Spectrum Considerations For 5G

Key Spectrum Considerations for 5G: Introduction

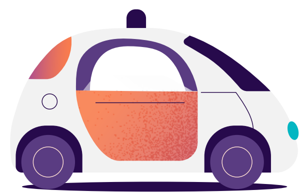
5G is the future of wireless and it will deliver significant benefits to consumers and many sectors of the economy through the deployment of ultra-fast, highly reliable, scalable, and very low latency networks.[1] Spectrum is the essential ingredient in 5G networks and ensuring sufficient access to enough and the right kinds of spectrum is a national priority.[2]

This paper identifies key technical considerations for policymakers as they proceed with on delivering spectrum bands already identified for next-generation wireless use, and in identifying and allocating additional bands in the near term. For the U.S. to unlock the enormous promise of 5G, policymakers should focus on these key spectrum characteristics in unleashing significant new allocations of low-, mid-, and high-band spectrum:

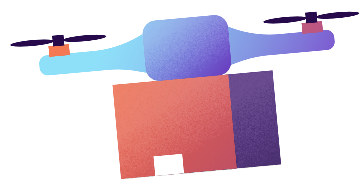
- Licensed, exclusive-use spectrum
- Flexible-use rights
- Prioritization of cleared spectrum
- Wide channels of contiguous spectrum to enable very high speeds, efficient performance, and multiple antenna technology, and
- Use of globally harmonized bands, which enables global scale and roaming.

This paper explores each of these considerations in more detail to explain 5G technology, spectrum characteristics, technology enablers, and ecosystem considerations needed to unlock the benefits of 5G. With a continued focus on carefully crafted spectrum policy, the U.S. can expand upon initial 5G launches and announcements and provide robust 5G networks that American businesses and consumers can utilize for connectivity, productivity, and innovation.

Benefits of 5G Include:



100x
faster



100x
more connections

5x
more responsiveness

What is 5G?

Tomorrow's 5G networks will surpass the capabilities of today's networks. These networks will offer unparalleled speeds (up to 100x faster than 4G LTE) and enable real-time connections with improved responsiveness (more than 5x more responsive), thereby supporting entirely new services, applications, and a massive increase of Internet of Things (IoT) devices (more than 100x the current number of devices).[3]

Up to 100x Faster

Each successive generation of wireless technology leapfrogs the capabilities of the prior generation, often in dramatic ways. We witnessed these leaps between 2G and 3G, between 3G and 4G, and we will see them realized in the next leap to 5G. The most tangible change between generations of technology is a significant increase in network speed.[4] 5G will be no exception.[5] While 4G LTE networks are fast, 5G networks will be much faster. With wide channels of mid- and high-band spectrum along with innovations like massive multiple-input and multiple-output (massive MIMO) antennas, 5G technology, with its new modulation, will enable consumers to reach speeds up to 100 times faster than 4G networks, at potentially 10-20 Gigabit/second (Gbps) peak speeds.[6]

This data throughput enhancement will enable more rapid downloads (files that would take several minutes to download will take mere seconds), faster access to ultra-high definition video content (including 4K and 8K video), and more immersive experiences in every industry, including healthcare, energy, transportation, law enforcement, e-commerce, logistics, and education, among others.[7]

5x More Responsive

Today, 4G LTE latency rates—the technical term for the delay between your request for data and when your mobile device receives it—are low, roughly 10 milliseconds over-the-air; 50 milliseconds end-to-end.[8] 5G latency rates will be five to ten times lower—or as low as a few milliseconds over-the-air.[9] This reduction in latency will enable near real-time consumer wireless experiences not possible today, unlocking or enhancing services and applications such as vehicle safety and collision avoidance, augmented and virtual reality, and real-time medical applications such as remote medical appointments.[10]

For example, autonomous vehicles will be one of the transformative societal changes enabled by 5G networks.[11] The National Highway Traffic Safety Administration reported the following statistics for the U.S. in 2016:

- 7,277,000 police-reported traffic crashes
- 37,461 traffic fatalities
- 3,144,000 people injured
- The economic cost of all traffic crashes for the last reporting year of 2010 was $242 billion.[12]

A responsive, reliable, and high-capacity 5G system, will transform every aspect of the transportation experience, including allowing vehicles to instantly communicate with other vehicles, traffic lights, and road sensors at speeds surpassing human reflexes. These far improved vehicle and surrounding IoT communications promise to significantly reduce traffic accidents and fatalities, reduce costs from crashes, improve pedestrian safety, and relieve traffic congestion.[13] Tomorrow's networks have the potential to revolutionize the way Americans live and work and to unleash economic growth and ingenuity.

100x More Devices

5G will support massive connection density, on the order of 100 times greater than 4G LTE.[14] This increase in capacity will allow the development of massive amounts of IoT devices and systems.[15] This volume of IoT, which is bringing broadband connectivity to everyday and industrial devices, sensors, and objects, will usher in positive changes, increased productivity, and economic growth across nearly every economic sector, from transportation and health care to public safety and energy.[16] Today, nearly 15 percent of all wireless connections in the U.S. are machine-to-machine connections, connecting devices and industrial sensors rather than people.[17]

That number is expected to increase to around 30 percent by the end of the decade as 600 million wireless connections come online, nearly all connected to 4G and 5G networks.[18] The number of IoT devices worldwide will conservatively surpass 20 billion by the year 2020, and this increase in connectivity stands to add roughly $2.7 trillion to U.S. GDP by 2030.[19]

The Future of IoT

The number of IoT devices worldwide will conservatively surpass 20 billion by the year 2020.

The Need For More 5G Spectrum

Tomorrow's 5G networks will require significant allocations of low-, mid-, and high-band spectrum to enable 5G technology to deliver its full potential. Three key spectrum considerations will be instrumental as more airwaves are brought to market:

1. An emphasis on licensed, exclusive-use spectrum
2. Flexible-use rights, and
3. Cleared spectrum for the best user experience

A mix of low-, mid-, and high-band spectrum is needed to fuel investment and innovation in terrestrial wireless services.

Sufficient bandwidth is crucial to allow for faster speeds and greater capacity to deliver data for the bit-hungry applications and use cases expected for 5G—and sufficient bandwidth means more spectrum. To that end, policymakers must make a wide range of spectrum bands available to help meet the demands of rapidly advancing wireless broadband and unlock the full potential of 5G.[20]

It should be a top priority of U.S. policymakers to make available hundreds of megahertz of mid-band spectrum and thousands of megahertz of high-band spectrum for terrestrial wireless use in the near term, as a full range of spectrum is needed for the successful deployment of 5G. While prior Administrations have helpfully developed specific numeric targets for identifying spectrum for wireless use, it is imperative that this Administration focus on specific spectrum bands that will support next-generation wireless connectivity, and develop a long-term strategy for exploration of additional potential bands for commercial use. Wireless operators will require a significant infusion of new spectrum to unlock the superior network capacity, faster data throughput rates, and substantial improvements in latency that 5G will enable.

Projections for growth in mobile broadband traffic provide a valuable insight into the network capacity and spectrum resources that will be needed. The 2017-2022 Cisco Visual Networking Index paper predicts that Internet traffic will more than triple in volume from 2017 to 2022,[21] and global mobile data traffic will increase seven-fold between 2017 and 2022.[22]

Further, global networked devices and connections will reach 28.5 billion by 2022, up from 18 billion in 2017.[23] These projections build upon the massive growth that has already occurred up to 2017: global mobile data traffic grew 71 percent in 2017 and mobile data traffic has grown 17-fold over the past five years.[24]

Furthermore, in Cisco's latest VNI report, they predict that the average 5G connection will generate nearly three times as much traffic as a 4G connection. With North America comprising the highest percentage of 4G and 5G connections (9%) of any region globally, the U.S. has a strong need for spectrum suitable for 5G.[25]

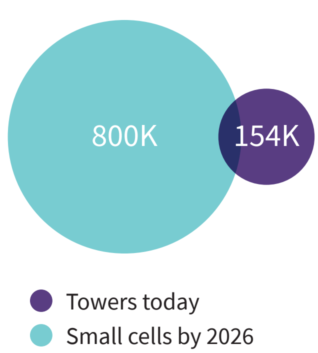
While U.S. wireless providers continue to invest in network resources and new technologies to make as efficient use of existing spectrum resources as possible, more spectrum must be made available to keep pace with projected massive growth in demand for mobile data. 5G promises great improvements in spectral efficiency (allowing the same amount of spectrum to provide even more mobile data to consumers), but improvements in spectral efficiency alone cannot match the exponential growth in demand for mobile broadband.

U.S. wireless operators are also densifying networks through the deployment of more than 300,000 small cells over the next few years[26], and continue to invest in network capacity with a forecasted deployment of 800,000 small cells by 2026.[27] However, the capacity limits of cell density are being reached in many areas throughout the U.S.—even with aggressive use of small cells. Therefore, only new spectrum allocations will allow wireless providers to keep pace with the explosive growth of wireless data as improvements in spectral efficiency and capacity alone will not suffice. It is critical in the near term that wireless carriers obtain hundreds of megahertz of mid-band spectrum and thousands of megahertz of high-band spectrum.

A Small Cell World

80%

of future infrastructure deployments will be small cells



Licensed, Exclusive Use Spectrum Will Enable A High-Quality Experience on 5G

Exclusive-use licenses have long been the cornerstone of the FCC's successful wireless strategy and form the backbone of our mobile networks today. The U.S. wireless industry has relied upon these exclusive licenses as it migrated through four generations of technology, becoming the global leader in the provision of 4G service. In the case of 4G deployment, well-designed public policy provided access to exclusive-use, licensed spectrum, which, when coupled with robust private investment, made U.S. technological leadership possible.
It should therefore be a top priority for policymakers to continue to make available spectrum for exclusive, licensed terrestrial use to support next-generation connectivity.

Exclusive-use licenses provide licensees with more certainty and predictability that their investments will be protected against harmful interference, and that they can fully "mine" the spectrum they hold, resulting in more intense and efficient utilization. Certainty and transparency are crucial for wireless operators to invest in any band.[28] Policymakers must ensure that future licensees have access to an environment that is interference-free and refrain from implementing policies and rules that would subject terrestrial, flexible-use licensees to any burdens and uncertainty that are inconsistent with the licensed spectrum rights for which they have paid or will pay.[29]

The certainty associated with exclusive-use licenses has led the U.S. wireless industry over the last eight years to invest $226 billion in infrastructure,[30] producing world-leading 4G networks.[31] Winning bidders in FCC spectrum auctions have contributed more than $114 billion to the U.S. Treasury.[32] Wireless providers are the number one and two U.S. "investment heroes" based on domestic capital spending.[33]

The U.S. should prioritize licensed, exclusive-use spectrum that has proven to be the core of our nation's successful spectrum policy.[34] Exclusive-use licensing helps ensure the security capabilities of the overall wireless network infrastructure by allowing private management and network development.

The FCC itself has noted that exclusive-use licensing "strike[s] the right balance between the benefits of competition, on the one hand, and the efficiencies of scale and scope that justify investments of capital and expertise."[35] Congress has also acknowledged the value of exclusive-use licensing, directing NTIA in reallocating spectrum to "give priority to options involving reallocation of the band for *exclusive non-Federal use*."

The wireless industry has and will continue to deploy multiple approaches to ensure the demand for wireless connectivity is met.[37] Wireless companies are deploying innovative new infrastructure technologies like distributed antenna systems and small cells.[38] They are also investing in research and development to improve spectral efficiency—with techniques like LTE Advanced using multiple bands of carrier aggregation—to boost network capacity, increase data rates, and utilize new spectrum bands to provide mobile broadband services.[39] Wireless companies can be expected to continue working with federal government stakeholders on ways to share spectrum that cannot otherwise be repurposed for exclusive use.

Flexible Use Licensing Ensures Highest and Best Use of Spectrum Resources

The flexible use policies of the FCC have provided the incentive, innovation, and productive use of spectrum assets from the different wireless operators over the years. It has enabled competitors to deploy 2G, 3G, and 4G wireless technologies at different paces and with various strategies along with associated services, creating more consumer choice. While some operators initially deployed new technology such as 4G in 700 MHz, others chose to deploy in AWS spectrum between 1695 MHz and 2200 MHz. Later low-band spectrum such as 700/800 MHz may be re-farmed for 5G, enabling deployment of a coverage layer. It is this type of flexible use that allows operators to compete and stimulates innovation and investment. This has served the U.S. well as demonstrated by the innovation and leadership in 4G. Deploying new technologies in a variety of bands provides the flexibility that operators need; this is the key to investment in spectrum – and new technology.

The Commission has found that ensuring that the radio spectrum is used efficiently and intensively is an important public interest goal and that "flexible use licensing can promote broadband deployment, ensure the spectrum is put to its most beneficial use, allow licensees to respond to consumer demand for new services, and maximize the probability of success for new services."[40] Accordingly, the FCC, NTIA, and other federal stakeholders have made great efforts to open more bands for flexible use across the entire allocation chart, including in the low and high bands. Recently, in an attempt to close the gap between high and low bands for mobile use, the FCC has inquired about expanding flexible use in the mid-band spectrum between 3.7-4.2 GHz.[41]

Cleared, Licensed Spectrum Enables The Best User Experience

Policymakers' paramount focus should be on clearing bands for licensed, exclusive-use spectrum available for 5G wireless services. Cleared spectrum provides the ability for operators to quickly and efficiently deploy 5G infrastructure to enable nationwide deployment and provide capacity/coverage to required areas. This accelerates the benefits of 5G service to consumers and yields the economic and job benefits associated with 5G rollouts.

There are circumstances where incumbent operations pose challenges to fully clearing spectrum for exclusive-use licensed purposes, and some type of sharing framework will be the best means to repurpose spectrum. In the event that sharing is required, the sharing regime should provide spectrum licensees with sufficient rights to warrant the investment necessary to deploy robust, next-generation networks. For example, to provide the certainty and transparency necessary to encourage investment, any sharing regimes must ensure the utility of the band for commercial use and any sharing conditions should be clear prior to auctioning the spectrum.

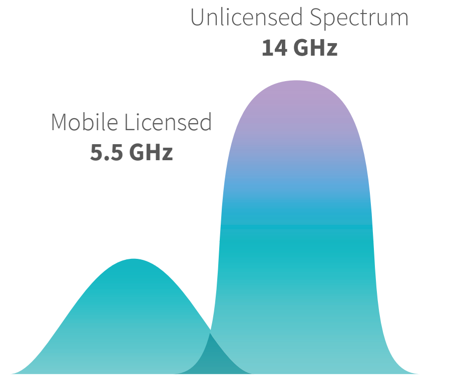
Additionally, while offloading mobile data to Wi-Fi/LTE-U/LAA or other technologies using unlicensed spectrum is an important and beneficial network response to the increasing data traffic on wireless networks,[42] primary focus should remain on licensed allocations. Unlike licensed spectrum, unlicensed spectrum, by its nature, cannot provide the certainty or quality necessary to fully support long-term service and investment. Parties operating unlicensed devices have no vested or recognizable right to continued use of any given frequency,[43] and unlicensed systems must accept any harmful interference caused by a licensed system or other unlicensed device.[44] Based on these characteristics, the unlicensed authorization regime does not allow parties full control or access to spectrum. At any time, new devices or uses can be added to the unlicensed spectrum band—reducing the available capacity and subsequently leading to a decrease in the data rates available for each operating unlicensed system or device in the band.

Unlicensed services can be useful in the home environment and certain indoor venues where – and largely because—the property owner has essentially exclusive use over the spectrum within that venue. In mobile and other public environments, however, there is no capability to effectively manage and deliver quality of service to consumers of unlicensed services.

The sharing mechanisms in place for unlicensed devices manage the interference environment so that multiple systems/devices can coexist, but cannot control the overall customer experience. Indeed, in some recent cases, parties attempting to manage unlicensed systems have been subject to FCC enforcement actions.[45]

Finally, because unlicensed devices operate in a shared environment, there are significant limits on the power levels that can be used—making it difficult to impossible to provide wide-scale coverage.[46]

A Balanced Approach



There is more than twice as much unlicensed spectrum (14 GHz) in high-band than mobile licensed (5.5 GHz).

The U.S. Government and 5G

The U.S. Government Should Ensure that Future Allocations are Appropriately Balanced Between Unlicensed and Licensed

Unlicensed spectrum is a key component in meeting consumer demand, but the U.S. Government must maintain a keen eye as to the ongoing balance between licensed and unlicensed spectrum. The FCC historically allocated more low-band spectrum to licensed services, recognizing its vital role in mobile network deployments and facilitating broad coverage, but in the mid- and high-bands, unlicensed spectrum dominates.

Today, in the mid-band, the U-NII bands offer 580 megahertz for unlicensed use, while there is no flexible-use licensed spectrum today and a commitment of only 70 megahertz of 3.5 GHz CBRS PAL spectrum in the future (which itself is subject to opportunistic sharing).

The FCC has initiated a separate proceeding on the 6 GHz band, where it proposes to allow unlicensed access to more than six times that amount—1.2 gigahertz.[47] As for high-band spectrum, 5.5 gigahertz has been committed to flexible-use licensing while nearly twice that amount—14 gigahertz—is reserved for unlicensed.[48]

U.S. policymakers must identify sufficient additional licensed spectrum to ensure that terrestrial wireless services—and 5G in particular—have access to sufficient spectrum in order to achieve their promise for consumers, the economy, and U.S. global competitiveness. And, to the extent that additional unlicensed spectrum is allocated, the rules governing access to and use of that spectrum must be technologically neutral and available for the full panoply of next-generation unlicensed technologies, including Wi-Fi, LTE-U, and LAA.

Therefore, while spectrum sharing is being explored in some bands, and while unlicensed spectrum has a valuable supplementary role in providing mobile and fixed broadband services, neither should be solely relied upon by wireless providers attempting to provide the full benefits of 5G services. Accordingly, policymakers must continue to make exclusive-use, licensed spectrum available for the development and deployment of tomorrow's 5G networks.

Spectrum Priority

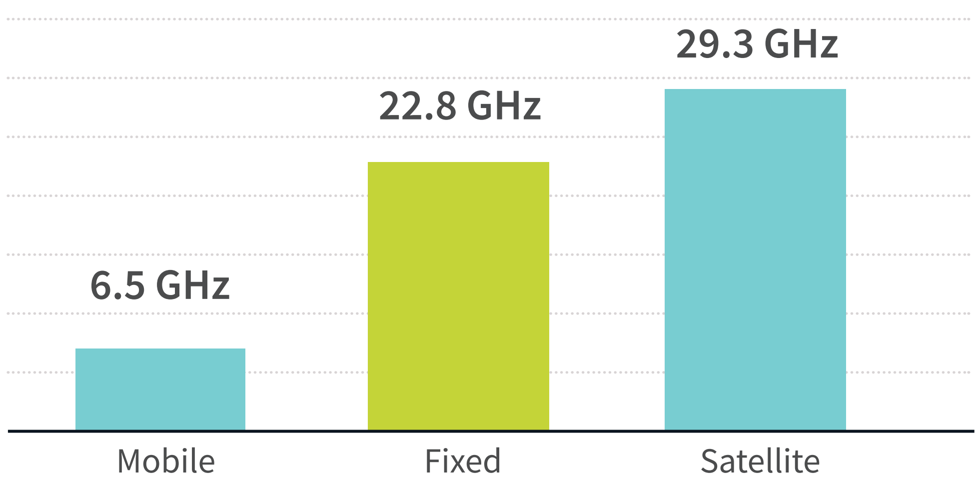
Policymakers Should Prioritize Additional Spectrum for Terrestrial Services

The manner and method of allocating spectrum is critical to ensuring widespread deployment of 5G technologies. Although the FCC has shifted to prioritizing flexible-use allocations to ensure that licensees are able to put the spectrum to its highest use, data demonstrate the necessity of making more spectrum available for terrestrial mobile use.[49]

Terrestrial mobile spectrum allocations trail other licensed services in availability. As shown in the figure below, terrestrial mobile has a fraction of the spectrum available (less than 6.5 gigahertz) as compared to fixed terrestrial services (nearly 23 gigahertz) and traditional satellite services (nearly 30 gigahertz including the Broadcasting-Satellite Service and Fixed-Satellite Service in the bands above 3.7 GHz).[50]

As such, policymakers should maintain their focus on making available spectrum that has previously been identified for wireless use, and on identifying and allocating new spectrum for 5G services, both of which are key to helping close this gap and enabling the U.S. to invest in and deploy next-generation networks that will provide the full benefits expected for 5G. And, as described in more detail above, policymakers must, when making additional spectrum available, ensure that (1) key technical considerations are satisfied, (2) a mix of low-, mid-, and high-band frequencies are available, and (3) licensed, exclusive-use opportunities are prioritized.

Spectrum Allocation



Technical Considerations Needed to Unleash the Benefits of 5G

Wireless Operators Need a Mix of Low-, Mid-, and High-Band Spectrum to Achieve the Full Benefits of 5G

Enabling 5G networks will take a combination of low-, mid-, and high-band spectrum to unleash the high speed and low latency that will be the hallmarks of 5G, to support the higher device density that will sustain these innovations, and to provide all of these advantages across the country. A robust combination is required because each frequency range provides unique benefits and challenges:

- **Low-band spectrum** (e.g., 600 MHz, 700 MHz, 800 MHz bands) provides a broad coverage layer, ensuring connectivity when deep inside of buildings, and interconnecting remote rural areas. It has beneficial physical characteristics that allow wireless signals to propagate further with better in-building penetration than higher frequency bands. This low-band spectrum is ideal for providing wide-area coverage in rural areas, which has helped deploy broadband to most of the U.S. population.

- **Mid-band spectrum** (e.g., the 3.45 GHz and 3.7-4.2 GHz bands) is the workhorse for 5G and the essential bridge of coverage, breadth, and spectrum depth to keep pace with traffic growth. It represents the "sweet spot" of spectrum innovation due to its favorable propagation characteristics for small cell deployment, including the ability to carry significant capacity while providing non-line-of-sight propagation over longer distances than millimeter wave spectrum. While a high-band cell site can be expected to provide coverage for only a few hundred yards, mid-band cell sites can deliver service as far as a few miles from the cell site (depending on the spectrum band and terrain/physical characteristics around the site). As a result, it is particularly valuable for 5G networks given the spectrum's balance of coverage with fewer facilities than high-band frequencies while still providing substantially greater capacity than low-band.[51]

- **High-band spectrum** (e.g., millimeter wave spectrum) is a powerful new tool for wireless networks, unleashing gigabits of data where traffic demand is highest. It can support key elements of 5G: significantly higher speeds, far quicker response times, and the ability to serve many more devices including IoT-enabled devices.[52] In addition, because high-band frequencies do not propagate as far as low-band frequencies, the spectrum can be reused in more closely spaced small cells. High-band spectrum's large channels of hundreds of MHz deliver a capacity scale not seen before in the mobile wireless industry.

Additional technical characteristics of these bands needed to unleash the full benefits of 5G include:

1. Wide channels of contiguous spectrum to enable very high speeds, efficient performance, and multiple antenna technology, and
2. Use of globally harmonized bands, which enables economies of scale and facilitates global roaming.

Wide Channel Bandwidths Are Important to 5G

Wide channel bandwidths are achievable with mid- and high-band spectrum and are indispensable to achieving the faster connections and lower latency that 5G promises. Therefore, it is important that licensees have the opportunity to assemble 100-megahertz bandwidth spectrum blocks.[53] While the FCC may not be able to immediately allocate 100-megahertz channels in all instances, mid-band and high-band spectrum blocks for 5G should have 100-megahertz channel sizes as a minimum goal whenever practical. Other countries have recognized this physical and technological reality and are focusing on the availability of 100-megahertz channels for 5G.[54]

Additionally, the International Telecommunication Union's 5G performance requirements for bandwidth include a floor of at least 100 megahertz, with up to one gigahertz in frequency bands above 6 GHz.[55] The 5G standard anticipates a peak data rate of 20 Gbps (in the downlink) and 10 Gbps (in the uplink)—which would require a 100-megahertz channel bandwidth.[56] Moreover, wide channels are a prerequisite to achieving 5G's low latency.[57] It is key that mid-band and high-band spectrum blocks for 5G that are focused on high data throughputs with 100-megahertz channel sizes as a goal whenever practical.

Contiguous Spectrum is the Most Efficient Way to Enhance Performance

Radio equipment capable of supporting several wide channels within the hardware's tuning range (as discussed in detail below) reduces costs to industry and speeds time to market. As noted above, mid- and high-band spectrum provide opportunities for a broad amount of nearly contiguous spectrum available for 5G along with improved propagation characteristics, costs for equipment, and deployment that will be much more economically feasible.[58] While carrier aggregation technology has allowed for the aggregation of non-contiguous spectrum blocks, use of this method introduces latency and signaling overhead (especially as more carriers/spectrum is added).[59]

Therefore, contiguous spectrum for 5G, as shown in the figure below as (a), should be prioritized to the extent possible to allow for faster data rates, lower latency, and improved spectral efficiency (allowing more capacity in the same amount of spectrum). Additionally, candidate bands should be prioritized that are adjacent to existing commercially allocated bands.

To allow for the most efficient deployments with the best spectral efficiencies and highest data rates, policymakers should prioritize spectrum allocations shown in figure (a) – large, contiguous blocks of spectrum. However, figure (b), so long as the allocation can be provided within the tuning range of mobile devices and base stations, would also be desirable.

Contiguous vs. Non-contiguous Spectrum

(a) Contiguous Band

(b) Non-contiguous Bands

Spectrum Must Support Multiple Antenna Technology for 5G

There are some significant characteristic and architectural differences between 4G LTE and 5G with respect to the Radio Access Network (RAN) design.[60] Importantly, the 5G RAN supports new, massive MIMO antenna arrays in base stations and devices, enabled by the higher spectrum bands targeted for 5G deployment and by the new radio architecture.[61]

Massive MIMO is unleashed in higher spectrum bands because of the reduced physical size of the radio and antenna components. An antenna array consists of a number of building blocks called elements. The element size depends on the spectrum band—the higher the frequency band of the spectrum, the smaller the element. Mid- and high-band spectrum can encompass a much larger number of elements within an antenna than low-band—greatly increasing the gain, or focus, of the antenna.

Today's 4G LTE systems, operating mainly in sub-2 GHz spectrum, have deployed antennas capable of achieving 4x4 or 8x8 MIMO. In mid- and high-band spectrum, the same size antenna can support five to thirty times the number of antenna elements—enabling the first 5G combinations of 64x64 or 128x128 MIMO systems.

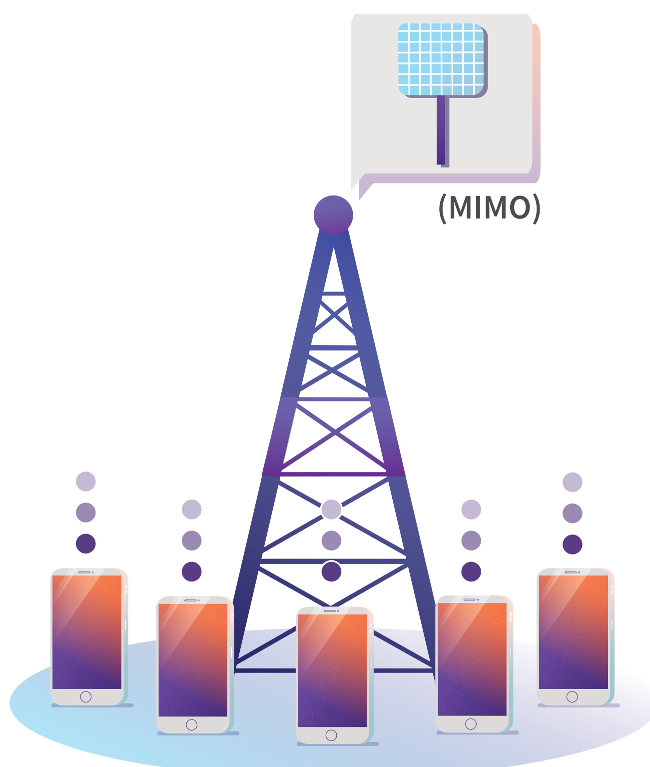
The 5G radio architecture is a second key enabler of massive MIMO technology. 4G LTE base stations are generally designed with a remote radio head mounted at the antenna, housing the transmitters and receivers, and connected via fiber optic cable to the baseband equipment at the base of the tower.

Thus, the class of MIMO which could be achieved by 4G LTE was limited by the number of transceivers that could fit within the remote radio head architecture, which was in turn driven by the larger components required in the lower-band spectrum. In contrast, the 5G base station integrates the transceiver equipment within the antenna—a miniaturization made possible by the component size reduction inherent to the higher frequency ranges.

Thus, a 5G antenna will incorporate 64 to 128 transceivers, working together to focus energy in the direction of the device—and delivering the high throughputs expected.

One national operator is already deploying massive MIMO in the 2.5 GHz band, with the option to upgrade the existing 4G LTE site to 5G NR via a software update.[62] By focusing on new mid- and high-band spectrum for 5G, especially bands that are targeted internationally by standards bodies, new spectrum made available by the FCC will be able to support massive MIMO in an expeditious fashion—delivering improved spectral efficiency and enhanced data rates for wireless subscribers.

Multiple Antenna Technology



Globally Harmonized Bands Provide Scale and Enable Global Roaming

In developing spectrum policy, policymakers should consider the opportunities that global harmonization can provide while also maintaining flexibility for U.S. leadership and innovation on key 5G spectrum bands. A harmonized approach to spectrum will fuel 5G and ultimately benefit U.S. consumers of wireless broadband goods and services.[63] Spectrum harmonization reduces coordination challenges between neighboring countries and enables economies of scale that lead to lower prices and a wider range of services and devices for consumers.

Specifically, continued global harmonization would result in a number of key benefits for wireless consumers, including: (1) manufacturing economies of scale to allow the development of equipment that can cover multiple bands in a single radio, leading to lower prices; (2) international roaming with affordable user devices; and (3) accelerating the availability of equipment in newly authorized bands that share a tuning range with early-deployed bands.[64]

Harmonized spectrum allocations allow equipment vendors to develop uniform radio products that can be deployed globally without fundamental changes to the underlying device. For example, certain device manufacturers have only a relatively small number of unique devices available globally primarily due to spectrum harmonization. These economies of scale can directly lead to lower device and infrastructure costs for consumers and wireless providers.

Moreover, when consumers roam from the U.S. to other countries, having similar (if not the same) spectrum bands available globally as are available in the U.S. greatly simplifies the roaming process. The mobile device will be able to operate internationally while relying on fewer, harmonized spectrum bands. This simplified, harmonized approach allows each device to be much less complex, much cheaper, and more energy efficient, therefore enabling superior battery performance.

Finally, if the same spectrum is allocated for 5G in many different countries, device manufacturers will be better positioned to expedite the development and deployment of compatible products, as they will not be required to manufacture specialty devices for each country or market. New devices can leverage existing components, or only require minor changes, prior to deployment.

Importantly, international harmonization is not limited to situations in which all regions have identical spectrum allocations.[65] Harmonization can be achieved through flexibility including through a "tuning range approach."[66] Adoption of "radio tuning ranges" provides the benefits of international harmonization, even when different countries use different segments of a frequency range for IMT.[67] Specifically, the tuning range approach can be leveraged so that devices are capable of operating within the radio tuning range, but only operate on the subset of frequencies within that range that are authorized in an individual country.[68]

This approach provides the benefits of harmonization while allowing regulators the flexibility to assign spectrum within this range for domestic use as appropriate.[69] It can be used to ensure that U.S. 5G bands are included in a globally harmonized range that allows the U.S. to take advantage of economies of scale and global roaming even when spectrum is not perfectly harmonized.[70]

While it is imperative that harmonization remain a top goal of U.S. policymakers, the U.S. may need to nonetheless move ahead with making key bands available for 5G even if other countries initially are not (e.g., the 28 GHz band, which was recently successfully auctioned in the U.S.). Government policymakers should ensure that their positions reinforce U.S. 5G leadership and do not undermine access to critical bands identified for 5G.

Further, U.S. policymakers should work carefully to ensure that neither U.S. nor international actions have an undue negative impact on bands that have already been identified here in the U.S. The U.S. can achieve this goal by retaining flexibility in the Radio Regulations to make its own decisions whenever possible, rather than being constrained to international consensus of interests that may not align with our own.[71] It is with this flexibility (in coordination with international efforts) that the U.S. may continue to lead the world in next-generation wireless deployment and reap associated economic benefits.

There has been a global push to accelerate 5G development and standardization. 3GPP, a collaboration of global standards organizations, worked with its members to complete the standards almost two years ahead of the original plan.[72] Meanwhile, key technology companies moved from R&D into full development and commercialization.

These technology companies include major chipset companies like Qualcomm, who in December 2018 announced the Snapdragon 855 processor for mobile phones, which will "support 'multi-gigabit' download speeds on 5G networks."[73] and at Mobile World Congress in February 2019 announced their second generation RF front end for mobile devices.[74]

Last November, Intel announced that its XMM 8160 5G modem would be available in 2019 for phones, laptops and gateways.[75] Intel is also supplying base station processors to Ericsson and Nokia.[76] Network suppliers such as Ericsson, Nokia, and Samsung have invested heavily in R&D and moved from trials to commercial deployments, supplying U.S. operators with the network equipment as each company rolls out its 5G networks.

But, these 5G networks would not be useful without devices. Most operators are starting out with mobile hotspots such as Netgear, but everyone is watching as smartphone suppliers like Samsung,[77] LG,[78] Motorola,[79] and others announce 5G devices. As the 5G ecosystem ramps up, we can expect a wide range of devices to come out to support the plethora of use cases envisioned for 5G.

Conclusions

To ensure U.S leadership in 5G deployment and services, policymakers must consider the following key spectrum characteristics in making significant new allocations of low-, mid-, and high-band spectrum available:

- Licensed, exclusive-use spectrum
- Flexible-use rights
- Prioritization of cleared spectrum
- Wide channels of contiguous spectrum to enable very high speeds, efficient performance, and multiple antenna technology, and
- Use of globally harmonized bands, which enables global scale and roaming.

With the full support of the FCC, NTIA, and the backing of Congress, policymakers are in a unique position to enable the U.S. wireless industry to once-again lead in wireless technology, enabling the full benefits of 5G for consumers, businesses, and the economy.

Appendix: Specifics of Spectrum Allocations Counts

Fixed Spectrum (MHz)		Spectrum (MHz)
928	929	1
932	935	3
941	944	3
952	960	8
3700	4200	500
5925	6425	500
6425	6525	100
6525	6875	350
6875	7125	250
10550	10680	130
10700	11700	1000
12200	12700	500
12700	13350	650
17700	19700	2000
21200	23600	2400
24250	25250	1000
29100	29250	150
31000	31300	300
71000	76000	5000
81000	86000	5000
92000	95000	3000
		22845

Mobile Spectrum		Spectrum (MHz)
617	652	35
663	698	35
698	728	30
728	746	18
746	757	11
776	787	11
817	824	7
824	849	25
862	869	7
869	894	25
1695	1710	15
1710	1780	70
1850	1920	70
1930	2000	70
2000	2020	20
2110	2180	70
2180	2200	20
2305	2320	15
2345	2360	15
2496	2690	194
3550	3700	150
24250	24450	200
24750	25250	500
27500	28350	850
37000	40000	3000
47200	48200	1000
		6463

Appendix: Specifics of Spectrum Allocations Counts

C Band Spectrum		Spectrum (MHz)
3700	4200	500
4500	4800	300
5150	5250	100
5850	7075	1225
		2125

Ka Band Spectrum (MHz)		Spectrum (MHz)
24750	25250	500
27500	30000	2500
37500	42000	4500
47200	50200	3000
50400	51400	1000
71000	76000	5000
81000	86000	5000
		21500

Ku Band Spectrum (MHz)		Spectrum (MHz)
10700	12200	1500
12200	12700	500
12700	13250	550
13750	14500	750
17300	17800	500
18300	20200	1900
		5700

SAT Band	Spectrum (MHz)
C Band	2125
Ku Band	5700
Ka Band	21500
	29325

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