

**Before the  
FEDERAL COMMUNICATIONS COMMISSION  
Washington, D.C. 20554**

In the Matter of	)	
	)	
Use of Spectrum Bands Above 24 GHz for Mobile Radio Services	)	GN Docket No. 14-177
	)	
Establishing a More Flexible Framework to Facilitate Satellite Operations in the 27.5-28.35 GHz and 37.5-40 GHz Bands	)	IB Docket No. 15-256
	)	
Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service Rules for the 42-43.5 GHz Band	)	RM-11664
	)	
Amendment of Parts 1, 22, 24, 27, 74, 80, 90, 95, and 101 To Establish Uniform License Renewal, Discontinuance of Operation, and Geographic Partitioning and Spectrum Disaggregation Rules and Policies for Certain Wireless Radio Services	)	WT Docket No. 10-112
	)	
Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0- 38.0 GHz and 40.0-40.5 GHz for Government Operations	)	IB Docket No. 97-95
	)	

**COMMENTS OF SAMSUNG ELECTRONICS AMERICA, INC. AND SAMSUNG  
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January 26, 2016

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**COMMENTS OF SAMSUNG ELECTRONICS AMERICA, INC. AND SAMSUNG  
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Samsung hereby responds to the Commission’s *Notice of Proposed Rulemaking* on the provision of Fifth-Generation (5G) mobile services in spectrum bands above 24 GHz.<sup>1</sup> Samsung

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<sup>1</sup> Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, *Notice of Proposed Rulemaking*, FCC 15-138 (Oct. 23, 2015) (“*NPRM*”). For purposes of these comments, “Samsung” refers to Samsung Electronics America, Inc. and Samsung Research America, collectively.

is enthusiastic about the potential of 5G to revolutionize the mobile experience and urges the Commission to take a leading role in bringing these services to market. 5G services will offer: (1) unprecedented data rates, (2) lower latency, (3) spectrum and energy efficiency, and (4) unprecedented mobility for consumers. The *NPRM* evidences the Commission's intent to develop a regulatory framework that will facilitate 5G mobile services. Samsung encourages the Commission to prioritize development of the 5G ecosystem and adopt technical and service rules which will foster the successful evolution to 5G.

## **I. INTRODUCTION AND SUMMARY**

Samsung strongly supports proposals by the Commission to make spectrum above 24 GHz available for 5G. Samsung shares the Commission's vision of 5G services as a significant improvement over predecessor wireless systems. 5G systems will, among other things, support groundbreaking applications, enable the "Internet of Things," and profoundly improve the way mobile services are integrated into daily life. In short, 5G technologies will transform mobile for consumers in America and around the world.

As detailed below, industry efforts and investment to develop 5G are well underway and have already borne amazing results. There are numerous initiatives around the globe focusing on millimeter wave ("mmW") technologies, and Samsung is at the forefront of nearly all of them. Development of the 5G ecosystem should be the top priority for the Commission, as it is for the industry both in the United States and around the world. One clear sign of the international recognition of the critical role that millimeter wave spectrum will play in the development of 5G technology is the adoption at the International Telecommunication Union's ("ITU") World Radio Conference ("WRC") of a resolution to study particular millimeter wave bands. The Commission should prioritize development of 5G and lead the way for the next era of global mobile technology.

Samsung draws on its decades of experience in the technology industry to offer the comments, detailed below, on the Commission’s specific proposals in the *NPRM*. As an initial matter, the *NPRM* seeks comment on potential licensing approaches for the 28 GHz (27.5-28.35 GHz), 39 GHz (38.6 to 40 GHz), and 37 GHz (37 to 38.6 GHz) bands.<sup>2</sup> Samsung fully supports the Commission’s proposal to make these bands available for mobile services, as Samsung’s testing has evidenced that mobile services can be accommodated in these bands. To optimize use of the 28 GHz, 39 GHz, and 37 GHz bands, the licensing and service rules across all three bands should be consistent to permit the most effective use of the spectrum.

Samsung further supports future efforts to identify and allocate additional spectrum in the 25 GHz and 31 GHz millimeter wave bands for mobile services. Since the adoption of the National Broadband Plan in 2010, the Commission has made the identification and allocation of spectrum below 6 GHz a key policy priority. The Commission must not slow these efforts. Samsung also provides detailed comments on the technical rules for the millimeter wave bands – technical rules which will promote the most efficient use of and deployment of services in the band. Finally, the Commission can extend Fixed Satellite Services (FSS) in the 28 GHz band under the current secondary approach or through secondary market processes such as a Commission auction. By maximizing the potential of these frequency bands, the Commission will unleash spectrum above 24 GHz to create unparalleled mobile experiences for the American public as well as the rest of the world.

## **II. DEVELOPMENT OF SERVICE RULES FOR 5G IN THE MILLIMETER WAVE SPECTRUM BANDS SHOULD BE A COMMISSION PRIORITY.**

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<sup>2</sup> *Id.* ¶ 4.

The comments submitted in response to the Commission’s *Notice of Inquiry*<sup>3</sup> on the provision of 5G mobile services in spectrum bands above 24 GHz affirmed Samsung’s own findings: 5G technologies will revolutionize mobile and their development is well underway. Numerous characteristics of the millimeter wave spectrum bands make these bands ideal candidates for 5G services. Given this rapid technological evolution, the Commission should act quickly to ensure that the United States remains a global leader in mobile broadband deployment.

**A. The Significant Benefits of 5G Will Change the Mobile Experience.**

The benefits of 5G are myriad. First, 5G delivers unprecedented speeds. As a baseline, 5G systems will provide gigabit-rate data services regardless of user mobility and/or location. Samsung has already completed a 5G network test in the 28 GHz band that achieved network data transmission rates of 7.5 Gbps.<sup>4</sup> Not only will 5G network speeds be much higher than 4G speeds, but users will also enjoy a more uniform high-speed experience throughout the entire 5G network. The increased density of 5G networks will ensure that data rates do not drop as dramatically when users move further away from wireless base stations.

Second, 5G is a critical input for next-generation applications. The high data rates possible over 5G networks will help support innovative applications that are both already in the market and in development. For example, new technologies such as virtual reality viewing of live events will need to leverage high bandwidth mobile services and will require significant data

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<sup>3</sup> Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, *Notice of Inquiry*, FCC 14-154 (Oct. 17, 2014) (“*Notice of Inquiry*”).

<sup>4</sup> Press Release, Samsung, Samsung Electronics Sets 5G Speed Record at 7.5Gbps, Over 30 Times Faster than 4G LTE, (Oct. 15, 2014), *available at* <http://www.samsung.com/uk/news/local/samsung-electronics-sets-5g-speed-record-at-7-5gbps-over-30-times-faster-than-4g-lte>.

rates. 5G will play an essential role in bringing innovative services and experiences to consumers.

Third, 5G systems will experience much lower latency than previous generations of wireless technology. 5G networks will deliver end-to-end latency of less than 5 milliseconds and air latency of less than one millisecond – one tenth the comparable latency of a 4G network.<sup>5</sup> This attribute will help support a variety of services with very low latency requirements, such as critical infrastructure monitoring. Other low-latency services enabled by 5G could include self-driving cars, public safety communications systems, augmented reality, and “tactile internet.”<sup>6</sup>

Fourth, 5G will provide consistent and better data rate for consumers across coverage area of single cell site as compared to the existing 4G networks. On a current 4G cell site, as a user moves further away from the cell site and closer to the cell edge, the data speed substantially drops from double digits to single digit Mbps. 5G has the potential to provide a mechanism to increase the cell edge data rate to triple digits Mbps. Further, this improvement will have a direct effect on experience of approximately 35 percent of consumers (almost 100M Pops across the U.S.) who live and work on the cell edge of each service provider’s coverage area today.

Fifth, 5G systems will make extremely efficient use of spectrum, which the Commission has highlighted as a key element of network design.<sup>7</sup> 5G networks are expected to have spectral efficiency levels of 10 bps/Hz, as compared to 1-3 bps/Hz on 4G networks. This is achieved in

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<sup>5</sup> 4G Americas, *4G Americas’ Recommendations on 5G Requirements and Solutions*, at 7 (Oct. 2014), available at [http://www.4gamericas.org/files/2714/1471/2645/4G\\_Americas\\_Recommendations\\_on\\_5G\\_Requirements\\_and\\_Solutions\\_10\\_14\\_2014-FINALx.pdf](http://www.4gamericas.org/files/2714/1471/2645/4G_Americas_Recommendations_on_5G_Requirements_and_Solutions_10_14_2014-FINALx.pdf) (“5G Requirements and Solutions”).

<sup>6</sup> *See id.*

<sup>7</sup> *See, e.g.*, Amendment of the Commission’s Rules with Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780 MHz, and 2155-2180 MHz Bands, *Report and Order*, 29 FCC Rcd 4610, ¶ 40 (2014) (citing “providing for the efficient use of spectrum” as a key goal of the Communications Act).

two ways – first, through the use of MIMO and advanced coding and modulation schemes, and second, by employing a new waveform design to exploit the non-Gaussianity of a channel and increase spectral efficiency.

Sixth, 5G systems will be highly energy efficient – 50 times more efficient than 4G. 5G systems should have a reduced cost and energy usage per bit as a result of low-cost network equipment, lower deployment costs, and enhanced power saving functionality on the network and user equipment sides. 5G systems stand to provide network access in sustainable and resource-efficient ways.

Seventh, 5G services will be highly mobile. Greater consistency of data rates throughout a 5G cell's coverage area will enable users to move about with little (to no) impact on device performance. Further, 5G technologies will cope efficiently with all degrees of mobility by providing “mobility on demand” based on each device's and service's needs.<sup>8</sup> Specifically, because 5G networks will perform at very high speeds, they will support services such as vehicular Internet access, vehicle-to-vehicle communications, fitness tracking, and Internet access aboard aircraft and trains. Ultimately, Samsung envisions that 5G systems will support mobility even at speeds from 300 to 500 kilometers per hour.

Finally, 5G will help make the “Internet of Things” a reality. 5G systems will be able to connect virtually all connected devices without human intervention, and 5G systems will be able to support 1 million simultaneous connections per square kilometer.<sup>9</sup> This will support a variety of machine-to-machine services, including wireless metering, mobile payments, smart grid and

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<sup>8</sup> 5G Requirements and Solutions, 12.

<sup>9</sup> Wonil Roh, Ph.D., Vice President & Head of Advanced Communications, Samsung Electronics Corp., Lab5G Mobile Communications for 2020 and Beyond: Vision and Key Enabling Technologies, IEEE WCNC 2014, Istanbul, at 8 (April 2014), *available at* [http://wcnc2014.ieee-wcnc.org/sites/wcnc2014.ieee-wcnc.org/files/u21/WCNC2014\\_Keynote\\_Samsung.pdf](http://wcnc2014.ieee-wcnc.org/sites/wcnc2014.ieee-wcnc.org/files/u21/WCNC2014_Keynote_Samsung.pdf).

critical infrastructure monitoring, connected home, smart transportation, and telemedicine.

To realize these vital benefits, the Commission must prioritize development of service rules for the millimeter wave bands. The Commission should strive for the U.S.-led deployment of 5G, just as it did with 4G LTE. The evolution to a new generation of wireless is one that will take several years, and the Commission should act expeditiously to ensure that 5G services can be deployed by 2020. Samsung outlines certain near-term steps that the Commission can and should take to ensure that the United States remains on track to be a leader in 5G. While Samsung appreciates that the Commission is juggling numerous spectrum priorities, Samsung urges the Commission to maintain focus on taking the important next steps toward deploying 5G.

**B. There Are Numerous Ongoing Efforts to Support the Development of 5G.**

Samsung has been a leader in numerous programs focused on research and development of 5G services. Through these activities, Samsung has been on the forefront of 5G development and testing. As the wireless industry moves toward 5G standards and technologies, it is essential that the Commission keeps pace with these worldwide efforts and that the diverse stakeholders involved engage in active technical discussions. Several parties have been working to develop 5G-enabled technologies, and the industry is on pace to make these services available commercially by 2020.

The migration to 5G is a global effort, and Samsung encourages the continued effort of the domestic and global wireless community. In the United States, several companies have embarked on efforts to research and develop technological solutions to enable 5G. For example, in September 2015, Verizon announced plans to begin field trials on 5G technology in 2016.<sup>10</sup>

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<sup>10</sup> Press Release, Verizon, *Verizon Sets Roadmap to 5G Technology in the U.S.; Field Trials to Start in 2016*, Sept. 9, 2015, <http://www.verizon.com/about/news/verizon-sets-roadmap-5g-technology-us-field-trials-start-2016/>.

The company laid out an aggressive roadmap to be the first company to deploy 5G technology, naming partners Alcatel-Lucent, Cisco, Ericsson, Nokia, Qualcomm, and Samsung.<sup>11</sup> In addition, Motorola Mobility has long been exploring potential uses of higher frequency spectrum and believes there is commercial potential in such spectrum.<sup>12</sup> New York University’s NYU Wireless Program is currently examining millimeter wave technologies and conducting other 5G research efforts.<sup>13</sup> As AT&T stated, the company “expects 5G to provide speeds and capacity many times greater than advanced LTE and to do so at lower cost.”<sup>14</sup>

Internationally, the Korean government has been playing a leading role in assisting the development of 5G, as well as encouraging domestic and international research activities and partnerships. Korea’s Ministry of Science, ICT and Future Planning established a 5G Forum, of which Samsung is an executive board member.<sup>15</sup> The 5G Forum has announced its plan to demonstrate 5G technologies at the 2018 Pyeongchang Winter Olympics.<sup>16</sup> In Korea, Samsung currently plays a variety of research roles in 5G efforts – from participation in the “Giga Korea Project,” focused on research and development of antenna technologies for 5G systems based on millimeter wave to work in conjunction with KAIST, a public research university, and other

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<sup>11</sup> *Id.*

<sup>12</sup> Comments of Motorola Mobility, GN Docket No. 14-177, RM-11664, at 3 (Jan. 15, 2015).

<sup>13</sup> See Jessica Lipsky, *5G Research Rides MM Waves*, EE Times, Sept. 11, 2014, available at [http://www.eetimes.com/document.asp?doc\\_id=1323851](http://www.eetimes.com/document.asp?doc_id=1323851).

<sup>14</sup> Reply Comments of AT&T, GN Docket No. 14-177, RM-11664, at 6 (Feb. 18, 2015).

<sup>15</sup> 5G Forum, “Members List,” at <http://www.5gforum.org/#!members/cp7n> (last visited Jan. 20, 2016).

<sup>16</sup> Limb Jae-un, *Gov’t to Commercialize 5G Technology by 2020*, Korea.net, Jan. 27, 2014, <http://www.korea.net/NewsFocus/Policies/view?articleId=117314>.

leading Korean universities to synchronize technical and academic perspectives on 5G.<sup>17</sup> In addition, Japan, China, the United Kingdom, and Germany have all undertaken considerable efforts to study and promote the migration to 5G.<sup>18</sup> Huawei indicates that equipment will be available for operations above 60 GHz in the short-term.<sup>19</sup> Nokia and NTT DoCoMo have begun trials and aim to provide an initial 5G deployment in time for the Tokyo 2020 Olympic Games.<sup>20</sup> Industry is poised to take advantage of the tremendous potential of 5G.

Companies are already developing products and applications that require the high performance enabled by 5G. For example, Ericsson is developing phased-array antenna solutions that would put one hundred or more antennas and radios on a single chip for use in high-capacity 5G small cells.<sup>21</sup> Meanwhile, Qualcomm has developed a chipset for multi-gigabit Wi-Fi, or “WiGig.”<sup>22</sup> Given the progress made by the industry thus far, it is essential that U.S. regulators keep pace with the development of technology. For 5G services to go live by 2020, stakeholders – including the Commission – must begin work now and continuously focus on the development of 5G technologies, services, standards, and regulations.

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<sup>17</sup> See Comments of Samsung, GN Docket No. 14-177, RM-11664, at 10-11 (Jan. 15, 2015) (“Samsung Comments”).

<sup>18</sup> *Id.* at 11-13.

<sup>19</sup> Comments of Huawei Technologies, Inc. (USA) and Huawei Technologies, Ltd., GN Docket No. 14-177, RM-11664, at 6-7 (Jan. 15, 2015) (“While antenna technology and design will continue, some mobile equipment operating in the 60 GHz bands is becoming available and will likely form the basis for future mmW systems in the short term and beyond.”).

<sup>20</sup> Marguerite Arnold, *Nokia, NTT DoCoMo Plan 5G Showcase at 2020 Olympic Games*, Fierce Wireless, Mar. 2, 2015, <http://www.fiercewireless.com/europe/story/nokia-ntt-docomo-plan-5g-showcase-2020-olympic-games/2015-03-02>.

<sup>21</sup> Comments of Ericsson, GN Docket No. 14-177, RM-11664, at 9-10 (Jan. 15, 2015) (“Ericsson Comments”).

<sup>22</sup> Press Release, Qualcomm, WiGig: Wireless Connectivity at Incredible Speeds, (Nov. 6, 2014), <https://www.qualcomm.com/news/onq/2014/11/06/wigig-wireless-connectivity-incredible-speeds>.

**C. The WRC-15 Adopted A Resolution To Study Particular Millimeter Wave Bands.**

Samsung's vision for 5G is a global vision. Indeed, a global effort will be necessary for 5G services to reach their full potential. The 2015 World Radiocommunication Conference ("WRC") adopted a resolution that will further the development of 5G systems. Resolution 238 seeks studies on compatibility of International Mobile Telecommunications ("IMT") in spectrum bands between 24.25 and 86 GHz.<sup>23</sup> The following spectrum bands are slated to be studied in time for WRC-19:

- 24.25-27.5 GHz, 37-40.5 GHz, 42.5-43.5 GHz, 45.5-47 GHz, 47.2-50.2 GHz, 50.4- 52.6 GHz, 66-76 GHz and 81-86 GHz, which have allocations to the mobile service on a primary basis; and
- 31.8-33.4 GHz, 40.5-42.5 GHz and 47-47.2 GHz, which may require additional allocations to the mobile service on a primary basis.

Samsung notes that the 37 GHz, 39 GHz, and 64-71 GHz bands under consideration in the *NPRM* are a subset of the bands to be studied by the WRC process. Samsung is pleased with the agreement around the world of the importance of this spectrum as the technology industry looks to the next generation of wireless services. This international recognition of the critical role that millimeter wave spectrum will play in the development of 5G technology demonstrates the importance of Commission action to move forward expeditiously with service and licensing rules for these spectrum bands.

Samsung applauds the FCC's leadership with the 28 GHz band even though it is not a band that will be part of the WRC-15 study process. As Chairman Wheeler explained, "[i]t

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<sup>23</sup> WRC-15, Resolution 238, Studies on Frequency-Related Matters for International Mobile Telecommunications Identification Including Possible Additional Allocations to the Mobile Services on a Primary Basis in Portion(s) of the Frequency Range Between 24.25 and 86 GHz for the Future Development of International Mobile Telecommunications for 2020 and Beyond at 28 (2015) available at <http://www.itu.int/md/R00-CA-CIR-0226/en>.

would have been far better if the Conference had agreed to study the 28 GHz band among the bands they agreed to consider for 5G, but the U.S. and other leaders in the 5G arena will go forward with our own studies. And I am fully confident that, as we and others move forward with 28 GHz, an international consensus will develop.”<sup>24</sup> Samsung supports the Commission’s position based on the technical data and the fact that this band could be a bridge internationally to the other bands being studied for WRC-19, such as 25 and 31 GHz.

### **III. ALLOCATIONS FOR MOBILE AND SERVICE RULES FOR THE 28 GHZ, 39 GHZ, AND 37 GHZ BANDS SHOULD BE ADOPTED IN A CONSISTENT FASHION.**

#### **A. Samsung Supports the Commission’s Proposal to Make the 28 GHz, 39 GHz, and 37 GHz Bands Available for Mobile Services.**

Samsung strongly supports the Commission’s proposal<sup>25</sup> to make the 28 GHz, 39 GHz, and 37 GHz bands available for mobile services. Samsung has conducted extensive research and testing on the potential of 5G services and their spectrum requirements. The results of this testing, combined with considerations of coverage, mobility support, and implementation feasibility, support Samsung’s conclusion that mobile services can be provided using the 28 GHz, 39 GHz, and 37 GHz bands, among others.<sup>26</sup> Moreover, opening comments in the *Notice*

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<sup>24</sup> FCC, Chairman Tom Wheeler’s Statement on World Telecommunication Conference 2015 (Dec. 17, 2015), *available at* [http://transition.fcc.gov/Daily\\_Releases/Daily\\_Business/2015/db1217/DOC-336917A1.pdf](http://transition.fcc.gov/Daily_Releases/Daily_Business/2015/db1217/DOC-336917A1.pdf).

<sup>25</sup> *NPRM* ¶¶ 25-53.

<sup>26</sup> S. Hur, et al., “Millimeter-wave Channel Modeling based on Measurements in In-building and Campus Environments at 28 GHz”, presented at COST IC1004 10<sup>th</sup> Meeting, May 2014; Y. Chang, et al., “A Novel Two-Slope mmWave Channel Model Using 3D Ray-Tracing Technique in Urban Environments”, submitted to IEEE PIMRC 2014; M. K. Samimi, et al., “Ultra-Wideband Statistical Channel Model for Non Line of Sight MillimeterWave Urban Channels,” submitted to IEEE Globecom 2014.

*of Inquiry* indicated that these spectrum bands are of great interest to the wireless industry, suggesting a strong incentive to innovate and make productive use of the bands.<sup>27</sup>

The 28 and 39 GHz bands are some of the most promising near-term homes for 5G services. This spectrum has positive characteristics that would allow for a relatively smooth transition to 5G. The 28 GHz and 39 GHz bands can support wide channel bandwidths, which will be needed to provide the significant performance gains that are expected over 4G services.<sup>28</sup> Both the 28 and 39 GHz bands have co-primary allocations for fixed and mobile services. Because the beams generated in these bands are narrow and readily adjusted, a licensee can deploy both fixed and mobile services within its geographic license area.<sup>29</sup> In sum, both bands are strong candidates for 5G millimeter wave services.<sup>30</sup>

Samsung also believes that providing mobile service is feasible in the 37 GHz band. The 37 GHz band can support wide channel bandwidths, as it consists of 1600 contiguous megahertz of spectrum from 37 to 38.6 GHz.<sup>31</sup> The 37 GHz band also contains several of the technical characteristics identified by Samsung as being essential for the provision of millimeter wave

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<sup>27</sup> See, e.g., Ericsson Comments, 7 (“Industry has an incentive to innovate and employ the 39 GHz band productively, especially if the rules for 37-38.6 GHz and 28.6-40 GHz were made uniform.”); *id.* at 37 (“The LMDS bands at 28 GHz will be of particular interest to the mobile industry for systems that may follow 4G into higher frequency bands.”); Comments of XO Communications, LLC, GN Docket No. 14-177, RM-11664, at 3 (Jan. 15, 2015) (“Among the upper microwave bands, XO believes that LMDS spectrum is well-suited for 5G commercial mobile operations.”).

<sup>28</sup> Samsung Comments, 8; Reply Comments of Samsung, GN Docket No. 14-177, RM-11664, at 4-5 (Feb. 18, 2015) (“Samsung Reply Comments”).

<sup>29</sup> See, e.g., Comments of Qualcomm, GN Docket No. 14-177, RM-11664, at 9 (Jan. 15, 2015) (“The narrower beams that can be generated in bands above 24 GHz could help limit interference to incumbent users of the band.”).

<sup>30</sup> Samsung Reply Comments, 5-6.

<sup>31</sup> *NOI* ¶ 62.

services.<sup>32</sup> The Commission’s decision to make the 28 GHz, 39 GHz, and 37 GHz bands available for mobile services is a vital first step toward deployment of 5G services.

**B. The 28 GHz, 39 GHz, and 37 GHz Bands Should Be Subject to Similar Licensing Rules to Allow the Most Effective Use of the Spectrum.**

The *NPRM* proposes adopting differing licensing regimes and requirements for the three licensed millimeter wave bands. For the 28 GHz band, the Commission has proposed to license a single 850 MHz spectrum block, with flexible mobile and fixed rights, and with counties as the geographic licensing area.<sup>33</sup> For the 39 GHz band, the Commission has proposed to maintain the existing channelization (14 licenses, each with 50 MHz paired with another 50 MHz), with flexible mobile and fixed rights, and with counties as the geographic licensing area.<sup>34</sup> Finally, the 37 GHz band has been proposed to be licensed using a “hybrid” approach, whereby “local operating rights” would be authorized by rule to property owners and the remaining rights would be authorized via auction, licensed on a county basis.<sup>35</sup>

Samsung believes that these proposals should be modified to provide a similar regulatory framework for each of the spectrum bands. The “hybrid” licensing approach as proposed would lead to confusion and not allow investment and scale to be brought to bear on the entire 37 to 40 GHz band as well as make interoperability challenging. A consistent licensing approach, allowing spectrum to be used on an exclusive basis, with full flexibility to deploy service will permit 5G services to be deployed in a robust fashion. Samsung therefore advises that, initially, the licensing framework should be the same for the 28 GHz, 39 GHz, and 37 GHz bands.

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<sup>32</sup> Samsung Comments, 44.

<sup>33</sup> *NPRM* ¶¶ 93-98, 110-111.

<sup>34</sup> *Id.*

<sup>35</sup> *Id.* ¶¶ 99-100.

The Commission should develop band plans in 37 GHz based on common spectrum bandwidth building blocks for the licenses in the millimeter wave bands. Samsung believes that 200 MHz building blocks should be used throughout the 37 to 40 GHz bands. Use of the existing channelization for the 39 GHz band would inhibit the ability of license holders to effectively use the spectrum in the most efficient manner as well as make interoperability with the 37 GHz band difficult. Indeed, multiple 200 MHz blocks will be needed to attain the data speeds and meet the capacity needs of wireless providers using 5G.

Samsung's proposed band plan is as follows. The Commission should issue a single 850 MHz license block at 28 GHz. At 37 GHz and 39 GHz, Samsung recommends that the Commission create multiple unpaired licenses of using 200 MHz building blocks.<sup>36</sup> The Commission will need to consider processes to achieve this new band plan to accommodate current 39 GHz licensees. We recommend the current spectrum rights be retained in the transition as well as considerations of market mechanisms such as incentive auctions to enable mobile wireless in 37-40 GHz with bandwidths of similar size to those available at 28 GHz (i.e., 850 MHz).

#### **IV. SAMSUNG SUPPORTS FUTURE EFFORTS TO IDENTIFY AND ALLOCATE ADDITIONAL SPECTRUM IN THE MILLIMETER WAVE BANDS FOR MOBILE SERVICES.**

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<sup>36</sup> The record should be further developed on the final band plan, some options include:

- (1) 15 license blocks each of 200 MHz in size. This provides the maximum flexibility for licensees as they acquire spectrum;
- (2) 4 license blocks (800 MHz, 800 MHz, 800 MHz, 600 MHz) – Provides multiple blocks of 800 MHz in size similar to 28 GHz. May be difficult to aggregate the current 39 GHz licenses and accommodate licensees who are not able to transition;
- (3) 6 license blocks (800 MHz, 800 MHz, 100 MHz, 600 MHz, 100 MHz, 600 MHz) – Provides 2 blocks of 100 MHz in size for legacy 39 GHz operations if they do not transition to 5G technology.

While the spectrum bands proposed by the Commission for 5G should be a top priority, additional spectrum should be identified and allocated for mobile services in future proceedings. In addition to the spectrum targeted in the *NPRM*, Samsung suggests that the Commission focus upcoming efforts on the 25 and 31 GHz bands (24.25-27.5 GHz and 31.8-33.4 GHz), which are already under study internationally for potential allocation for mobile services in any further proceedings seeking to identify additional spectrum above 24 GHz. Further, based on Samsung's research, the LMDS B2 band at 31.0-31.3 GHz is also a good candidate for mobile services. The Commission should investigate these bands in the future for 5G as doing so will promote a more internationally harmonized spectrum approach for the millimeter wave bands.

5G will require international harmonization at a level that has not been achieved with other mobile broadband spectrum bands. The Commission has frequently highlighted international harmonization of spectrum as a key policy goal and has endorsed the benefits of global harmonization.<sup>37</sup> Global harmonization will promote global interconnection, roaming and interoperability. It also makes the implementation of mobile and base station antennas much simpler and minimizes interference issues between operators and countries. Global harmonization is particularly important in light of the wide bandwidth required for 5G services at frequencies above 24 GHz. While international harmonization is obviously a greater challenge with larger blocks of spectrum, the rewards have the potential to be tremendous.

The 25 GHz and 31 GHz bands are supported for study internationally which make the bands likely to be internationally harmonized. Four out of six regional preparatory groups

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<sup>37</sup> See, e.g., Amendment of the Commission's Rules With Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780 MHz, and 2155-2180 MHz Bands, *Report and Order*, 29 FCC Rcd 4610, at ¶ 42 (2014) ("International harmonization will enhance international roaming, create economies of scale that lowers device costs, speed deployment, and reduce interference potential near international borders.").

involved in the WRC support the 25 GHz band for study.<sup>38</sup> Five out of six regional preparatory groups support the 32 GHz band for study.<sup>39</sup> This international consensus is a crucial first step for achieving global harmonization. In a 5G world, international harmonization will be more important than ever before. Going forward, the Commission should prioritize study of bands such as the 25 GHz and 31 GHz band which have been already identified for international action.

New spectrum allocations will be necessary to unleash the limitless potential of 5G services. Samsung fully expects that both consumers and wireless licensees will require access to significant amounts of millimeter wave spectrum to meet the growing demand for high speed, low latency mobile broadband services. The Commission should continue to make new spectrum allocations a top priority and should initiate an additional proposed rulemaking that seeks comment on the 25 and 31 GHz bands for mobile broadband services.

## **V. THE TECHNICAL RULES SHOULD BE CAREFULLY CRAFTED TO SUPPORT ROBUST DEPLOYMENT OF 5G SERVICES.**

The specific rules for the millimeter wave bands must be carefully designed to promote the proliferation of 5G technologies. Samsung has conducted extensive testing in the millimeter wave bands and, based on its testing, provides input on various technical issues related to 5G. Samsung applauds the Commission for taking the first steps with this *NPRM* to craft rules which

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<sup>38</sup> See WRC-15, Asia-Pacific Telecommunity Common Proposals (Sept. 29, 2015) available at [https://www.itu.int/md/dologin\\_md.asp?lang=en&id=R15-WRC15-C-0032!A24!MSW-E](https://www.itu.int/md/dologin_md.asp?lang=en&id=R15-WRC15-C-0032!A24!MSW-E); WRC-15, Arab States Common Proposals (Sept. 10, 2015) available at [https://www.itu.int/md/dologin\\_md.asp?lang=en&id=R15-WRC15-C-0025!A22!MSW-E](https://www.itu.int/md/dologin_md.asp?lang=en&id=R15-WRC15-C-0025!A22!MSW-E); WRC-15, European Common Proposals (Oct. 14, 2015) available at [https://www.itu.int/md/dologin\\_md.asp?lang=en&id=R15-WRC15-C-0009!A25!MSW-E](https://www.itu.int/md/dologin_md.asp?lang=en&id=R15-WRC15-C-0009!A25!MSW-E); WRC-15, Member States of the Inter-American Telecommunication Commission (CITEL) Proposals (Sept. 29, 2015) available at [https://www.itu.int/md/dologin\\_md.asp?lang=en&id=R15-WRC15-C-0007!A24-A11!MSW-E](https://www.itu.int/md/dologin_md.asp?lang=en&id=R15-WRC15-C-0007!A24-A11!MSW-E); WRC-15, Regional Commonwealth in the field of Communications Common Proposals (Oct. 4, 2015) available at [https://www.itu.int/md/dologin\\_md.asp?lang=en&id=R15-WRC15-C-0008!A25!MSW-E](https://www.itu.int/md/dologin_md.asp?lang=en&id=R15-WRC15-C-0008!A25!MSW-E).

<sup>39</sup> *Id.*

will foster productive use of spectrum above 24 GHz and ultimately enable creation of unparalleled mobile experiences.

**A. Millimeter Wave Band Spectrum Should Be Licensed on an Unpaired Basis.**

The Commission has proposed to not mandate a duplexing option at this stage of millimeter wave technology research and development.<sup>40</sup> Frequency Division Duplex (“FDD”) and Time Division Duplex (“TDD”) can therefore both be deployed in the 28 and 39 GHz bands under the Commission’s proposal. Samsung believes that licensing of the spectrum should be unpaired – allowing for the most efficient deployment of duplexing technology.

Samsung supports flexibility in the Commission’s rules to permit both TDD and FDD. For mobile use of the millimeter wave bands, TDD may be the optimal solution. Samsung employed TDD in its test bed and has generally found that TDD works best for mobile broadband applications in higher frequency bands. Use of TDD in these bands is needed to allow for beamforming and antenna arrays to be developed and function most efficiently. FDD has inherent inefficiencies due to the fact that fixed bandwidth must be pre-assigned to downlink and uplink frequencies respectively without any flexibility to dynamically accommodate the downlink/uplink traffic volumes. While study continues on the benefits and drawbacks of TDD and FDD, the spectrum should be licensed on an unpaired basis to permit maximum flexibility for deployment in the bands.

Additionally, Samsung agrees with the Commission’s tentative conclusion to allow license holders to deploy either fixed or mobile services in their licensed spectrum.<sup>41</sup> A number of existing incumbents are already utilizing the 28 and 39 GHz spectrum for fixed backhaul, and Samsung would expect those services to continue. Indeed, these services could potentially

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<sup>40</sup> *NPRM* ¶ 269.

<sup>41</sup> *Id.* ¶¶ 93-95.

expand in certain geographic areas. This proposal would provide new, flexible rights to operate in the licensed geographic area and provide the fastest transition to expanded use of the band.

**B. Base Station/Mobile Station Power.**

The Commission proposes to adopt 1640 watts (or 62 dBm) per 100 MHz of bandwidth EIRP as the maximum transmission power limit for base stations operating in the 28, 39, and 37 GHz bands.<sup>42</sup> The Commission also seeks comment on whether a higher transmission power limit should apply if fixed backhaul service is provided (as opposed to mobile broadband service).<sup>43</sup> For mobile transmitters in the 28, 39, and 37 GHz bands, the Commission proposes to adopt a maximum peak EIRP limit of 43 dBm (20 watts).<sup>44</sup>

Samsung believes that the power limits proposed for the millimeter wave bands are too restrictive for fixed base stations. In particular, Samsung would support base station power limits up to 75 dBm (and potentially higher) to support future use of this spectrum for mobile broadband services. The power limits proposed by the Commission are significantly less than what has been traditionally allowed in the millimeter wave bands. For example, the 28 and 39 GHz bands are permitted to operate up to 85 dBm.<sup>45</sup> Unlicensed devices operating in the 57-64 GHz band are permitted to operate up to 82 dBm.<sup>46</sup> While Samsung anticipates that a detailed link budget for use cases associated with the 28, 37, and 39 GHz bands will be developed in the near-term (and Samsung commits to filing such link budget data as soon as practical), Samsung is confident that increasing the power limits for the millimeter wave bands will allow for more

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<sup>42</sup> *Id.* ¶ 274.

<sup>43</sup> *Id.* ¶ 276.

<sup>44</sup> *Id.* ¶ 279.

<sup>45</sup> 47 C.F.R. §101.113(a).

<sup>46</sup> *Id.* §15.255(b)(1)(ii).

robust services to consumers and allow licensee flexibility to develop and deploy innovative new services. Additionally, Samsung supports the development of a power limit classification for customer premise equipment that is transportable (not mobile) that would operate with higher power than mobile equipment (43 dBm) but likely less than base stations. Such equipment would be small cell sites that are operated in a fixed environment within buildings – so would need higher power than mobile transmitters but not as much power as a traditional base station. Samsung continues to work with the wireless industry to develop a proposed power level for such customer premise equipment and anticipates providing more technical details on such devices during the reply comment cycle of this proceeding.

**C. Out-of-Band Emission Limits.**

The Commission seeks comment on whether a radiated emission limit of  $43+10\log(P)$  can be supported by 5G transmitters operating in the 27.5-28.35 GHz, 37-38.6 GHz, and 38.6-40 GHz bands, and if so, what resolution bandwidth and frequency offset should be considered to define out-of-band emissions and spurious emissions.<sup>47</sup> The Commission requests that commenters provide technical showings on how the proposed radiated emission limits can mitigate the risk of harmful interference to operations by adjacent users.<sup>48</sup>

Samsung supports the Commission proposal for out-of-band emission limits at this time. However, Samsung is continuing to study the availability of technical components required to comply with these limits and may file supplemental information in the future once that review is completed.

**D. Interoperability.**

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<sup>47</sup> *NPRM* ¶ 286.

<sup>48</sup> *Id.*

The Commission proposes to require that mobile equipment operating within each millimeter wave band be interoperable using all air interfaces that the equipment utilizes on the frequencies.<sup>49</sup> The Commission also seeks comment on Straight Path’s contention that it should be possible to achieve interoperability between different technologies, e.g., switching between LTE and Wi-Fi.<sup>50</sup> Samsung opposes interoperability requirements between different technologies. Such a requirement would put far too heavy a burden on developers who cannot be sure what technologies may be developed in these spectrum bands.

Different considerations on interoperability come into play in the licensed spectrum bands. Samsung has been gaining experience in operating at 28 GHz and interoperability may be feasible in that band. However, interoperability in the 37 to 40 GHz bands is still uncertain because the hardware to support operation throughout the entire band is still being developed. More testing and development is necessary to be sure that interoperability across the entire 3 GHz of spectrum is technically feasible.

**VI. THE COMMISSION CAN EXTEND FIXED SATELLITE SERVICES IN THE 28 GHz BAND VIA AN AUCTION OR SECONDARY MARKET PROCESS.**

**A. FSS Should Remain Subject To Operating On A Non-Interference Basis To Terrestrial Licensees in the 28 GHz Band Unless New Rights Are Purchased.**

The Fixed Satellite Service (“FSS”) is permitted to deploy geostationary and non-geostationary FSS systems to provide Earth-to-space gateway-type services on a non-interference basis to existing terrestrial licensees in the 28 GHz band.<sup>51</sup> The Commission proposes three possible options for FSS in the 28 GHz band: (1) allowing FSS operators to purchase rights in an auction to obtain primary rights or to enter into a secondary market

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<sup>49</sup> *Id.* ¶ 296.

<sup>50</sup> *Id.* ¶ 296.

<sup>51</sup> *Id.* ¶ 124.

transaction to obtain such rights,<sup>52</sup> (2) allowing FSS incumbents with existing operations that are not located within the service area of an active 28 GHz terrestrial license to have a “closed” filing window to obtain primary rights for these existing earth stations,<sup>53</sup> and (3) allowing FSS user equipment to deploy in the 28 GHz band on a secondary basis, utilizing a sharing mechanism to protect primary 28 GHz licensees.<sup>54</sup> The Commission suggests sharing through the following mechanisms.

- Use of a Spectrum Access System which would require terrestrial licensees to provide satellite operators with essential information needed to avoid causing interference to terrestrial operations (similar to system in place for the 3550-3700 MHz band).<sup>55</sup>
- Use of beacon signaling which would require new 28/39/37 GHz licensees to transmit beacon signals to assist satellite earth stations in determining the presence of terrestrial operations.<sup>56</sup>
- Limit FSS transmissions toward the horizon below a specified elevation angle and require new terrestrial licensees to screen out incoming signals above the same elevation angle or another complementary angle.<sup>57</sup>
- Use of active signal cancelling whereby FSS operators would be required to provide terrestrial licensees with information on the content or format of their uplink transmissions sufficient to provide terrestrial operators with the ability to generate countervailing suppression signals.<sup>58</sup>
- Allow the use of mobile FSS terminals that would be required to mute their signals instantaneously whenever they lose location awareness or signal lock with their serving satellites.<sup>59</sup>

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<sup>52</sup> *Id.* ¶ 132.

<sup>53</sup> *Id.* ¶ 140.

<sup>54</sup> *Id.* ¶ 149.

<sup>55</sup> *Id.* ¶ 152.

<sup>56</sup> *Id.* ¶ 154.

<sup>57</sup> *Id.* ¶ 156.

<sup>58</sup> *Id.* ¶ 157.

<sup>59</sup> *Id.* ¶ 159.

Samsung supports the Commission proposal to allow FSS operators to participate in the auction for 28 GHz rights or to enter into secondary market agreements to obtain protection for their satellite systems. This market-based approach should be embraced. It will provide FSS operations, which were authorized on a non-interference basis, with the ability to expand their operations or otherwise obtain protections not previously provided to them by the Commission.

Samsung opposes, however, the Commission's suggestion to increase the protection rights for FSS parties. As the Commission noted, these FSS systems were authorized on a non-interference basis and the incumbents invested at their own risk with these facts disclosed prior to their commencement of operations. Satellite users have been able to find sharing solutions feasible based on use of the band for uplink feeder link stations that have generally high gain antenna and sufficient link margin for communications. Samsung undertook a preliminary compatibility study to examine the coexistence of 5G millimeter wave services with Federal fixed and mobile satellite services in the bands adjacent to LMDS, including the 30-31 GHz band and the 31-31.3 GHz band.<sup>60</sup> The study found that, under the existing parameters and licensing rights, although a single beam spot of an FSS receiver covers the land area of 711 major cities, a mobile base station in the adjacent channel does not cause significant interference to space station FSS.<sup>61</sup> FSS systems are adequately protected under the current rules and further protection is not warranted.

Finally, Samsung opposes increased sharing via a spectrum access system between FSS and terrestrial operations in the 28 GHz band. The Spectrum Access System concept has not yet been deployed and demonstrated to be viable in the 3.5 GHz band. It is unclear how the status of incumbent licensees would be affected under this framework. Accordingly, the Commission

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<sup>60</sup> Samsung Comments, 42-43.

<sup>61</sup> *Id.*

should limit the experiment of this new methodology to that band until it demonstrates its feasibility.

## **VII. CONCLUSION**

The successful evolution to 5G depends on rapid and thoughtful Commission action. The Commission should prioritize development of consistent allocations for mobile and service rules for 5G in the millimeter wave bands. In addition, efforts should continue to identify and allocate additional spectrum for mobile. Samsung is enthusiastic about the tremendous potential of 5G and urges the Commission to take a leading role in bringing these services to market to the American public as well as the rest of the world.

Respectfully Submitted,

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January 26, 2016