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The 5G for Business Guidebook

A Guide for Finding the Best 5G Fit for Your Organization

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Cradlepoint 5G Strategy Group

Version 3

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.

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

	FIXED LOCATIONS	TEMPORARY SITES
Current	Failover beyond critical traffic	High-performance pop-up sites
	Primary wireless for larger sites	Store-in-store connectivity
	Cellular SD-WAN	Proximity marketing
	Fiber replacement	AR applications for temporary sites
	Industrial 4.0 with private 5G	Large event broadcasting
Future	AR-enabled marketing	Mobile VR-enabled training

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 [wahy*uhr*-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.

VEHICLES	IoT
Multiple in-vehicle applications	Robust Smart City applications
HD video streaming	Immersive and interactive kiosks
Video offload	HD video surveillance
High-bandwidth command and control	Proximity marketing or public safety
Autonomous driving for agriculture	AI-enabled video for public safety
In-transit healthcare diagnostics	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 Coverage Layer (including 4G LTE, Gigabit-Class LTE, and low-band 5G),
- The Capacity Layer (also called mid-band 5G)
- The High Capacity Layer (also called mmWave or FR2).

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

Spectrum Layers [spek-tr*uh*m 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-sh*uh*n]

> *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.

Practical Performance	4G LTE	Gigabit-Class LTE	Low-Band 5G
Download:	10-50 Mbps	50-350 Mbps	60-400 Mbps
Upload:	5-15 Mbps	30-60 Mbps	30-75 Mbps
Latency:	30-60 ms	30-60 ms	20-40 ms NSA 8-12 ms **SA**
Propagation	High	High	High

Source: Cradlepoint 5G Strategy Group

5G Standalone Core (SA) [stand-*uh*-lohn kohr]

> *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.*

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.

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.

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 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.

Expected Practical Performance of High-Band 5G (mmWave)

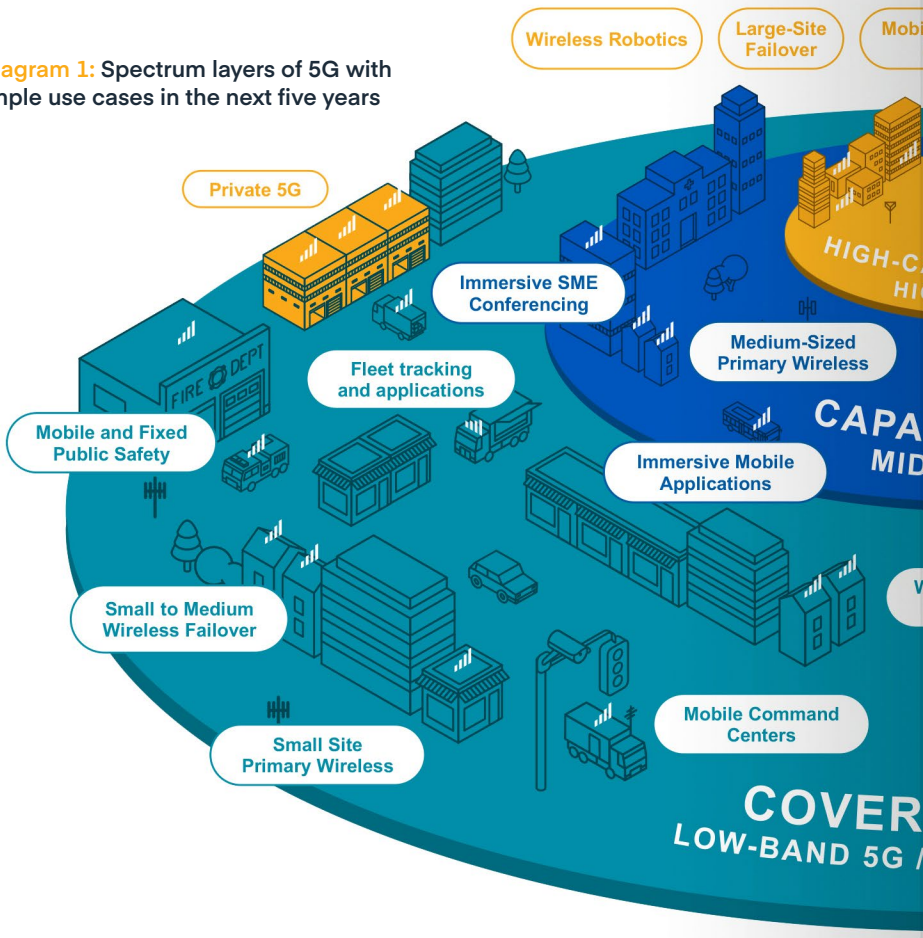
Download:	300 Mbps-3 Gbps
Upload:	50-200 Mbps (with 5G Standalone Core: 150 Mbps-1.5 Gbps)
Latency:	20–40 ms (with 5G Standalone Core: 8-12 ms)
Propagation	Low

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.

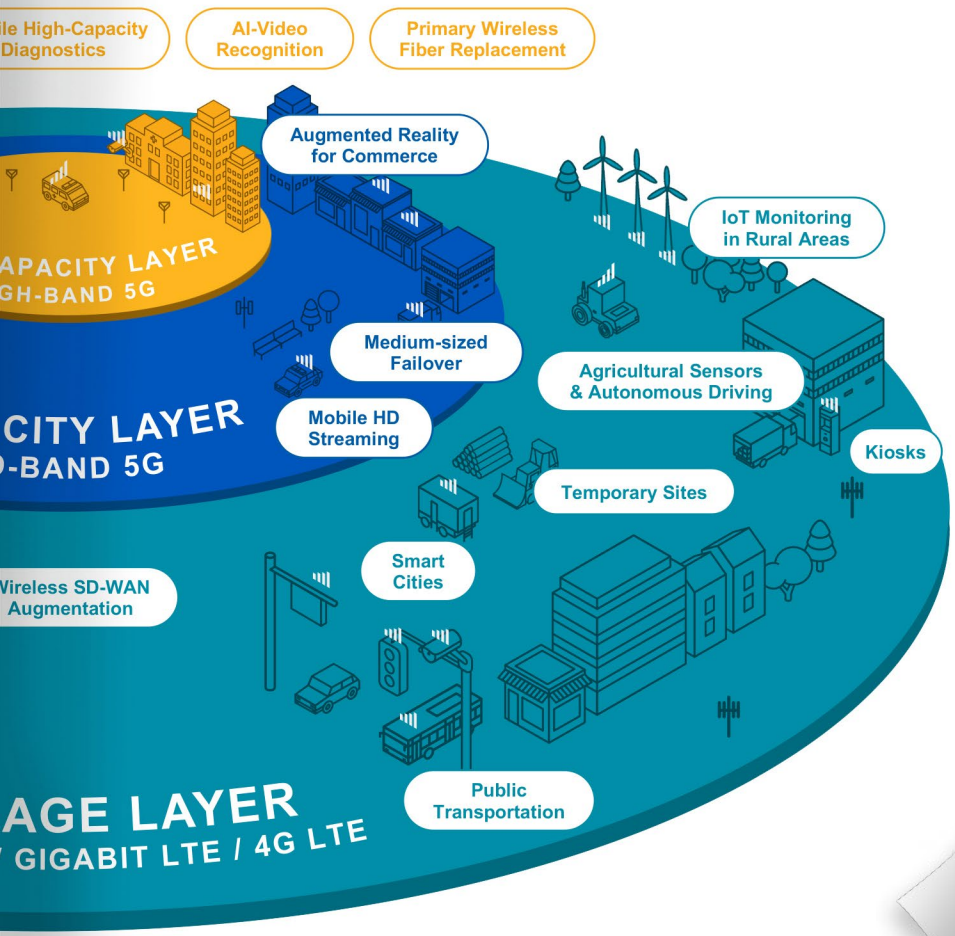
Diagram 1: Spectrum layers of 5G with sample use cases in the next five years



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.



03 Find Your 5G

Your organization may be eager to start experiencing the benefits of 5G, but where do you start? With different circumstances at widely distributed, diverse locations, the right type of 5G will vary from one deployment to the next. For each site in your network, you will want to find the right solution for the right situation — and manage them on the same platform and at scale. Here are some scenarios that will help you find the 5G deployment that is best for you.

UTRA-NR Dual Connectivity (ENDC), or Just Dual Connectivity [doo-*uh*l kon-ek-tiv-i-tee]

> *A capability where 5G modems simultaneously establish both a 5G and a 4G connection — both connections actively pass traffic. For instance, if the 5G signal starts to weaken, the LTE connection continues to pass traffic. This capability only applies to the non-standalone core.*

The current generation of 5G modems has an important capability called **dual connectivity** that will help seamlessly transition the 4G network to 5G. Per the definition above, the 5G module contains both a Cat 20 LTE modem and a 5G modem simultaneously passing traffic. Although this capability provides better connection integrity and throughput, the real value is that an organization can deploy a 5G adapter or router today in the coverage layer and lean on the Cat 20 LTE modem to pass most of the traffic. Then within the product's lifecycle, a faster mid-band and high-band service will likely roll out in their area, and the organization can immediately benefit from the higher-performing service.

Situation: What if only the coverage layer is available?

Due to the global pervasiveness of 4G LTE, the rapid rollout of Gigabit-Class LTE, and the timing of capacity layer licenses in some countries, organizations may find that coverage layer services are the most available cellular services for many of their fixed or vehicle locations. Should an organization wait for the capacity and high-capacity layers to reach their locations, or are there other options?

The case for deploying 5G routers and adapters in the coverage layer today

Typical WAN infrastructure has a life cycle of 3-7 years. Mobile operators across the globe have made significant investments in capacity layer licenses, and they are eager to start earning a return on their investment. This means there is a high likelihood that the capacity layer will roll out during the life cycle of a cellular networking solution.

The capacity layer is expanding fast and will likely be available over the life cycle of a cellular networking solution.

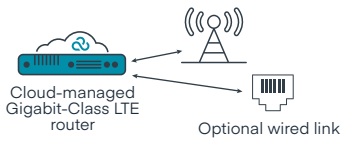
Because of dual connectivity, organizations that deploy 5G solutions in a coverage layer today can immediately experience the performance of a Cat 20 modem coupled with a 5G modem. Then, the moment that 5G capacity-layer service is turned up, it will automatically connect and the performance will significantly increase. The advantage of this case is that the company meets future-proofing company standards and simplifies capital planning. Further, the organization gets the opportunity to understand the nuances of 5G in the low-band layer and can take immediate advantage when capacity-layer 5G rolls out.

Deploying 4G routers in the coverage layer today, then adding 5G adapters later

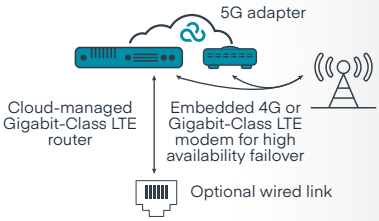
Whether for in-vehicle or fixed locations, another strategy an organization can consider is deploying 4G routers today. Then add 5G adapters later when the appropriate layer of 5G service is available. As shown in Diagram 4, there is a lot of flexibility in how the solution can be architected. After the 5G adapter is deployed, the 4G modem can be used as a supplemental link or failover modem.

Diagram 2: Gigabit-Class LTE / 5G Deployment

Now: Deploy Gigabit-Class LTE Today



Later: Add 5G Adapter



The advantage of this direction is that the organization deploys solution elements in step with the service delivery. Organizations should ensure that the routers they will be adding 5G adapters to are ready to handle the requirements of 5G.

Situation: What if capacity layer (mid-band) services are available?

If capacity-layer services are available in your area, you should consider using it for wireless failover, as an active link, or for all-wireless broadband.

If an organization has locations that are already in the capacity layer and their use cases require the performance of mid-band, here are some factors that they should consider.

Indoor or outdoor?

While significantly better than mmWave, capacity-layer services may have propagation challenges. Since most in-vehicle deployments use an external antenna with a short run to the router, the issue of indoor vs. outdoor is moot.

Fixed sites may need to use an external 5G adapter to get the full strength of capacity-layer 5G. Using an adapter versus an external antenna ensures no signal loss between the adapter and the router.

In some cases, the reception will be strong enough indoors that the deployment will not require an outdoor adapter. The deployment may only require an indoor router with an embedded 5G modem or an indoor 5G adapter.

Adjunct or all-in-one?

An adjunct solution means that the 5G adapter is connected to any router with the port size and processing power to handle the higher speeds of 5G. The advantage of an adjunct solution is that there are many options for the router.

An all-in-one solution means that an enterprise-class router has an embedded 5G modem or can recognize a 5G adapter as an embedded modem. The advantage to an all-in-one solution is that the number of devices to be managed is cut in half, and one platform manages the router and the modem.

Situation: What if high-capacity (high-band or mmWave) services are available?

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.

If an organization is fortunate enough to have locations in the high-capacity layer, it can access the fastest cellular speeds on the planet.

Although use cases for vehicles will initially be limited, the use cases for IoT and branches will be numerous. In many locations, mmWave services will rival fiber performance — but with the flexibility of wireless. Because of its low propagation characteristics, 5G mmWave services will always be exterior deployments, and organizations will need to build professional installation into their deployment plans.

04 What You Can Do Today

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

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.

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

05 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.

5G Executive Briefing

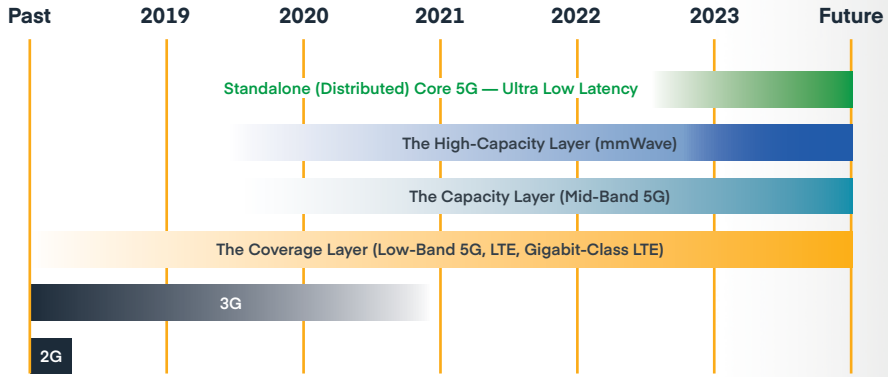
Cradlepoint offers a personalized half-day 5G executive briefing to help your organization understand and begin to develop strategies that take advantage of 5G. The facilitators are seasoned telecommunications veterans. Many are from the large wireless operators, have participated in the 5G working groups, and have been involved in early 5G network trials. If your organization is interested, please visit this link to request a workshop:

cradlepoint.com/5g-workshop

06 Looking Forward

As with any disruptive technology, the early years of 5G will be transitionary as operators build out their networks and react to consumer and business demand. In Diagram 3, the Cradlepoint 5G Strategy Group provides estimates of average global operator rollout timeframes. As you can see in Diagram 3, rolling out capacity and high-capacity spectrum layers will take several years. In particular, deploying mmWave 5G line-of-sight towers will be a monumental undertaking. Gigabit-Class LTE will quickly replace 4G LTE as the 4G technology of choice in most markets. 2G and 3G will be phased out, and their spectrum will be re-farmed for 5G.

Diagram 3: Estimated global 5G rollout timing



Source: Cradlepoint 5G Strategy Group, 2019

During this transition, some organizations may be inclined to hold back and wait for more clarity. However, those same organizations may regret their position in a few years when competitors roll out new technologies and applications and rapidly gain significant competitive advantage.

As the 5G landscape changes over the next few years, 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/5G**

About Cradlepoint

Cradlepoint is a global leader in cloud-delivered 4G and 5G wireless network edge solutions. Cradlepoint's NetCloud™ platform and cellular routers deliver a pervasive, secure, and software-defined Wireless WAN edge to connect people, places, and things — anywhere. Many businesses and government agencies around the world, including many Global 2000 organizations and top public sector agencies, rely on Cradlepoint to keep mission-critical sites, points of commerce, field forces, vehicles, and IoT devices always connected. Cradlepoint was founded in 2006, acquired by Ericsson in 2020, and operates today as a standalone subsidiary within Ericsson's Business Area Technologies and New Businesses. Cradlepoint is headquartered in Boise, Idaho, with development centers in Silicon Valley and India and international offices in the UK and Australia.

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