Understanding the 5G details that provide business value for manufacturers.

This white paper provides an overview of 5G network technology and how it brings business value to Manufacturing companies. It explores what the technology can make possible and its commonalities and differences with other network connectivity options. This paper also examines which use cases benefit from 5G and which do not, and most importantly it discusses how and why 5G and legacy network technology can and should coexist.

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business

Introduction

You're no doubt hearing a lot about 5G these days: 92% of manufacturers expect 5G implementation to lead to business improvement, and 93% expect it to reduce costs, according to an Institute of Manufacturing study.[1] You're also likely hearing that your business needs 5G because "it's fast". While that's true, 5G does in fact dramatically speed up data transfer and greatly reduces latency – there's much more to consider about 5G as your business continues its digital transformation.

Not all 5G is equal - by design

Developing and executing a network strategy for the future –one that optimizes operations, controls costs and enables agility and flexibility -- means more than just "getting 5G." As 5G becomes more ubiquitous, businesses will still need a range of network options, just as they do today. The truth is, 5G is not best for everything, and – by design – not all 5G is equal. That's why Verizon continues to support a broad range of network technologies and offerings, from 4G LTE and fiber to managed and virtual network services, in addition to heavily investing in its multi-bandwidth 5G network. And that's why we've fostered an ecosystem of innovative solution providers to help companies create new business value through the strategic design and deployment of information and networking technology.

You may or may not need 5G today, but you definitely need flexibility now and in the future. Most manufacturers have use cases with high potential to benefit from 5G, such as device monitoring and enhanced wireless security across the factory. This white paper is designed to help you understand 5G and its place in current and future enterprise operations so you can make strategic investment decisions.

5G is considered foundational for future smart manufacturing that may involve digital twins, digital threads, expanded Industrial Internet of Things (IIoT) use cases, new forms of robotics, AI support for quality control and production planning, smart facilities and more. It can provide a bridge from legacy equipment to new devices and techniques. Annual spending on smart manufacturing technologies like digital twins, simulations, autonomous mobile robots and asset tracking systems will nearly triple from 2021 to 2030, to almost $1 trillion according to ABI Research; that spending excludes 5G edge networks, which ABI forecasts will have 5-year CAGR of 43%.[2] Meanwhile, IoT implementations, advancements and enterprise spending continue to surge.

Look to the future

Some of these technologies may be in your future, or your present, so your business should buy the connectivity that you need to enable the use case outcomes you want to see. However, it isn't just about getting what you need for now. It's about future-proofing your investment so it can scale to enable the use cases of the future without needing to replace your entire investment. Today, 48 percent of businesses believe they are losing at least $5 million in potential revenue because they lack network transformation; 17 percent believe they are losing more than $10 million.[1] At Verizon, we cover all areas of connectivity so you can not only buy the right size for now, but you can do it in a way to easily expand it in the future. We believe the business need should drive the network choice – not the network services provider.
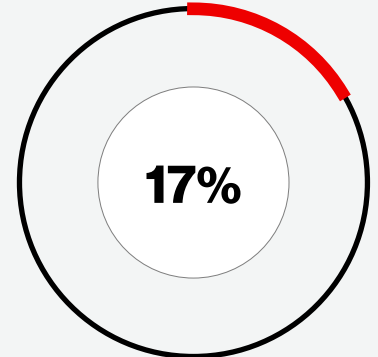
What is technical debt in your network infrastructure costing you?

20%
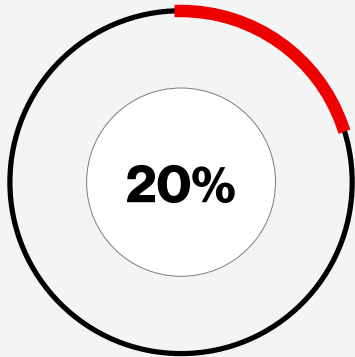
$1 million to $5 million
potential loss of revenue

31%
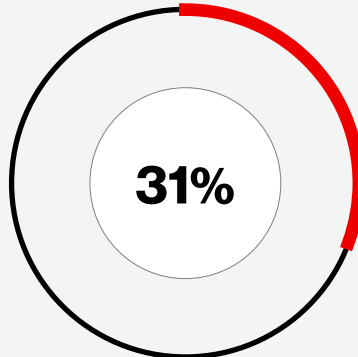
$5 million to $10 million
potential loss of revenue

17%

$10 million to $20 million
potential loss of revenue

> The value in 5G is the barriers it removes and the new ways of doing business it makes possible. Therefore, getting the most value from 5G and other communications infrastructure depends on using the right bandwidth (5G or other) for each use case.

Source: IDC Enterprise Network Transformation Maturity Index
based on survey of 402 IT decision makers worldwide.

What 5G is, and what it isn't

"5G" is a commonly used term, but it can also be a misunderstood one. That is because 5G is not a single technology or band of wireless spectrum; it describes a range. The various spectrum bands within the 5G umbrella are each best suited for different use cases. The best option for achieving millisecond responsiveness in an advanced factory automation system is not the best for streaming instructional manuals and how-to videos to a technician on an oil rig. For these and other reasons, 5G should not be considered a commodity. Important performance differences exist among 5G spectrum bands, and in 5G connectivity and services from different providers.

Any enterprise that decides to use 5G must choose and optimize the 5G spectrum for its use cases. Most likely, it will need multiple bands, and

would be best served by keeping some of its networks and connected devices on legacy or other non-5G networks. Conversely, legacy machines and sensors can be included on 5G networks, which means a complete rip-and-replace upgrade isn't necessary.

When the right band is selected, the 5G connectivity still lends itself to enhancement to provide the full benefits that businesses envision. Other components and network technology, such as Verizon's Network-as-a-Service (NaaS) Solutions, multi-access edge computing (MEC) architecture and software applications that take advantage of the new processes 5G enables, all help to unlock the full value.

Spectrum overview

Not all 5G is created equal, and that is by design. There are three primary types of 5G – high-band, mid-band and low-band – plus differences within these categories that arise from the usage environment and network provider. Each of the three bands has strengths and weaknesses related to its coverage area, interference resistance, endpoints supported, latency, speed and more.

In many operations today, WiFi is used in place of 4G LTE. 5G is faster and safer than public WiFi,[3] and has the important enterprise advantage of providing persistent connectivity. Unlike with wireless LAN technology, 5G users and connected devices don't experience hiccups and potential services interruptions as they are handed off from one WiFi hotspot to another. Additionally, 5G is inherently more secure than WiFi.

Latency, or the lack thereof, |makes a difference

One of the most important differences between 5G and 4G LTE is latency, which describes the time it takes for signals to be sent and received and accounts for the lag that may be experienced when viewing streaming video or gaming. It is an important variable in the performance of real-time systems, especially when high volumes of IoT or other devices are connected to the network. Latency on 4G LTE networks is typically around 20 – 30 milliseconds (ms); 5G latency depends on the band, but typically is 10 ms or less. Latency is especially important in industrial environments because it is a major variable for the performance of systems that rely on cameras, sensors, actuators, industrial controls and other networked components for automated operations.

Choosing a 5G bandwidth for a use case or facility doesn't mean you can only use that bandwidth. Multiple 5G bands, and non-5G spectrum, can interoperate in an enterprise network. For example, Verizon 5G Nationwide uses the Verizon 4G LTE network infrastructure and its massive fiber-optic backhaul resources.

Industrial site   Facility   Business   Enterprise
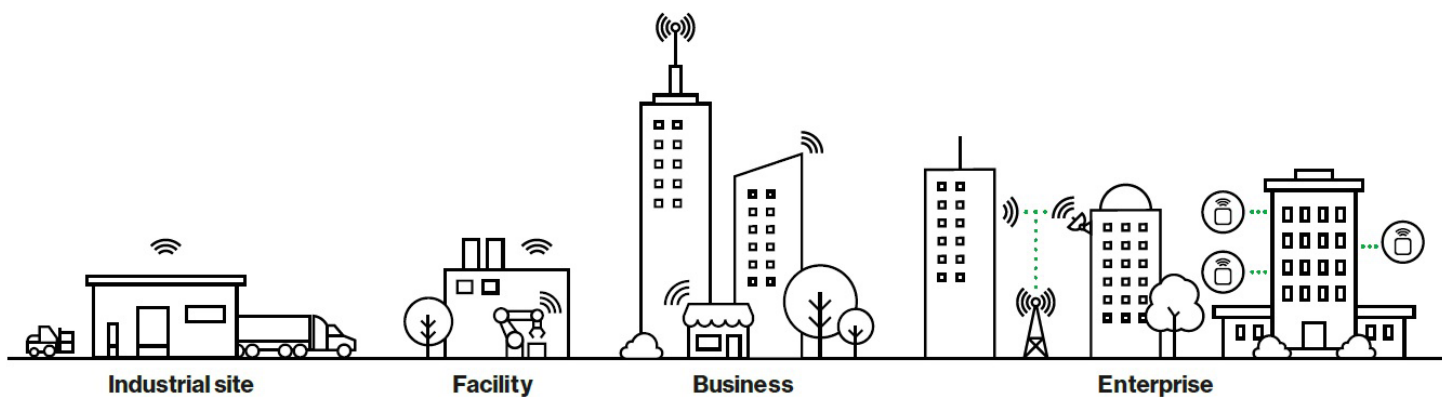
Seamless private and public network options with WiFi/LTE/5G

Low-band (< 1GHz)

Low-band's strengths seem counterintuitive – it is good for dense, indoor environments, but also for covering wide areas, making it advantageous for providing 5G connectivity to rural areas. Low-band also excels at simultaneously supporting a high volume of connected devices, providing high service reliability for high-mobility work environments. It is extremely well suited for equipment monitoring within a factory. The peak speed for low-band is approximately 200 Mbps, which is relatively slower than other 5G options.

Mid-band, including C-band (1 – 7 GHz)

Mid-band is often called "the Goldilocks band" because its balance of coverage area and speed is just right for many leading enterprise use cases. Mid-band spectrum has a wider channel size than low, which can be used to provide subscriber services through hotspot-based mobile broadband. Mid-band is an excellent option for many types of connected machines because it provides low-latency performance in urban and suburban environments. Its ability to provide fast, reliable city-wide coverage makes mid-band a popular choice for smart city applications, and for users in manufacturing, education, public services and other sectors. Mid-band is forecast to provide nearly 65 percent of 5G's total socioeconomic value according to research by GSMA, the leading global wireless industry association.[2]

C-band

If mid-band is the Goldilocks band, C-band is the sweet spot within it because it provides an outstanding balance of coverage range, interference resistance, speed and latency for many enterprise applications. In C-band Verizon has achieved 1.4 Gbps peak download speeds near active cell sites and 500 Mbps further away.[3] C-band is between 3.7 and 3.98 GHz, placing it in the middle of the overall 5G band. It was initially mostly used in Europe and Asia but the infrastructure is developing quickly in the U.S. Many of the next-generation business processes and benefits that 5G enables are expected to be run in the C-band bandwidth. For example, C-band is enabling IoT remote monitoring applications that require connectivity to connected devices and sensors spread over remote areas. In factories and distribution centers, C-band can be used in a MEC configuration to support robotics, AGVs and other intelligent equipment.

### High-band (also called mmWave, or Ultra Wideband/UWB)

Much of the original attention and hype around 5G centered on the high-band variety, which has the fastest speeds, the highest throughput and the lowest latency. The bandwidth can potentially support 1 million devices per square kilometer. It is viewed as the enabling technology for high-speed automated manufacturing and IIoT applications that aren't possible with legacy networks, next-

generation virtual workspaces to connect a remote workforce, high resolution streaming and as a fundamental component of the metaverse, both for consumer and enterprise uses.

High-band technology can do a lot and solve for many manufacturing use cases. Its great speed requires a tradeoff for range, which may be limited to 2,500 meters in dense urban environments (although range can be boosted with private network configurations). That illustrates why the total network configuration is key to 5G performance and value, not just the bandwidth. Virtual networks, fixed-wireless access (FWA) infrastructure and other components can offset range/speed limitations for high-band and other bandwidths to give each enterprise the performance it requires for its specific needs.

Besides their fundamental differences, 5G bands, even with the same category, can be further differentiated because the enterprise may use a public or private network, which may be licensed or unlicensed.

Private 5G networks are enterprise-specific 5G wireless implementations (or mmwave and/or C-band) that can be created for indoor or outdoor environments. Because they are enterprise-specific, they are segregated from public networks – cellular communication stays on premises – and can be configured to the organization's specific security and performance requirements. Controlled authorized user access and device management and the inherent privacy of on-premises networking help keep the network secure.
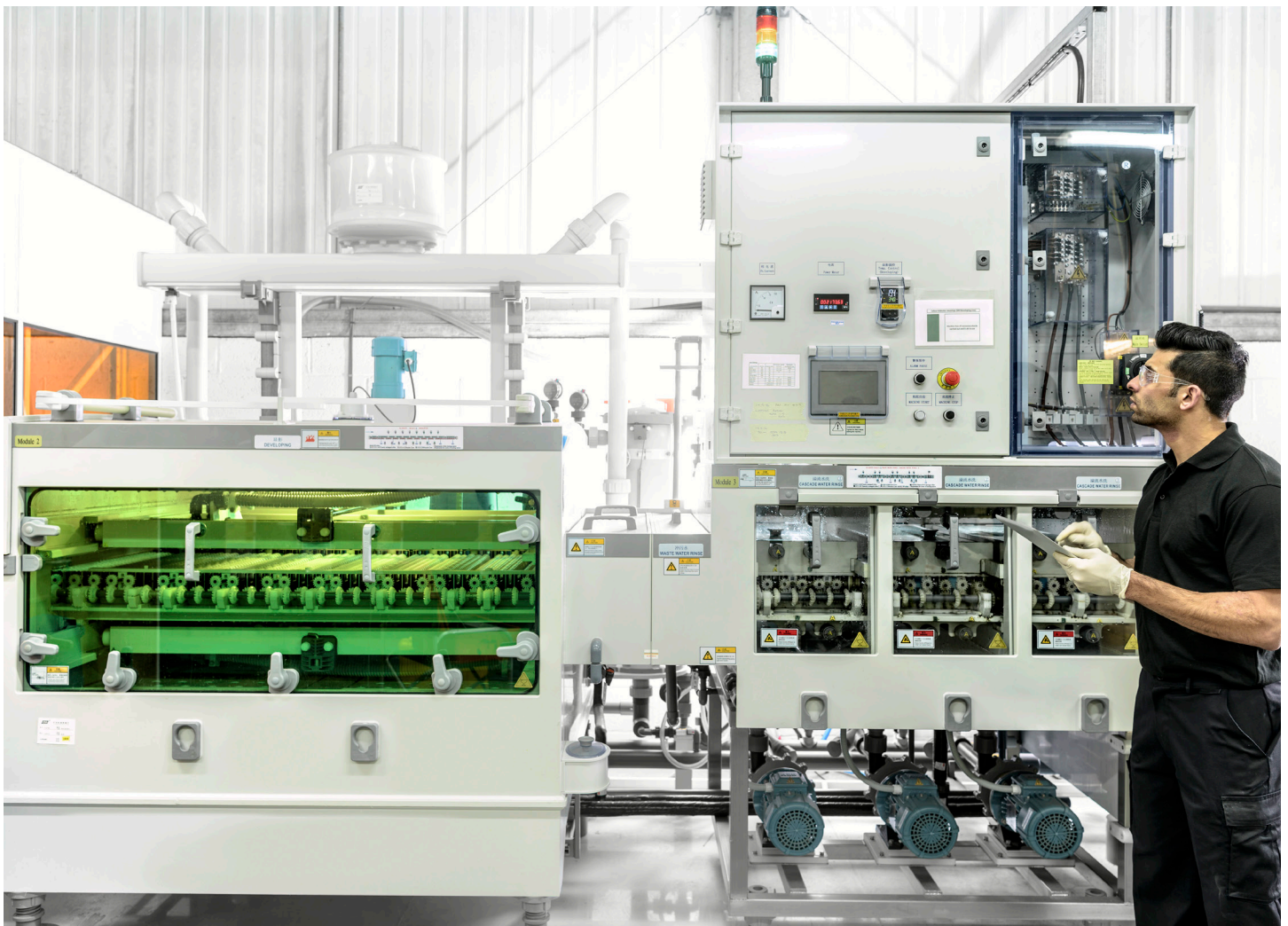
"5G fixed wireless access bring the performance and reliability of wired broadband to business operations far from the confines of the corporate headquarters and enables companies to grow and expand with fewer constraints on deployment timelines and costly infrastructure upgrades."
Jason Leigh, Research Manager, 5G and Mobile Services IDC

Private 5G networks are considered relatively easy to integrate for organizations that already have 4G LTE connectivity. They enhance organizational capabilities by providing high-bandwidth, low latency coverage that can support scaled implementations of things that many manufacturers are already using or considering, such as artificial intelligence and machine learning, virtual and augmented devices, remote monitoring, IoT devices and other networked devices.

Private networks can operate on licensed or unlicensed bandwidth. **Licensed spectrum** is dedicated for the use of the entity that holds the license, for example a telecom provider or the military. By purchasing separate spectrum licenses, Verizon and other wireless providers avoid interfering with each other's networks.

Unlicensed spectrum comes without some of the regulatory protections that apply to standard, licensed bandwidth. Although unlicensed spectrum can enable some higher performances, the lack of regulatory protections increases the risk of interference and can reduce the overall value proposition of the deployment.

In fixed wireless access (FWA) implementations clients get dedicated 5G connectivity, including a dedicated receiver. It is often used to provide high-speed connectivity where fiber or cable are impossible or impractical. FWA also reduces interferences and enables enterprises to support higher user/device densities.

This 5G spectrum overview is helpful for understanding the 5G options that are available, but not what type of connectivity you need. That it largely because there is no single right answer for most enterprises. A company is likely to need a mix of 5G, WiFi and fiber technologies to optimize operations across its office, industrial and remote operations; legacy wired and wireless network will still serve some needs effectively. When it comes to 5G, manufacturers of all sizes need a variety of configurations and specifications depending on the use cases being solved for.

Verizon's Spectrum holdings

Which 5G bands does Verizon support? All of them, plus physical fiber. We own spectrum in all 5G bands and are investing in each. The alternative would be to provide sub-optimal solutions to accommodate the bandwidth and other infrastructure we have available. That is unacceptable, so we are continuing to make these investments and commitments so that we can effectively meet our customers' needs. We also are continuing to invest in fiber, so customers can run their applications and systems anywhere and aren't forced into putting everything on one network or the other.

Verizon 5G Business Internet uses high-band and mid-band, and our 5G Nationwide service operates on low-band and uses **Dynamic Spectrum Sharing (DSS).** The DSS technology allows 5G service to run simultaneously with 4G LTE on multiple spectrum bands. With DSS, if users move outside of Verizon's 5G Ultra Wideband coverage area, their 5G-enabled device can stay on 5G technology using lower frequency bands.

Verizon is the U.S. leader in C-band and has invested more than $52 million before the end of 2022. With our continued investment, 250 million people will have C-band access by the end of 2024.[4]

All of Verizon's bandwidth offerings are available in both public and private networks.

Verizon can provide customers the connectivity they need, so they will not have to miss out on capabilities or reconfigure their ideal use cases to accommodate network technology limitations.

Verizon services and their customer benefits

5G is an integral part of an interdependent ecosystem, but there are other aspects that are significant variables to the performance and value an enterprise receives. 5G performance can be held back or get a boost from the network availability, network configuration, security and supporting infrastructure, which increasingly includes IoT and other edge devices. These and other infrastructure components and partners that the network provider brings to the table matter.

Enterprises should have a flexible network architecture that allows network functions to be configured and reconfigured dynamically in response to conditions, and that can accept new connectivity and device types over time. Adopting Network-as-a-Service (NaaS) provides that flexibility, and NaaS is an important component of

Verizon's offering. Our NaaS supports multiple technologies and assets from partners. As you've seen, Verizon supports all types of 5G plus 4G LTE networks and fiber. That enables customers to select the devices and network endpoints that are best for specific use cases (e.g. digital twins, shop-floor device monitoring, condition-based management, quality control with intelligent cameras and AI, streaming virtual reality for training and more) without having to run any on sub-optimal networks.

Private 5G

Verizon released the first U.S. private network offering. Verizon's Private 5G is a private network that combines 5G Ultra Wideband small cells with an on-premise packet core and radios. Verizon's Private 5G Network leverages the best of 5G Ultra Wideband and 4G LTE capabilities as different operational environments require, and also maintains interconnection to the organization's legacy local and wide area networks and enterprise applications. While all cellular traffic stays on-premises, Private 5G allows authorized remote user access to enterprise applications.

Private 5G Network creates a highly reliable, highly secure connectivity environment to support a massive amount of connected devices, data volume and high fidelity applications in a variety of operating environments. These are attributes that excel in Manufacturing operating environments while ensuring there are no "dead spots" for coverage, especially in comparison to 802.11 wireless deployments, which a manufacturer cannot afford to have especially when real time communications, automated robotics, quality control or safety mechanisms must remain active at all times.

MEC/Verizon 5G Edge

Multi-access edge computing puts computing, storage and network resources close to where data is produced and used. MEC implementations can be public or private. A complementary technology for 5G, public MEC provides both an IT service environment and cloud-computing capabilities at the edge of the public mobile network, within the radio access network (RAN) and in close proximity to mobile subscribers, devices, enterprises and other organizations—all with a range of networking and computing needs. Private MEC brings similar compute and storage resources together but co-locates them on the customer premises with a private, on premises 5G RAN.

Combining the RAN, compute, storage and devices on or close to the premises enables support for

the most critical and latency-sensitive applications – data does not need to be transmitted to the data center for real-time processing. The setup also improves security and provides for data sovereignty. Our partnerships with AWS, Microsoft Azure and Google Cloud enable specific 5G edge performance improvements and capabilities for their respective cloud environments.

MEC has a strong value proposition for smart manufacturing because it reduces latency in intelligent systems. That results in improved performance for things like M2M communication and AI-supported intelligent cameras that are currently being used for inspection and quality control on production lines. Edge compute infrastructure is needed to effectively orchestrate a high density of sensors and process the large volumes of data each sensor produces. MEC and 5G provide outstanding performance for AGVs and robotics in factories. With MEC, the computing power and bandwidth needed to run advanced processes can be delivered from the factory floor using legacy and/or low cost devices – manufacturers may not have to invest in more expensive smart devices with their own intelligence built in.

Security

Verizon's 5G security efforts build upon our long-held position as an industry leader. When designing our 5G network Verizon used the proven "security by design" approach, which builds in security at various levels (you can learn more in this white paper). We are a leading contributor to industrywide 5G and IoT security initiatives because security must extend beyond the network to the endpoint level, including IoT devices, sensors, smart factory equipment and other emerging endpoints. Verizon understands how to apply network scanning, anomaly detection, segregation and other security techniques across OT and IT networks to optimize protection and performance. By managing network security and hosting devices, we get valuable insights into the digital landscape. Our NaaS offering helps

organizations keep their network security up-to-date and take advantage of innovation from a recognized leader in network and cyber security.

Partners

Simply relying on the 5G wireless network to deliver the application performance needed for next-generation use cases misses the fact that the benefits of 5G can be maximized only with a holistic approach that covers work processes and infrastructure. Verizon can draw on its extensive partner ecosystem to bring together the right mix of hardware, software, network, business solution specialists and leading cloud providers to help organizations take full advantage of 5G capabilities. More than 900,000 machine-to-machine (M2M) chipsets, modules and devices have been certified for our networks.

The optimal technology mix to support each enterprise's needs for speed, scale, types of endpoints (laptops, mobile phones, IoT devices, robotics, monitored machinery, et al), coverage area and latency is a moving target. Needs will change over time, so the network infrastructure needs to be flexible. The cloud is a big driver of these changes. With each enterprise application or workload that moves to the cloud, the optimal configurations of on-premises resources, cloud.

resources and network bandwidth change. New types of endpoints, such as IoT devices, also change underlying infrastructure needs. Verizon understands this. We can deploy connectivity with speed and morph over time by starting with FWA and then deploying fiber when the time is right. We work closely with the leading hyperscalers and leaders in cloud migration, optimization, solutions and security from throughout the cloud ecosystem.

5G use cases and real-world examples

Many manufacturing concerns are already designing and benefiting from 5G-driven next-generation business processes in traditional operating environments. The UK's Port of Southampton is an example
of how 5G benefits a much different industrial environment, one that is spread across 210 acres. The port is the gateway for approximately 600,000 vehicles that are imported annually. Port services operator Associated British Ports (ABP) relied on a public 4G to run its operations across the facility, which includes 45 ship berths and four cruise terminals. Network dead zones and outages were common.

The connectivity losses forced ABP employees to manually record their activity – including the exact locations where offloaded vehicles were placed for storage – instead of recording them automatically on handheld computers. The manual operations were bad for productivity and morale, and led to data entry errors that resulted in time-consuming searches for cargo. Replacing public 4G connectivity with a private 5G network provided superior coverage and reliability. The enhanced performance and added bandwidth also give ABP flexibility to continue developing next-generation processes to raise responsiveness and intelligence throughout the organization.

> "The private 5G network gives us the ability to be creative with technology, and to really test our ability to bring new ideas and innovation through our ports," says Scott Sier, ABP's head of technology and digital experience."
> Scott Sier, ABP's head of technology and digital experience.

Die Cut Products, another manufacturer – a precision stamping and fabrication company, implemented 5G via fixed wireless access to connect people and production machinery. The company also previously experienced network outages, which delayed shipments and invoicing and hurt customer service.
The company wanted to migrate its ERP system and some infrastructure to the cloud and to expand the use of virtual machines, but needed lower latency and more reliable connectivity to have the confidence to make the move. The 5G network that was installed solved those problems while doubling the bandwidth available to users and equipment. The company now runs applications, infrastructure and voice from a single secure network, with faster performance and much more uptime than it had before.

Our white paper Giving manufacturers an edge in the digital future describes multiple use cases. It presents examples and independent thought leadership about how 5G can help manufacturers solve some of their most persistent challenges, including reducing downtime, mitigating labor shortages, raising productivity and quality, improving supply chain visibility and more.

Another white paper 5G Delivers for Transformational Applications offers more information about how 5G enhances work for people and machines, and you can learn more about additional 5G use cases here.

The future playbook for manufacturers

Manufacturers are always looking for a cost-effective way to accommodate future change. You can't start over with new network infrastructure every time more users or endpoints need to be supported or the user profiles and connected device types change. As manufacturers progress toward Industry 4.0 and make more use of IoT devices, decisions about which assets should have their lives extended and which should be replaced will become more pressing. Even before many organizations had piloted or adopted 5G, 80 percent of business decision makers said the technology would create new opportunities for their company.[5] The World Economic Forum (WEF) forecast that 5G would create $13.2 trillion in economic value between 2020 and 2035.[6] As previously noted, leaders at one in six enterprises believe they are losing more than $10 million annually because their networks can't support their desired business transformation. That is a big reason why 96 percent of those enterprises surveyed have started transitioning to Network as a Service or were planning the transformation. Factories of the future will be more connected, and will require higher performance connectivity.

Many enterprises are laying the groundwork for 5G today. Going into 2022, consulting firm EY found that 17% of enterprises had already invested in 5G and an additional 30% had plans to do so during the year,[7] which would nearly double adoption. The ability to adapt these technologies at the pace and investment level you want requires network infrastructure and a network provider that both have the flexibility to accommodate multiple types of connectivity simultaneously. NaaS is a foundation, because it enables network changes to be made rapidly without requiring a rip-and-replace approach to what is already there. NaaS lets enterprises align their goals for cloud, 5G and new business processes with their preferred timetables for pursuing them.

We've gained insight from our experience with organizations that have successfully introduced 5G, NaaS and other advanced network-based technologies into their operations. Most successful programs began with the enterprise establishing an overall plan that serves as a framework to guide decisions at every step, including what type of partners to bring in, and when. An important step to plan development is to investigate a range of 5G use cases that the enterprise could pursue and determine the potential business value each could provide. This may result in a far-reaching, very aspirational plan – it's fine if the plan is big but important to start small. Identify a pocket of your business where you can validate the use case and the outcomes, tweak and tune the program and then scale it.

The choice is yours

Many connectivity options are available—such as WiFi, 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 – including technical requirements such as network bandwidth, latency, compute power and device density.
- Privacy and compliance – considers data residency, data sovereignty, privacy and regulatory compliance.
- Availability – including spectrum availability, cost and local regulatory constraints.

These factors together lead to several choices for 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.

The next step is to perform a deployment readiness evaluation by analyzing what it will take to develop and deploy the use case. The key considerations here are capabilities and device readiness. The capabilities assessment is 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 evaluates the future readiness of the existing devices that are 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?

Why Verizon?

Verizon provides all the flexibility organizations need and all the functionality that 5G has to offer. We are the ideal partner for network and business transformation because we support all the connectivity options manufacturers need for today and tomorrow, with low, mid and UWB 5G bandwidth, 4G LTE and physical fiber plus a partner ecosystem and NaaS solutions from Verizon services to blend and scale it all seamlessly. Our 5G customers include companies in diverse industries and public sector organizations that are improving their innovation, responsiveness and reliability with our next-generation services and solutions.

With Verizon, organizations have a strategic partner. Our networks—including America's most reliable 5G network and one of the world's largest and highest performing global IP networks—are among our greatest assets. By the end of 2022 we had more than 175 million points of presence (POPs) covered by 5G services worldwide plus more than 1 million miles of fiber. Our customers 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 plus professional and managed services can connect systems from your factory floor through the supply chain to empower you to overcome the business challenges that you face. We can connect all of your ecosystems, bridging the physical and digital worlds through smart equipment, AI, digital twins and more, bringing users and applications together to achieve new levels of production quality, efficiency and business success.

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 www.verizon.com/business/solutions/industry/manufacturing/.
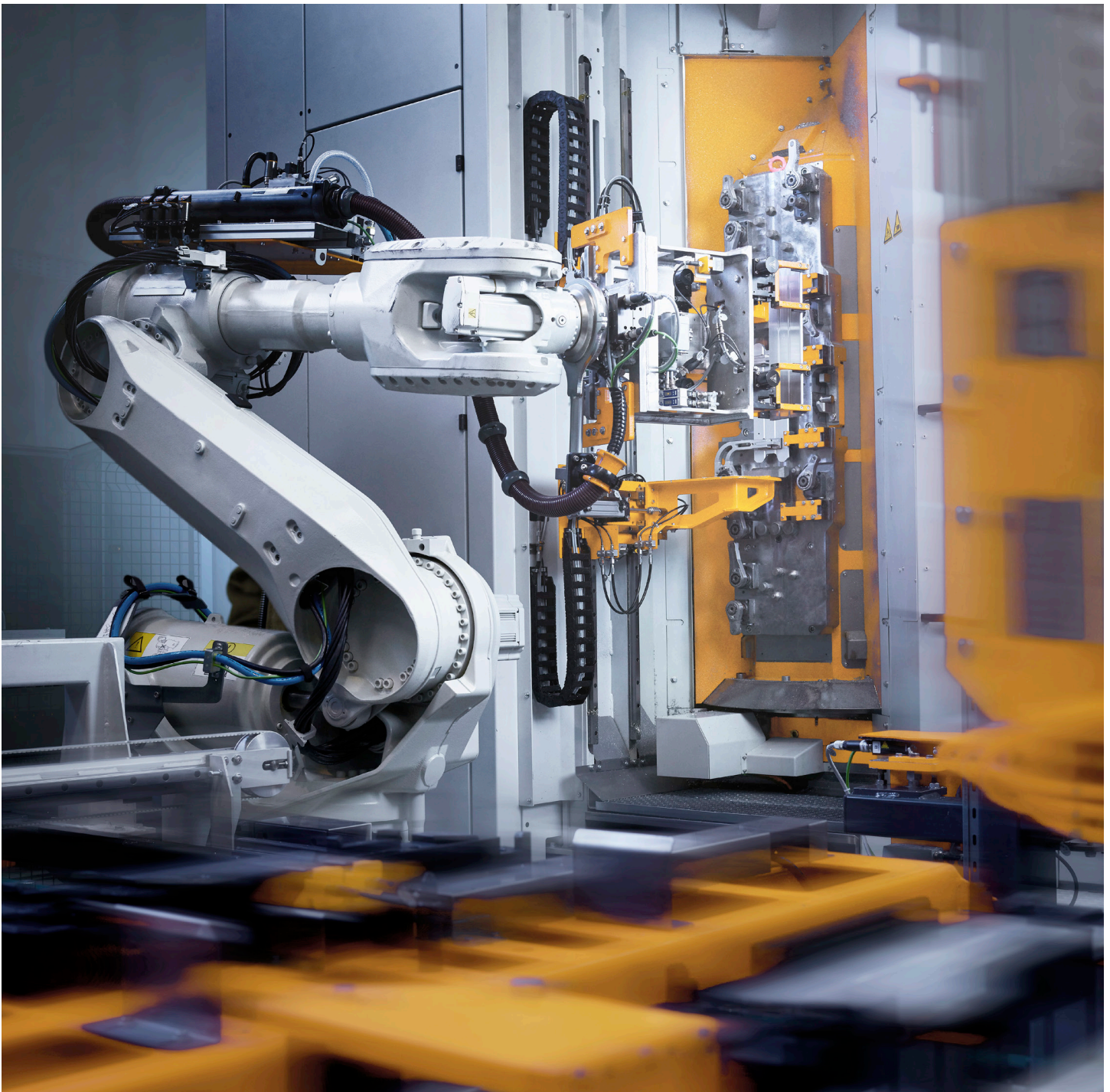
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