A roadmap to Enterprise Intelligence

Giving manufacturers an edge in the digital future.

verizon

What is Enterprise Intelligence?

From virtual consultations to digital twins, digital technologies are reshaping the manufacturing landscape and redefining customer expectations. At the same time, rising costs are threatening to swamp profits, and manufacturers must tackle new regulations and new cyberthreats. Change – and new disruptors – are everywhere you look.

Digital transformation is essential to building a more efficient, more agile and more successful manufacturing organization; but it isn't enough. Leaders must embrace new ways of working and set out a strategy that brings together disconnected systems to create powerful, scalable platforms that enable innovation and order-of-magnitude change.

Old ways of working simply aren't up to the challenges of today. They are too expensive, too inflexible, and too hard to scale. The network is key to changing how manufacturing operates. It enables providers to leverage the latest technologies – including artificial intelligence (AI), machine learning (ML) and the Industrial Internet of Things (IIoT) – to generate unprecedented insight and make decision making smarter and faster. We call this Enterprise Intelligence.

In manufacturing organizations, Enterprise Intelligence means improving supply chain visibility to increase agility and robustness. It means increasing automation to improve efficiency, cut waste and enhance quality control. And it means making better use of data from throughout the supply chain and beyond to identify customer wants, fluctuations in demand and external factors that could disrupt operations.

Organizations that achieve Enterprise Intelligence will be more agile, more resilient to events beyond their control, and ultimately more successful, both in terms of customer outcomes and financial performance. The insight that Enterprise Intelligence gives these organizations will give them the confidence to act and the ability to deliver.

They'll be able to think like a startup while caring for all the things that manufacturing organizations need to worry about – like workforce shortages, regulatory change, thin operating margins and cybersecurity. Instead of fretting where the next 5 or 10% saving will come from, they'll be able to go looking for innovation that will enable them to achieve amazing things, like cutting waste by 50%, improving efficiency by 100%, or doubling revenue. And when they find them, they'll be able to capitalize on those ideas quickly, not encumbered by legacy systems and inflexible networks.

In this paper, we look at the challenges facing manufacturing organizations and how achieving Enterprise Intelligence can help solve them.

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Executive summary

Over recent years, the ability to deliver products to the market as planned and promised has been compromised by various events, including a pandemic, war and interruption of shipping. This has highlighted the fragility of supply chains and accelerated manufacturers' need to transform.

Getting the right data to the right people at the right time is key to enabling faster, smarter decision making, improving demand forecasting and meeting production plans. Attaining this will require extensive integration between operational technology (OT) and business systems (IT). That integration needs to be digitally driven and actionable in real time.

At the same time, there's a growing need to improve efficiency and sustainability. While environmental, social and governance (ESG) issues are not new, they are now a common boardroom topic that requires vision and commitment to address. As regulation and public pressure grow, sustainability initiatives are being pushed further back into production and sourcing processes, requiring additional traceability and reporting capabilities.

Now is the time for the manufacturing industry to accelerate digital transformation to thrive in the new digital economy, fend off the threats from both familiar and non-traditional competitors, reduce supply chain risk by increasing visibility and responsiveness, and leverage various government programs to support infrastructure development. However, many companies are held back by lack of skills, inertia, legacy business models and reliance on physical assets.

In this paper we'll look at how achieving Enterprise Intelligence can transform operations, create more robust supply chains and position manufacturers for the future. And we present a roadmap to realizing this goal, taking into account the many challenges associated with transformation.

Annual spending on smart manufacturing technology will approach $1 trillion by 2030, nearly triple the level of 2021

ABI Research[2]

The imperatives today are different

Manufacturers need to be able to act faster – whether that's recognizing and responding to demand signals, bringing new products and services to market faster, or reducing latency in shop floor systems. Technology is crucial to achieving that.

The era of instantaneous information has already started. Direct machine-to-machine (M2M) automation is replacing human intervention for core business processes. Artificial intelligence (AI) and machine learning could offer users actionable business intelligence, predictive analytics and insights on quality improvements and cost optimization – all in less than a second.

But it is going to get even faster. Edge computing and 5G are now shortening the data loop by bringing the processing to where the machines and operators are working. This means that there is ultra-low latency between events, decisions and actions. The last mile of operations is brought to life in real-time. As technology areas converge, the resulting intelligence and value generation at their intersections will create new, digitally connected touchpoints. These touchpoints open up many opportunities for manufacturers to address the key imperatives they face.

De-risking the supply chain

Recent volatility – and not just the pandemic – has exposed global supply chain vulnerabilities. Semiconductor shortages, geo-political instability, shipping issues and many other factors have led manufacturers to question long-held norms around how products are sourced, manufactured and distributed. Manufacturers are looking for ways to take risk out of their supply chains, even as new channels of engagement with customers and partners introduce new risks. In many segments, companies are simultaneously under pressure to make their products more sustainable.

Embracing new channels

There's a growing emphasis on customer engagement and lifetime value. That's changing relationships with distributors, retailers and end customers. Manufacturers are exploring new channels, including direct to consumer (DTC) models. As part of this, and to address changing demands, they are looking to offer more product configuration options. Increased personalization can improve customer satisfaction but puts pressure on manufacturing processes. In many sectors, there is growing customer demand for Equipment as a Service (EaaS) or Product-as-a-Service (PaaS) models. This, and aftersales offerings like connected monitoring services and asset downtime management, will help manufacturers to create new and more reliable revenue streams.

Connecting digital threads

The combination of smart products and more secure and capable connectivity will enable manufacturers to reimagine aftersales customer engagement and services. Sensors, analytics, AI and real-time communication can produce insights from within the supply chain and provide signals to manufacturing companies to help reduce risks and optimize production planning. Leaders must connect these digital threads, in a highly secure way – to drive better operating efficiency and quality and to improve customer satisfaction and sales.

There are obstacles in the way

Manufacturers must simultaneously satisfy competing imperatives, including:

- Tapping new sources of data
- Sharing more data with suppliers, partners and customers
- Improving their experiences
- Strengthening data protection and IT/OT cybersecurity.

Pursuing these goals individually on a project-by-project basis is likely to result in a lot of resource conflicts and other roadblocks. To pursue these goals in a complementary way and better connect their supply chains, operations and ultimately their products and services, manufacturers need to focus on the underlying information infrastructure. By pursuing a SICF approach, organizations will be able to effectively meet today's challenges and quickly pivot to pursue new opportunities that emerge.

Let's identify some of the specific, day-to-day challenges manufacturers face because of the broader trends outlined above.

Unscheduled downtime

This can result from shortages caused by supply chain disruption, equipment failures, lack of labor, false restarts when equipment didn't need to be turned off or reset, and other causes. For high-volume or high-value manufacturers, just minutes of unplanned downtime can cause millions of dollars in losses.

- What if digital twins, AI and condition-based monitoring could predict and prevent equipment failures and alleviate production bottlenecks?
- What if improved training or real-time access to a knowledge library could reduce false restarts by equipment operators?

Mismatches between production and demand

Forecasting has become harder because of the issues identified above, even though there is more data being created that manufacturers could act on than ever before.

- What if you could connect all your digital threads – data from the shopfloor, the supply chain, from demand signals and other sources?

Labor shortages

Staffing challenges were a problem well before COVID-19 took millions of people out of the workforce. Many manufacturers are struggling to maintain their operations, let alone expand, because they can't get enough people with the right skills.

- What if cameras and AI could take over some manual inspection and other quality control tasks?
- What if new-generation automated guided vehicles (AGVs) could reduce the need for people to stock production stations and manage picking and put away operations?
- What if augmented and virtual reality could close skills gaps by improving the training experience and reducing the time to competency?

Lack of supply chain visibility

Globalization and supply chain complexity have made it harder for manufacturers to get the visibility they need soon enough to act on it. Collaboration and coordinated planning with the extended value chain of partners is fundamental to an organization's supply chain risk management, as is having the capability to confirm the integrity, trustworthiness and authenticity of parts, components, products and services purchased.

Early warning signal (EWS) systems automatically monitor and analyze factors like socio-economic and geo-political shifts, local holidays, supplier stock, production anomalies, weather events, and other unscheduled, unforeseen changes. They also leverage data from internal operations, such as sensor data from manufacturing floors, warehouses, vehicles and critical infrastructure. This enables them to provide greater insights and improve the ability to manage business risks.

- What if you could validate the integrity of raw materials and components automatically?
- What if you could forecast and provide advance notification of supply chain disruptions?

Improved customer experience

This has become a required element for the products and services that manufacturers provide. AR/VR, mobile and other technologies are playing a role, and helping to create new aftermarket services. Customer experience is also a key variable to business growth. How can a manufacturing company maintain customer loyalty? Does it have the production agility to customize configurations and products? Does it have the insight to provide personalized usage suggestions, replacement parts and service at the right time? Digital competency is a large variable for these abilities.

- What immersive experience lessons from the consumer goods and entertainment industries could manufacturers learn from and adapt for their own customers, dealers and distributors?

Quality control challenges

Assuring quality has become harder, because of changing suppliers, insufficient and inexperienced workers and other factors.

- What if sensors, cameras, AI analysis and high-speed networks could detect or even predict quality problems in real time, thus reducing defects, scrap and rework?

Nearly 6 in 10 manufacturers are using AI in their quality control processes.

MIT, Genesys global business leaders survey.[3]

Information security risks

Manufacturers are working to better respond to customer needs, establish value-added ecosystems and partnerships, and effectively and efficiently invest in sustainability initiatives. As a result, manufacturing companies are creating not only digital factories, but smart, digital products and digital experiences. The industry also has moved towards adopting the digital threads concept, taking lessons learned from the aerospace and defense sector for aggressively adopting digital twins and intelligent operations.

The corresponding explosion in smart products and equipment, sensors, Industrial Internet of Things (IIoT) devices and other endpoints makes protecting intellectual property and the security and integrity of data even harder.

- What if you had the computing and network bandwidth to support advanced encryption, continuous monitoring for intrusion detection and response, and other cybersecurity practices in traditional and new edge environments?
- What if you could extend safeguards across IT and OT networks?
- What if you had the high bandwidth and low latency of 5G, but in a private, isolated network?

Maintaining sustainability

This is fast becoming a business and societal imperative. Manufacturers can make progress through remote monitoring of emissions and performance, AI-driven diagnostics, remote configuration changes and smart energy management.

- What technologies, solutions and organizational changes are needed to do this and to position the enterprise to support a circular economy?

Connectivity issues

Lack of connectivity among multiple siloed OT and IT systems was already a problem for many manufacturers. Solving it takes on more urgency for those that want to deploy new digital elements and raise their competitiveness.

Manufacturers need to achieve complete shopfloor connectivity to support emerging applications of IIoT sensors, RFID, drones, cameras and more. Applications like this are critical to providing the visibility needed to attain new levels of control over operations.

Manufacturers that are not digitally transforming and rethinking how to network to enable data from disparate sources at touchpoints across the supply chain, shop floor and product lifecycle to improve processes and strategies are going to find themselves falling well behind the first movers that are. IoT devices, “lights out” factories, engineering simulations and digitized customer experience – the hallmarks of smart manufacturing – generate petabytes of data.

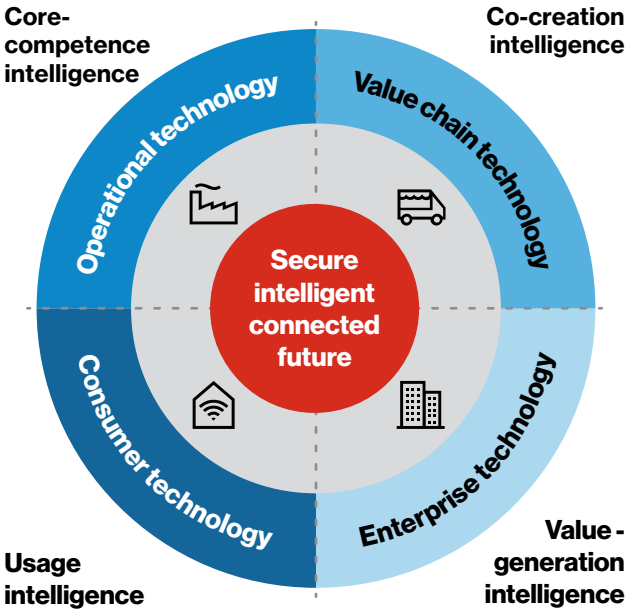
- What if you could provide high-performance, low latency connectivity across all your sites – including production and warehousing areas?

Manufacturing has the highest AI adoption rate among all industries. Numerous AI use cases have been proven to provide value for manufacturing operations, and now with 5G the possibilities and offerings are extending to supply chain, customer engagement and aftersales services.

Stanford global business leaders survey[2]

A new approach is required.

Solving these challenges and becoming future-ready requires a different approach. The secure, intelligent, connected future framework provides a strong foundation for manufacturers.



Secure and intelligent

We see a future where new players (mostly telecoms, network equipment providers, and sensor/actuator manufacturers) will create secure and intelligent platforms for connected use cases. This will need a special blend of connectivity, edge computing, AI capabilities, cybersecurity technologies, and clouds. Enterprises that adopt these new platforms will complement connected assets with analytics, AI and machine learning (ML) to facilitate autonomous, secure decisioning. In doing so, enterprises will continuously translate information into insights, driving intelligent “next best actions” that are contextual, consistent, and guided by clearly articulated business objectives.

Connected

The introduction of secure, low lag, high throughput connectivity and “edge” processing capability will revolutionize autonomous decision-making. Brand-new, real-time connections will enable a continuous stream of actionable insights between organizations, supply partners, customers, and intelligent products. Some of these new connected value chains can drive top-line growth, others bottom-line savings, and many can do both.

Closed-loop future

At maturity, manufacturers will have designed and implemented a closed-loop integration of their assets and supply chains that enables them to act on insights without human interactions or dependencies. This will enable new capabilities like Continuous Product and Process Improvement (CPPI), Design for Reusability (DFR), and Retained Product Ownership (RPO).

SICF provides the connectivity needed to advance visibility to actionable visibility.

Connected operations

Technology can bridge the physical and digital worlds so that materials, labor and data all flow in a coordinated way. This positions organizations to strengthen security across the value chain while improving their own operations. Improved IT/OT integration can help solve the perennial problem of matching production volume to demand forecasts. And AR/VR can provide immersive experiences for staff, such as production line and warehouse workers, to improve quality and productivity, reduce unplanned downtime, accelerate training, shorten the learning curve for new hires, and help institutionalize knowledge.

Connected supply chains

To prevent and mitigate supply chain delays, more advanced and integrated planning and execution must be put in place. Leveraging an end-to-end, near real-time visibility across the different players of the extended value chain is required from customers to suppliers at tier-2 or tier-3 levels. From inventory management to inbound and outbound logistics, near real-time planning and execution are becoming more and more critical. A successful solution must address two key aspects – OT/IT integration among several business partners, and continuous ubiquitous data connectivity.

Connected products and services

The focus on sales and aftersales parts and services starts with improving customer satisfaction by enabling immersive online experiences – both at dealerships and the customer's home or business. These are being delivered through digital twin, 3D modeling and AR/VR technologies. Immersive experience continues with remote training and technical support for dealers, distributors and customers, condition-based monitoring for additional services and sales, and to help prevent unplanned product downtime. Smart products open up many more service and sales opportunities.

Key definitions

Edge computing
(aka multi-access edge computing or mobile-access edge computing)
This is an extension to the network model that decentralizes the processing and storage of data to the edge. It brings resources, such as compute, closer to the devices where data is generated and gathered, and the end users and applications that consume it. Edge computing can replace or augment centralized systems, like cloud computing. Processing and storage can be done entirely at the edge or a mix to suit operational and regulatory requirements. Edge computing is both an enabler and value enhancer for the Industrial Internet of Things (IIoT).

Private 5G networks
Because private 5G networks are enterprise-specific, they are segregated from public networks and can be configured to the organization's specific security and performance requirements – such as keeping data on site. Private 5G networks provide high-bandwidth, low-latency coverage that can support AI and machine learning, virtual and augmented devices, remote monitoring, and IIoT solutions.

The very same elements can become the enablers for a more sustainable way of doing business, allowing, for example, asset and product lifecycle extension, product as a service and reduced operational waste both in the shop floor and for the customer.

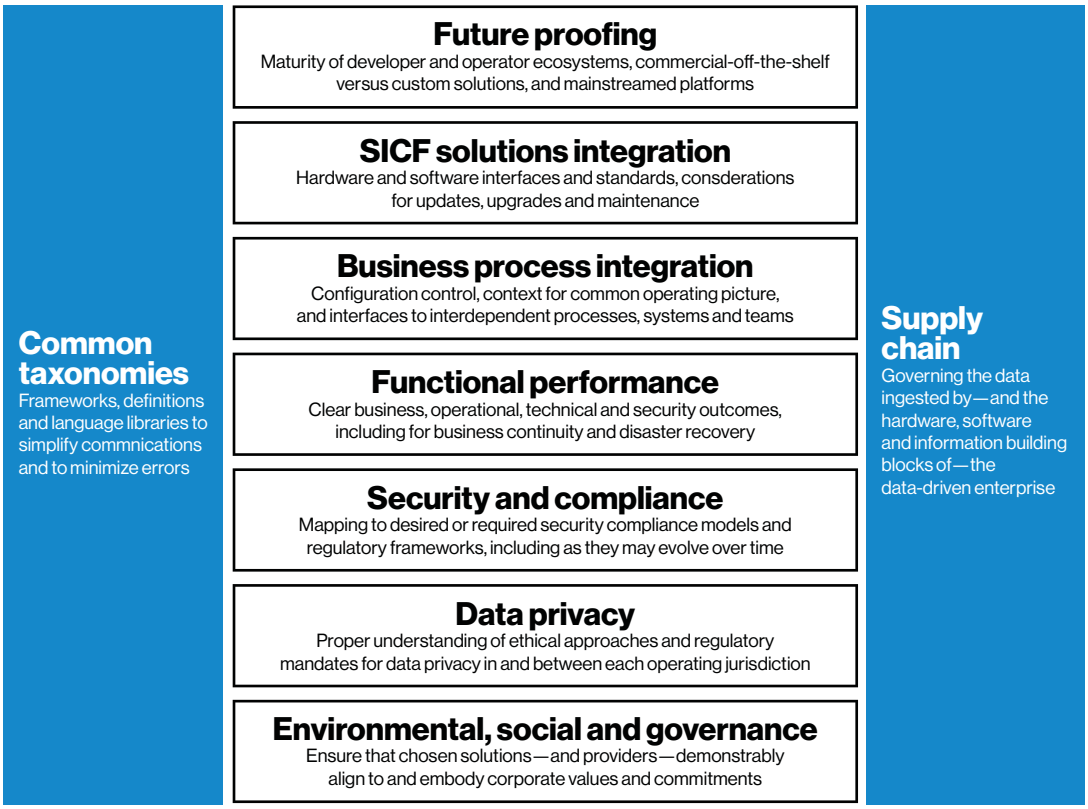


Figure 1: Layered critical decision factors for ingesting SICF solutions

Let us emphasize, there is no "killer app" that enables these outcomes. Instead, it is the combination – the connectedness – of all these capabilities enhancing the value of all the others. Looking at a historical parallel, rapid smartphone adoption did not occur because of the inherent value of the phones themselves or the individual applications (apps) on them – it was the combination of all of these elements. A smartphone is not valuable because it has GPS or a camera; it is valuable because such capabilities allow developers to use the device as a platform for developing compelling experiences.

Manufacturing companies should look at digital investments in much the same way, particularly with respect to considering private 5G and edge computing (also known as MEC) deployments. These bedrocks, in combination, set the stage for such breakthrough capabilities as condition-based maintenance on the factory floor and computer vision-aided quality assurance (QA). These and other specific use cases will be covered later.

No single technology can solve every use case due to lack of speed, segmentation, device density, or some combination of those factors. This is why we believe that defining a path to embedded responsiveness in all technology layers is critically important. It is important to note that future infrastructure decisions won't come down to 4G vs. 5G and legacy Wi-Fi vs. Wi-Fi 6. These and other technologies will be complementary. For example, existing network technology will still work fine for a system that counts items on a moving conveyor. However, a lower latency, higher bandwidth network will be needed if an intelligent camera will be performing quality inspection on items moving on the conveyor.

The factory of the future will have a heterogeneous range of communications, where

current IT and OT networks, legacy Wi-Fi, LTE, 5G and other technologies will coexist and interact in public and private networks, with each used according to process needs and environmental constraints. Enterprises therefore need network optionality that can be managed through a single provider to reduce unnecessary network management and integration complexity and cost.

In 2022, ABI Research predicted companies worldwide would increase their spending on smart manufacturing technologies like digital twins, simulations, autonomous mobile robots and asset tracking systems from $345 billion the year before to $950 billion by the end of the decade. And that forecast does not include spending on industrial software or supporting technologies, such as edge computing, AI and warehouse robotics.[2]

Such smart manufacturing requires both IIoT sensors and actuators to optimize performance. Edge compute infrastructure is needed to effectively orchestrate a high density of sensors, process the large volumes of data per sensor these systems demand and respond with almost zero latency.

A subset of the cloud computing discipline, edge computing can enable real-time analysis and computation on virtual edge platforms of large datasets created by nearby sensors and IIoT devices. Multiple MEC instances can curate and forward insights (rather than raw datasets) into a single, centralized cloud platform, thereby saving time and money. This approach is useful because it enables real-time data engineering and decision making, which are critical for automating industrial control systems. MEC can also improve supply chain security by enabling improved traceability – for materials, parts and finished products – and authentication.

A roadmap for transformation

To transform and digitize business models for meeting value realization goals, Verizon recommends manufacturers should focus on business plans, revenue streams and operational improvements that are oriented towards secure, connected assets, partners, products and customers. Contemporary innovations such as 5G, private networks, software-defined networking (SDN), Network-as-a-Service (NaaS), edge computing, AI, smart devices and cloud computing will bring once-disconnected areas of the organization much closer together and offer new value to be harvested at their intersections. To date, large companies have tended to concentrate digital transformation efforts on enterprise technology (back-office IT systems), often missing the opportunities from connecting the "domains of intelligence" represented by:

Operational technology

Factories, warehouses, depots, transportation systems and shop floors.

Value chain technology

For interactions among customers, enterprises and supply chain partners.

Customer technology

Where "dumb" products–without the customer experience sophistication of smartwatches and phones – have had to compete with smart home environments. This extends to the industrial space with smart equipment and other products that perform their own diagnostics and other functions.

Historically, the primary factor preventing enterprises from improving those areas is latency – not just in the traditional network sense, but across all aspects of the enterprise, from applications to infrastructure. Typically, the current enterprise technology paradigm does not have the embedded agility required to respond in real time. This is where manufacturing companies can begin to invest in the next generation of capabilities that will embed greater responsiveness in their platforms.

The primary way to reduce latency is through more agile and scalable capabilities in the infrastructure that underpins the organization. That means faster networks, shorter distances that data needs to travel, security inspection at the edge, real-time analytics and automation.

Enabling capabilities include:

More agile, automated networks	Private, onsite cellular networks (LTE, 5G)	Edge computing	Workflow engines
• Based on dense fiber and spectrum deployments • Integration with service management systems • Network function virtualization (NFV) to enable rapid changes	• Enable a massive increase in device density • Enhanced security and control over data, including sovereignty	• Localization of analytics and AI and machine learning models to improve responsiveness	• With a relational understanding of the components and the ability to orchestrate across the various technology layers to drive desired outcomes

Network as a Service arrangements can provide a more flexible, programmable and scalable network than traditional network infrastructures, see Verizon NaaS enabling the digital world

Based on manufacturing industry trends and current market knowledge, Verizon recommends prioritizing the following solutions.

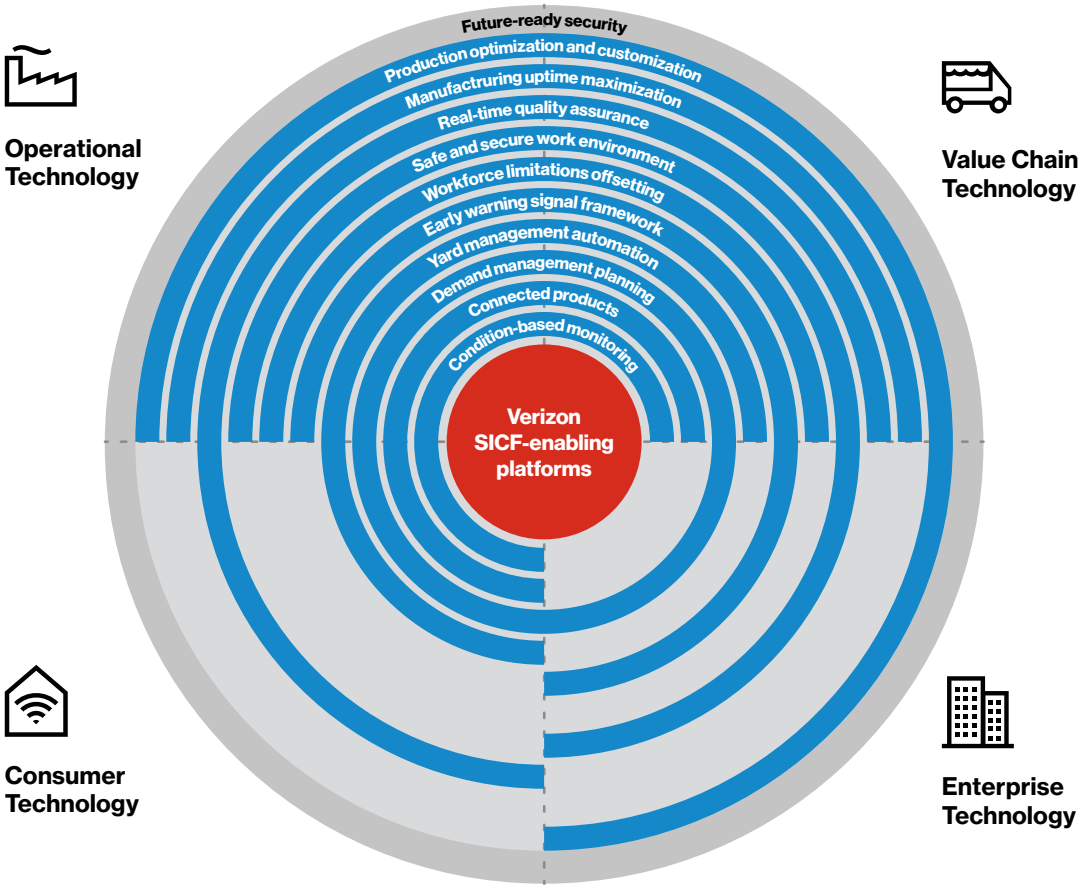


Figure 2: SICF solutions for manufacturing companies

Smart manufacturing

Optimizing and customizing production
RFID tags, vision systems, IoT sensors and edge servers on 5G networks give manufacturers the item-level traceability needed for both custom and just-in-sequence manufacturing and enable complete tracking from material through production to inventory and shipping. Digital solutions for item-level tracking also provide the visibility to reduce safety stocks and optimize production. With manufacturers offering many more configuration options to satisfy customer preferences, tighter tracking is needed to make the production process more manageable and efficient.

Reducing manufacturing downtime
When materials and labor come together it is up to production systems to produce the output. On the shopfloor, advanced connectivity solutions can reduce unplanned downtime, enhance quality control and improve visibility by improving IT/OT integration across digital threads, digital twins and predictive maintenance solutions. MEC sets the foundation for applying augmented and virtual reality to reduce hands-on maintenance requirements.

- Manufacturers can extend inspection and diagnostic capabilities to assets that are in hard-to-reach or dangerous environments using drones
- Uptime and QA efforts can get a boost by using sensors to monitor for vibrations, temperature, moisture and other conditions that affect materials and equipment
- Observing conditions over time and analyzing them with machine learning models can provide advance warning of developing faults, for example with welding robots or other industrial equipment

$950B

According to ABI Research, spending on smart manufacturing technologies like digital twins, simulations, autonomous mobile robots and asset tracking systems by the end of the decade.

Protecting and assuring production quality in real time
5G and MEC servers provide the low latency needed for network sensors, machine vision cameras and audio signal analysis to perform inspection that can reduce scrap and rework by identifying quality problems immediately as they develop. Quality issues caused by production equipment can be addressed through digital twins and AI-driven predictive or condition-based models to facilitate consistent performance and uptime.

Providing a safe and secure work environment
Enterprises can prevent and detect falls, track and limit worker exposure to dangerous environments, get a real-time view of all personnel and equipment locations, monitor lone workers and their safety, implement geofencing, enable incident response and provide overall monitoring and security. This can be done by using a combination of:

- Edge compute connectivity
- Motion, temperature, audio and other sensors
- Biometric and wireless employee identification
- Cameras and drones
- AI for threat assessment and alerting
- RTLS tags

all connected using secure 5G networks.

The same technologies can also protect worker safety by monitoring to verify that processes are carried out in the prescribed sequence, and issuing warnings if they are not. AGVs, robotic pick-pack and other automated production and warehouse management solutions reduce labor requirements and can boost safety while raising throughput and quality. Such solutions are mostly associated with efficiency improvement, because extending IT/OT integration to these operations provides more granular, timely visibility into operations to enable more efficient coordination across inbound materials, production and outbound logistics.

Applying technology to offset workforce limitations
Expert systems help organizations institutionalize individual knowledge, while AR and VR can accelerate training and shorten the learning curve for new hires. Forward-leaning organizations are using AR and VR to interact with their products, equipment, technicians and customers in new ways. These solutions – supported by 5G and MEC – help mitigate the losses from retiring staff and produce more consistent results across the workforce. Of course, higher degrees of automation from the shop floor to the back office also free employee time for more productive activity.

Integrated supply chains

Deploying early-warning signal framework (EWS)
EWS is a rapidly emerging risk and threat management framework across a business value chain for forecasting the impact of a wide range of factors. The EWS framework extends from internal to supply chain operations, monitoring potential hazards that would impact the ability to meet demand volume.

EWS can only be enabled by truly connecting the enterprise, operations, value chain and customer technologies for end-to-end visibility. Manufacturers should seek to maximize the signals available to the EWS by connecting data from all aspects of their business to it, including sensor data from manufacturing floors, warehouses, vehicle fleets and critical infrastructure. They should also encourage or require key vendors and suppliers to deploy appropriate sensors and connect them to the platform. Relevant data would include data on electric grids, water supplies, weather, traffic, public health and more.

Automating yard management
Get your products and finished goods to and from your supply chain partners faster by optimizing yard operations. With 5G infrastructure, today's highly accurate real-time locating systems (RTLS) and even drones, organizations can reduce time wasted looking for materials in their distribution yards, conduct safer, more frequent and more accurate inspections and inventory checks, streamline materials handling and more.

Applying machine learning to better predict demand
Some CPG manufacturers are creating automated machine learning (AutoML) models to identify the latest tastes and trends at the source to alleviate unpredictable lifecycles. By leveraging data manufacturers can anticipate the entire product journey based on historical data and analytical prediction – considering trends, design changes, seasonality, regional variations, global compliance, transportation risks, financial volatility and more. SICF allows enterprises to predict how long it will take the products to reach the dealer or customer and what the business impact could be.

Immersive customer engagement and support

Strengthening customer experience through more connected products
Expanding the native connectivity of their products gives manufacturers opportunities to improve their top and bottom lines. Using solutions like an early warning signal framework, IoT sensors and MEC infrastructure–with advanced cybersecurity layered throughout – manufacturers can deliver new user experiences, improve product performance and reliability and introduce new revenue-producing services.

By including innovations in AR, self-diagnostics and remote support as part of the offering, manufacturers can extend their relationships with customers after the sale. Immersive experiences can be delivered online, at dealerships and at the customer's home or business through 3D modeling, AR/VR, metaverse, digital twin and other solutions. As 5G coverage expands, so do the possibilities for touchless, over-the-air (OTA) product updates, automated customer service and more.

Condition-based monitoring
Condition-based monitoring for the final product post-sales can inform changes to settings or parts replacements to improve performance and reduce unplanned downtime, create alerts if emissions or other outputs are out of acceptable thresholds, and more. With condition-based monitoring, organizations can make adjustments to assets or perform maintenance based on actual, real-time conditions. This represents an advancement over predictive maintenance, where maintenance recommendations are made based on historical analysis of past usage.

Setting the technology foundation.

Verizon has developed a vision for manufacturers to succeed in the digital future by modernizing with the building blocks shown below.

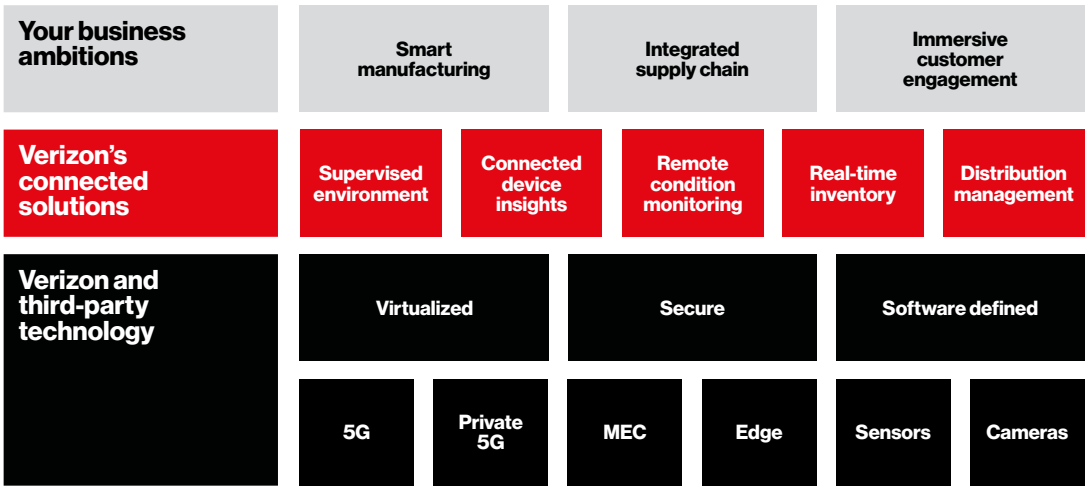


Figure 3: Design elements to succeed in the connected, digital future

This design does not represent an either/or option to existing communication systems, because a "one-size-fits-all" approach is inappropriate. This becomes clear when organizations begin formally studying and planning for future connectivity needs, which usually call for an interoperable mix of current systems and enhanced capabilities. The foundation for these and other decisions is a comprehensive connectivity plan that is aligned with the manufacturer's innovation roadmap. The best plan for an existing facility won't likely be best for a new one being constructed, so flexibility within a standardized framework is essential.

The connectivity plan to support infrastructure transformation could include private cellular networks (like private 5G), Wi-Fi 6 and even distributed antenna systems (DAS), depending on:

- The density of the physical infrastructure
- The use cases that need to be deployed, real-time applications and "things" that need to be connected
- The environment and the obstacles to door-to-door and floor-to-floor connectivity, inside or out

MEC infrastructure is needed to effectively orchestrate a high density of sensors and devices (including IoT devices) and process large volumes of data per sensor, such as when applying AI. These systems demand and respond with almost zero latency.

Most sites will not need a complete "rip and replace" program, but they will likely need some new components for their current communications infrastructure. Current wired and Wi-Fi infrastructure will remain effective for some systems and locations. Therefore, organizations will need to ensure interoperability, including for security standards, across new and existing elements.

Next steps

As manufacturers embark on the road to digital transformation, one of the steps is to identify opportunities for transformation where early value can be unlocked. Verizon has developed a framework that helps our customers identify these opportunities in a simple, two-step approach. Step one is to identify the optimal connectivity technologies to support the desired use cases, and step two is to conduct a readiness assessment for folding those technologies into existing operations.

Connectivity technology selection

Identifying the connectivity necessary to support key use cases should be the jumping-off point. Many connectivity options are available – such as Wi-Fi, 4G, 5G, MEC and others – and it's important to base decisions on quantifiable parameters that are relevant to the use case. Verizon's framework considers three key aspects:

Performance

Technical requirements such as network bandwidth, latency, compute power and device density.

Privacy and compliance

Issues like data residency, data sovereignty, privacy and regulatory compliance.

Availability

Considerations like availability of spectrum, cost and local regulatory constraints.

These factors together lead to several choices for an optimal connectivity technology, including wired or wireless and public or private. The list of options can be further reduced by considering the operational cost of the transport, assessing the use of backhaul traffic and calculating the capex requirements.

Deployment readiness evaluation

The next step is to perform a deployment readiness evaluation by analyzing what it will take to develop and deploy the use case. Key considerations here are:

- **Capabilities**
  A review of the internal platforms and systems that are available to support the use case. Missing capabilities may be developed internally or sourced from a partner.
- **Device readiness**
  Identification of the readiness of existing devices intended to be included in the use cases. The need for costly replacement or retrofitting could inhibit deployment.

The figure below shows how Verizon can help address these questions.

Verizon's connected solutions	• **What solutions are currently available?** • **How can they be connected and leveraged?**
Verizon's enabling technologies and capabilities	• **What technology enablers are essential to the use case?** • **Are internal platforms/systems capable of supporting these?** • **What new capabilities must be developed/outsourced?** • **Who are the key partners we will work with?**
Verizon and third-party technology	**Based on the connectivity technology choice:** • **What new hardware/network infrastructure will be required?** • **Will devices need to be upgraded?**

Figure 4: Readiness evaluation questions to investigate.

Verizon is the partner you need.

It's easy to say that you have extensive global industry experience, but how many providers can back it up? We have experience helping manufacturing companies improve efficiency, increase supply chain visibility and robustness, automate operations, make better use of data, and secure their intellectual property and data.

With Verizon, organizations have a strategic partner. Our networks – including the most reliable 5G network in the U.S.[1] and one of the world's largest and highest performing global IP networks – are among our greatest assets. Our customers also benefit from the billions that we have invested in developing the platforms, technologies and solutions that organizations need. But our greatest strengths are our vision, our people, and our proven ability to deliver.

The network can be a multiplier, increasing the value of your investments and expanding your capabilities. The combination of our advanced networks, cutting-edge solutions and professional and managed services can connect systems across your enterprise to empower you to overcome the business challenges that you face. We can connect all of your ecosystem, bringing users and applications together, to achieve all that you can imagine.

We call the result Enterprise Intelligence. It can make you more efficient, more agile, better prepared for unexpected challenges, and ready to seize new opportunities.

Our platforms could help you achieve your goals. To find out more about our capabilities and experience in the manufacturing sector, visit our website.

verizon.com/business/solutions/industry/manufacturing

1 **Most reliable 5G network based on more first place rankings in RootMetrics® 5G data reliability assessments of 125 metro markets conducted in 1H 2022. Tested with best commercially available smartphones on three national mobile networks across all available network types. Your experiences may vary. RootMetrics rankings are not an endorsement of Verizon. Visit rootmetrics.com.**

2 ABI Research, 38 Technology Industry Stats You Need to Know for 2022, 2022

3 MIT, Genesys global business leaders survey, copyright © 2021, All rights reserved MIT Technology Review; www.technologyreview.com

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