to make the necessary design change, so as to fix the problem and reduce after market service costs for future products and reduce the overall cycle to fix manufacturing or design problems.
- **Agile and sustainable production models for Manufacturing 4.0:** Plug-and-play systems are giving way to IP-enabled factories. Proprietary protocols will yield to open standards-based systems and allow easy integration across various systems in the manufacturing ecosystem at a significantly lower cost due to Internet of Things (IoT) sensors replacing proprietary sensors and APIs replacing complex integrations.

Networking plays an important role to enable autonomous, self-healing, flexible, smart, connected, and responsive production models. In exhibit I, we found that 55% of the respondents state they will be investing extensively in network-enabled equipment over the next five years.

**Exhibit I
Networking of Plant Equipment Will Soar**

Q: How extensively has your company IP-enabled and networked its plant floor equipment today and what do you expect the extent will be in five years’ time?



Critical Issue #2: Transformative Technologies in Manufacturing

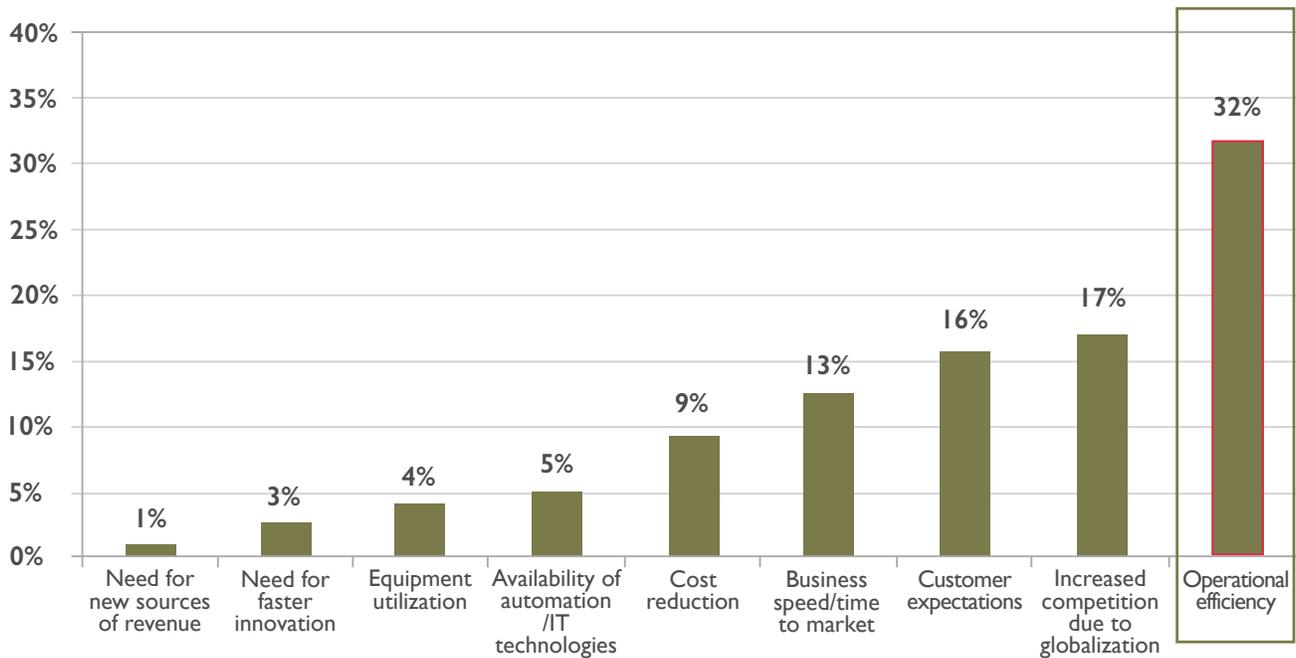
Technology convergence drives a creative disruption in traditional business and operating models, opening up new possibilities to manufacturers. Adoption of these technologies comes with its own set of challenges, but the promise of benefits and the need to transform make it imperative for manufacturers to embrace change. Key outcomes of transformative technologies include:

- **New ways to improve profitability:** Developments in intelligent machines, the Internet of Things, Big Data, shop floor analytics, modeling and simulation, mobile, cloud, and 3-D printing technologies will allow manufacturers to rethink traditional operations and engineer newer ways to improve profitability.
- **Operational models as a result of transformative new technologies:** The influence of new technologies will steer a shift from traditional operational models. Examples include a change from reactive maintenance to predictive maintenance and siloed enterprises to connected enterprises.
- **Emergence of new business models:** The impact of transformative technologies on performance allows for the creation of new business models. For example, manufacturers who were selling tangible products such as a pump, valve or compressor have now shifted to selling “performance as a service”. Instead of selling the machine with warranty performance, manufacturers are able to sell with committed uptime of the machine to the end user. This would not have been possible without onset of transformative technologies.

Manufacturing organizations are very prudent in implementing new technology assets, as they are very comfortable in running systems/assets until their end of useful life. However the industry is progressively changing its attitude to implement newer technologies primarily due to competitive pressures. In exhibit 2, 32% of the respondents have chosen operational efficiency as the single biggest driver to implement transformative technologies.

Exhibit 2

Q: What is the most important business factor driving your company’s move toward Manufacturing 4.0?



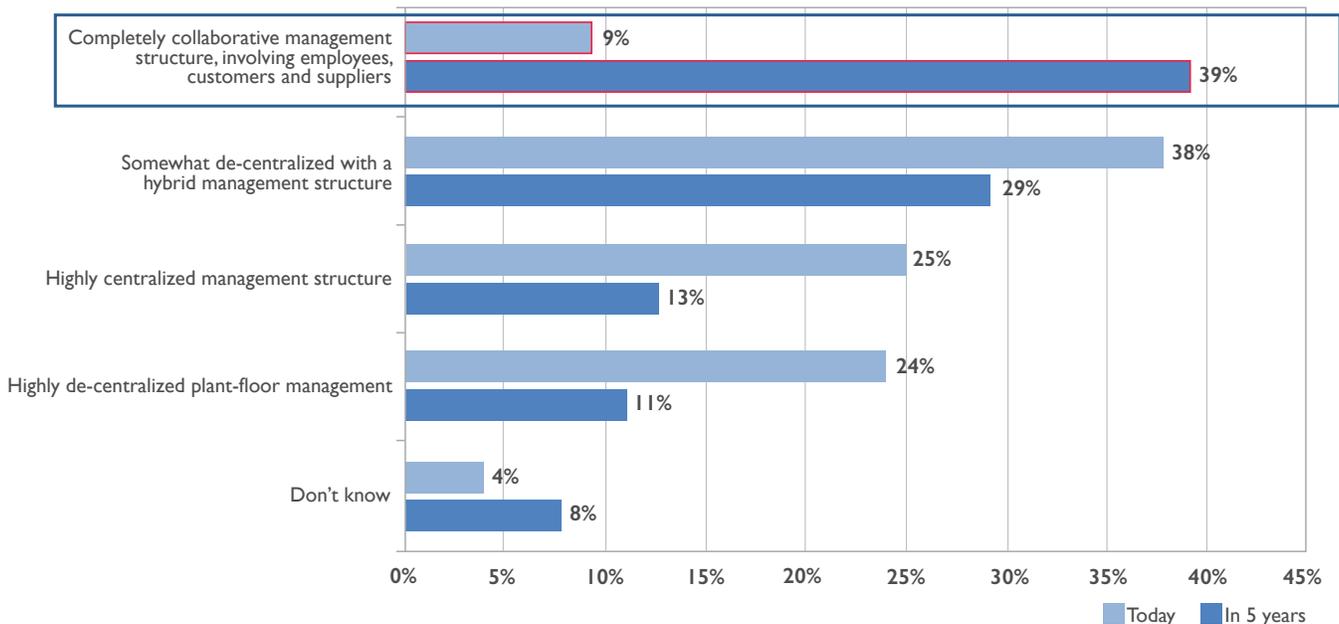
Critical Issue #3: The Collaborative Manufacturing Enterprise

Manufacturers must now successfully manage rapid, continuous, collaborative, and often disruptive innovation processes across the enterprise to drive growth, new products and services, operational efficiencies, and competitive success in the world of Manufacturing 4.0. The mindset of manufacturers needs to change from experiencing site-functional operational excellence to engineering enterprise-scale excellence by connecting the plants, measuring performance and replicating best practices. The critical process that needs to be internalized by manufacturers in order to achieve an innovation-driven culture includes:

- **Design-manufacturing integration:** Using design for manufacturability techniques and product lifecycle management approaches helps drive innovation. This helps manufacturers maintain a single version of the truth and helps compare the end product with design specifications in real time. The ability to seamlessly interact and exchange information between the various manufacturing processes is vital to continuously improve manufacturing operations.
- **Collaborate to win:** Managing collaborative innovation with employees, suppliers, external partners and customers is imperative in today’s world and a key factor in creating next-generation products.
- **Achieve N=1:** As customers demand customized products, the need for manufacturers to achieve mass customization is critical in order to grow the customer base. Mass customization is in practice across several industry verticals such as apparels, white-labeled goods, automotive, packaging, life sciences, etc. The connectivity between production and demand networks helps manufacturers to quickly deliver customized products. Another case in point is the advancement of personalized medicine. Drugs are developed not just based on the patient’s condition but are also dispensed using automated kiosks in exact dosage. As manufacturing operations are transformed, organizations are poised to become ultra-collaborative across the manufacturing value chain. As shown in exhibit 3, 39% indicated that in the next five years, factories would move away from command-and-control organizations to collaborative enterprises of the future.

Exhibit 3 Command-and-Control Giving Way to Collaboration

Q: How would you characterize how your factories are managed today, and what do you anticipate will be the primary way your factories will be managed in the next five years?



Critical Issue #4: Cybersecurity in Manufacturing

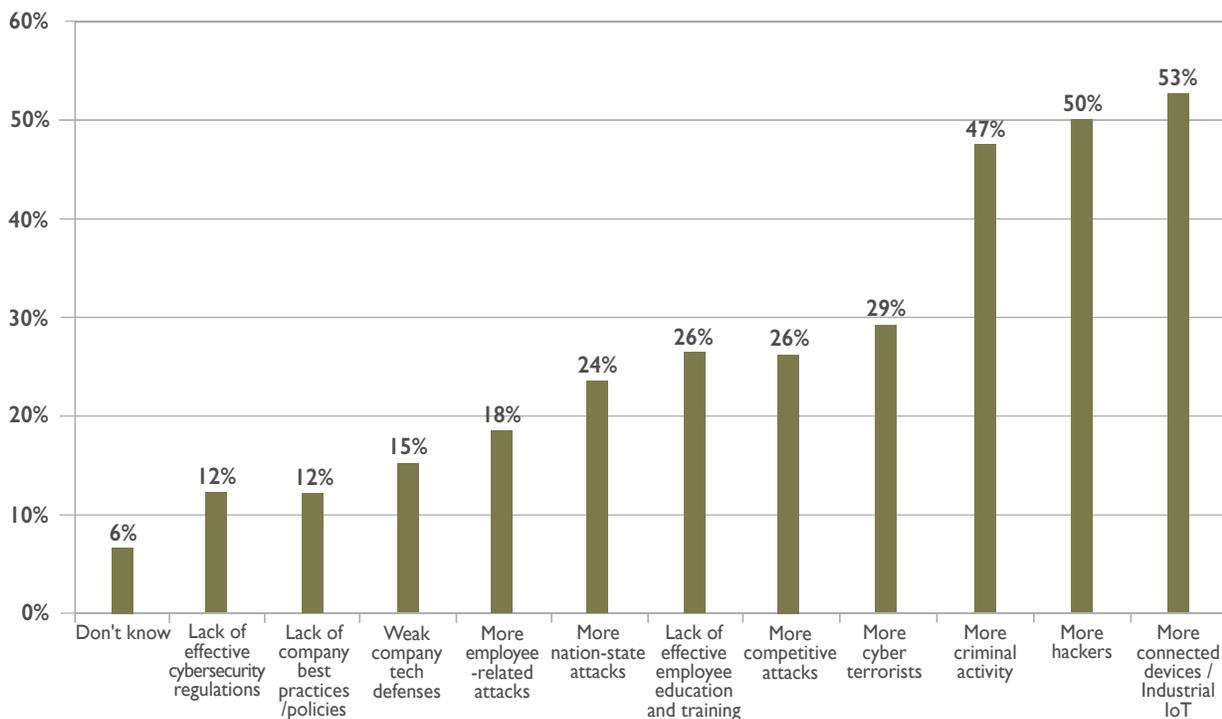
In the age of ubiquitous connectivity, devices and machines are Internet-enabled to demonstrate remote monitoring and control capability. However, every point of connectivity translates into severe cybersecurity vulnerabilities. In the face of such increasing vulnerability to external cyber threats and potential internal disruption, manufacturing companies must identify the most effective cybersecurity processes and technologies, and create a culture that will ensure operational continuity, data security and IP protection. Key steps to achieve a resilient enterprise include:

- **Discover and implement security technologies:** The first step in cybersecurity is to assess maturity level and present state of affairs. Usually manufacturers call in a third-party firm to conduct a comprehensive cybersecurity audit to identify areas of vulnerabilities. Post this discovery of cyber vulnerabilities, detection methodologies and security technologies (i.e. firewalls, unidirectional diodes, security, information and event management, etc.) across the manufacturing operations.
- **Create an IT/OT Center of Excellence (CoE):** Today’s manufacturing world (or Operational Technology world) has a lot to learn from 30 years of advancements in IT security. Hence, building a CoE with cross-domain expertise (IT/OT) is critical in improving manufacturing cybersecurity.
- **Training to be on the leading edge:** It is unfortunate today that cyber hackers are ahead of the curve. At times, IT breaches can go unnoticed for significant durations of time. Hence, training internal staff or partnering with cyber-security solutions experts is critical in order to stay one step ahead or manage not just known/existing threats as they occur but also mitigate against emerging threats such as the large scale global “WannaCry” ransomware attack. Deploying advanced, forensic-based cybersecurity like machine learning could also help to thwart cybersecurity issues.

Ubiquitous connectivity and platform convergences between information and operational technology leads customers to choose the increase in connected devices as #1 factor for investments in cybersecurity.

Exhibit 4 2016 Cybersecurity in Manufacturing

Q: What’s driving the increase?



Critical Issue #5: Next-generation Manufacturing Leadership

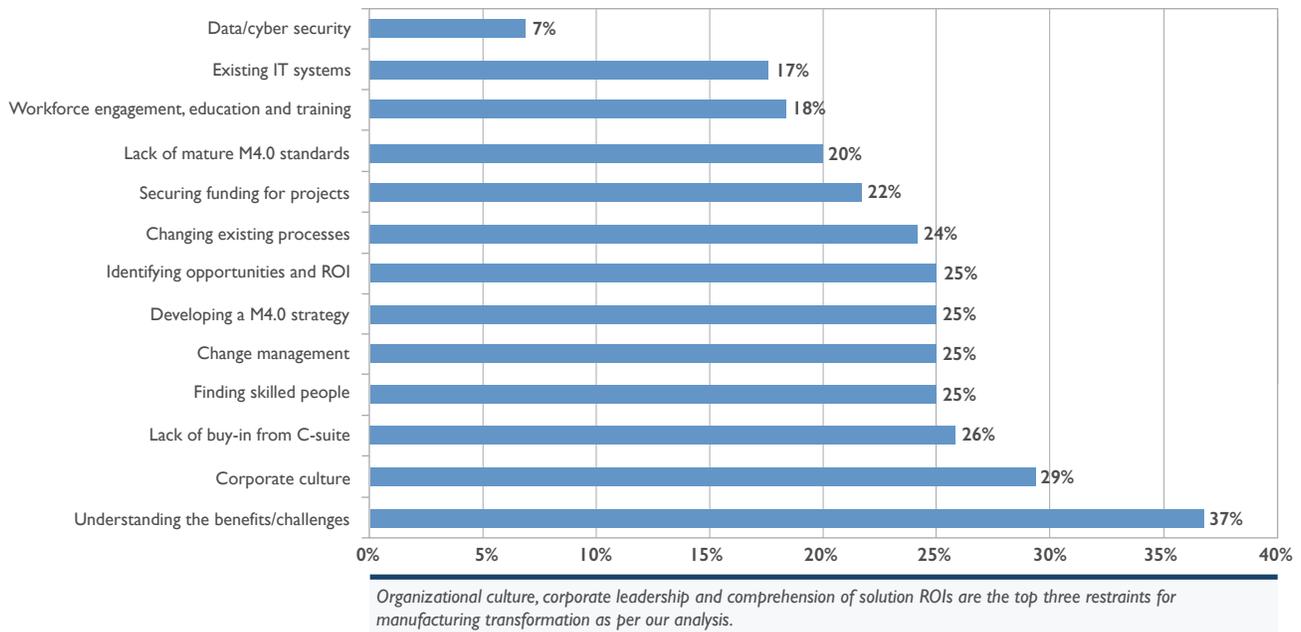
Manufacturing 4.0 requires manufacturing leaders and their teams to become more collaborative, innovative, and responsive and to make decisions based on a greater understanding of manufacturing’s role in company strategy. In exhibit 5, we asked what the top challenges are to implementing M4.0? Organizational culture, corporate leadership and comprehension of solution ROIs were the top three restraints for manufacturing transformation per our analysis.

Leaders must embrace new behaviors, structures, and strategies, such as the following:

- **Future-focused leadership behaviors and mindsets:** The composition and focus of the C-Suite of every manufacturer is being redefined. For example, we have seen the emergence of creative titles such as chief disruptive officer. As every manufacturer is poised to face disruption, the time is now to have CXOs scan the horizon for the next big disruption and constantly be ready to improve.
- **Build a future-focused workforce:** As competition intensifies, leadership planning and development at all levels are important. The lack of availability of skilled and ultra-skilled resources further stresses the need for advanced planning and skill development.

Exhibit 5

Q: What do you think are the three most significant challenges to implementing M4.0 in your company?



Critical Issue #6: The Changing Manufacturing Workforce

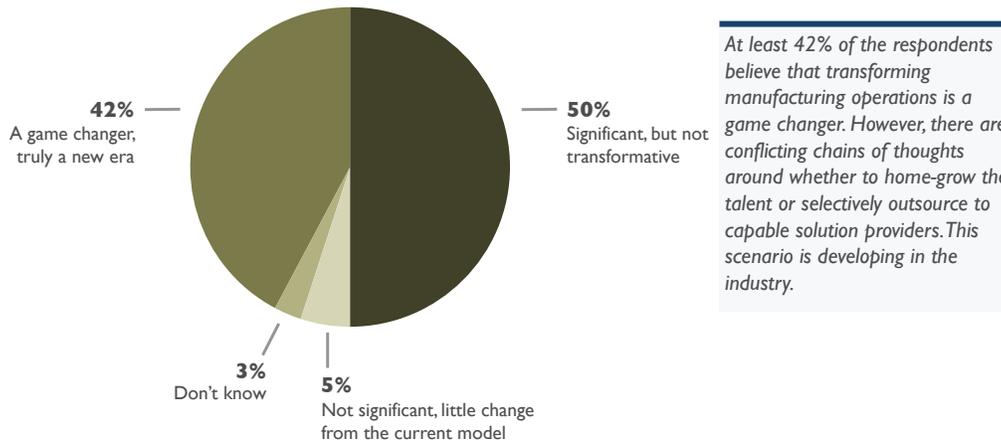
Next-generation leaders need to focus on identifying, attracting, developing and retaining the next generation of people and skills. The skills needed in Manufacturing 4.0 are vastly different, as they will need to be trained on OT and IT skill sets. Some of the emerging skill sets include analytics, machine learning, computation, physics-based modeling, etc. To maintain a leading-edge organization some of these best practices will need to be followed:

- **Attracting tomorrow’s workforce:** Redefining the cultural image of your organization and making it attractive for millennials through advocacy and promoting aspects of cutting-edge technology will become vital as manufacturing companies battle for tomorrow’s workforce. We have already seen this in technology companies and we expect this to happen in manufacturing within the next three to five years.
- **Partnerships and the power of force-multiplier effect:** Reducing the skills gap and identifying new skills for the

future of manufacturing through education, apprenticeships, and industry partnerships will be required to bridge the gap in internal skills. Several manufacturing companies and IT Services Providers are already striking partnerships with associations like the Manufacturing Leadership Council, Smart Manufacturing Leadership Coalition, Digital Manufacturing and Design Innovation Institute (DMDI), etc. to promote IT/OT convergence and pilot the future of manufacturing.

Exhibit 6

Q: Ultimately, how significant an impact will M4.0 have on the manufacturing industry?



While manufacturing organizations continue to be challenged by the aforementioned issues, one thing is very clear: most organizations are pressing on, convinced that transformation is the path to the future. Now as a first step let's take a look at the manufacturing industry characterization which will help to self-assess your relative position against industry pioneers.

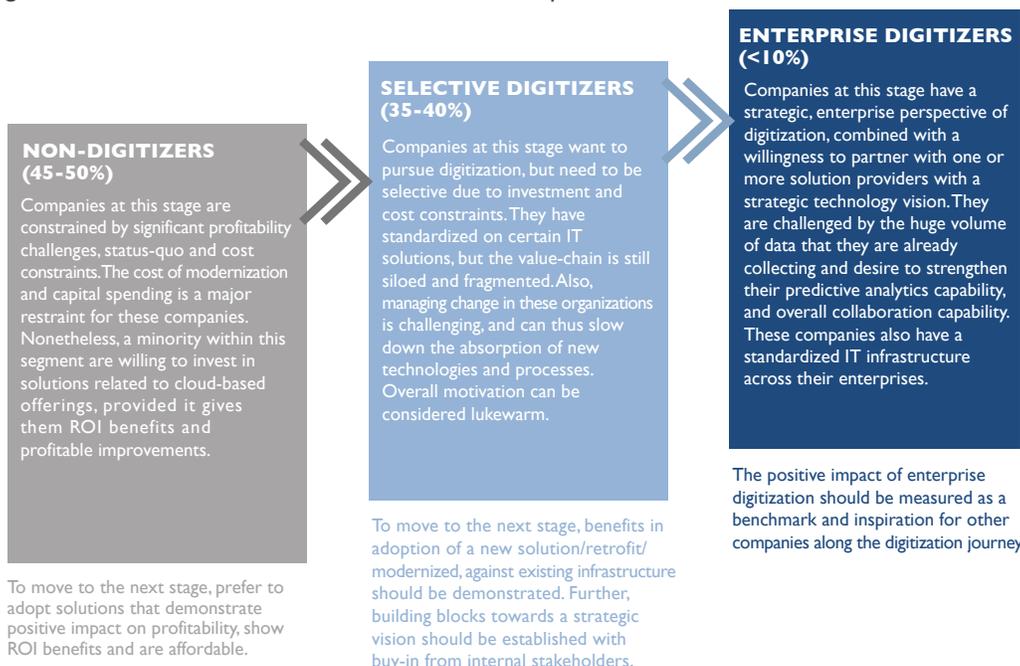
THE COMPLEX JOURNEY: MANUFACTURING INDUSTRY CHARACTERIZATION

Frost & Sullivan has analyzed the manufacturing industry and created a benchmark tool for manufacturers to gauge their relative positioning on the journey to transformation. As digital technologies enable this transformation, we have characterized the market into three types in exhibit 7: non-digitizers, selective digitizers and enterprise digitizers.

Exhibit 7

An Overview of the Journey to Enterprise Digitization

Enterprise digitizers account for <10% of the Global market, at present:

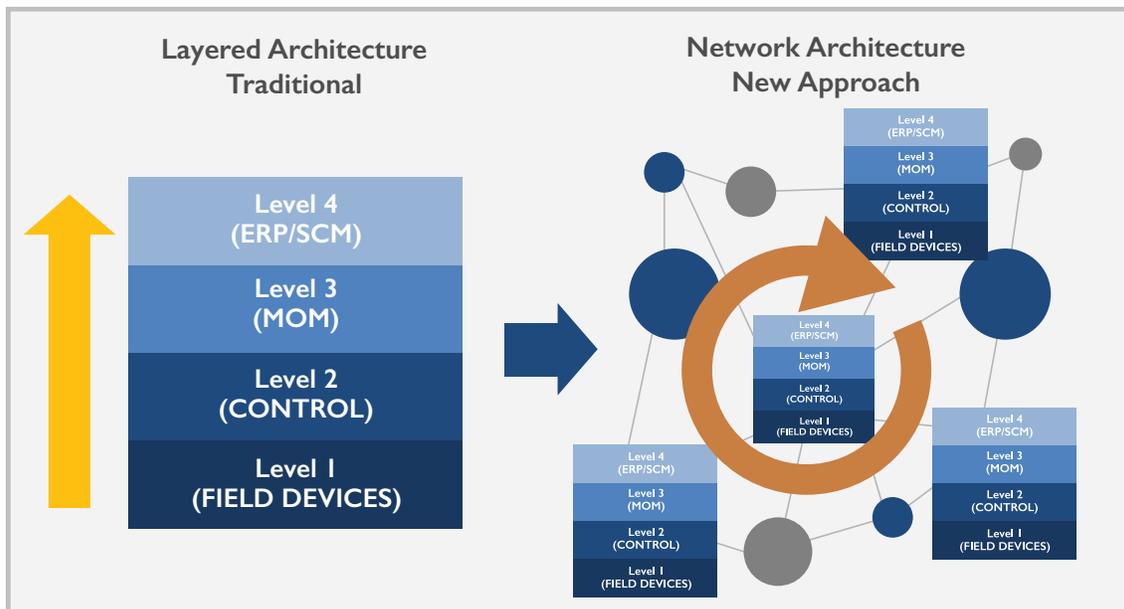


As you look at the manufacturing landscape characterization, 50% of the market is at the non-digitizers level. Manufacturers at this stage are usually challenged by investments or fear of uncertainty in moving away from time-tested processes. However, it is important to evaluate a transformation roadmap in order to avoid being disrupted. If done right we believe the journey to transformation is on average a four-to six-year process. The suggested timeline does depend on present stage of maturity and complexity of the manufacturing landscape. To ease the journey, it is prudent to follow these important traits of an enterprise digitizer:

- **C-suite buy-in:** Complete ownership from C-suite leadership to shop-floor personnel on benefits/results of digitization
- **Modernize at minimal capital:** Assessment of the present-day infrastructure to identify areas of investment that deliver maximum profit impact at minimal investment/modernization
- **End-to-end transformation:** Clearly defined roadmap of people, process and technology

Non-digitizers and selective digitizers must embrace the aforementioned traits in a sequential manner to realize the benefits of transformation. However, there is one common step across the digitization stages—the transformation of information networks and architectures. As an outcome of IT-driven transformation, the operational model of manufacturing is changing from sequential processes to everything being connected and interacting. This drives a fundamental change in the operations and infrastructure, while driving a transformation in business processes. For example, due to the addition of networking, connectivity and intelligence to the shop floor, equipment and processes will be able to self-monitor themselves and alert humans, only in case of a process deviation. So, the asset/process itself will have an important role to play in the self-control of the manufacturing operations. The deployment of IT to integrate previously heterogeneous systems strips away the hard-coded layers that are prolific in today’s manufacturing ecosystems. This results in a shift from traditional/layered manufacturing architecture to networked architecture approaches.

Exhibit 8
Manufacturing industry’s shift from layered architecture to networked architecture



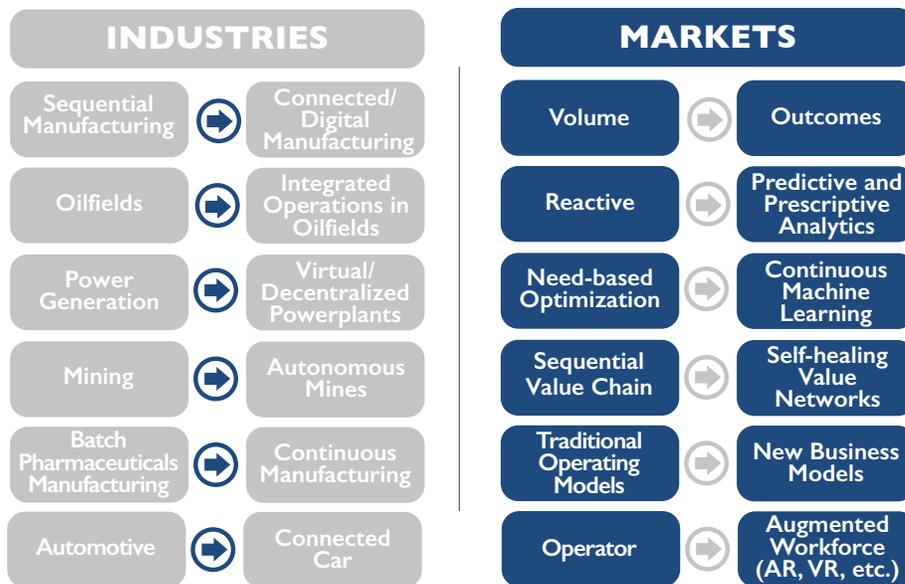
A major European automobile company has old, hard-structured systems. Now it has to replace more and more of these systems in less time. It recognizes that it actually has to dissolve this old pyramid style and hard-wired system connections in terms of open, network-based systems where you can attach a new system and replace it again quickly. This has a deep influence on how systems are designed, and will also drive a lot of changes in future factory control systems.

As companies merge, are acquired, or maintain the status-quo despite market challenges, manufacturing networks often become extremely complex and difficult to manage. With manufacturing companies realizing the strategic value of big data and analytics, most leading organizations are striving to streamline communications/data flow between various system types. This is one of the primary reasons for an uptick in IT related investments across manufacturing organizations.

THE ROLE OF IT IN MODERNIZING MANUFACTURING

Within the manufacturing industry sector, most of the companies are saddled with aging systems that are hard-coded with proprietary algorithms that prevent them from being seamlessly integrated with other systems. However, the future of process and discrete manufacturing is collaborative, de-centralized, digitized, and optimized. Frost & Sullivan has analyzed several process and discrete industries to understand the transformation scenarios. Every industry shown below is in an “invest-to-transform” cycle.

Transformation: Tectonic Shifts Affecting Industries and Markets for the Next Decade



Explaining some of the industry transformation:

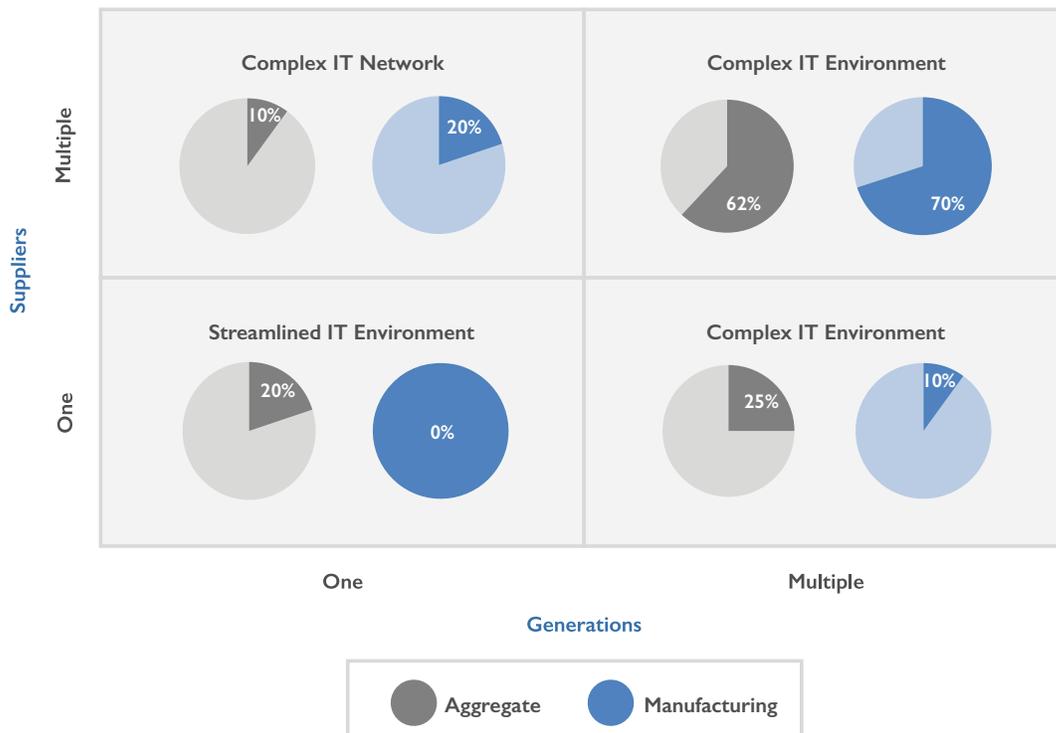
- **Oilfields:** Companies are shifting from siloed oilfield operations to integrated, collaborative and digitized production fields. This is helping companies optimize lifting costs of hydrocarbons, while effectively balancing the utilization of resources and opportunities.
- **Mining:** This market was in need of digital disruption due to intense manual work involved. Today, leading companies have invested in total autonomous trucks for hauling ores, while delivering record improvements on human and equipment safety.
- **Power:** This is one industry that has come an exceedingly long way and reaped significant benefits from digitization. Smart meters, decentralized power generation units (wind, micro grids, etc.), buy back of excess power by end customer solar roof panels (has resulted in end customers being both power consumers and generators, while utility companies playing the role of aggregator and transmitter), and integration of network and security operations centers have enabled millions in savings to the industry as a whole.
- **Pharmaceuticals:** Traditionally, batch-type processing was time consuming and put a lot of stress on the compliance cycles. Integrating smart manufacturing IT principles, leading companies are revolutionizing the space by shifting to continuous pharmaceutical manufacturing processes.

One of the primary enablers of M4.0 transformation is the integration of IT with operational technologies (OT). The adoption of advanced manufacturing technology (machine learning, analytics, etc.) is steering end users to prudently evaluate their IT/OT landscape in order to be better prepared for the future. Most manufacturers have aging, inflexible IT architectures that prevent them from easy integration with other systems.

The IT Infrastructure Landscape

The need for modernization and streamlined environments is even more pronounced today. In exhibit 9, 70% of enterprises have heterogeneous IT infrastructures with varied competency requirements to maintain and manage these systems. Compared to an overall industry aggregate of 62%, the supplier heterogeneity and multiple generations of systems are considerably higher in manufacturing industries. In addition 0% of the manufacturing establishments have a streamlined IT environment today. The level of asset heterogeneity, vintage and make have been primarily due to a lack of long-term vision, mergers and acquisitions. For brownfield projects, manufacturers will need to rely on IT to modernize and streamline communication. This creates a strategic need for manufacturing organizations to build a scalable, reusable, extensible and reliable IT solution. The goal of manufacturers is to head to the bottom-left side of the chart shown below. In this scenario, there is one supplier and one generation of systems within an enterprise. As per our analysis, none of the manufacturing companies are at this stage of maturity today. “Manufacturing architectures in the future will have to integrate homogeneously with multiple manufacturing sites. The sites will leverage a distributed plant model. Now in order to control the flow of everything, an IT architecture is required that brings in all inputs of information that manufacturers need to know about customer demand. In a way enterprises of the future will leverage IT to achieve central control, yet decentralized, execution. That to me is the model of the future.” Director of Supply-chain - A leading US-based think tank. The benefits of this scenario are a streamlined IT environment and unified skillsets that do not need constant training and updates. In greenfield projects, manufacturers have to strive to achieve a streamlined IT environment (lower left hand quadrant of the exhibit) in order to achieve easy interoperability between various systems and facilitate responsive enterprises of the future.

Exhibit 9



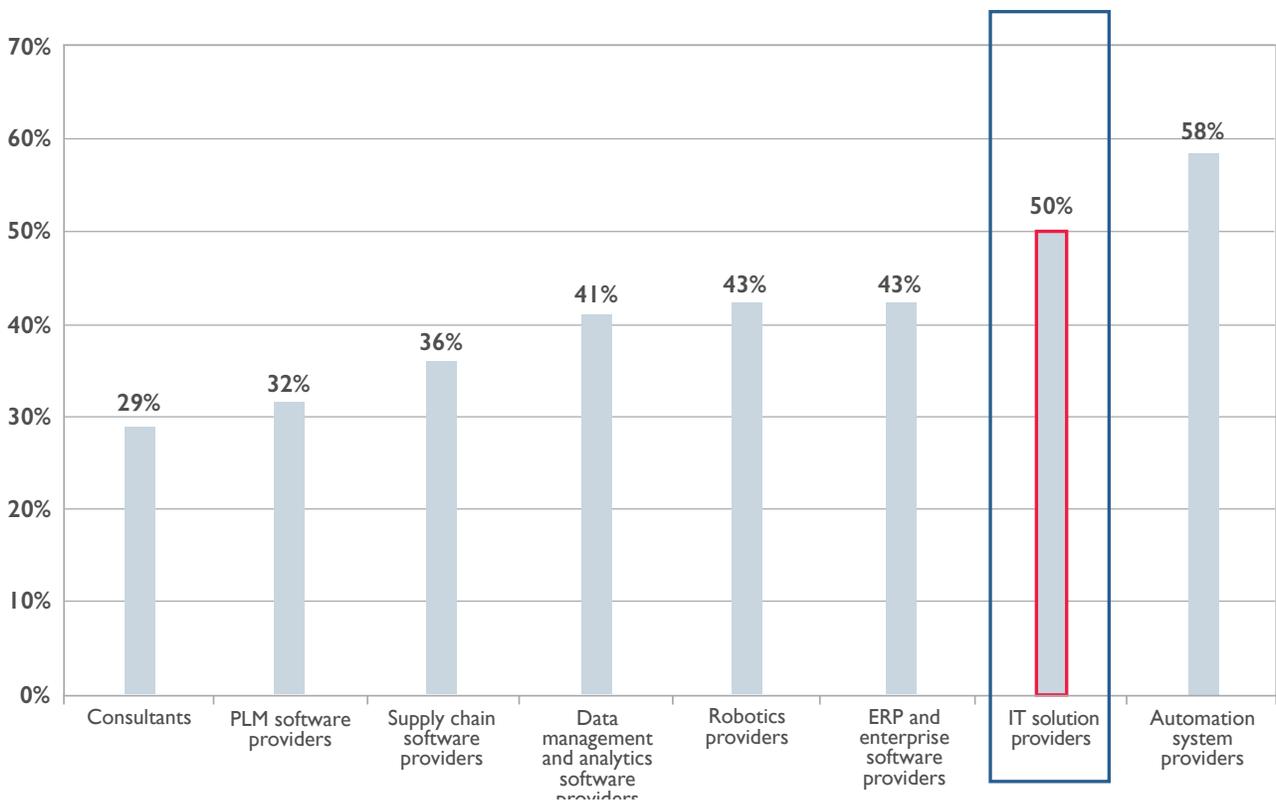
While the need to streamline IT is evident, manufacturers need to think about, “build or buy” partnering strategies. Pioneering enterprises have gone down the path of building these systems and applications by themselves. However, the pace of technology refresh cycles (halved in recent times) has forced these pioneers to abandon efforts and rely on capable solution partners.

Mixed Opinions on M4.0 - IT infrastructure providers play a leading role in enabling manufacturing transformation

As the industry transforms, manufacturing customers will need to partner with capable solution providers to enable the transformation. The challenge is to understand unique capabilities of solution providers. While the need for IT and OT expertise is important, half of the manufacturing customers surveyed, believe that IT solution providers were instrumental in steering the customers journey towards M4.0.

Exhibit 10

Q: How capable are your technology and service providers in providing the solutions needed to enable your company’s M4.0 transformation?



In our research, specific case examples of manufacturers have demonstrated excellence in leveraging IT and achieved success in transforming their operations and business models. Many of these companies were traditionally product manufacturers and their revenues depended on transactional sales/one-time sales. Use of converging IT/OT platforms has resulted in transformed business models, newer avenues of revenue and benefits to the manufacturers. These use cases clearly show that solution providers have been able to shift IT from a cost center to a profit center. Further, IT is the fabric that enables these traditional product manufacturers to integrate with partner solutions and deliver profit-impacting business outcomes.

COMPANY	BEFORE - PRODUCT	TODAY AND BEYOND DIGITAL SOLUTION
Flowserve	Industrial Pump	Pump-as-a-Service <i>Cognitive analysis at machine speed levels</i>
Rexnord	Gear Drive	Smart/Digital Gear Drive <i>Tracking critical parameters in real-time to achieve optimal asset management</i>
Thermo Fisher	Chemical Analyzer	TruDefender FTi <i>Product clouds to remotely identify substances and deliver safety-as-a-service</i>
Fluke	Measurement Tools	Fluke Connect <i>Managing and delivering asset-driven condition monitoring as a service</i>
Keysight Technologies	Test and Measurement Equipment	Test-as-a-Service <i>Capture and store test data to drive informed decision making</i>
Cartasite	Emission Monitoring Product	Automated VOC Emissions Monitoring <i>Converging emission monitoring systems with thermal imaging cameras to alert open hatch tank positions</i>

In order to achieve successful manufacturing transformation and avoid the pitfalls, we have put together our playbook and best practices for you to utilize on your journey.

TRANSFORMATION PLAYBOOK: DIGITAL FRAMEWORK AND STRATEGIC CONSIDERATIONS

The manufacturing transformation has four levels:

- **Level 1 – Plant Floor/Process:** The factory is a powerhouse of systems and devices that need to be connected in order to collect data and drive insightful outcomes. Modernizing aging infrastructure within a shop floor is the first step to future-proof the enterprise.
- **Level 2 - First-mile Connectivity:** In the future, manufacturing operations will have inbound supply chains aligned with the external market demand. This is to ensure visibility and achieve predictive performance optimization on production lines and make them more demand driven.
- **Level 3 – Secure Last Mile:** This is an outbound view to engage customers through channels and indirect channels. In order to meet mass-customization requirements, manufacturers need to establish an open-channel interface between the factory and points of sale. This is a trend already taking shape in consumer goods like athletic shoes, luxury cars, etc. BMW, for instance leads the auto industry in the use of sophisticated factory automation to produce precisely configured individual vehicles on flexible production lines. Apparel makers have been customizing apparel for over 50 years. But custom cars produced by automakers on a regular assembly line to deliver low cost benefits is a very recent trend and U.S. automakers outside of Tesla have yet to fully implement this approach.

- **Level 4 – Integrated Enterprises:** Progressively, the manufacturing community is realizing the value of an end-to-end view of operations. The ability to weave a digital tapestry across the different functions of the organization (design, supply chain, manufacturing, production, after-market services, and lifecycle services) allows manufacturers to achieve early visibility on possible disruptions, monitor and prevent quality issues from happening, optimize and predict performance, etc. Further, manufacturing organizations are shifting from site-specific efficiency improvements to enterprise-scale efficiencies. This requires plants across different geographic regions to be connected through cloud technologies, while enabling centralized KPI monitoring.

It is often very challenging for manufacturing companies to wade through such a complex ecosystem from level 1 through 4 and achieve manufacturing digitization. There are several uncertain aspects around value, ROI, benefits, change management, risk, adoption rate, loyalty, etc. While these are fears, the flip side is the availability of key opportunities to drive alternative monetization, structure scalable enterprises of the future, market leadership, stay ahead of the curve, etc.



To prepare yourself for a modernization roadmap, ask yourself the following questions:

- Do you have a 360° on what you need to do to transform the manufacturing operations?
- Do you know why you need to transform your manufacturing operations? What are your strategic business objectives?
- What is the purpose of the core transformation elements? How do investments in these aspects help you achieve your strategic objectives?
- Have you identified areas of quick wins and strategic wins as a result of your transformation?
- Do you have senior leadership buy-in and investments to support this transformation exercise?
- Have you looked at ROI models to understand outcomes and benefits?
- Are you able to establish “quick sprints” to prototype and iterate in order to achieve the best solution?

Compare your responses with our suggested list of best practices.

Best Practices to Achieve IT Modernization:

One of the first things manufacturers need to streamline is enterprise architectures. This changes the way one will interact with internal and external systems. Outdated architectures will need to be modernized with simpler, standards-based integration to facilitate low-latency data flow across the manufacturing networks. Examples: A large commercial aircraft manufacturer used IT systems and open architecture to connect with 80 different suppliers across the globe. The IT platform served as a gateway for the organization to share design data (without data loss) and continuously monitor product build quality, production delays, efficiency levels, etc. Similarly a large US-based food and beverage manufacturer moved from site-functional efficiency monitoring to linking approximately 15 plants. This helped the organization instantaneously monitor line efficiencies, predict quality issues and ensure enterprise-wide optimization of asset utilization.

CHALLENGE	BEST PRACTICES	RECOMMENDATIONS
<p>Complex technology evolution and heterogeneity (make, vintage, type) in present-day IT ecosystems</p> <p>IT, being perceived as a cost-center</p>	<ul style="list-style-type: none"> Assess present-state and re-define architectures to enable seamless IT/OT integration. Rationalize on vendor management portfolios to streamline IT landscape, while engineering cost-efficiencies of scale. Integrate and streamline the various point solutions into a seamless “Value Chain” to drive enterprise wide modernization initiatives Invest-to-transform: IT should be viewed as a digital fabric to bring together operational and system silos. Leverage IT as an enabler of new business models Outsource strategic core activities to third-party service providers 	<ul style="list-style-type: none"> Partner with a solution provider with demonstrated capabilities and is a trusted technology solution provider, who can co-ordinate and integrate systems (IT and OT) from EDGE to cloud, securely. Shift from hierarchical to flat/networked IT architectures Drive standardization in IT-deployment models to streamline resource utilization. Virtualize IT infrastructure, to drive economies of scale efficiencies.
<p>Focus is still on site-functional excellence</p>	<ul style="list-style-type: none"> Start small, but create a structured transformation roadmap to achieve rich benefits. To gain full benefits of modernization, companies must shift from site-functional implementations to standardized enterprise-scale deployments. 	<ul style="list-style-type: none"> Align technology deployment with business objectives, to overcome hurdles Capture baseline performance value and continuously measure for performance variability.
<p>Creating a data-driven culture and obtaining C-suite buy-in</p>	<ul style="list-style-type: none"> Breathe and live digital, by instilling a ‘connect-to-perform’ culture across the company. Not a Holy Grail: Experiment and do ‘fast sprints’, fail fast, but innovate to transform in a sustained manner. 	<ul style="list-style-type: none"> Iterate with short-sprints solution innovation, to right-size the solution quickly. Leverage IT to strategically leverage data as a performance-enabler.
<p>Legacy IT investments are extreme points of security vulnerabilities</p>	<ul style="list-style-type: none"> Security should be a driver/enabler for/of IT modernization. Embrace modern IT-infrastructure to process data efficiently and achieve real-time insights. 	<ul style="list-style-type: none"> Gain holistic visibility of the IT-landscape to enable strategic decision making. Upgrade your systems, through managed-service contracts instead of ‘rip and replace’

We have learned from pioneering organizations that selecting an IT partner for the journey to transformation is key to agility and scale. Some of the critical attributes crucial to supplier selection are outlined below.

TAKING ACTION: ACHIEVING YOUR TRANSFORMATION

Most manufacturing IT runs lean. Resources are scarce. For many organizations that have been in a cycle of perpetual cost cutting and being asked to do more with less, they are evaluating where they provide the most value and focusing there. For everything else, they are building a business partner ecosystem to fulfill those needs.

Leveraging a trusted partner to provide IT services and solutions can accelerate transformation and result in increased value for the business. There are many aspects to building a successful partnership. Some qualities to consider when selecting an IT modernization partner include:

- **Capability and competency:** Partners must have demonstrated experience and a proven track record. Increasingly, business acumen has become a critical component. Additional requirements include technology foresight with the ability to future-proof IT architectures and provide organizational change management capabilities.
- **Culture fit:** Given the multi-year length of most engagements, sustained delivery excellence, bench strength, strategic geographic presence, technology roadmaps, domain expertise and application development capability are key attributes.

- **Integration expertise:** As Industrial Internet of Things (IIoT) and new technology advancements infuse agility within manufacturing environments, the biggest opportunity lies in integrating siloed systems together to work harmoniously. The partner should have demonstrable expertise and a track record in multi-site integration along with the ability to manage complex projects.

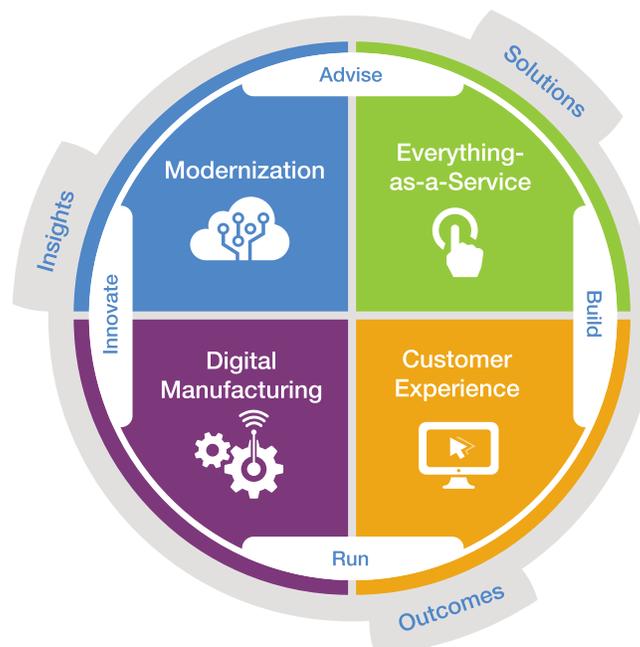
Undertaking a full-scale modernization initiative using only in-house resources can be risky, time consuming and cost prohibitive. NTT DATA Services, an NTT Group company, is one solution provider whose comprehensive modernization capabilities and extensive systems integration experience help manufacturers successfully navigate complex transformational journeys.

NTT DATA Services leverages proven methodologies and innovation to address the people, process and technology challenges issues defined in this paper. As a pioneering leader focused on delivering positive business outcomes, the organization transforms businesses across a full spectrum of manufacturing industries, including automotive, chemicals, discrete, energy, high-tech, process and aerospace. NTT DATA Services' portfolio ranges from business process outsourcing to infrastructure, cloud, security, modernization, organizational change management and digital transformation.

The NTT Group is serious about research and development. The organization spends more than \$2 billion annually on R&D and employs more than 6,000 researchers in innovation centers around the globe. To help clients stay on the leading edge, researchers focus on IoT, robotics, artificial intelligence, automation, autonomics, cyber security and other innovative technologies. This level of investment positions the organization to help manufacturing customers succeed in their transformation journey.

Another differentiator that sets NTT DATA Services apart is its industry focused IT consulting capabilities. Traditionally, modernization in manufacturing was driven by the customers. The onset of advanced technologies and the pace of technology refresh continue to challenge the internal capabilities of customers. This requires solution providers to conduct discovery sessions with clients and advise on solution implementation models. It is a challenging market, as it demands a high degree of domain expertise in order to deliver advisory services. NTT DATA Services' consulting and managed service capabilities are able to articulate the best strategy, implement the technology solution set, and maintain it for life.

NTT DATA addresses core manufacturing user challenges by aligning with their clients' needs:



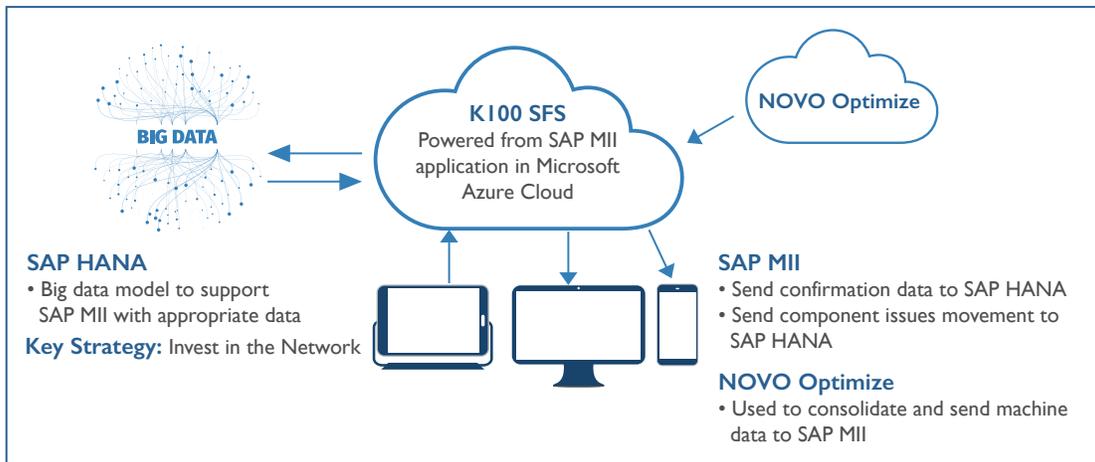
Success Story:

A global leader in tooling and wear-resistant solutions integrated the diversified worlds of IT and OT to structure a digitized manufacturing entity of the future.

Challenge: The organization had several business challenges. The prominent ones were:

- Outdated shop floor data collection systems
- Lack of visibility of people, materials and machines
- More time spent on data collection rather than driving insights from data
- Multiple digital solutions, but extremely siloed infrastructure

Solution: In order to streamline operator dashboards, document views, order overview, etc., across multiple manufacturing locations, the organization partnered with NTT DATA to roll out SAP MII as the primary operator interface for shop-floor data registration. Further, NTT DATA helped the organization centralize development, quality and production aspects on the SAP MII platform, hosted in a cloud environment. As next steps, both organizations have come together to create a five-year roadmap strategy on rolling out SAP MII as an enterprise standard across NA, EMEA and Asia Pacific plants.



Benefits: The key benefits realized by the organization include:

- Less discrepancy between planned and actual operational cycles
- Standardized use of operator interfaces across different cross-functional areas
- IT/OT integration leads to a systematic elimination of errors in production processes
- Immediate actionable data for shop-floor supervisors
- Structured a value-inversion model, wherein plant-floor analytics drive a financial view of production operations

Summary:

Embracing technology and sustained innovation is vital to next-generation manufacturing. Advancements in cognitive technologies will disrupt, collapse and transform traditional ways of doing business. Manufacturing organizations must structure a future vision for their business. The vision is to create the factories of the future that will have a series of functional attributes: smart, customized, self-diagnosing, risk-resilient, responsive, cross-functional, and highly integrated. To achieve this vision and level of transparency in manufacturing there needs to be a seamless exchange of information between the factory and various networked systems of the manufacturing ecosystem. This is enabled by IT organizations that are fundamentally changing from being cost centers to enablers of business transformation in manufacturing industries.

Extending IT and its concepts to Operations will flatten manufacturing networks and drive a creative destruction of traditional business models. This will help manufacturing companies tectonically transform customer experiences and drive recurring revenue streams at improved profitability. The future of manufacturing is challenging, but with the right strategy, technology solution sets and an able partner, organizations will be able to structure smarter, faster and simpler manufacturing operations.

ABOUT NTT DATA

NTT DATA partners with clients to navigate and simplify the modern complexities of business and technology, delivering the insights, solutions and outcomes that matter most. We deliver tangible business results by combining deep industry expertise with applied innovations in digital, cloud and automation across a comprehensive portfolio of consulting, applications, infrastructure and business process services. NTT DATA is a top 10 global business and IT services provider with 100,000+ professionals in more than 50 countries, and is part of NTT Group, a partner to 85% of the Fortune 100.

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