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

To: The Commission

COMMENTS OF HUAWEI TECHNOLOGIES, INC. (USA) and HUAWEI TECHNOLOGIES CO., LTD.

Huawei Technologies, Inc. (USA) and Huawei Technologies Co., Ltd. (collectively "Huawei")[1] submit these comments in response to the Further Notice of Proposed Rulemaking

[1] Huawei Technologies, Inc. (USA), based in Plano, Texas, is a subsidiary of Huawei Technologies Co., Ltd., headquartered in Shenzhen, Guangdong Province, People's Republic of China. Continuous innovation based on

("FNPRM") adopted by the Federal Communications Commission ("FCC") in the above referenced proceeding to facilitate mobile broadband and 5G wireless technologies in certain millimeter wave ("mmW") spectrum bands above 24 GHz.[2] As the next frontier of innovation for the wireless industry and, more generally, the broader information and communications technology ("ICT") ecosystem, 5G systems will achieve "zero distance between people and connected machines—the ability to transmit huge amounts of data instantaneously, to countless devices all over the world."[3] Huawei applauds FCC's adoption of service rules for the four mmW frequency bands in the Report & Order ("R&O"),[4] making the United States the first country in the world to have high-frequency spectrum available to support wider channel bandwidths and the consequent capability to deliver the high data rates needed for 5G systems.[5] The Commission's immediate action to open another 18 GHz of licensed spectrum in eight other mmW frequency bands marks another crucial step for the FCC in its support for the development and deployment of high-performance mobile systems and services.

Huawei commends the Commission for its forward-looking and expeditious action in the FNPRM, proposing to include eight additional mmW bands in its Upper Microwave Flexible Use Service ("UMFUS"), all of which have been designated as candidate bands for International

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customer needs drives our more than 170,000 employees globally—including 1,500 employees in the United States—in order to create maximum value for telecommunications carriers, enterprises, and consumers and enable a better connected world.

[2] *See In the Matter of the Use of Spectrum Bands Above 24 GHz For Mobile Radio Services et al.*, GN Docket No. 14-177, Report and Order and Further Notice of Proposed Rulemaking, FCC 16-89 (rel. July 14, 2016) (*Spectrum Frontiers R&O/FNPRM*).

[3] The Mobile Industrial Revolution: Anticipating the Impact and Opportunities of 5G Networks on Business, Forbes Insights in association with Huawei, at 21 (June 14, 2016), *available at* http://www.forbes.com/forbesinsights/huawei/index.html.

[4] *See Spectrum Frontiers R&O/FNPRM* at ¶ 4.

[5] *See* News Release, Federal Communications Commission, FCC Takes Steps to Facilitate Mobile Broadband and Next Generation Wireless Technologies in Spectrum Above 24 GHz (July 14, 2016), *available at* https://www.fcc.gov/document/fcc-adopts-rules-facilitate-next-generation-wireless-technologies.

Mobile Telecommunications ("IMT") 2020—or IMT-2020—at the International Telecommunications Union's ("ITU") World Radio Conference 2015 ("WRC-15").[6] By beginning the process of opening these additional bands in parallel to the ITU study efforts, the FCC will ensure that the U.S. wireless industry is well prepared for IMT-2020 and primed to take a leading global position in "serving the needs of the networked society."[7]

Huawei believes that the value of 5G to our future networked society is considerably more than just another next-generation wireless standard or mobile infrastructure upgrade. Rather, Huawei believes 5G will be the flexible enabler of a hyper-connected, intelligent digital world, connecting people to things, and things to each other with a massive number of smart nodes and ultra-low real-time latency. As a powerful platform for the creation of new applications, business models, businesses and industries, 5G will "enable life-saving healthcare advances, smart-city energy grid and water systems, immersive education and entertainment, and, most importantly, new applications yet to be imagined."[8] And by doing so, 5G will engender a more expansive ICT ecosystem highlighted by collaboration between the ICT sector and vertical industries.

As the FCC's action affirmatively recognizes, such innovations require progressive spectrum policies to ensure that operators have sufficient spectrum resources in both low and

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[6] *See* World Radio Conference 2015 (*WRC-15*), International Telecommunications Union (*ITU*), Nov. 2-20, 2015, *Final Acts of WRC-15*, 296-298 (2016) (*Final Acts of WRC-15*) (setting forth Resolution 238 which directs the ITU's Radiocommunication Sector to conduct and complete appropriate studies for WRC-19 to determine the spectrum needs for the terrestrial component of IMT in the frequency range between 24.25 and 86 GHz).

[7] INT'L TELECOM. UNION, IMT VISION – FRAMEWORK AND OVERALL OBJECTIVES OF THE DEVELOPMENT OF IMT FOR 2020 AND BEYOND, Recommendation ITU-R M.2083 at 1 (Sept. 2015). This ITU-R Recommendation "establishing "the vision for IMT for 2020 and beyond, by describing potential user and application trends, growth in traffic, technological trends and spectrum implications, and by providing guidelines on the framework and the capabilities for IMT for 2020 and beyond." *Id*. at 3.

[8] Oversight of the Federal Communications Commission: Hearing Before the Senate Committee on Commerce, Science and Transportation, 114th Cong. 5 (Sept. 15, 2016) (Statement of Tom Wheeler, Chairman, Federal Communications Commission).

high-frequencies bands that will support diverse wireless connectivity requirements.[9] In the comments that follow, Huawei expresses and explains its support for the addition of the eight proposed mmW spectrum bands under the newly adopted UMFUS framework. Huawei also shares specific views on the benefits of global harmonization of spectrum bands for IMT-2020, flexible uses in the proposed bands under the UMFUS Part 30 rules, common sub-band channel assignments across the proposed bands and maintaining the current sharing mechanism in the 71-67 and 81-86 GHz bands. Finally, Huawei discusses the studies and demonstrations which document the characteristics, feasibility and advantages of mmW band use for 5G services.

I. Proposed Additional mmW Frequency Bands

In the FNPRM, the FCC proposes the following additional mmW spectrum bands above 24 GHz for flexible, mobile and fixed use wireless broadband—the 24 GHz band (24.25-24.25 and 24.75-25.25 GHz); the 32 GHz band (31.8-33.4 GHz); the 42 GHz band (42-42.5 GHz); the 47 GHz band (47.2-50.2 GHz); the 50 GHz band (50.4-52.6 GHz); and the E-Band (71-76 GHz and 81-86 GHz).[10] As noted in the FNPRM, all of these frequency bands are among those recommended as candidate bands for further study by the ITU and, based on study results, possible designation for IMT-2020.[11] The FNPRM proposes to use the newly adopted Part 30 UMFUS technical and licensing rules for each of these bands allowing for flexible mobile and fixed use wireless broadband services.[12] With the exception of the E-Band, the FCC similarly proposes to use geographic area licensing in these bands, with Partial Economic Areas ("PEAs")

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[9] *See Implementation of Section 2006(b) of the Omnibus Budget Reconciliation Act of 1993, Annual Report and Analysis of Competitive Market Conditions with Respect to Mobile Wireless, Including Commercial Mobile Services*, WT-Docket 15-125, *Eighteenth Report*, FCC 15-125 at ¶ 47, 59 (rel. Dec. 23, 2015).

[10] *See Spectrum Frontiers R&O/FNPRM* at ¶ 373.

[11] *See Final Acts of WRC-15* at 298.

[12] *See Spectrum Frontiers R&O/FNPRM* at ¶ 375.

as the license area size.[13] For the E-Band, the Commission proposes adapting the licensing framework developed for the Citizens Broadband Radio Service ("CBRS") in its 3.5 GHz band proceeding and codified in Part 96 of the Commission's rules.[14] Block size per license and mechanisms for sharing with Federal and non-Federal users would vary across the eight bands under the FNPRM.[15] Similar technical parameters—channel plans, power and emissions—are proposed across all of the bands per the Commission's new Part 30 rules.[16] Huawei's further views on these proposals are addressed below.

a. Additional UMFUS Frequency Bands

Huawei commends the FCC for initiating further discussion on additional proposed mmW bands for 5G services, consistent with the bands selected by WRC-15 for additional study and possible designation for IMT-2020. In Huawei's view, FCC's action in this regard is not only consistent with, but will supplement and advance, the study efforts of these bands by the ITU study groups. Further, given that all of the proposed mmW bands already have a mobile primary designation on the U.S. Table of Allocations, Huawei believes that such designation will assist in their global adoption.[17] As expressed earlier in this proceeding, Huawei believes that global harmonization of spectrum bands for 5G services will result in important efficiencies and facilitate more rapid development and deployment of 5G network technologies, services and devices.[18] Further, Huawei agrees that "[g]lobal harmonization is critical to getting the greatest

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[13] *See Id.*

[14] *See Id* at ¶ 440. *See also Amendment with the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, GN Docket No. 12-354, Report and Order and Second Further Notice of Proposed Rulemaking, 30 FCC 3959 (April 15, 2015).

[15] *See Spectrum Frontiers R&O/FNPRM* at ¶¶ 385; 399; 403, 406; 417.

[16] *See Id*. at ¶¶ 383-385; 389; 403-407; and 410-417.

[17] *See* 47 CFR § 2.106

[18] *See* Huawei Comments at 15.

benefit out of the available spectrum;"[19] that is, harmonization "fosters global roaming and helps manufacturers to take advantage of the economies of scale available in a global marketplace, resulting in lower prices and a wider range of broadband services and devices."[20]

With limited exception, therefore, Huawei supports the Commission's intentions to make available these additional bands under the newly adopted Part 30 UMFUS rules. Huawei would recommend, however, for the proposed 42 GHz band that the Commission extend the applicable frequency bands from 42-42.5 GHz to 40-42.5 GHz band for UMFUS. Huawei notes that this would allow for a contiguous 5.5 GHz block of spectrum with the inclusion of 39 GHz band as adopted in the R&O.

Industry is devoting significant resources to innovating and developing equipment for all of the mmW bands in order to provide ultra-high data rates and high capacity services required for 5G systems. Huawei looks forward to the future availability of globally harmonized spectrum which will facilitate the build-up of new ecosystems around these bands. Global spectrum harmonization remains a key objective for the mobile industry; getting there will require consistent efforts in which stakeholders work together at national, regional and global levels to enable optimal use of the scarce spectrum resource in support of a better interconnected world. Huawei again appreciates the leading role taken by the FCC to proactively prepare for the transformative capabilities of 5G wireless connectivity.

b. Part 30 Rules/UMFUS

Generally, Huawei supports bringing the mmW bands identified in the FNPRM within the scope of the new Part 30 rules of the UMFUS. The flexibility permitted in the UMFUS rules

[19] Tom Wheeler, Chairman, Federal Communications Commission, Remarks at the International Institute of Communications Annual Conference 5 (Oct. 14, 2015)

[20] *See Id.*

appears to accommodate the needs and likely future growth of wireless users, as well as the introduction of new services by providers. Indeed, as acknowledged in the FNPRM, these bands will likely attract a variety of users that seek to implement a range of wireless services and applications.[21] The UMFUS designation for these bands appears to favorably accommodate the expected variation of end user service scenarios under this common regulatory framework.

Huawei observes that while the licensing rules may be different among bands, the technical operating rules should be common to enable common equipment development and deployment across all of the bands. This includes not only the physical radio parameters, but also sharing protocols to better enable disparate services to share spectrum bands. For example, there is an "economies-of-scale" benefit in equipment manufacturing for 5G access and backhaul systems by having common technical rules for all UMFUS bands (e.g., channel bandwidths, power levels, emission masks and antenna gains). Further, for purposes of interoperability, Huawei believes that it is necessary for user equipment to support a radio interface across an entire spectrum band in order to support a variety of channel assignments to various services providers within a band. End users cannot be expected to have several handsets to accommodate usage within a band or indeed between common bands.

c. Sub-Band Channel Assignments

Huawei notes that the FCC has proposed different sub-band channel assignments among the proposed eight mmW bands, ranging from 40 MHz channels in the 24 GHz band, up to a single 500 MHz channel in the 42 GHz band.[22] Huawei believes there is value in having common sub-band channel assignments across the multiple bands and encourages the FCC to ensure such commonality for these bands. Consistent channel plans enable some degree of

[21] *See Spectrum Frontiers R&O/FNPRM* at ¶ 372.

[22] *See Id.* at ¶¶ 385, 403.

commonality of radio hardware and services that will be utilized across the bands and across geographies. A common sub-band channel assignment across these bands can also enable disparate services and technologies to coexist within a band or to be located in any band. To the extent there is commonality of channels among the proposed bands, user equipment that operates according to one standard or technology may coexist with other systems by selection of an appropriate channel. Similarly, for example, fixed and mobile services may better share operations within a band by having a common channel plan (e.g., with the mobile service and backhaul).

Huawei would prefer a base 200 MHz sub-band channel assignment across all eight of the bands.[23] These 200 MHz assignments could be aggregated or subdivided by the licensees if desired to suit their needs, but the common overall channel framework of 200 MHz would enable general equipment for separate services within a possible mixed-service band. It is also helpful for sharing if the (new) channel edges are aligned with existing and continuing band channel plans. As some of the bands may require guard bands to protect adjacent services, this protection should be accommodated within the sub-band channel assignments. As an alternative, the FCC might consider scaling the sub-band channel assignments with increasing frequency, i.e., the 71 GHz band could have wider channels (e.g., 500 MHz) than the 39 GHz band. Whatever channel plan is selected, however, Huawei believes the plan should ensure consistency within bands to enable multi-service compatibility of equipment.

d. Sharing

The key to success of sharing among both common and disparate services is the willingness of all parties to take coordinated action to share spectrum assignments. As the FCC

[23] FCC acknowledges that its proposal for 500 MHz channels in the 47 GHz band "would not align with the band plan in other bands, where we are using multiples of 200 megahertz." *See Id.* at ¶ 417.

itself notes, "it will be imperative for all stakeholders, including wireless and satellite industries, to engage proactively to help shape these [sharing] solutions."[24] The application of new technologies—beamforming, antennas and power-control, and dynamic operation, for example—will ensure the continuing enablement of new services and opportunities without a universal need for exclusivity in all spectrum assignments. As expressed in comments submitted on the NPRM, Huawei believes techniques adopted in other bands attest to the importance of a central enabler to facilitate realistic and viable sharing.

With respect to the E-Band (71-76 GHz and 81-86 GHz), a tiered framework similar to that adopted by the Commission in the CBRS is proposed in the FNPRM, with a sharing scheme that protects incumbents from harmful interference but allows additional usage through Priority Access licenses and General Authorized Access.[25] However, the Commission notes that the existing "traditional coordination process" for sharing "has been effectively used for over a decade to facilitate co-existence between commercial systems and Federal systems."[26]

As expressed in comments submitted on the NPRM,[27] Huawei endorses the inclusion of the E-band for 5G services. Huawei considers the band to be extremely suitable for high-density mobile services; additionally, indoor/outdoor sharing is practical due to shielding effects of building materials and geography. Further, Huawei noted that the band is suitable for sharing by operators for backhaul and access needs and, in fact, many current deployments in the E-Band are for backhaul services.

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[24] *See Id.*at ¶ 132.

[25] *See Id.* at ¶ 440.

[26] *Id*. at ¶ 439.

[27] *See* Huawei Comments at 21.

Huawei is concerned, however, that the non-exclusive licenses in the band may make it difficult to establish nationwide services while also introducing unnecessary complexities to band management. In addition, Huawei believes the shorter and limited proposed licensing term—one year, non-renewable licenses for Priority Access—will serve as a disincentive to investment and build-out of mobile systems across wide areas in this band. Huawei also believes the FCC proposal for license by rule, license-light, and/or unlicensed (for indoor) use of this band is unnecessary in light of the additional 7 GHz of unlicensed spectrum designated for the 64-71 GHz band in the R&O together with the 92-95 GHz band.[28] While Huawei strongly supports the identification of the E-band for flexible mobile and fixed use wireless broadband, Huawei believes FCC should retain the current sharing system in this band, which has been proven over decades of use, rather than introducing the CBRS-like sharing process.

II. Channel Propagation Measurement

Due largely to the impetus of this rulemaking proceeding, there has been much industry and academic study activity related to mmW propagation for "mobile-like" applications in urban and indoor environments. These are environments where people and their communications devices are most highly concentrated and would benefit from high-speed, high-bandwidth mobile access. As a result of these collaborative study efforts, industry is now better able to develop system deployments and equipment to exploit the mmW bands above 24 GHz and up to ~100 GHz. These studies and measurements continue to be ongoing across industry and academia. As a whole, this research has confirmed the usefulness and practicality of mmW spectrum to deliver high through-put access for mobile communications and it has validated sharing processes which are enabled by the propagation phenomena. Also significant in this process has

[28] *See Spectrum Frontiers R&O/FNPRM* at ¶ 325. *See also* 47 CFR § 2.106.

been the initiative and ongoing contribution of the National Institute of Standards and Technology ("NIST") through its international 5G Channel Modeling Alliance project.[29] The project provides a venue for fundamental research into measurement, analysis and statistical representations of mmW propagation channels. Numerous government, industry and academic stakeholders participate in the projects, including representatives of Huawei, FCC and New York University Wireless, among others.[30] As developments and deployments continue, the continuing guidance in mmW communications research and standardization developed by the NIST Alliance project will be invaluable to all stakeholders.

Huawei and others in the industry have demonstrated, and continue to demonstrate, prototype high-bandwidth 5G systems in major international exhibits. For example, Huawei and Deutsche Telekom, Germany's largest mobile operator, jointly showcased mmW Multi-user Multiple-input and Multiple-output ("mmW Mu-MIMO") technology in a live demo in February 2016 at the Mobile World Congress ("MWC") in Barcelona, Spain.[31] The live demo utilized the mmW band at 73 GHz and achieved up to 70 Gbps user data speed with high spectrum efficiency. Huawei's demonstrations at the MWC also included new 5G radio access

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[29] *See* 5G mmWave Channel Model Alliance Wiki (*5G mmW Channel Model Alliance Wiki*), *available at* https://sites/google.com/a/corneralliance. com/5g-mmwave-channel-model-alliance-wiki/home; *see also* 5G mmWave Channel Model Alliance, National Institute of Standards and Technology, *available at* https://www.nist.gov/ctl/5g-mmwave-channel-model-alliance.

[30] *See* 5G mmWave Channel Model Alliance Wiki.

[31] *See* Press Release, "Huawei to Bring 73 GHz mmWave Mu-MIMO Live Demo to Deutsche Telekom" (Feb. 18, 2016), Huawei Technologies, Ltd., *available at* http://www.huawei.com/en/news/2016/2/73GHzmm-Wave-Mu-MIM-live-demo. Huawei and Deutsche Telekom jointly won the award for Most Notable Partnership between an Operator and Solutions Provider for 5G Trials and Development at the 2016 5G World Awards held in London, England—*see* Press Release, "Huawei and Deutsche Telekom Jointly Win 5G Global Cooperation Award," Huawei Technologies, Ltd. (June 30, 2016), *available at* http://www.huawei.com/en/news/2016/6/5G-Global-Cooperation-Award. Huawei continues to extend the global open partnership initiatives with more 20 operators and 10 industry partners spanning Asia, Europe and North America. Huawei believes that customer-oriented innovation with an open partnership is the foundation to create the next generation of wireless technologies.

technologies, full 5G duplex radio, ultra-low latency communications, massive MIMO and mmW technology for 5G.

Collectively, such studies and demonstrations indicate that communications applications are practical both for local mobile and backhaul applications in short range urban scenarios.[32] The mmW bands are also useful for fixed service use to provide neighborhood high-speed wireless/fibreless network access for both residential and commercial users.[33] The radio link budgets work for short range mobile communications outdoors and also for self-coordinated backhaul. Also studies have confirmed the usefulness of mmW channels for indoor communications, particularly for offices and malls[34] as well as in associated high-density pedestrian environments. These are the principal areas of coverage where future high-bandwidth/short-range communications, is planned and, indeed, is a growing necessity. The mmW channels are also especially suitable for high-capacity backhaul to support such wideband commercial access services.[35]

The flexibility of the UMFUS Part 30 designation of mmW bands enables this dual/multiple use and sharing with established and other future services. The studies show that propagation is heavily dependent on the environment with severe attenuation and blockage/shielding by local features and topography. This environmental shielding for

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[32] *See* Katsuyuki Haneda et al, "5G 3GPP-like Channel Models for Outdoor Urban Microcellular and Macrocellular Environments," Summary Paper, 2016 IEEE 83rd Vehicular Technology Conference (VTC 2016-Spring) (May, 2016), *available at*: http://arxiv.org/pdf/1602.07533v2.pdf.

[33] *See* Zhouyue Pi, Junil Choi, and Robert Heath Jr. "Millimeter-wave Gbps Broadband Evolution towards 5G: Fixed Access and Backhaul" (2015), *available at* https://arxiv.org/abs/1507.03969.

[34] *See* Katsuyuki Haneda et al "Indoor 5G 3GPP-like Channel Models for Office and Shopping Mall Environments," 2016 IEEE International Conference on Communications Workshops (ICCW) (May 2016), *available at* http://arxiv.org/pdf/1603.04079.pdf.

[35] *See* "From Today to Tomorrow: Huawei Microwave & mm-Wave Whitepaper" (Feb. 2016), *available at* http://www-file.huawei.com/~/media/CORPORATE/PDF/white%20paper/huawei%20microwave%20whitepaper-2016.pdf.

equipment operating at ground level enables intensive re-use of frequency channels by ensuring (due to environmental blocking) that transmissions do not propagate to other neighborhoods. The mmW frequencies of access networks are severely attenuated by geography (e.g., hills and mountains) and buildings; thus, they may be reused in separated areas. Huawei notes that most 5G personal "mobile" type applications will be at ground levels, streets and indoors, i.e., in "cluttered" propagation conditions; consequently, they will not spread far outside intended areas of coverage.

In these typical deployments, the coverage cells are small. While, of course, maximum coverage size of a cell is a goal, in these cases the user traffic usually is such (i.e., large) that maximum cell capacity is reached before the largest area limit (range) is reached. At least part of the limitation on cell range is the practical power transmission capability of the mobile devices and user equipment. Frequency reuse is thus required using low-power short-range cell deployments. In other words, the high density traffic levels for which the mmW channels are planned are not well-suited for general wide area mobile coverage (such as that provided by current low frequency, i.e., < 3.6 GHz cellular systems). The transmissions of both uplink and downlink are power controlled for minimum interference (i.e., just enough power is transmitted to communicate the necessary user traffic and with narrow directed beams and minimum interference to other nearby users). Therefore, unlike many other radio systems, the mobile access services are self-interference limited deployments and thus minimize interference outside their boundaries. Among other things, battery limitations of the mobile (user) equipment and personal radiation exposure limits constrain the maximum power/bandwidth.

The mobile system operating paradigm protocols are designed such that the mobile devices do not transmit in a band unless they are directed to do so by the subtending fixed base

station. Coordination is thus guaranteed both within the mobile service region and with other spectrum users that may be sharing the area nearby. The mobile service base stations may be deployed only in areas where they, and their flock of associated mobiles, will not interfere with coordinated services such as fixed links, satellite ground stations and science research facilities. The consequence of this is that low-power levels for the mobile applications are well suited to sharing/compatibility with other services' systems that may be nearby.

To operate/manage the small cell mmW access, it is planned that the mmW coverage will often be associated with low frequency (i.e., < 3.6 GHz) wide area coverage channels that will provide signaling and operational/traffic coordination for local-area wide-band high-bandwidth channels used in areas of high traffic concentration.[36] These deployment models coupled with the concentrated propagation characteristics enable sharing between both the mobile services and other terrestrial uses such as fixed, backhaul and fixed satellite services. Such sharing is facilitated, for example, by there being specific operating locations/areas for sharing with satellite ground stations.[37]

Much of the collective research on mmW channels for 5G communications has been summarized in a technical "white-paper" published as part of the Channel Modeling workshop held at the 2015 IEEE Globecom conference. This paper has been updated since its initial release.[38] Huawei also notes that further research on channel behavior and models is ongoing in

[36] See Zhenyu Shi, Yi Wang, Lei Huang and Jianglei Ma, "System Capacity of 72 GHz mmWave Transmission in Hybrid Networks," IEEE VTC Fall Conference (Sept. 2016).

[37] In this sense, Huawei supports the commission's proposals for designation of fixed satellite service and fixed services operating areas and point-to-point operating beams as a means for band-sharing.

[38] A summary of much of the recent industry research on mmWave propagation for mobile applications has been reviewed and published at workshops associated with recent IEEE Globecom conferences. The most recent summary "white paper" can be found at: http://www.5gworkshops.com/5GCM.html

a number of projects globally including, for example, the mmMagic research initiative in Europe in which Huawei is a participant.[39]

Propagation penetration loss models showing good isolation between indoor and outdoor environments are provided in the Globecom white paper.[40] In addition, other industry studies have catalogued the behavior of channels indoors and building material losses.[41] Together these conclude that indoor applications of mmW can coexist with other systems outdoors for many situations because of the high loss of building walls—that is, in most scenarios.[42] For many modern buildings, for example, thermal coating of glass acts to significantly isolate indoor mmW applications from outdoors and vice-versa. Also, concrete (and also brick and stone) is a major barrier to mmW signals. A range of building penetration losses have been summarized for mobile system planning in the 3GPP channel model for frequencies above 6 GHz.[43]

Huawei generally supports the power levels and emissions that are included in the UMFUS rules. These are practical and sufficient for small cell mobile services and, at the same time, low enough to protect other services that may be sharing bands with UMFUS services. However, Huawei does not recommend allowing excessive increased power above the levels adopted in the R&O (i.e., perhaps requested to facilitate greater service ranges). Allowing

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[39] The mmMAGIC project (*Millimetre-Wave Based Mobile Radio Access Network for Fifth Generation Integrated Communications*) has a main objective to develop and design new concepts for mobile radio access technology (RAT) for deployment in the 6-100 GHz range. This is envisaged as a key component in the 5G multi-RAT ecosystem and will be used as a foundation for global standardization. *See*: https://5g-mmmagic.eu/. An early summary of the mmMAGIC channel modeling program is available at: https://bscw.5g-mmmagic.eu/pub/ /bscw.cgi/d76988/mmMAGIC_WhitePaper-W2.1.pdf.

[40] *See infra* note 38.

[41] See Jian Li, Ziming Yu, Jia He, David Steer, Wen Tong , "Multi-Zone Propagation in Millimeter-Wave Bands for Indoor Hotspot Deployment," IEEE VTC Fall Conference 2016, workshop W4; 5G Millimeter –Wave Channel Models.

[42] Huawei notes that natural wood and ordinary glass are relatively transparent to mmW signals, especially below 60 GHz.

[43] *See* TR38-900 Rel 14 and following releases, *available at* http://www.3gpp.org/ftp//Specs/archive/ 38_series/38.900/ 38900-e00.zip.

increased power levels will result in a greater occurrence of intersystem interference and poor sharing among the multiple services using the UMFUS bands. That is, power levels for mobile use as adopted in the R&O are essentially appropriate to ensure harmonious sharing with established services. Huawei would also note that a regulatory increase in other services' allowed power levels would adversely affect the Part 30 mobile systems that may be sharing the same bands. Huawei holds the view that to ensure compatibility with existing shared services, any contemplated increase in power levels should not be universally allowed without due care, careful analysis and study.

Huawei also endorses the flexibility and broad scope of the UMFUS technical rules as also applicable to the proposed bands. Huawei believes these rules will enable the growth of services and industries sharing the bands as they also evolve and adopt new technology and protocols to enhance their system capabilities through continuous innovation.

III. Conclusion

The combination of technological innovation and human imagination has led to extraordinary advances in wireless technologies—advances that were seemingly inconceivable just a decade ago. Government plays a critical role in sparking innovation with its allocation and assignment of spectrum. Huawei commends the FCC for taking early and essential action enabling access to additional spectrum for the next generation of wireless technologies both in the adoption of the R&O and its immediate consideration of another eight mmW spectrum bands for that purpose in the FNPRM. Huawei endorses the major proposals put forth in the FNPRM, recommends a few modifications (e.g., the extension of the 42 GHz band, the spectrum sharing mechanism for the E-Band and common sub-band channel assignments across the bands), and supports similarly expeditious action to finalize the rules for these mmW bands. The FCC has

distinguished itself by moving forward in advance of the ITU study results for these bands, and its action also sends an important signal to all governments of the imperative in "making this spectrum available in the near term [to] best enable potential users, technology developers and innovators to have relative certainty about the spectrum structure in the mmW bands for these new uses."[44]

Respectfully submitted,

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[44] *See Spectrum Frontiers R&O/FNPRM* at ¶ 7.