Spectrum Strategies for 5G: 2019 Update

If the US wants to lead the World in the 5G Era,
it is critical to allocate Low and Mid band spectrum for Mobile 5G

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EXECUTIVE SUMMARY

Wireless 20/20 believes that a balanced portfolio of 5G licensed and unlicensed high, medium and low band spectrum will be required to support 5G network deployments worldwide over the next decade.

In this update of our report **Spectrum Strategies for 5G**, Wireless 20/20 examines the state of the spectrum availability as it applies to 5G Fixed and Mobile Broadband deployments. In this report we focus on the state of the sub-6GHz spectrum availability as it applies to 5G mobile deployments in the US. By asking "What spectrum bands will US operators use for Mobile 5G?", we examine not only the current spectrum holdings of the top 4 US mobile operators, but also, the potential availability of suitable spectrum for mobile 5G deployment in the US. A balanced portfolio of 5G licensed and unlicensed high, medium and low range spectrum will be required to support 5G network deployments over the next decade. Wireless 20/20 believes that it is critical for the FCC to allocate Low and Mid band spectrum for mobile 5G if the US wants to lead the World in the 5G Era.

This updated report provides an overview of the dependencies between the 5G applications, spectrum requirements and spectrum ranges in a way that may be attractive for the deployment of 5G Fixed and Mobile broadband services. 5G Americas published a white paper in September, 2017 entitled **Spectrum Landscape for Mobile Services** that highlighted the importance of spectrum harmonization across licensed and unlicensed low-, mid- and high-range to support smooth 5G network deployments and delivery of 5G services. The initial 3GPP standard covers both fixed and mobile applications and completes the common part of 5G NR in both NSA and SA modes, laying a solid foundation for a global unified 5G system with worldwide market scale. The global 5G standard for a new OFDM-based air interface is designed to support the wide variation of 5G device-types, services, deployments and spectrum bands. The 3GPP ratified the 5G New Radio (5GNR) Non-Standalone (NSA) specification just before yearend 2017. Exhibit 1 presents the key potential 5G spectrum bands included in the 5GNR NSA specification and identified by 5G Americas.

Exhibit 1

5G Spectrum Strategies for Low-, Mid- and High-Band Ranges

Range	Band	Frequency Band	Bandwidth	Frequency Range
Low	71	600 MHz	81 MHz	617MHz - 698MHz
	44	700 MHz	100 MHz	703 MHz - 803 MHz
Mid	66	(AWS) 1700.2100 MHz	100 MHz	1710-1780 and 2110-2200 MHz
	40	2.3 GHz	100 MHz	2.3 – 2.4 GHz
	41	2.5 GHz BRS/EBS in US	194 MHz	2496 - 2690 MHz
	42	3.5 GHz	200 MHz	3400 - 3600 MHz
	43	3.6 GHz	200 MHz	3600 - 3800 MHz
	C-band	4.4 GHz	590 MHz	4400 - 4499 MHz
High	n258	24 GHz mmWave	3.25 GHz	24.25 - 27.5 GHz
	n257	26 GHz mmWave	3.00 GHz	26.5 - 29.5 GHz
	n261	28 GHz mmWave	850 MHz	27.5 - 28.35 GHz
	n260	37 GHz mmWave	1 GHz	37.0 - 38.6 GHz
	n260	39 GHz mmWave	2 Ghz	38.0 – 40.0 GHz
	n257	47 GHz mmWave	1 GHz	47.2 - 48.2 GHz

Source: 5G Americas, 3GPP 5GNR NSA specification and Wireless 20/20, December 2018

As indicated in Exhibit 2, each spectrum band has specific characteristics that make it suitable for certain deployment scenarios. While the low range of spectrum below 1 GHz has very good propagation characterisitcs that make it feasible for large area coverage, it has limited capacity due to lack of available spectrum and component design considerations. The mid-range of spectrum from 1 – 6 GHz provides a type of coverage more feasible for urban as well as rural deployments, with increased capacity. Together, the low- and mid- bands are considered sub-6GHz frequency bands.

The high-band of spectrum in the mmWave range is more limited in coverage, but could provide very high capacity due to the amount of unused spectrum available at these frequencies. While mmWave spectrum offers more capacity

and higher speeds, it cannot cover large geographic areas and will require significant new small cell infrastructure deployments. There is growing momentum behind allocating licensed spectrum in the mmWave bands. In this range, 24 MHz, 26 GHz and 28 GHz have emerged as three of the most important bands. The availability of large blocks of unused spectrum in the mmWave bands will enable ulta-high speed broadband services.

Most of these bands are designated for licensed spectrum, but certain mid- and high- bands have been designated for dynamic sharing or unlicensed usage. Given the diversity of future applications no single band can meet every 5G requirement.

Exhibit 2

5G Spectrum Strategies For Low-, Medium- and High-Band Ranges

Spectrum Bands	*Licensed*	*Shared*	*Unlicensed*
Low-band ***Below 1 GHz*** *Limited capacity with large area coverage and indoor penetration*	*600 MHz US* *700 MHz EU*		
Mid-band ***1 – 6 GHz*** *Good for urban deployment with increased capacity*	*AWS (Band 66)* *2.5 GHz* *3.3 - 4.3 GHz* *4.4 - 4.99 GHz*	*3.5 GHz CBRS US* *3.7-4.2 GHz US* *5.9-7.1 GHz US.*	*5-5.9 GHz*
High-band ***Above 20 GHz*** *Limited coverage with potential for very high capacity*	*4.25 - 29.5 GHz* *27.5-28.35 GHz* *37-38.6 GHz* *38.6-40 GHz*	*37-37.6 GHz* *57-71 GHz*	*64-71 GHz*

Source: Wireless 20/20, December 2018

US MOBILE OPERATORS USE HIGH-BAND MMWAVE SPECTRUM FOR 5G FWA

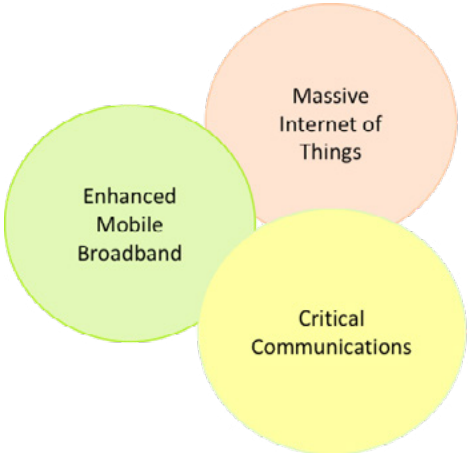
In 2016, the 3GPP published TR22.891, which contains more than 70 different use cases for potential 5G requirements, categorized in to three different groups:

- **Enhanced Mobile Broadband**.
- **Critical Communications**.
- **Massive Internet of Things**.

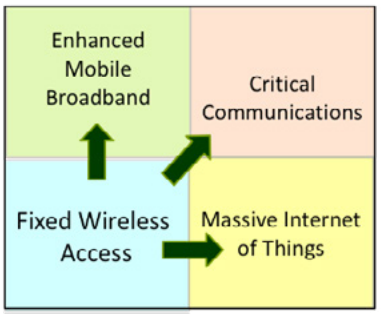
Exhibit 3

New Paradigm for 5G Use Cases

3GPP Original 3GPP Paradigm for 5G Use Cases



Wireless 20/20 Paradigm for 5G Use Cases



This is exactly why Verizon has been concentrating on the Fixed Wireless Access use case in order to develop an ecosystem of vendors to advance mmWave technology and showcase the building blocks that will ultimately be necessary for the commercial deployment of mobile 5G. Verizon is using 5G FWA to reduce the capital cost of extending the reach of FiOS services via fixed wireless to more US households in select metros.

Verizon launched Verizon 5G Home wireless broadband services powered by millimeter-wave spectrum in limited areas of Sacramento, Los Angeles, Houston and Indianapolis beginning in October 2018. Verizon has built a strong ecosystem partners to help drive forward with 5G industry standards for both fixed and mobile applications. Verizon estimates the overall market opportunity for 5G residential fixed wireless broadband services to be approximately 30 million households nationwide.

Wireless 20/20 believes the 5G Fixed Wireless Access use case is an ideal application to enable the industry to develop and test many of the piece-parts that will ultimately be integrated in smartphones.

Verizon and AT&T were first movers in conducting field trials of 5G technologies to support fixed wireless services in the US. Both operators have wireline operations that have been deploying fiber, but have been testing 5G FWA as a more cost-effective approach to expand the coverage and capacity of their fixed broadband networks. Wireless 20/20 believes the 5G Fixed Wireless Access use case is an ideal application to enable the industry to develop, and test many of the piece-parts that will ultimately be integrated in smartphones.

Both AT&T and Verizon have aggressively pursued acquisitions of mmWave spectrum in the Verizon launched Verizon 5G Home wireless broadband services powered by millimeter-wave spectrum in limited areas of Sacramento, Los Angeles, Houston and Indianapolis beginning in October 2018. Verizon has built a strong ecosystem partners to help drive forward with 5G industry standards for both fixed and mobile applications. Verizon estimates the overall market opportunity for 5G residential fixed wireless broadband services to be approximately 30 million households nationwide.

Verizon completed the $1.8 billion acquisition of XO Communications in early 2017, with 102 licenses in 28 GHz and 39 GHz bands that cover 63% of US Pops. Verizon also acquired Straight Path with 133 licenses in the 28 GHz band and 735 licenses in the 39 GHz band. Through the acquisition of XO and Straight Path, Verizon controls 235 of 766 total active LMDS licenses. In February 2018, AT&T closed the acquisition of backhaul provider FiberTower, with average holdings of more than 375 MHz in the 39 GHz band in the top 100 markets. As a result of these acquisitions, AT&T and Verizon currently control approximately 58% of the licensed mmWave spectrum.

Under Chairman Pai, the FCC is now pursuing a comprehensive strategy to Facilitate America's Superiority in 5G Technology (the 5G FAST Plan). The Chairman's strategy includes three key components: (1) pushing more spectrum into the marketplace; (2) updating infrastructure policy; and (3) modernizing outdated regulations.

The FCC is currently conducting its first 5G spectrum auctions in the 28 GHz and 24 GHz bands.

Auction 101: 27.500–28.350 GHz band, divided into two 425 MHz spectrum blocks, with a total of 3,072 licenses up for auction to 45 bidders.

Auction 102: 24.25 – 24.45 GHz licensed as two 100 MHz blocks (Blocks A & B) 24.75 – 25.25 GHz licensed as five 100-megahertz blocks (Blocks C – G) for a total of 2,909 licenses up for auction.

After 152 rounds in 35 days of bidding activity in the FCC's Auction 101 for 28 GHz spectrum, the total amount of provisionally winning bids has surpassed $700 million as of January 21, 2019. The 28GHz spectrum auction is "predominantly a Verizon auction" since Verizon already owns 76% the nation's 28GHz spectrum covering fully 258 million POPs, thanks to its acquisition of XO Communications that closed in 2017. T-Mobile also acquired 28 GHz spectrum licenses covering a total of 100 million POPs through its 2013 acquisition of MetroPCS. Although most of this mmWave spectrum is currently used for wireless backhaul, T-Mobile owns roughly 20% of the commercial 28 GHz band in New York City, while Verizon owns the remaining 80%. In addition to Verizon, AT&T, T-Mobile, US Cellular, Frontier, Windstream and a host of smaller and rural telcos are among the companies that were qualified to bid in the ongoing 28GHz auction.

Auction 101 will be followed by Auction 102 for virtually nationwide spectrum in the 24 GHz band offering licenses in key locations like Chicago, New York City, Boston and Los Angeles. Licenses in the upcoming 24GHz Auction 102 will be available in Partial Economic Area geographic sizes, which means they are much larger than the county-size licenses in the 28GHz auction. With the completion of these two auctions, the FCC will have made 1.55 GHz of mmWave spectrum available for 5G. The FCC also plans to auction the upper 37 GHz, 39 GHz, and 47 GHz bands later in 2019. In addition, the FCC is working to free up another 2.75 gigahertz of 5G spectrum in the 26 and 42 GHz bands by 2020. With the completion of these auctions, the FCC will release nearly 5 GHz of 5G high-band mmWave spectrum into the market—more than all other flexible use bands combined.

Recognizing that unlicensed spectrum will also be important for 5G, the FCC is also creating new opportunities for the next generation of Wi-Fi in the 6 GHz and above 95 GHz band. The FCC also made available 600 MHz of spectrum in the 37-37.6 GHz band for dynamic shared access between different commercial users, and commercial and federal users. In all, the new FCC Spectrum Frontiers rules open up almost 11 GHz of spectrum for flexible use wireless broadband – 3.85 GHz of licensed spectrum and 7 GHz of unlicensed spectrum.

THE FCC NEEDS TO ALLOCATE MORE LOW- AND MID-BAND SPECTRUM FOR MOBILE 5G

In order for the US to maintain its leadership in the field of Mobile 5G, the FCC must lay out a clear path for sub-6 GHz spectrum suitable for mobile 5G deployment.

Although much of the activity on 5G spectrum in the US to date has focused on millimeter (mmWave) spectrum, it is not clear that mmWave spectrum will be suitable for mobile 5G network deployment in the near to mid-term future. Low and mid-band wireless signals travel further and penetrate obstacles like buildings better than high-band spectrum. As per Ericsson's June 2018 Mobility Report "In general, all the current 3GPP bands including low bands (600 MHz, 700 MHz, 800 MHz, 850 MHz and 900 MHz) and mid-bands (1.5 GHz, 1.7 GHz, 1.8 GHz, 1.9 GHz, 2.1 GHz, 2.3 GHz and 2.6 GHz) are being considered for 5G services in the future". The FCC ultimately plans to make low- and mid-band licensed spectrum available for 5G services. However, the FCC has yet to lay out a clear strategy for allocating additional sub-6GHz spectrum for 5G. This makes 2019 an even more critical year to start planning and allocating harmonized 5G spectrum in the low- and mid-bands.

We consider a spectrum to be suitable for 5G deployment if it consists of a minimum of 100 MHz of bandwidth, because, in order to deliver speeds close to 1Gbps, 100 MHz will be needed if an efficient modulation scheme is used that produced 10bits/Hz, assuming TDD technology. According to Joan Marsh, AT&T's VP of Regulatory Affairs, ideally 200 MHz blocks are needed for favorable 5G deployments and maximize the number of blocks available for auction. If FDD technology is used, this would enable 2x100 MHz of spectrum in order to deliver 1 Gbps downlink speeds. There is always an opportunity to use asymmetrical downlink vs. uplink spectrum bandwidth, for example by allocating 100MHz for uplink and 40 MHz for downlink. There is also the option of combining two separate spectrum bands, where one is used for DL and the other is used for UL (Example, AWS use case of 1700/2100 MHz for UL/DL).

By this definition, currently neither AT&T, Verizon nor T-Mobile controls sufficient sub-6GHz spectrum that is suitable for mobile 5G network deployment. T-Mobile participated in the 600 MHz auction and was able to secure an average of 30 MHz of this low-band spectrum in many markets nationwide. As of yearend 2018, T-Mobile has deployed an Extended Range LTE network using its 600 MHz in more than 1,250 cities and towns throughout 36 states. T-Mobile has also been working with Nokia to complete tests of 5G data transmission over its 600MHz radio spectrum setting the stage for a broad and potentially fast rollout of 5G services across the US. Although there is 70 MHz of total available bandwidth in the 600 MHz Band 71, this is clearly not enough by itself for mobile 5G network deployment.

Only Sprint has the 100 MHz of bandwidth in the 2.5 GHz spectrum band that could support 5G deployment with user downlink speeds that could deliver 1Gbps service. Sprint controls around 120 MHz of 2.5 GHz spectrum in 90 percent of the top 100 U.S. markets, and the 2.5 GHz spectrum band is included in the Non-Standalone 3GPP 5G NR specification (initial part of Release 15).

US Mobile operators have several options when it comes to securing additional sub-6 GHz spectrum for mobile 5G. These include:

A. Re-farm spectrum from 2G and 3G and use carrier aggregation to allocate 100 MHz of spectrum for 5G.

B. Lobby the FCC to open 3.5 GHz spectrum for 5G.

C. Lobby the FCC for finding 4 GHz or 6 GHz spectrum that could be used for 5G.

D. Work with the FCC and existing 2.5 GHz spectrum holders in order to open up the additional 2.6 GHz spectrum that is not held by Sprint.

E. Partner with current holders of virgin sub 6 GHz spectrum in the USA (i.e. DISH Networks) and combine their AWS spectrum with existing AWS spectrum to aggregate the necessary 100 MHz for Mobile 5G.

For Verizon, the most logical approach would be option E, where it could partner with DISH and combine DISH's AWS-4 spectrum with its own and thereby control a large chunk of 1700 / 2100 MHz spectrum for 5G (see Exhibit 4). DISH has to meet certain FCC-designated buildout requirements or it will risk having to forfeit these valuable spectrum licenses. DISH Network recently announced plans to deploy a neutral host 5G cellular NB-IoT network starting with an investment of $500 million to $1 billion by March 2020, a date that coincides with the FCC requirement that, Dish must build out the spectrum to 70% of its license territory by March 2020. Dish has positioned the cellular NB-IoT network as the first phase in the deployment of a standalone neutral host 5G network using the unused low and mid-band

acquired over the period from 2008-2014. In July 2018, the FCC requested updates and more detailed information on DISH buildout plans for the 50+ MHz of low- and mid-band spectrum that is apparently lying fallow in these bands.

Exhibit 4

Total Millimeter Wave Spectrum with FiberTower's Terminated Licenses

Dish Unused Spectrum	Bands	Year and Method Acquired
6 MHz	700 MHz band E Block	$712 million in 2008 auction
40 MHz	AWS-4 band	Advanced Wireless Services from Modified Mobile Satellite Services
10 MHz nationwide	H Block	$1.546 billion in 2014 auction

Source: FCC and DISH Network filings

AT&T is currently promoting the availability of 5G Evolution in parts of a dozen cities during spring 2019 using existing LTE spectrum and advanced LTE network technologies such as 4x4 MIMO and 256 QAM. By early 2020, AT&T expects to have a standards-based, nationwide mobile 5G network using its low band spectrum (sub-6 GHz), while also offering 5G+ coverage over millimeter wave spectrum. But if the Mobile 5G promise is to be met by the 2020 timeframe, additional sub 6-GHz spectrum will be necessary. AT&T could enter a bidding war with Verizon over DISH's spectrum, or consider lobbying the FCC to open new sub-6 GHz 5G spectrum (which could be 2.5 GHz, 3.5 GHz, 4 GHz or 6 GHz).

T-Mobile participated in the 600 MHz auction and was able to secure an average of 30 MHz of this low-band spectrum in many markets nationwide. As of yearend 2018, T-Mobile has deployed an Extended Range LTE network using its 600 MHz in more than 1,250 cities and towns throughout 36 states. T-Mobile has also been working with Nokia to complete tests of 5G data transmission over its 600MHz radio spectrum setting the stage for a broad and potentially fast rollout of 5G services across the US. Although there is 70 MHz of total available bandwidth in the 600 MHz Band 71, this is clearly not enough by itself for mobile 5G network deployment. For T-Mobile, it could increase its effort to lobby the FCC to assign the 3.5 GHz spectrum band for 5G. If successful, this will give T-Mobile a chance to acquire new, and relatively unencumbered spectrum suitable for 5G. Otherwise it could join AT&T in lobbying for new 5G spectrum in the 4 GHz or 6 GHz bands.

For Sprint, the most logical approach would be option D, where Sprint would potentially consider working with other 2.5 GHz owners and essentially control a contiguous 200 MHz of spectrum from 2496 – 2590 MHz in the USA. Sprint currently controls around 120 MHz of 2.5 GHz TDD spectrum in 90 percent of the top 100 U.S. markets The FCC has already issued an NPRM to extend the geographic coverage of 2.5 GHz EBS spectrum to county boundaries and issue additional licenses in existing white spaces.

A merged Sprint and T-Mobile would have an average of 319 MHz of sub 6 GHz spectrum in the top 50 markets. By comparison, AT&T has 177 MHz and Verizon has 114 MHz. As such, the FCC and Department of Justice may require T-Mobile/Sprint to divest some of their spectrum holdings as a condition for approval of their proposed merger. As a concession to obtain approval of the proposed merger, T-Mobile/Sprint may offer to divest Sprint's leases of "EBS" spectrum in the 2.5 GHz band. This divestiture would make FCC Commissioner Jessica Rosenworcel's recent **proposal** to hold a voluntary incentive auction for EBS licenses in the 2.5 GHz band more compelling. The Commissioner's proposal recognizes that the 2.5 GHz spectrum band has the choice mix of propagation and capacity that are essential for widespread 5G deployment. Wireless 20/20 is developing a comprehensive plan for transitioning more than 100 MHz of prime 2.5 GHz EBS spectrum to commercial use through an incentive auction for commercial 5G mobile and fixed broadband uses in both urban and rural areas.

HARMONIZING SPECTRUM BANDS FOR 5G

Wireless 20/20 believes that the time is now for the planning and allocation of harmonized spectrum in sub-6 GHz low- and mid-bands to help carriers successfully deploy 5G enhanced mobile broadband and massive IoT services nationwide.

Exhibit 5 indicates that China, Canada and the EU have all recognized the benefits of allocating sub-6 GHz 5G spectrum and are focusing on the 3.5 GHz spectrum band. Canada has the opportunity to designate the 3.5 GHz spectrum for 5G since most of that spectrum is unused in metro markets. Despite calls for harmonized 5G spectrum, the US and EU seem to be on different paths at least in the near term. Several spectrum bands were identified by the ITU WRC-15 for future 5G services, including three bands above 6GHz in the 24 GHz, 31 GHz and 40 GHz bands. Europe is currently focusing on sub-6 GHz spectrum for initial 5G trials and deployments, including 3.5 GHz C-Band (3.4 - 3.8 GHz), to be allocated for 5G across multiple markets. The EU Council adopted a decision which calls for the coordinated use of the 700 MHz band to drive the roll-out of 5G wireless technology and boost mobile broadband connectivity in all EU member states. As a result of this decision, European mobile operators will obtain exclusive access to the 700 MHz band (694-790 MHz) by June 2020, a timeframe that coincides with the expected deployment of 5G networks in Europe.

Since 2016, the FCC has been pushing for US operators and their vendors to get a head start with 5G by unilaterally identifying new mmWave spectrum bands above 6 GHz. During the Obama administration, the FCC's Spectrum Frontiers1 Notice of Proposed Rulemaking/

Final Notice of Proposed Rulemaking (NPRM/FNPRM) was adopted to establish a spectrum environment conducive to 5G investment. These new rules opened nearly 11 GHz of high-frequency spectrum for mobile and fixed wireless broadband – 3.85 GHz of licensed spectrum and 7 GHz of unlicensed spectrum.

These rules also created a new Upper Microwave Flexible Use service in the 28 GHz (27.5-28.35 GHz), 37 GHz (37-38.6 GHz) and 39 GHz (38.6-40 GHz) bands. The FCC will continue to seek comment on bands above 95 GHz. The FCC made plans to license spectrum in the

28 GHz, 37 GHz and 39 GHz bands on an exclusive-use, flexible-rights licensed basis, and has identified the 64-71 GHz band for unlicensed experimental sharing or other non-exclusive access arrangements.

5G Americas has promoted the 'tuning range' concept to achieve regional and global harmonization and encouraged the engagement of national regulators with one another to identify solutions to co-existence issues to allow regional and global harmonization to take place. Wireless 20/20 believes that policymakers throughout the world should initiate additional activities to consider lower frequency bands in addition to proceeding with the mmWave bands in the 24-86 GHz band.

Exhibit 5
Comparing EU Council and USA FCC 5G Spectrum Proposals

Europe	*EU Council*	*FCC*	*USA*
		600 MHz band	*Auction completed 39 months for repacking*
By June 2020 for EU 5G	*700 MHz band (694-790 MHz)*		*Already licensed for LTE*
C-Band for 5G pre-2020	*3.4 – 3.8 GHz*		*CBRS shared*
WRC-15 EU 5G	*24.5 – 27.5 GHz*		
		27.5 – 28.35 GHz	*28 GHz 5G*
WRC-15 EU 5G	*31.8 – 33.4 GHz*		*28 GHz 5G*
		37.0 -38.6 GHz	*37 GHz 5G*
		38.6 – 40 GHz	*39 GHz 5G*
WRC-15 EU 5G	*40.5 – 43.5 GHz*		
		64 – 71 GHz	*Unlicensed 5G*

Source: Wireless 20/20, December 2018

5G LOW- AND MID-BAND SPECTRUM REQUIREMENTS

It remains clear that low and mid spectrum bands are emerging as critical ingredients for 5G mobile networks to be deployed nationwide in the US. Wireless 20/20 recognizes that mmWave bands offer a huge amount of spectrum, which could deliver orders of magnitude improvements in network speed, capacity and latency. The tradeoff is that mmWave spectrum generally requires line-of-sight, can be affected by weather, and offers relatively limited coverage. Providing nationwide mobile 5G service in these high spectrum bands will also require the deployment of large numbers of small cells—and the formula has yet to be developed to do this economically at scale.

There is also still considerable work to be done to develop the beam-forming antennas and other technology required to deliver 5G mobile services using mmWave bands. As a result, mmWave band networks will likely be built in denser urban areas and other fixed wireless targeted deployments, where it makes the best economic sense and where the most subscribers can be reached.

If the industry is limited to mmWave spectrum, the map will look like 'islands' of 5G in a sea of LTE and LTE Advanced deployments. The FCC recognizes the importance of low- and mid-range spectrum in the 5G race, and recently proposed policies to increase the usability of additional 3.5 GHz band spectrum for 5G. T-Mobile and the CTIA have been leading an effort to make the 3.5 GHz CBRS band more '5G friendly' by lengthening the terms of the licenses and expanding the geographic service areas. Also in August 2018, the FCC opened an inquiry into new opportunities in the 3.7 - 4.2 GHz band, to be used for the "next generation of wireless services". This effort is also backed by Google and several wireless ISPs, who would want to use this spectrum allocated for fixed wireless services.

Wireless 20/20 believes that for the US to maintain its leadership in the field of mobile 5G, the FCC must lay out a clear path for sub-6 GHz spectrum suitable for mobile 5G deployment. Focusing primarily on mmWave as the path to mobile 5G has many challenges. Other countries and regions that want to be leaders in the new 5G wireless era will also need to allocate more licensed 5G mobile spectrum. The time is now for the planning and allocation of harmonized spectrum in sub-6 GHz low-and mid-bands to help carriers successfully deploy 5G enhanced mobile broadband and massive IoT services nationwide.

This White Paper was authored by Berge Ayvazian, Fred Campbell and Haig Sarkissian, Senior Analysts and Principal Consultants at Wireless 20/20.

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