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5G Americas Spectrum Recommendations for the U.S.

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INTRODUCTION

With the advent and popularity of the smartphone, mobile data usage has been steadily increasing year over year along a steep trend line that is expected to continue. Technology continues to advance to improve spectrum efficiency, but more spectrum will be needed to meet the mobile data demand. Licensed spectrum has been used by operators as the raw material to deliver wireless data for mobile and nomadic use cases.

Incumbents who do not utilize their spectrum very often, in both the temporal or geographical domain, create an opportunity for a shared spectrum allocation in which mobile services can utilize the spectrum when the incumbent is not operating. However, licensed spectrum has fueled the smartphone revolution. So, it is important to continue to provide enough spectrum runway so that mobile data network supply can continue to meet mobile network demand. Allocation of licensed, shared, and unlicensed spectrum is necessary for the success of 5G. However, the focus of this paper is on licensed spectrum. Allocation of spectrum under one regulatory approach is not a substitute for the other. Future spectrum should be allocated and deployed in areas where it can provide the most benefit to wireless consumers.

Exponential growth in mobile data demand in conjunction with the spectrum needs of upcoming bandwidth intensive applications envisioned for 5G necessitate the availability of new licensed spectrum pools. This paper reviews the potential spectrum resources in the U.S. below 6 GHz as well as above 6 GHz. In particular, the recent NTIA announcement about 3.45-3.55 GHz spectrum, and the FCC Mid-Band Notice of Inquiry (NOI) about the 6-24 GHz range, are discussed as important spectrum resources that need additional attention. One key characteristic of these potential 5G spectrum resources is that they are mainly in occupied bands and require clearing and/or development of sharing mechanisms.

Noting that spectrum identification and allocations take considerable time before the spectrum can be deployed and to meet current and future traffic demands, regulators and government agencies will need to take immediate actions in making sure that a sufficient amount of licensed spectrum is available for 5G deployments, in the appropriate timeframe. Contained in this paper are recommended actions for the U.S. to facilitate the deployment and success of 5G technology and the services it will enable. As discussed in the paper, it is highly desirable to have globally-harmonized licensed spectrum allocations for 5G applications.

1. 5G SPECTRUM LEGISLATIVE ACTIVITIES

5G Americas applauded the passing of the RAY BAUM'S Act as part of the Omnibus in March of 2018. This legislation, named for recently deceased Energy & Commerce staff director Ray Baum, RAY BAUM'S Act¹ ensures a pipeline of spectrum for commercial use, provides needed flexibility for spectrum auction deposits so licensed spectrum can be auctioned this year, and streamlines the siting of wireless facilities on federal property, establishing best practices for state and local jurisdictions to follow. This bill was the result of a bipartisan, bicameral agreement between Senate and House leaders. The Act provides key provisions from the Senate approved MOBILE NOW ACT (S.19) to accelerate the development of next-generation 5G wireless technology.

¹ [Ray Baum's Act](#), February 8, 2018

2. STATUS OF SPECTRUM IN THE U.S.

SPECTRUM BELOW 3 GHZ

Spectrum below 3 GHz mainly includes the licensed spectrum currently in use for 3G/4G services and unlicensed spectrum used by Wi-Fi/Bluetooth. It is expected that 3G/4G spectrum will be repurposed for 5G over the long term, but, in the short term other spectrum options are necessary to support 5G. Bands with some potential for 5G include 1300-1390 MHz, 1780-1850 MHz, 1435-1525 MHz, 2700-2900 MHz, and 2900-3100 MHz. It would take several years before all or some portion of these bands may become available for 5G mobile services since all are currently used for Federal systems in the U.S. WRC-15 allocated portions of the 1427-1518 MHz to mobile services in many countries, but the U.S., China, and Russia have not yet adopted this allocation. The rest of the bands were not allocated to mobile services in WRC-15, but in the U.S., there is the option that some of the federal systems in these bands could relocate to other bands and make these bands available for commercial 5G services. For example, The FAA (Federal Aviation Administration) has considered relocating its operation from 1300-1350 MHz and freeing up this band for 5G.

SPECTRUM BETWEEN 3 GHZ AND 24 GHZ

3.1 TO 3.55 GHZ SPECTRUM

The 3100-3550 MHz band is allocated to the Federal Government Radiolocation service on a primary basis, and to non-Federal radiolocation on a secondary basis. In addition, the 3100-3300 MHz band is allocated to Federal and non-Federal Earth exploration-satellite and space research on a secondary basis and the 3300-3500 MHz band is allocated to the amateur service on a secondary basis.

The NTIA (National Telecommunications and Information Administration), in coordination with the DOD (Department of Defense) and other federal agencies have been considering repurposing a portion of this spectrum for wireless broadband services. Recently, they identified 100 megahertz of spectrum in the 3450-3550 MHz band for potential broadband wireless use. In the United States, military radar systems currently operate in 3450-3550 MHz and Amateur Radio has an allocation in this band. DOD plans to submit a proposal under the Spectrum Pipeline Act to carry out a comprehensive radio-frequency engineering study to determine the potential for introducing advanced wireless services in this band without harming critical government operations. This is a very encouraging step in the direction of making the badly-needed mid-band spectrum available for the 5G broadband services in the U.S.

This spectrum is immediately below the CBRS (Citizens Broadband Radio Service) band. International spectrum harmonization could lead to the creation of a global market for equipment that includes the 3450-3550 MHz band, and could help bring services to the market quicker, and provide economies of scale for suppliers, operators and consumers.

Being immediately below the CBRS band makes the 3450-3550 MHz band even more appealing because this band expands the amount of licensed mid-band spectrum beyond the 70 MHz that will be available for Priority Access Licenses (PAL) in the CBRS band.

CBRS SPECTRUM STATUS AND ITS CHALLENGES FOR USE AS A 5G BAND

The CBRS band (3550-3700 MHz) has a three-tier structure including incumbents (e.g. U.S. Naval Radar, DOD personnel), PALs (Priority Access Licensees), and GAA (General Authorized Access) users, in the order of spectrum access priority. Out of the 150 MHz of spectrum allocated to CBRS, a maximum of 70 MHz is reserved for PALs and a minimum of 80 MHz to GAA. GAA users will also be able to use the PAL spectrum when not in use by PAL licensees. The band is currently under development and requires SAS and ESC certification. PAL licenses have not yet been auctioned.

The CBRS spectrum, with its current three-tier structure, does not necessarily offer a plausible 5G spectrum solution in 3-5 GHz to the U.S. mobile service providers because of the limited amount of available spectrum and its low transmitter output power. This contrasts with the status of the 3-5 GHz in all other major economies where this spectrum has been considered as a 5G priority band and has at least 300 MHz of spectrum earmarked for 5G services. Major global operators' initial rollout plans are mainly focused on 3-5 GHz spectrum, while this spectrum range is generally missing in the U.S. operators 5G plans.

In a recent NPRM, the FCC proposed some rule changes for the PAL spectrum use, including longer license terms, license renewability, larger geographic license areas, and targeted auction methodology. 5G Americas, in its comments, recommended a 10-year license term with renewal expectancy, a Partial Economic Area-like license area, and bidding on specific blocks of PAL spectrum. These changes, if adopted, will make the PAL spectrum more attractive for 5G use and facilitate creation of a sizable swath of mid-band spectrum when considered together with the 100 MHz of spectrum below the CBRS band.

3.7 – 24 GHZ

Spectrum in the 3.7-24 GHz band was the subject of a recent FCC NOI. Three bands including 3.7-4.2 GHz, 5.925-6.425 GHz, and 6.425-7.125 GHz were specifically discussed. This is clearly a good first step in the direction of providing greater spectrum in the 3-5 GHz range.

3.7 – 4.2 GHZ

The band 3.7-4.2 GHz holds significant promise for terrestrial mobile, as it overlaps and is adjacent to the 3 GHz spectrum that is being made available for 5G services in Europe. It is also adjacent to the CBRS band discussed above. The band is also utilized by C-band satellite downlink and Fixed Services, and these uses will need to be addressed as part of the process to enable this band for terrestrial 5G. The FCC is currently considering options for 3.7-4.2 GHz, and a Notice of Proposed Rulemaking is expected in the summer of 2018. The FCC should analyze and get up-to date information on the C-band earth stations to ensure that if re-allocated, current users of the band are accommodated.

5.925-7.125 GHZ

At present, the bands 6.425-7.125 GHz contain fixed links licensed to common carriers, the industrial/business pool, and public safety organizations. The band is also home to licensed mobile uses, such as remote broadcasting and public safety.

The FCC has opened an inquiry highlighted above inviting interested parties to comment on whether and how 5.925 -7.125 GHz might be further utilized for wireless broadband. The Notice of Inquiry asked whether the band could be more intensively utilized by fixed and mobile services, and whether the band could be an expansion opportunity for unlicensed devices. The FCC has received many varied comments on its proposals, including some support for making some portion available for licensed broadband, but also comments from incumbents raising harmful interference concerns with respect to existing operations. A possible next step for the FCC would be a Notice of Proposed Rulemaking if it chooses to move forward. Otherwise there is no further action to be taken.

Recommendation: Quickly finalize rules for the CBRS band in the U.S. by June 2018 and move toward an auction of the resulting licenses as soon as practicable (1H2019)

Recommendation: Certify a Spectrum Access System by August 2018 for the CBRS band

Recommendation: Prioritize rulemaking (in 2018) and allocation of the 3.7-4.2 GHz band for licensed 5G deployment by 2020,

Recommendation: Open more mid band spectrum such as 3.45-3.55 GHz by 2022 or earlier.

Recommendation: Continue to look at spectrum opportunities for licensed use of spectrum in the range 7-24 GHz

SPECTRUM ABOVE 24 GHZ

ABOVE 24 GHZ SPECTRUM ALLOCATIONS

There has been significant progress in the U.S. towards making spectrum above 24 GHz available for 5G. These bands have traditionally been used for fixed and satellite services. The FCC has been driving this process in several steps:

- Notice of Inquiry (NOI) issued in end of 2014
- Notice of Proposed Rulemaking (NPRM) issued in end of 2015
- Report and Order (R&O) and a Further Notice of Proposed Rulemaking (FNPRM) issued on July 14, 2016
- Second Report and Order, Second NPRM, Order on Reconsideration, and Memorandum Opinion and Order, issued on November 22, 2017

On July 14, 2016, the FCC adopted and released an R&O and FNPRM making available more spectrum for flexible-use wireless broadband than ever before- a total of 10.85 GHz. Specifically, the rules create a new Upper Microwave Flexible Use Service (UMFUS) in the 28 GHz (27.5-28.35 GHz), 37 GHz (37-38.6 GHz), and 39 GHz (38.6-40 GHz) bands, and an unlicensed band at 64-71 GHz.

In the process, the FCC asked additional questions regarding implementation of the rules governing those bands and proposed additional bands for consideration: 24-25 GHz (24.25-24.45/24.75-25.25 GHz), 32 GHz (31.8-33.4 GHz), 42 GHz (42-42.5 GHz), 48 GHz (47.2-50.2 GHz), 51 GHz (50.4-52.6 GHz), 70 GHz (71-76 GHz), and 80 GHz (81-86 GHz). It also sought comment on how the FCC can provide access to additional spectrum above 95 GHz. There were also several Petitions for Reconsideration urging the FCC to revisit some of the proposed rules.

On November 22, 2017, the FCC issued a Second Report and Order, Second Further Notice of Proposed Rulemaking, Order on Reconsideration, and Memorandum Opinion and Order. Comments were due January 23, 2018 and Reply Comments were due February 22, 2018.

On March 27, 2018, the Chairman of the FCC announced that he would like to have auctions of the 28 GHz and 24 GHz bands by the end of the year and would be seeking comments on auction procedures through a Public Notice adopted in April 2018.² No announcement has been made with respect to auction of additional bands already allocated for mobile services, including 37 GHz, 39 GHz, and 47 GHz.

WHAT THE SECOND REPORT AND ORDER, ORDER ON RECONSIDERATION, AND MEMORANDUM OPINION AND ORDER ACCOMPLISH:

- Made available an additional 1700 MHz of high band spectrum for flexible terrestrial wireless use in the 24 GHz ((24.25-24.45/24.75-25.25 GHz) and 47 GHz (47.2-48.2GHz) bands
- Maintained the spectrum allocations adopted in the 28 GHz, 37 GHz, and 39 GHz bands, with several minor modifications to the rules that were previously established

² [FCC Fact Sheet](#), March 27, 2018

ABOVE 95 GHZ

At its Open Meeting on February 22, 2018, the FCC adopted their Spectrum Horizons Notice of Proposed Rulemaking (NPRM) that seeks comment on a plan to make the spectrum above 95 GHz more readily accessible for new innovative services and technologies. The NPRM seeks comment on proposed rules to permit licensed fixed point-to-point operations in a total of 102.2 GHz of spectrum; on making 15.2 GHz of spectrum available for unlicensed use; and on creating a new category of experimental licenses to increase opportunities for entities to develop new services and technologies from 95 GHz to 3 THz with no limits on geography or technology.

26 GHZ (25.25-27.5 GHZ)

The FCC in its Spectrum Frontiers Second Further Notice of Proposed Rulemaking reiterated that the millimeter wave bands that were in the prior NPRM/FNPRM or raised in the record, but which have not yet been made available for flexible terrestrial wireless use, are still under consideration by the Commission. Among the other mmWave bands listed above, several commenters in this docket supported the use of the 25.25-27.5 GHz (26 GHz) band for exclusive, licensed use due to the attention that the 26 GHz band is receiving from countries primarily in Asia and the European Union for 5G. The Spectrum Frontiers proceeding on addressing additional millimeter bands is ongoing and it is expected that these bands will be considered in future Commission items. The 26 GHz band should be one of the bands considered. This band is directly adjacent to both the 24 GHz band and the 28 GHz band and therefore is in a unique position to help in the establishment of an equipment tuning range that would allow different regions/countries to select from this frequency range to implement 5G based on national interests.

Recommendation: The Commission should take necessary actions to allow flexible use based on Part 30 in the 26 GHz band.

FURTHER RECOMMENDATIONS FOR SPECTRUM ABOVE 24 GHZ

As discussed in the previous sections, the FCC's Spectrum Frontier Report and Orders and associated FNPRMs have opened the mmWave bands for mobile use. There has been clear progress in bringing 5G spectrum to the marketplace, but auction rules must still be adopted, and the auctions still must be held, before the potential of 5G in these spectrum bands can begin to be fully realized.

After the Second Report and Order released on November 22, 2016, the amount of spectrum planned for licensed or shared use rose to 5.55GHz with the opening of 1.7 GHz of spectrum in the 24 GHz and 47 GHz bands, in addition to the 3.85 GHz of spectrum opened in 2016 in the 28 GHz (27.5-28.35 GHz), 37 GHz (37-38.6 GHz), and 39 GHz (38.6-40 GHz) bands. However, the additional spectrum in the 31.8-33.4 GHz band and the 50.4-52.6 GHz band was left in a pending state. This would potentially increase licensed spectrum by 3.8 GHz, raising the total for licensed spectrum in the mmWave bands to 9.35 GHz. The Commission should quickly authorize rules for licensed operations in these bands and proceed to adopt auction rules.

Recommendation: The FCC should quickly adopt auction rules and proceed to auctioning the licensed mmWave spectrum that has been allocated via the mmWave Orders as soon as Q42018

Recommendation: The FCC should quickly issue service rules for the remaining 3.8 GHz of licensed mmWave spectrum that was left unaddressed after the 2nd Report and Order

Moreover, out of the 5.55 GHz of licensed spectrum so far opened in mmWave bands, the FCC reserved 600 MHz for shared use with Federal government services in 37-37.6 GHz. However, the extent of future Federal users and their particular applications and utilization was left unclear in the FCC's decision, as were the details of the sharing framework. This makes it difficult to judge the actual long-term availability of spectrum for commercial use in this specific 600 megahertz of spectrum. The uncertainty around a 37-37.6 GHz sharing framework and its availability for commercial users could impact the development of standards and the ecosystem pertaining to the remaining 37.6-40 GHz range, for which service rules are already issued. If the Commission decided to move forward with the auction of the 37.6 – 38.6 GHz band for which service rules already exist, any technical changes necessary as a result of finalizing sharing arrangements for the 37-37.6 GHz band could be implemented on a prospective basis.

Recommendation: The FCC in coordination with the NTIA should quickly resolve the sharing framework and operability questions and issue the remaining rules for 37-37.6 GHz so the band can be used. Ideally, these rules should be aligned with the rules adopted for 37.6-40 GHz to benefit from the scale generated by equipment capable of operating across the entire 37-40 GHz range

Recommendation: The FCC should consider moving forward with the auction of the 37.6 – 38.6 GHz band quickly rather than delay auction while the 37-37.6 GHz rules are finalized

Recommendation: The FCC is encouraged to complete the re-banding of the 39 GHz band and make that band available for auction as soon as possible

3. IMPACT FROM POTENTIAL UNAVAILABILITY OF 3-5 GHz SPECTRUM

The 3-5 GHz range of spectrum has the most potential to provide a global band for 5G coverage and capacity. A global ecosystem has tremendous benefits for the U.S., including progressing technology leadership and improving experience for the U.S. population. Harmonizing international spectrum provides economies of scale for infrastructure, devices and roaming that are all beneficial to U.S. consumers.

The benefits of economies of scale from a global band includes facilitating research and development. The industry can leverage the existing R&D by bringing new spectrum to market at reduced capital costs. Lowering the cost of production/deployment has an economic effect of improving U.S. industry competitive advantages. The effect goes beyond telecom and would benefit the many industries that require connectivity in general e.g. all industries that rely on telecommunications.

There is also a benefit in shared innovation. More spectrum in a common global band also prevents fragmentation of innovation.

In addition, speed of deployment in mid-bands such as the 3-5 GHz range can be faster than in mmWave, due to reuse of the existing macro site grid, as well as, the network capacities being greater than on lower frequency bands through the use of massive MIMO. Deployment in the 3-5 GHz range will particularly be expedited if large amounts of spectrum are made available (e.g., by opening 3.7-4.2 GHz and 3.45-3.55GHz in addition to the CBRs band).

U.S. 5G LEADERSHIP

The U.S. is clearly leading the world in mmWave spectrum allocations, thanks to the FCC's determined and expeditious actions. However, that leadership in the mmWave bands may erode through delays in adopting auction rules, and indeed in holding the auctions themselves. Consequently, the more important metric—the deployment of 5G in mmWave in spectrum bands—could lag the rest of the world longer term. For this

reason, 5G Americas was very pleased that the FCC will consider a Public Notice for adoption at its April 2018 Open Meeting, and likely be requesting comment on auction rules for an auction by year end.

Recommendation: Adopting service rules is only a first step in making spectrum operational. Shortly after adopting service rules, the FCC should strive (as a general practice in all bands) to set and publish attainable schedules for adopting auction rules and holding the spectrum auction for all available bands as quickly as possible

SUCCESS OF 5G IN THE U.S.

5G spectrum plans in the U.S. have so far been mainly focused on the spectrum above 24 GHz to address the needs of some of the use cases and deployment scenarios. While mmWaves are helpful in providing large bandwidths necessary for eMBB (enhanced Mobile Broadband), their fundamental propagation challenges prevent them from being an appropriate means for large area coverage. Having set a high level of expectations in the users' mind, the success of 5G greatly hinges on 5G services availability everywhere, which will greatly hinge on the spectrum allocations and auctions below 6 GHz.

CONCLUSION AND RECOMENDATIONS

As 5G services are deployed in the U.S., they are expected to cover a wide range of applications which in turn will drive a wide variety of deployment scenarios. The different physical characteristics of spectrum leads to some applications being more suitable for, and expected to be deployed in, certain spectrum ranges including low-band, mid-band, and high-band. Each of these spectrum ranges has specific characteristics that make it suitable for certain deployment scenarios. Low-band for large-area coverage, mid-band for urban deployment with increased capacity, and high-band for limited coverage and very high capacity. As a result, no single band can meet every 5G requirement and fulfil the promises of 5G.

The future success of 5G services in the U.S. depends upon timely availability of sufficient spectrum resources to support the development, investment in and deployment of 5G. A U.S. regulatory framework that prioritizes and supports these needs both in the short (2018-2019) and long term is necessary. The following list of recommendations could drive the creation of such spectrum resources.

1. 3 to 8 GHz:

- 1.1. Quickly finalize rules for the CBRS band in the U.S. by June 2018 and move toward an auction of the resulting licenses as soon as practicable (1H2019)
- 1.2. Certify a Spectrum Access System by August 2018 for the CBRS band
- 1.3. Prioritize rulemaking (in 2018) and allocation of the 3.7-4.2 GHz band for licensed 5G deployment by 2020
- 1.4. Open more mid band spectrum such as 3.45-3.55 GHz by 2022
- 1.5. Continue to look at spectrum opportunities for licensed use of spectrum in the range 7-24 GHz

2. Above 24 GHz:

- 2.1. The Commission should take necessary actions to allow flexible use based on Part 30 in the 26 GHz band
- 2.2. FCC should quickly adopt auction rules and proceed to auctioning the licensed mmWave spectrum that has been allocated via the mmWave Orders as soon as Q42018
- 2.3. The FCC should quickly issue service rules for the remaining 3.8 GHz of licensed mmWave spectrum that was left unaddressed after the 2nd Report and Order

- 2.4. The FCC in coordination with the NTIA should quickly to resolve the sharing framework and operability questions and issue the remaining rules so the 37-37.6 GHz band can be used. Ideally, these rules should be aligned with the rules issued for 37.6-40 GHz to benefit from the scale generated by equipment capable of operating across the entire 37-40 GHz range
- 2.5. The FCC is encouraged to complete the re-banding of the 39 GHz band and make that band available for auction as soon as possible

3. 5G Leadership:

- 3.1. Adopting service rules is only a first step in making spectrum operational. Shortly after adopting service rules, the FCC should strive (as a general practice in all bands) to set and publish attainable schedules for adopting auction rules and holding the auction

ACKNOWLEDGEMENTS

The mission of 5G Americas is to advocate for and foster the advancement of 5G and the transformation of LTE networks throughout the Americas region. 5G Americas is invested in developing a connected wireless community for the many economic and social benefits this will bring to all those living in the region. 5G Americas' Board of Governors members include América Móvil, AT&T, Cable & Wireless, Cisco, CommScope, Ericsson, Intel, Kathrein, Mavenir, Nokia, Qualcomm Incorporated, Samsung, Shaw Communications Inc., Sprint, T-Mobile USA, Inc., Telefónica and WOM.

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The contents of this document reflect the research, analysis, and conclusions of 5G Americas and may not necessarily represent the comprehensive opinions and individual viewpoints of each particular 5G Americas member company.

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