5G: Crossing the Generational Divide

Introduction

The hype surrounding fifth-generation wireless technology, or 5G, seems to have reached a fever pitch. The promise of faster download speeds, greater data capacity, and significantly lower latency (response time) could be the foundation of future innovation across the telecommunications and technology value chains. Throughout the last decade, advances in 4G wireless technology have driven the proliferation of smartphones, social media platforms, and the growing digital economy. 5G is expected to be the next evolution of wireless technology, building upon previous generations to meet the projected expansion of data demands in the global economy.

In this issue of *Strategy Insights*, we:

- provide a brief history of wireless generations;
- define the key basics of 5G;
- separate the reality from the hype;
- discuss the United States and its place in the global 5G race; and
- explore the potential implications of the technology from an investment perspective.

We are not trying to pick winners and losers on an individual company basis; rather we are looking across broader industry groups to understand which ones may benefit as 5G becomes a reality.

We believe the investments needed to build the wireless network to support 5G may prove beneficial for multiple industries across the Communication Services and Information Technology sectors. However, this spending is likely to take place over several years and may bring risks, such as higher-than-expected costs and increased regulatory hurdles. Therefore, we do not see 5G as a silver bullet for any one company or industry. As we understand the opportunities and risks for each industry, we look for the most advantageous way to position client portfolios for 5G. For example, we are actively looking for ways to increase exposure to the fastest-growing segments of the Real Estate sector, such as the tower operators and data center companies that could benefit from the infrastructure and data expansion that will likely accompany 5G.

As we were writing this paper, both the global economy and markets were buffeted by the worldwide spread of the COVID-19 pandemic. We recognize the crisis could affect the rollout of 5G since the pandemic is likely to influence capital spending decisions for many businesses and industries. However, the crisis has also brought about significant changes in behaviors for both consumers and enterprises in a very short time. Ultimately, these behavioral changes may increase the need for a more robust 5G network as e-commerce and telecommuting become more prevalent.

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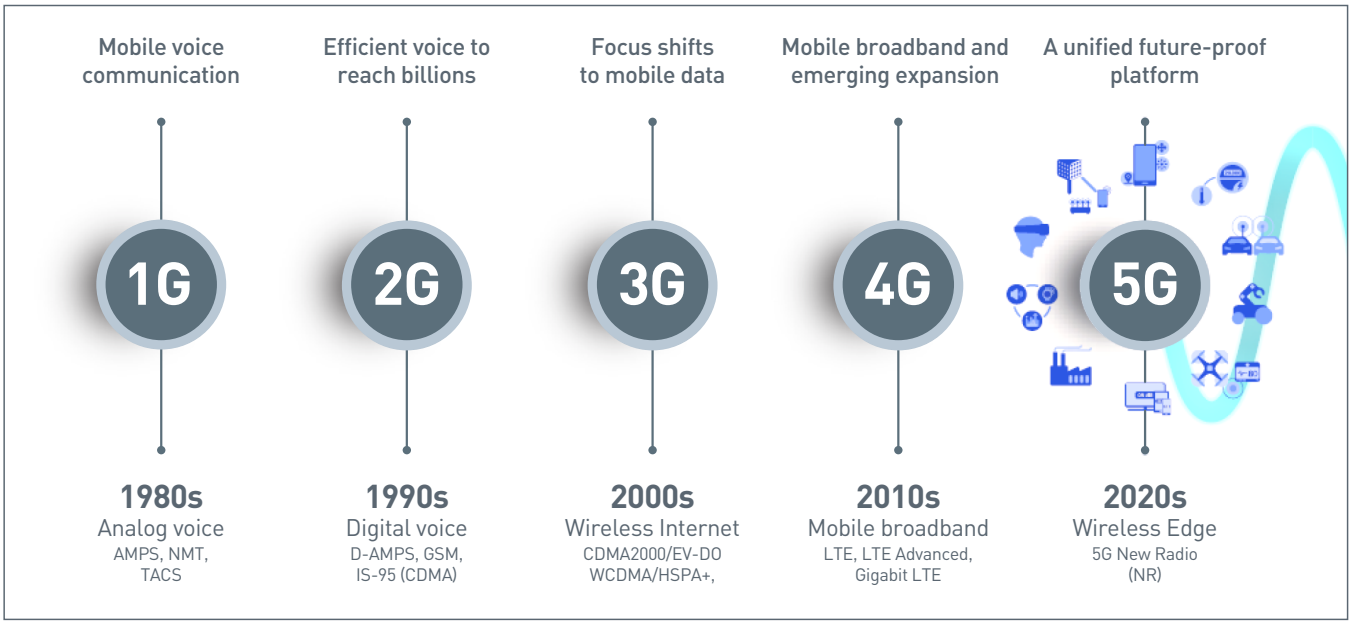
Brief History of Wireless Generations

Historically, wireless telecommunication advances (that is, a new generation) have occurred about every 10 years. This evolution of technology has been an incremental process with each new generation building upon the last to meet the growing data demands that can strain existing network infrastructure (Chart 1). Mobile communication began with the first wireless generation (1G) in the 1980s that enabled only mobile voice calls using analog technology. Today, 1G has been completely phased out across the globe. In the early 1990s, 1G was replaced by 2G as digital technologies supplanted analog systems, which drastically improved wireless voice and data transmission. 2G offered a more secure and reliable communication channel along with higher data capacity, better sound quality, and specialized services such as caller ID and the first-ever text message in 1992.[1] An additional benefit of 2G systems was the ability for seamless roaming.

In the 2000s, 3G offered improved talk and text quality, including video calling and higher data transmission speeds, allowing for wireless internet services. The capabilities of 3G wireless technologies provided access to global positioning systems and spawned the Apple iPhone in 2007 and the App Store in 2008. By 2010, after significant infrastructure investment, 4G mobile networks were launched with 10 times (x) faster download speeds, enabling all 3G services in addition to high-definition mobile TV, video streaming/conferencing, and cloud computing. 4G served as the foundation of the smartphone revolution, allowing for the proliferation of the application (app) culture. The cell phone evolution was completed; cell phones went from simple devices used to make phone calls to full multimedia platforms.

The amount of internet traffic between 2018 and 2024 is forecasted to be 4x the aggregate amount prior to 2018, helping to drive the projected explosion of data. To service these growing demands, 5G wireless technology promises to provide download speeds 200x faster, upload speeds 100x faster, and with just one-tenth the latency of existing 4G networks.[2]

Chart 1
Mobile Has Made a Leap about Every 10 Years



Source: QUALCOMM Inc., PNC

[1] "The First Text Message Celebrates 25 Years," December 4, 2017, https://www.npr.org/2017/12/04/568393428/the-first-text-messages-celebrates-25-years.

[2] OECD, "The Road to 5G Networks," July 11, 2019, https://www.oecd-ilibrary.org/docserver/2f880843-en.pdf?expires=1583336484&id=id&accname=guest&checksum=27BF0127EABCEA16F0750514F99E68BF.

5G networks are expected to bring significant enhancements to three critical areas of wireless networks: speed, capacity/bandwidth, and latency. While the rollout of 5G worldwide started in 2019, adoption is expected to ramp up over the coming years as the number of connected devices significantly pressures existing network capacity. Current estimates see mobile internet users approaching 5 billion by 2025 from 3.6 billion in 2018,[3] a growth rate of nearly 40%.

Key Basics of 5G

What Makes 5G So Different?

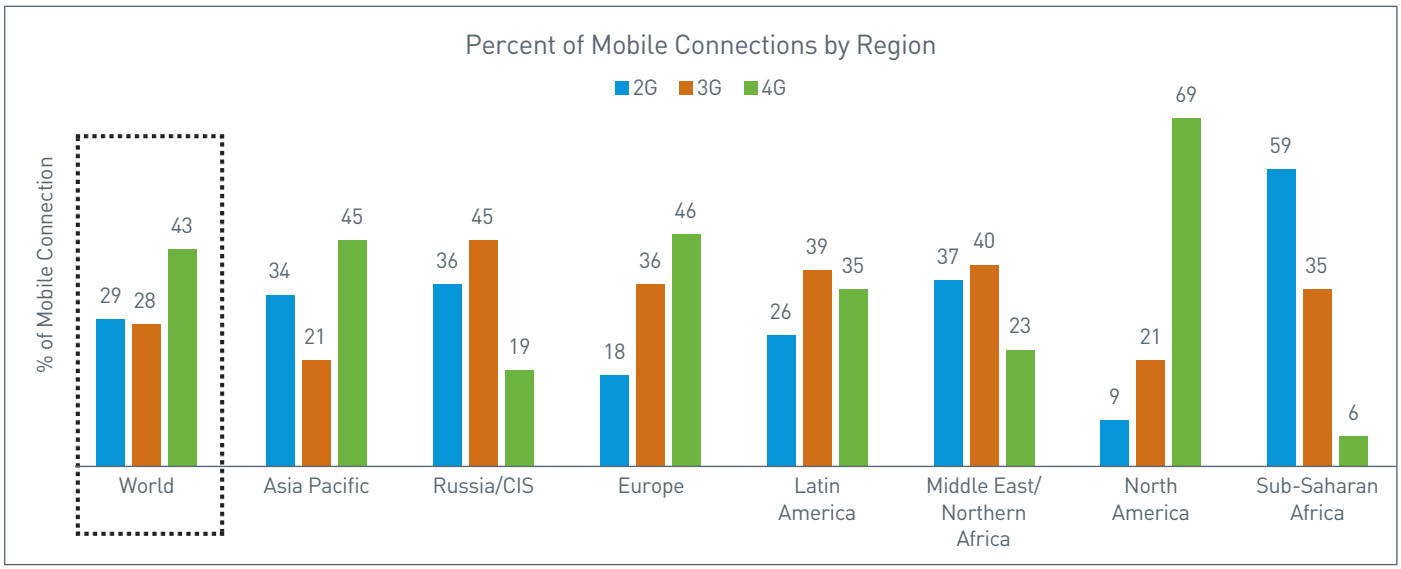
The Federal Communications Commission (FCC) defines 5G spectrum in four bands:

- low-band between 600MHz and 900MHz (sub-6GHz);
- mid-band between 2.5GHz and 4.2GHz (sub-6GHz);
- frequencies above 24GHz (millimeter Wave, or mmWave); and
- unlicensed spectrum.

US telecommunication service providers are expected to deploy licensed spectrum across both the sub-6GHz (both low-band and mid-band) and mmWave frequencies, each with benefits and drawbacks. mmWave may be up to 50x faster than 4G but has a more limited distance range, and coverage is currently limited given the lack of infrastructure to support the service. mmWave will require a dense cellular base infrastructure, using small cell antennas, to maximize its capabilities. Deployment of this small cell infrastructure is expected to be methodical and require significant investment. Another drawback of mmWave is its inability to penetrate objects such as buildings or trees.

While low-band sub-6GHz is robust and can travel long distances, including penetrating walls and windows, it is not faster than 4G. Alternatively, mid-band sub-6GHz has download speeds only up to 5x faster than 4G but with a reasonable coverage area, and it works indoors. Both sub-6GHz bands can operate effectively with a less dense cellular base deployment. While the faster speeds, increased capacity, reduced latency, and improved reliability are all advantages of 5G compared with 4G systems, the buildout of this network will likely take years and initially will build off of existing 4G networks. Once rolled out, however, 5G is expected to enable services including autonomous vehicles, electronic health

Chart 2
Breakdown of the Mobile Economy



Source: GSMA

[3] GSMA: The Mobile Economy 2019, https://www.gsma.com/r/mobileeconomy/.

services, augmented/virtual reality, and many other mobile data-intensive services that have yet to be developed.

Mobile Adoption by Wireless Generation

As of 2018 (latest data available), connections over 4G networks made up 43% of all global mobile internet traffic (Chart 2, page 3). While the transition to 5G is expected to accelerate in the coming years, 4G is anticipated to remain the dominant wireless network, with connections estimated to climb to 59% of global wireless traffic by 2025. Somewhat surprising to us, on a global basis 2G mobile traffic, at 29%, remains slightly larger than 3G's 28%. This is largely driven by frontier markets across the Sub-Saharan Africa and Asia-Pacific regions, where the transition to advanced wireless generations has been slow. However, current forecasts call for 2G networks to decline rapidly to about 5% by 2025.

Citizens Broadband Radio Service

Traditionally, 80% of smartphone data usage occurs indoors,[4] with the majority of users accessing a wireless fidelity (Wi-Fi) connection as their primary entry point onto a fully public (requiring no password) or private (password required) network. However, with the coming increases in mobile data demand 5G will enable, many existing Wi-Fi networks are simply not equipped to handle the millions of devices that will need a wireless connection.

With Wi-Fi, a router enables an internet connection to nearby devices using a radio frequency rather than wires. Any wireless-capable device within range of the signal can connect to the Wi-Fi network and interface with the internet and other devices across that network. Since Wi-Fi hardware is generally inexpensive and operating expenses are low, it has traditionally been the go-to option for homes and businesses. However, extending these networks can be costly and complex; therefore, many businesses are seeking an alternative solution.

***Spectrum** relates to the radio frequencies allocated to the mobile industry and other sectors for communication over the airwaves.*

As a solution to these increased demands, in 2015 the FCC opened access to a 150MHz wide segment of the 3.5GHz wireless **spectrum** called the Citizens Broadband Radio Service (CBRS). Previously only available to the US Department of Defense, this band will support "progressed cordless solutions, like 5G," according to FCC Chairman Ajit Pai. Access to CBRS will allow a company to create and manage its own private 5G or Long Term Evolution (LTE) network fully customized to its services. Relative to current Wi-Fi networks, CBRS offers greater coverage, increased security (data are encrypted and authentication is required), and much higher speeds. Importantly, because CBRS is public spectrum, it enables wireless carriers and companies with short latency requirements to deploy a limited coverage, 5G network without the costs of having to bid for full spectrum licenses, in theory keeping cost low and making it scalable (Table 1).

Table 1
Wi-Fi versus CBRS

Wi-Fi	CBRS
Supports Wireless Local Area Network (WLAN)	Supports LTE, 5G, WiFi, and other networks
Shared, unlicensed band	Not shared, licensed band
Requires several access points	Requires neutral host
Data generally not encrypted	User identities authenticated and data encrypted
More expensive to scale	Less expensive to scale

Source: PNC

[4] "Inside Small Cells: A Guide to Mission-Critical Communication," Cisco, https://www.cisco.com/c/dam/en/us/solutions/collateral/service-provider/small-cell-solutions/smallcells-infographic.pdf.

A defining feature of 5G networks, including CBRS, is the ability to divide the spectrum by tiers, which allows the unused parts of the spectrum to be shared for commercial use. This is what enables the greater data capacity of 5G. The shared spectrum in CBRS is prioritized by three user tiers: incumbent users, Priority Access License (PAL) users, and General Authorized Access users (Chart 3). In this model, a Spectrum Access System helps achieve the most efficient use of spectrum by protecting incumbent users (such as US military radars and fixed satellite stations), offering Tier 2 access to licensed users who have purchased PALs at auction, and allowing general access to any remaining spectrum.

What's Going to Be the Killer 5G App?

The advancement to the 3G network in the 1990s ushered in the use of apps. Apps have become easier to use with the buildout of the current 4G network and its advanced speeds. As one example, ride-share apps such as Lyft and Uber have become a way of life for millions of people worldwide. However, these services and a host of other apps arguably would not be around without the network speeds of 4G. The question arises, what will be the killer 5G app(s) 5 or 10 years from now? Our short answers are: we don't know yet, and there likely won't be just one!

As the 5G upgrade progresses, we will surely marvel at the faster speeds, greater data capacity, and lower latency that enable our current technologies to work even better. However, it will also make possible the technologies that are just now on the precipice of becoming reality and will undoubtedly allow a host of future innovations that many of us cannot even conceive of yet. Remember, 4G was not built for ride sharing, but rather this service came about because of the capabilities 4G offered. 5G provides better "pipes" for our digital world so that our best and brightest entrepreneurs, innovators, and technology companies can drive forward with new use cases that are not part of our current lexicon.

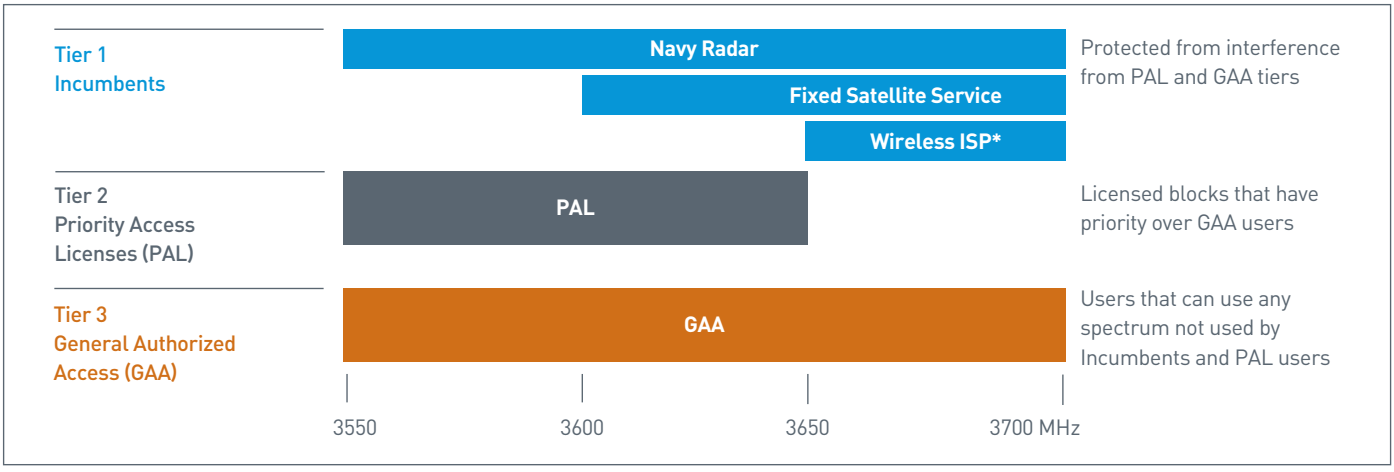
While we may not be able to envision all the killer apps that could shape the future, there are several interrelated technologies that may not be able to reach their full potential without 5G technology. Cloud computing, the internet of things (IoT), artificial intelligence (AI), machine learning (ML), autonomous vehicles, augmented reality (AR), and virtual reality (VR) are just some of the current technologies we expect will become more mainstream over the next several years. However, these megatrends will depend on 5G to reach their full potential.

Separating the Reality from the Hype

What Is IoT and When Is it Coming?

The concept of IoT is not a new phenomenon, but it has been more of a distant reality until now. 5G's

Chart 3
Tiers of CBRS



**Wireless ISPs to transition to Tiers 2/3*
Source: PNC

unprecedented jump in speed and data capacity should allow for IoT to become both an economic and technological reality. So what is IoT, and why do we need it?

Simply put, IoT is the concept of integrated connectivity across all digital devices. It is an ecosystem of connected "things" which enables more seamless and essential relationships: people to people, people to machines, and machines to machines. The concept can be as straightforward as turning on a light through your smartphone or using voice control to adjust the master bedroom temperature. More complex uses would include smart grid management for entire cities or automation across connected factory processes. The idea is fairly simple — place a sensor on every device, creating a fully connected network of "things." But the potential outcomes are close to limitless once the reality of a robust 5G wireless network is fully implemented.

The International Data Corporation (IDC) estimates there are currently more than 25 billion internet-connected devices globally. That number is expected to increase significantly to 41.6 billion, generating an estimated 79.4 zettabytes (a trillion gigabytes) of data by 2025. This massive increase in data will be processed and used throughout the network to help create value for industries, governments, and individuals.

For example, the significant focus of IoT spending in industrial uses provides the opportunity to deliver greater efficiency improvements. Some industry participants have even referred to this group as the industrial internet-of-things (IIoT). In one use case, an IIoT ecosystem enables condition monitoring and predictive maintenance in manufacturing processes. Sensors integrated into each machine would collect physical data, such as temperature, pressure, and sound frequencies, and store and analyze these data, for conclusive information, in the cloud. The data could then be analyzed in real time, noting any variation in the normal machine output that would require immediate attention. This condition-monitoring process is much more efficient compared to the traditional method of collecting, storing, and analyzing data manually from each machine on the floor, and reacting only when a problem occurs. It also could raise the efficiency of the manufacturing system (less unscheduled downtime), increasing workplace safety, and possibly lowering operating costs.

While the Industrials sector may represent the first phase of the IoT rollout, it likely will not stop there. With a relatively low cost to place sensors on many devices, we would expect the IoT to expand to cover nearly every facet of our lives with unprecedented and robust data analysis. But we need 5G's attributes to bring this to fruition, and like 5G a fully connected IoT will develop over time.

The Concept of Edge Computing

In essence, edge computing provides the functions of analysis, networking, and storage closer to the origin of the data, on an edge server, so that certain insights can be generated and executed in real time. While 5G enables high speed connectivity and large processing capacity, the vast amount of data generated from the millions of devices connected in IoT still requires some processing time. To achieve greater efficiency, lighter, more mission-critical tasks could be done through edge computing rather than sent to a data center which is part of the public cloud. A good example might be real-time traffic and weather information used by autonomous vehicles. Processing these data on an edge server near an intersection could be critical for accident avoidance. Less real-time-dependent data (for example, from social media providers used for predictive analytics) could be sent to the public cloud. Unlike traditional on-premise data centers, edge servers can be placed anywhere, including oil rigs, cars, or even in conjunction with cell towers. However, building out these edge servers will require significant capital expense.

Does 5G Pose Cyber Security Risks?

In our view, the answer is likely yes.[5] In older networks, such as 3G and 4G, all network traffic flows

[5] "Secure 5G and Beyond Act of 2019 (S. 893)," GovTrack.us, www.govtrack.us/congress/bills/116/s893; K. Kaska, H. Beckvard, and T. Minárik, "Huawei, 5G and China as a Security Threat," The NATO Cooperative Cyber Defence Centre of Excellence; L. Sullivan and C. Schuknecht, "As China Hacked, U.S. Businesses Turned a Blind Eye," NPR, April 12, 2019, www.npr.org/2019/04/12/711779130/as-china-hacked-u-s-businesses-turned-a-blind-eye.

through hardware, creating **choke points**. However, because 5G is a software-defined network, there are no hardware choke points, increasing its vulnerability to cyber threats. In addition, while 5G's expanded bandwidth will enable IoT, this will actually expand the network's susceptibility. As IoT grows, all "things" attached to the 5G network act as a gate through which hackers could potentially gain access and attack the system.

Also, 5G's software infrastructure uses internet protocol (IP), which is the language computers use to communicate over the internet. This use of IP in conjunction with well-known operating systems may make it easier for hackers since these are basic and standard structures. In prior networks, if a threat was detected, network administrators could implement a lock down ("safety switch"), which would shut down all network traffic. However, in 5G's software-based network, the safety switch itself could be hacked because it, too, is now software.

With this reality, how do we protect such an important yet susceptible network? With so many participants in the United States alone (corporations and federal, state, and local governments), it is hard to determine who is ultimately responsible for network security. This becomes even more complicated when looking at it from an international perspective. Robust security of the 5G network is required not only for the privacy of users but also for national security.

World leaders recognize the importance of the issue and have started to respond. In March 2019, a bipartisan coalition of senators introduced legislation requiring the president to develop a strategy for securing the nation's 5G infrastructure. There have also been widespread calls for European Union and NATO coordination in the rollout of 5G, requiring international strategic cooperation. While 5G has the potential to radically improve connectivity and promote economic growth, it also has some apparent risks on the cyber security front.

Can Blockchain Be an Answer to 5G Cybersecurity Threats?

As 5G drives more connections and data become more free-flowing globally, perhaps the emerging technology Blockchain could help prevent 5G's security risks. Blockchain is the underlying technology for cryptocurrencies, but it also has many other applications. Blockchain essentially acts as a distributed ledger that can store data (transactions and records) in an immutable and more trusted manner. The "blocks" hold encrypted data that cannot be modified, therefore when two parties conduct a transaction using these blocks, there is no need for intermediaries to verify the content. The idea of Blockchain is to link (chain) up these encrypted data storage units (blocks).

***Choke points** allow for concentrated surveillance of network activity and strong security.*

Blockchain's use of encrypted data greatly reduces the chances of data being hacked because transactions in the distributed ledger are traceable and irreversible, and theoretically cannot be modified by external parties. So while the technology is indeed new and not widely used in its current form, it may have the potential to create a new level of security for future digital transactions.

Where Does the United States Stand in the Global 5G Race?

South Korea, the United States, and China are the furthest along in their respective rollouts of 5G networks. At this point, however, only South Korea has nationwide 5G capabilities, but here geography matters. At only 1% the size of the United States by area, South Korea requires only a fraction of the infrastructure that would likely be needed in the United States and certainly China. The rollout of 5G networks across various countries will be governed by budgetary constraints of the respective countries' national telecommunications service providers (telecoms). In addition, country-specific spectrum award processes and regulatory hurdles are also likely to affect rollout progress.

Another governing factor is the ability to obtain the necessary equipment to build the networks. The telecom equipment required to upgrade from 4G to 5G is highly concentrated among a few providers. As has been widely publicized, China's Huawei Technology Co. Ltd. (Huawei) is the world's leading provider of 5G equipment, raising security concerns by the US and other governments.

As of year-end 2019, Huawei's technology is in 31% of the world's 2G, 3G, and 4G LTE telecom equipment. Ericsson (27%) and Nokia (22%) round out the rest of the three largest global telecom equipment providers.

With each successive network generation building off of the prior generation, it is difficult to build the next generation network with equipment from a different provider, creating a high degree of "stickiness" within networks. The United States is reluctant to use Huawei's technology, so it will need to rely on other providers for network buildout since there is no easy solution for evolving any of this equipment into its own. This will likely make the rollout longer and more difficult.

Will 5G Create a Capital Spending Spike?

The rollout of 5G infrastructure might be expected to create an incremental spike in capital expenditures (capex) by companies in the 5G value chain, but the reality is this may not be the case. There seems to be a bit of a "chicken and egg" scenario playing out so far. Because the technology is relatively new, there are few handsets globally that work on a 5G network, and going too fast on the network buildout without 5G-capable handsets means the telecoms may not realize an appropriate return on their investments. As an example, Apple Inc. won't have its first 5G iPhone until at least the fall of this year, depending on the impact of supply chain disruptions due to the COVID-19 pandemic.

As we have noted, the success of the 5G rollout globally is highly dependent on the telecoms – in the United States this includes Verizon Communications Inc., AT&T Inc., and the new T-Mobile US, Inc./Sprint Corp. So far the network deployment has been slow (city-by-city and town-by-town) and can be quite costly. For an effective nationwide network, telecoms will need to increase their available spectrum (Chart 4). FCC auctions for this spectrum are highly competitive, with more than 14,000 individual licenses for service in metropolitan areas nationwide. One auction for mmWave spectrum licenses reached almost $8 billion, double what analysts anticipated, signaling the huge appetite for these high-speed wireless networks. Not surprisingly, the highest bids were for licenses in the biggest US cities, such as New York, Los Angeles, and Chicago.

Another large cost for the telecoms includes the "densifying" of their networks, particularly in urban areas. This entails installing small-cell 5G antennas on utility poles, building rooftops, and even homes; these antennas will need to be linked with fiber-optic connections to local hubs. Not surprisingly, this process is heavily affected by regulatory hurdles.

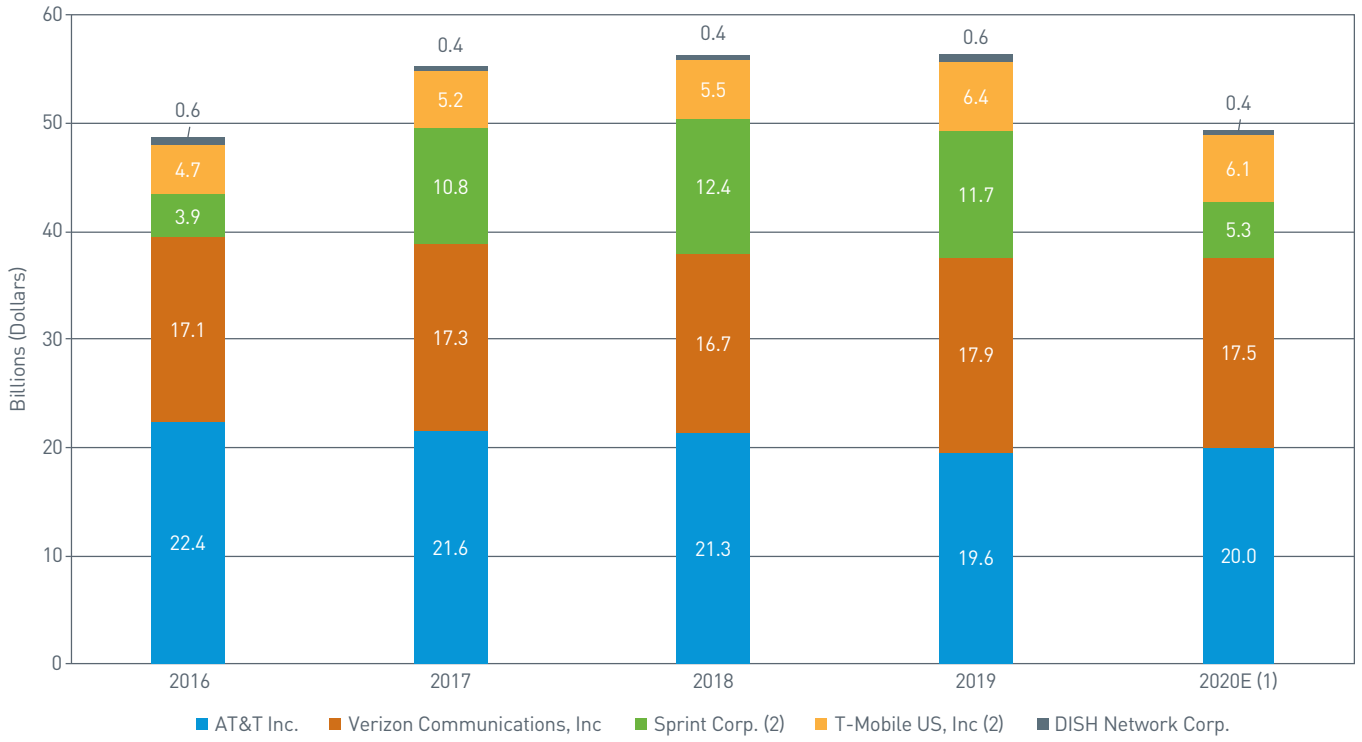
Despite these obvious costs, capex levels for the telecoms have actually been relatively consistent

Chart 4
Spectrum Control by Carrier

	Spectrum (MHz)				
	Low-band	Mid-band		Total ex mmW	High-band
	<1 GHz	1.7-2.3 GHz	2.5-6 GHz	<6 GHz	24 GHz+ (mmW)
Verizon	46	68	-	115	1718
AT&T	76	95	-	171	644
T-Mobile	38	75	-	113	469
Sprint	14	36	155	205	-
DISH	25	74	-	99	-
New T-Mobile	38	111	155	304	469
New DISH	39	74	-	113	-

Source: UBS, Above-Listed Company Reports

Chart 5
US Wireless Companies' Capital Expenditures on Fixed Assets



(1) Midpoint of guidance range

(2) Numbers are specific company. Courts decided in February 2020 to allow the merger of Sprint and T-Mobile

Source: Company Reports, PNC

over the last several years and are expected to remain so in 2020 (Chart 5). We believe this is because new networks build on existing networks and do not require a complete teardown and rebuild of existing infrastructure. 4G networks have seen a significant amount of investment over the last several years as telecoms strive to improve their networks to keep pace with growing data needs. In addition, as 2G and 3G networks begin to sunset, the capex previously directed at these networks can be repurposed toward 5G. This mirrors the capex trends we saw in the transition from 3G to 4G a decade ago.

Outside of what the telecoms will need to spend, 5G will create the need for additional cell tower capacity to handle the vast increases in data growth. This may create a modest near-term boost in capex for the cell tower operators (for example, American Tower Corporation, Crown Castle International Corp., and SBA Communications Corporation), but their capex budgets are fairly small because the cost to build and maintain the towers is relatively low.

Although additional areas of the 5G value chain may also see capex increases, most of the growth related to 5G is likely to occur under these companies' normal operating budgets. This would include companies tied to cloud computing such as Amazon.com, Inc., Microsoft Corporation, and Alphabet Inc.; semi-conductors such as Broadcom Inc., Qualcomm Incorporated, and Lam Research Corporation; data center real estate investment trusts (REITs) such as Equinix Inc. and Digital Reality Trust, Inc.; and others. However, for the majority of all of the companies in the 5G value chain, we do not expect the promise of 5G to lead to significant increases in capex budgets. Rather, the generation of appropriate cash flows and returns on invested capital are likely to govern their pace of spending.

Potential Investment Implications of 5G

5G promises to bring exciting growth opportunities for companies, entrepreneurs, and investors in the value chain, but it will also bring inherent risks. Given these realities, deciding how to invest in 5G is not as simple as buying everything 5G-related. For example, smartphone makers, when the phones do actually get produced, may see a one- to two-year revenue growth improvement as consumers upgrade to new phones. After this initial spike, replacement cycles will likely settle back into their equilibrium rate of roughly every four years. Also, while more silicon (chips/sensors) will be required to connect the IoT, the additional capex this may require, and the inherent cyclicality of the semiconductor manufacturers, bring their own set of risks for the group.

There is clearly an opportunity and a need for the telecoms, tower operators, and data center managers to build out a robust infrastructure network to make 5G a reality. However, the cost, scale, and regulatory hurdles of this endeavor may create a hesitancy for telecom carriers especially to be too aggressive in this buildout. Many of these companies are not fully confident they have received an appropriate return for the investments they made in upgrading the 4G network, which likely weighs on their decisions about the pace of 5G deployment.

Ultimately, there is much we do not know about how 5G will progress, making a clear-cut investment recommendation difficult at this point. However, we feel fairly confident 5G will drive huge leaps in data demand because essentially everything is connected in an IoT network. The need to move, store, analyze, and leverage data should provide a significant long-term catalyst for the tower operators and data storage companies that comprise a majority of the weighting in the S&P 500® Real Estate sector. (Tower operators and data storage companies are classified under the subindustry specialized REITs within this sector.) We expect these 5G-related companies to significantly outgrow their sector peers, such as retail and other property-exposed companies, and we are actively looking for additional ways to increase our exposure to the fastest growing segments of the Real Estate sector.

ESG Implications for 5G

We believe a robust understanding of the possible environmental, social, and governance (ESG) issues associated with 5G can help investors navigate both the risks and opportunities posed by the innovations using 5G architecture. While we can look to the ESG issues that arose from 3G and 4G technology enhancements as a guidepost, the issues associated with 5G innovation will likely originate from different sources.

Environmental Considerations

Energy management is a key environmental risk regarding 5G technologies. The Sustainable Accounting Standards Board (SASB)[6] indicates that energy management is a material risk for both the telecoms and specialized REITs, vital to 5G's infrastructure management. Investors focused on environmental issues associated with these industries can consider metrics on energy use by source (for example, renewables) as well as programs and policies related to energy reduction measures. Specific to REITs, industry participants also suggest monitoring greenhouse gas emissions for direct, onsite operations and purchased energy.[7]

While climate change risks are pervasive across many sectors of the economy, 5G technologies may actually provide new opportunities to mitigate some of these concerns. For instance, we believe 5G will enable more efficient agriculture practices, which have become highly important as the world's population grows and food production will likely need to double. Agricultural IoT devices could allow more precise measurement of moisture, fertilization, and nutrition levels back to farmers as well as the ability to monitor weather patterns and drought conditions. This could potentially increase farming efficiency and crop yields while lowering costs at the same time.

Social Considerations

The promise of improved social outcomes from 5G may only be realized with a successful and widespread rollout of the network. This latter point

[6] SASB is a tool for businesses to identify, manage, and communicate financially material sustainability information to investors.

[7] Nareit Guide to ESG Reporting Frameworks, February 2019, https://www.reit.com/sites/default/files/media/PDFs/Research/Nareit_Guide_to%20ESG_Reporting_2_21_19.pdf.

is critical because it could be expedient for major companies to overlook underserved and less densely populated communities. Economically disadvantaged and rural populations may have the most to gain from advances in IoT, whether in public services, access to food, or better health care. However, if relegated only to more affluent areas, those most poised to benefit from 5G innovations risk being left behind.

From a purely ESG perspective, perhaps one of the largest risks associated with 5G involves the rollout of the small-cell antennas needed to densify the network. The pervasive nature of the antennas has created new risks associated with "not-in-my-backyard-ism" ("NIMBYism"), resulting in regulation by local authorities. Public sentiment is already having an impact on the physical rollout of 5G hardware.

At different points, there have been attempts by both the administration and federal regulators to nationalize part of the rollout in an effort to streamline infrastructure development and sidestep local governments. For example, the FCC adopted a declaratory ruling and third report and order titled "Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment" in late 2018 that preempts state and local requirements related to the deployment of 5G infrastructure.[8] NIMBYism can be a key source of the increased costs and onerous permitting that add to the delay in delivering 5G infrastructure. Fortunately, the major telecoms have partnered with communities and universities across the country to attempt to overcome these challenges.

Outside of the convenience that 5G will deliver, it could greatly enhance the quality of life for people around the world. The quantity and speed of data analysis is likely to improve social and environmental outcomes of products and services in industries like health care, as well as enable smart-city development.

Smart cities would rely on IoT to help municipalities manage resources and distribute public services more efficiently. It may sound a bit like "big brother," but data collected can enable smart buildings, transportation, energy, and health care. For example, a smart transportation system might use real-time, data-driven analysis for communication and navigation operations from car-to-car (collision avoidance), car-to-infrastructure (automatic toll collection), and mobility as a service (contactless commuter rail payments or big data-informed placement of bus stops).

5G also has the potential to deliver significant innovations and cost improvement in the delivery of health care services through wearables (such as the Apple watch), online consultations, and remote surgical procedures. The ability to analyze real-time data from different diagnostic tools (such as blood pressure cuffs, bed monitors, infusion pumps, etc.) using 5G could improve health care diagnostics and provide a series of preventative measures that may not be available to parts of the global population today.

Governance Considerations

In our view, one of the most significant ESG-related considerations for the future of 5G technologies involves product governance, and more specifically, data privacy and security. With sensors potentially everywhere we turn – from our traffic lights and sidewalks to our cars and homes – there will likely be more personal data than ever available to governments and companies. While this echoes the network vulnerability concerns we previously noted with regard to cyber security, the reality is this could present risks to individuals or groups if this data are used to reduce personal freedoms. Providers and application developers will need to exercise good governance practices.

Conclusion

While the prospects and hype for 5G are exciting, we certainly do not expect to start living like The Jetsons or buying flying cars anytime soon. 5G's emergence alongside the other megatrends like cloud, AI, ML, and IoT are all concurrently enabling a march toward the next technological advancement. It is exciting to think about what the next killer app could be. However, while 5G is the enabler of this advancement,

[8] "Overview of Legal Challenges to the FCC's 5G Order on Small Cell Siting," February 25, 2019, Congressional Research Service, https://fas.org/sgp/crs/misc/LSB10265.pdf.

a healthy dose of skepticism is warranted about what 5G will and won't be able to deliver.

The network buildout is highly dependent on the telecoms, which have thus far shown a reluctance to be overly aggressive. This means it will likely be a multiyear process, and the reality of 5G may take longer than expected. Unfortunately, the worldwide COVID-19 pandemic and the resulting restrictions to contain the virus are likely to further delay the network buildout. Ironically, changes in consumers and enterprises as a result of the crisis are likely to increase the needed attributes of 5G, as more commerce moves online and many employees work to a greater degree from home.

From an investment perspective, we believe that trying to pick any single security based on 5G alone will be difficult, given the individual cyclicality of the companies involved in the 5G value chain and their specific company-level risks. However, we do see strong secular opportunities to invest in asset classes leveraged to 5G, and we currently see companies in the specialized REITs industry with "5G exposures" as long-term beneficiaries of this trend.

So as we await the coming speeds, bandwidth, and low latency of 5G, we may have to wait a bit longer than we would like, but 5G is coming. We are likely to look back in 10 years and marvel at the things 5G enabled us to do and the benefits it delivered on a global basis. While we await that point, it's important not to forget that the current 4G speeds are already pretty fast, especially for the existing capabilities of our smartphones today. While we don't see this as the base case, if all 5G turns out to be is social media pages loading a bit faster or movies downloading/streaming in seconds, 5G will have significantly underdelivered on its promise. Good things take time, though, and soon enough we will all surely be talking about how exciting and life-changing 6G will be!

Written in partnership with the Investment Strategy Team and Advantage Equity Team

For more information, please contact your PNC advisor.