The big book of 5G for business

A comprehensive look at 5G and how it can benefit businesses and agencies

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Contents

01 Why you should care about 5G

Besides swapping a "4" for a "5" and being able to download Netflix movies faster, should you really care about 5G? Well, consider this: How did 4G change your life and transform entire industries?

To name a few examples, 4G turned the transportation-for-hire industry on end with Uber and Lyft. 4G fueled social media's exponential growth with the likes of Facebook, WhatsApp, and Instagram. And 4G brought educational opportunities to millions in remote areas throughout the world.

The "hype train" tells us 5G will spawn unimaginable applications. While that may be an exaggeration, most technology experts agree that 5G will be as disruptive as 4G was — at the very least.

The bottom line for organizations? **Wireless WAN** applications that are good with 4G will be great with 5G, and applications that couldn't be run with 4G are now feasible in 5G.

Pushing wireless broadband performance to unprecedented levels likely will benefit businesses even more than consumers. For instance, consider the following examples. Organizations that could only use 4G LTE for failover of its most critical traffic can now use 5G for failover of all traffic. Organizations using wireless video for facial recognition can deploy machine recognition. Firefighters who today can use cellular sensors can now have building diagrams fed into their masks, allowing them to virtually see through the smoke.

Wireless WAN
[wahyuhr-lis waan]

An organization that deploys cellular edge networking as essential WAN infrastructure (in either branch, mobile, or IoT use cases) is operating a Wireless WAN.

Table 1 offers a sample of Wireless WAN use cases by type of deployment. The list progresses top to bottom from use cases that will most commonly be deployed today to use cases that will most commonly be deployed as faster layers of 5G roll out, and as applications are developed to utilize the faster speeds.

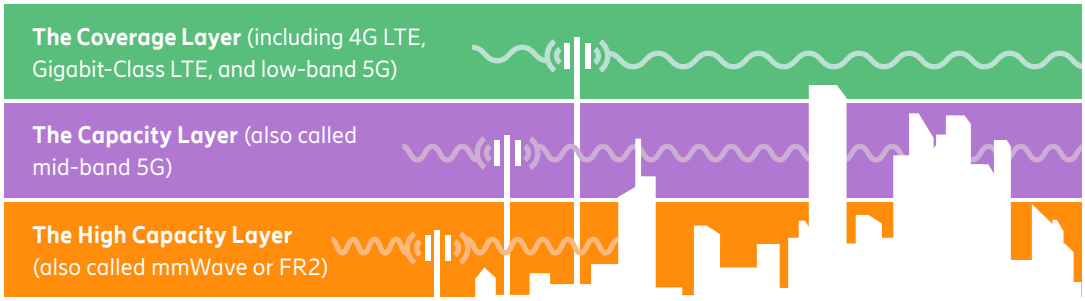
Table 1: Sample 5G use cases today and into the future

	Fixed locations	Temporary sites	Vehicles	IoT
Current ↓ Future	• Failover beyond critical traffic • Primary wireless for larger sites • Cellular SD-WAN • Fiber replacement • Industrial 4.0 with private 5G • AR-enabled marketing	• High-performance pop-up sites • Store-in-store connectivity • Proximity marketing • AR applications for temporary sites • Large event broadcasting • Mobile VR-enabled training	• Multiple in-vehicle applications • HD video streaming • Video offload • High-bandwidth command and control • Autonomous driving for agriculture • In-transit healthcare diagnostics	• Robust Smart City applications • Immersive and interactive kiosks • HD video surveilance • Proximity marketing or public saftey • AI-enabled video for public safety • AI-enabled video for marketing

02 What you should know about 5G

5G has three spectrum layers — and you will likely use all of them

Despite what you may have heard, 5G is far more than one type of spectrum. In fact, there are three spectrum layers in 5G that businesses will need to understand:



The combination of the coverage and capacity layer has also been called "Sub-6 GHz" or FR1.

Spectrum layer
[spek-truhm ley-er]

A contiguous grouping of radio frequencies that have different performance and propagation characteristics.

Each category of 5G spectrum has unique characteristics and tradeoffs. Most important to know is the tradeoff between propagation and performance in each spectrum layer. Spectrum layers with high **propagation** have lower performance characteristics while spectrum layers with low propagation have higher performance characteristics. Now let's look at the essentials you should know about each.

Propagation
[prop-uh-gey-shuhn]

The distance a radio signal can travel and the degree to which a radio signal can penetrate obstacles before losing integrity.

The coverage layer (including low-band 5G)

Since its inception, cellular service has operated in the coverage layer that uses spectrum below 2 GHz (mostly below 1 GHz). The coverage layer has strong propagation characteristics, but it has the lowest data capacity of all spectrum layers.

Today's coverage layer comprises 4G LTE, Gigabit-Class LTE, and low-band 5G technologies. In 2020, several mobile operators launched 5G services in the coverage layer and called it low-band 5G. Generally, low-band 5G has approximately the same performance as Gigabit-Class LTE. Due to propagation characteristics and low bandwidth allocation, performance is generally capped in the following ranges.

Table 2: Coverage layer practical performance

Technology:	4G LTE	Gigabit-class LTE	Low-band 5G
Download:	10-50 Mbps	50-350 Mbps	60-400 Mbps
Upload:	5-15 Mbps	30-60 ms	30-75 Mbps
Latency:	30-60 ms	30-60 ms	20-40 ms NSA, 8-12 ms SA
Propagation:	High	High	High

The rollout of low-band 5G has been rapid in many countries, including the U.S. Network operators were eager to show national 5G coverage, even with less optimal performance.

5G Standalone Core (SA)

The use of 5G cells for both signaling and information transfer. Early 5G deployments will use the 4G Evolved Packet Core (NSA) for signaling. Use of the 5G Standalone Core will provide improved network efficiency and latency performance.

Introducing the capacity layer (also called mid-band 5G)

5G introduces two new spectrum layers to cellular communications. The first is called the capacity layer and operates between 2-7 GHz. The capacity layer offers significantly more bandwidth but lower propagation than the coverage layer. This layer is most often called mid-band 5G and is where many believe the sweet spot of 5G is — mitigating the tradeoffs between performance and propagation.

Table 3: Expected practical performance of the capacity layer

Download:	250 Mbps-1.5 Gbps
Upload:	50-100 Mbps (with 5G Standalone Core: 50-350 Mbps)
Latency:	20-40 ms (with 5G Standalone Core: 8-12 ms)
Propagation:	Medium

As you can see, the capacity layer offers dramatic performance improvements over the coverage layer. You will also notice that propagation is worse than the coverage layer, but as you will see next, capacity layer propagation is still significantly better than the high-capacity layer or what is called mmWave.

Because it mitigates the tradeoffs between propagation and performance, many believe that the coverage layer is the sweet spot of cellular broadband.

In some countries, access to the capacity layer has been challenging for many operators. For instance, in the U.S., the capacity layer has been allocated to the government and other industries. In 2020 and early 2021, the U.S. government auctioned billions of dollars in mid-band spectrum licenses to mobile operators and private companies. Those operators are aggressively rolling out mid-band infrastructure.

Introducing the high-capacity layer (also called high-band or mmWave)

The second spectrum layer to be introduced with 5G is called the high-capacity layer — also called high-band 5G and mmWave spectrum, named for the actual distance between radio waves. This layer is typically identified as above 24 GHz and can carry much more data than low and mid spectrum layers.

While these higher frequencies are more susceptible to weather, structural interference, and distance, operators have discovered how to use this spectrum with new antennas, dense architectures, and beam-forming techniques. These technologies have been incorporated into the new 5G standard, and most major operators will include mmWave in their 5G rollout architecture. However, mmWave 5G will be limited to areas where line-of-site transmissions can reach denser populations.

High-capacity or mmWave 5G will roll out more slowly than the capacity layer and will initially only cover small parts of large cities. That said, the projected performance of mmWave 5G is tantalizing.

Table 4: Expected practical performance of high-band 5G (mmWave)

Download:	300 Mbps-3 Gbps
Upload:	50-200 Mbps (with 5G Standalone Core: 150-1.5 Gbps)
Latency:	20-40 ms (with 5G Standalone Core: 8-12 ms)
Propagation:	Low

Spectrum layers and the use cases of 5G

So, let's put it all together. As you may have gathered from reading the prior sections, the 5G landscape is quite diverse. This means that organizations will have some sites, vehicles, and IoT deployments in the coverage layer serviced by LTE, Gigabit-Class LTE, or low-band 5G. Organizations will have other sites in the mid-band capacity layer, or in high-band mmWave. Organizations will need to ensure that their edge networking solutions can seamlessly adapt to each technology area and to the phases of network operator rollouts.

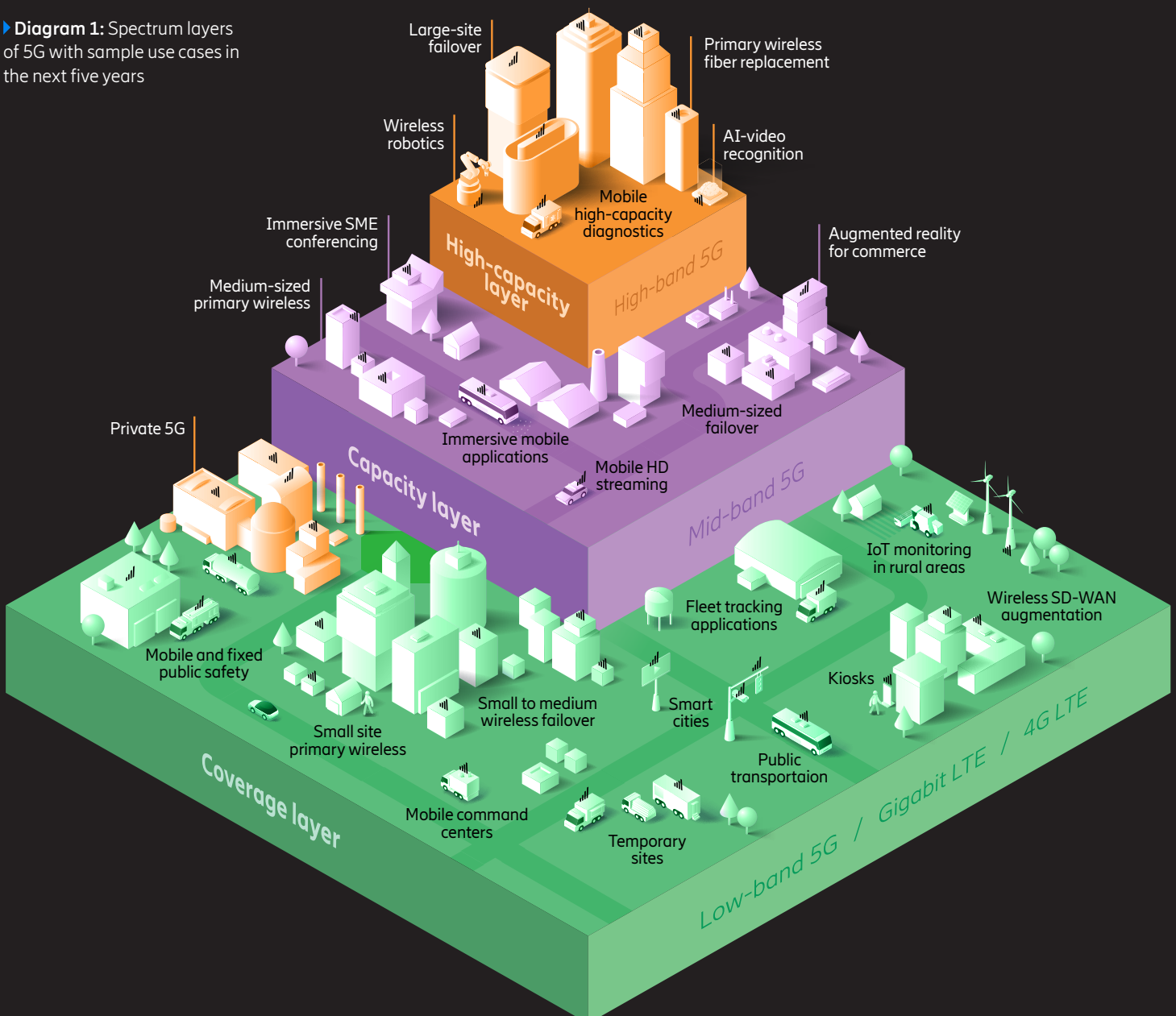
Diagram 1 shows each spectrum layer supporting the 5G landscape along with sample use cases that would fit well in those bands. Many applications will run well in the coverage layer while others require higher 5G performance.

The mid-band capacity layer requires greater densification than the coverage layer, and therefore will be less pervasive. Since the capacity layer has significantly better performance compared to the coverage layer, high-bandwidth applications will run capably.

Due to the acute densification required by high-capacity mmWave, coverage will be much smaller than other spectrum layers. Applications requiring the highest performance will be deployed in high-capacity mmWave areas.

Other applications naturally perform well in multiple spectrum bands, such as temporary sites, public transportation, and augmented reality for commerce. And some apps run in independent environments such as Private LTE/5G.

Diagram 1: Spectrum layers of 5G with sample use cases in the next five years



03 What you can do today

In the spirit of "bringing the future into the present," the full promises of 5G will not be realized without foresight and alignment of resources today. Below is a suggested planning exercise that could bring significant value to your organization.

Explore transformative use cases for a competitive edge

The recommended first step is to meet with strategic lines of businesses. Hold several sessions to look at your business from a visionary perspective. You likely will ask the following questions:

- How will our market and customers change in 2, 5, and 7 years?
- How can technology help us exploit those changes?
- What technology gaps could prevent us from seizing these opportunities?
- What role can wireless wide area networking play in these advancements?
- What steps should we take now to prepare?

After this exercise, you will want to document these directions in a technology roadmap. Then consider meeting with stakeholder groups — such as finance, marketing, and procurement — that can help turn these plans into active projects. You may consider using the matrix in chapter one of this guidebook as a starting point for potential use cases.

> "Planning is bringing the future into the present so that you can do something about it now."
>
> **Alan Lakein,** author

Meet with wireless operators to discuss plans and options

There is great value in meeting with carriers today and sharing your high-level plans. Not only will you learn more about their plans, but you can also forge valuable relationships for later deployments. At the minimum you will want to discuss:

1. Wireless broadband technology coverage for all your sites
2. Flat-rate plans and national discounts
3. How POCs might work in each of your sites

Meet with network vendors or resellers

Next, you should consider meeting with edge networking vendors or their resellers. In the early days of 5G, edge networking is the glue that makes hybrid networks run at enterprise-class levels. Similar to discussions with operators, you will want to:

1. Share plans and ask about various ways to accomplish your goals
2. Diagram solutions
3. Plan out what a POC might look like and compare to the plans suggested by your operator

04 What to consider for your next edge network refresh

The software and hardware that directly make 5G connections work are only part of what you need for a next-generation Wireless WAN.

Review VPN tunnel design

Reducing latency is a big thrust of 5G. Unfortunately, VPN tunnel latency may negate the benefits. Your IT team will want to make changes to the VPN architecture to prepare for the advantages of 5G. The team could consider architectures that avoid sending data back and forth between the edge, the cloud, and data centers. They also could consider architectures in which branches directly connect to cloud applications via TLS.

Plan for Multi-Access Edge Computing advantages

Applications that haven't been practical due to high latency may now be practical because of an element of 5G called Multi-Access Edge Computing (MEC). MEC places computing power at the edge of the cellular network to process real-time computing tasks, saving critical milliseconds. Organizations may need to work with cloud computing companies and operators to appropriately stage computing resources for ultra-low latency applications.

Consider a distributed architecture at the network edge

Unfortunately, critical tools such as firewalls, routers, IDS/IPS, and computing banks add latency to edge networks. The closer these services can move to the network's edge, and away from a centralized architecture, the better for latency.

Implement higher-throughput devices at the network edge

With the possibility of multi-Gigabit speeds, it would be a shame if network edge devices were limited by their interface speeds and CPU capabilities. As organizations look to refresh their edge infrastructure, they should consider minimum interface speeds of 2.5 Gbps. Processors should be able to run full services and broadband speeds well over 1 Gbps to best prepare for the future.

Increase core network bandwidth

It stands to reason that if the edge is significantly growing its capacity, the core of the network will experience a multiplying effect. Backbone infrastructure changes take time, so planning ahead will be important.

05 The future of 5G

5G is poised to reshape our digital landscape like never before. Beyond being just another upgrade in the connectivity realm, 5G represents a leap forward that can change how enterprises operate and bring us closer to a world of seamless, lightning-fast communication.

Many of today's businesses need data transmitted without delays or interruptions and can benefit from various 5G functionalities, such as network slicing — a network architecture that enables virtualized networks to operate on the same physical network infrastructure.

What is 5G network slicing?

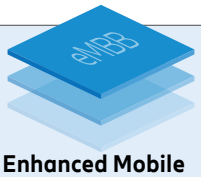
Virtual network slices are like tailor-made suits for connectivity. Just as a bespoke outfit is crafted to fit your body perfectly, these slices customize network resources to match the specific demands of applications — all from the same underlying infrastructure.

5G network slicing

Network slices are virtual networks that operate on top of shared 5G infrastructure and are available only on 5G networks with a standalone core. Each virtual network or "slice" is optimized for a defined business purpose by tailoring throughput, latency, speed, reliability, security, and more.

This enables the network to support a wide range of services with varying needs, from high-speed consumer Internet to critical applications like autonomous vehicles and industrial automation. For example, applications of critical nature, such as operational and navigation systems, might be placed on a low-latency slice to which the carrier allocates priority resources to. The carrier may charge a premium for this kind of service, offer an SLA (service level agreement) to accompany the service, and charge less for a slice set up as a best-effort service. The initial network slices will likely follow the original recommendations of the 5G standard.

Available network slices include:

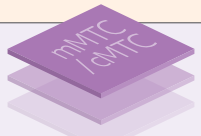


Enhanced Mobile Broadband (eMBB)

Tailored for use cases requiring high throughput and low latency, the eMBB slice enables mobile video streaming and broadcasting, in-car entertainment, mobile gaming, and social networking from user devices in dense areas.

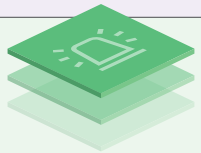
Ultra-Reliable Low Latency Communications (URLLC)

Designed to meet strict requirements for reliability, availability, and ultra-low latency, URLLC slices support autonomous vehicles, AR/VR, mobile robots, and remote-control applications.



Massive or Critical Machine Type Communications (mMTC or cMTC)

Reserved for low-cost, long-life IoT devices, mMTC or cMTC slices are designed for transmitting or receiving small data volumes, including applications like meters, sensors, trackers, and wearables.



Public safety

Built for government and public safety agencies, these slices enable reliable, high-bandwidth connectivity for push-to-talk communications, IoT operations, and remote monitoring feeds.

To support unique business needs, each slice can be further divided. Carriers can develop custom slices including a default slice for best-effort traffic.

The evolution of 5G

Looking ahead, carriers will begin to increase the performance characteristics of 5G beyond just using different spectrums. The standard approach will be through carrier aggregation — a technique that involves combining multiple carriers into a single channel for better network capacity. Although predominantly used to increase 4G speeds, carrier aggregation is expected to gain widespread use for bolstering 5G's performance.

Carriers will also look to increase uplink speeds more than in the past as 5G continues to evolve. Traditionally, emphasis has been placed on optimizing downlink speeds. But with the proliferation of applications requiring faster upload speeds, such as interactive video and autonomous functionalities, ensuring these connectivity needs are met is imperative.

As the 5G landscape changes over the next few years, it's important to stay informed about changes not only by reading technology news, but by staying close to best-in-class vendors, resellers, and operators who can help you prepare for the future. For more information on 5G edge network solutions, go to **cradlepoint.com**

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