

**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 Notice of Proposed Rulemaking

¹ Huawei Technologies, Inc. (USA), based in Plano, Texas, is a subsidiary of Huawei Technologies Co., Ltd., headquartered in Shenzhen, People’s Republic of China. Huawei is a global leader of information and

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(“NPRM”) issued by the Federal Communications Commission’s (“FCC” or “Commission”) on the identification of spectrum bands above 24 GHz for the provision of Fifth Generation or “5G” mobile radio services.² Huawei appreciates the opportunity to share with the Commission our views and experiences related to the suitability of the proposed millimeter wave (“mmW”) bands for mobile use, building on the comments Huawei submitted one year ago pursuant to the FCC’s Notice of Inquiry (“NOI”) issued in October 2014.³ Huawei believes this NPRM represents a critical next step in facilitating innovation and investment in 5G wireless technologies and services through the identification of spectrum bands with wide contiguous bandwidth and service goals for 5G systems.⁴

As “one of our nation’s most precious resources,”⁵ spectrum is a “critical input in the provision of mobile wireless services”;⁶ spectrum is also “crucial to promoting consumer choice and competition throughout the country” and “is similarly crucial to fostering innovation in the marketplace.”⁷ The FCC has documented that consumer demand for wireless broadband services “while at home, at work and in transit” is “skyrocketing” and will continue to increase

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communications technology (“ICT”) solutions. Continuous innovation based on customer needs drives our more than 170,000 employees globally—including 1,500 employees across 10 states in the United States—to enhance customer experiences and create maximum value for telecommunications carriers, enterprises, and consumers. The company’s vision is to enrich life and improve efficiency through a better connected world. See <http://www.huawei.com/en/>.

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, Notice of Proposed Rulemaking, FCC 15-138 (rel. Oct. 23, 2015) (*Spectrum Frontiers NPRM*).

³ See Huawei, Comments, GN Docket No. 14-177, RM 11664 (filed Jan. 15, 2015) (“Huawei Comments”).

⁴ See *Spectrum Frontiers NPRM* at ¶ 11.

⁵ See *Amendment of the Commission’s Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, Report and Order and Second Further Notice of Proposed Rulemaking*, GN Docket No. 12-354, 30 FCC 3959 at ¶ 1 (2015).

⁶ 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 (rel. Dec. 23, 2015).

⁷ See *Policies Regarding Mobile Spectrum Holdings; Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, WT Docket No. 12-269, GN Docket No. 12-268, Report and Order, 29 FCC Rcd 6133, 6156-6167 (*Mobile Spectrum Holdings Report and Order*), recon. denied, Order on Reconsideration, 30 FCC Rcd 8635 (2015) (*Mobile Spectrum Holdings Reconsideration Order*).

over the next few decades.⁸ As consumer demand grows, “the demands on wireless networks and the need for access to spectrum will continue to increase.”⁹ Spectrum is fundamental to service providers’ ability to deploy next generation networks utilizing “a mix of particular spectrum bands” that feature diverse “engineering properties and deployment capabilities.”¹⁰ Indeed, as the Commission recognizes, low-band spectrum “has certain propagation advantages for network deployment over long distances, while reaching deep into buildings and urban canyons,” whereas high-band spectrum “allows for better transmission of large amounts of information.”¹¹ Despite the fact that mobile connectivity has already shattered the limits of time and space and dramatically changed the way people live and work, fulfilling future demand for even higher data rates and the requirements of new applications will not only necessitate technological innovation in mobile systems, such as further advances in the efficient use of spectrum, but also the availability and access to additional low- and high-band spectrum by mobile service providers.

From Huawei’s perspective, the evolution toward 5G mobile technologies and services is dependent on three factors. First, as noted, Huawei believes that accelerating technological innovation will create new applications and deliver new experiences, thereby demonstrating the commercial value of 5G to potential users.¹² Second, Huawei believes that new technical standards, application scenarios and business models leveraging 5G mobile technologies should

⁸ See *Mobile Spectrum Holdings Report and Order* at ¶ 6157.

⁹ See *Id.* at ¶ 6157.

¹⁰ See *Id.*

¹¹ See *Id.*

¹² See Huawei News Release, “Huawei Rotating CEO Ken Hu Says 5G Needs Deep Innovation” (July 18, 2015), available at: http://www.huawei.com/ilink/en/about-huawei/newsroom/press-release/HW_444980. Huawei is investing \$600 million in 5G research and development through 2018 and has more than 500 experts at nine research centers worldwide currently engaged in 5G research focusing on air interfaces, radio access network, network architecture, devices, security, and energy efficiency.

be developed through open cooperation and cross-industry collaboration.¹³ This will require active involvement of all stakeholders in the information and communications technology (“ICT”) industry, as well as governments, academia, and vertical industries. And third, government has a unique responsibility in managing spectrum resources. Forward-looking policies on spectrum allocations are essential to the development of 5G and, Huawei believes, render this FCC action to be of particular importance.

These comments primarily focus on the mmW spectrum bands above 24 GHz proposed by the FCC to be authorized for the provision of mobile services. Huawei believes the criteria employed by the Commission to identify suitable spectrum bands are all highly relevant, that the four bands identified in the NPRM satisfy the criteria and that these bands, therefore, are technically suitable for mobile services. Huawei believes that the Commission should give strong consideration to adding the 71-76 GHz and 81-86 GHz bands (or the “E-band”) to the bands that will be authorized for mobile services as the band similarly satisfies the suitability criteria for mobile use. In these comments, Huawei also expresses its views on the importance of security in relation to the myriad of services and applications that 5G technologies will make possible, with appropriate features built into system designs. Huawei also offers views on technical issues regarding duplexing, antennas and interoperability.

¹³ Huawei has played a leading role in defining and promoting 5G around the world and has been actively contributing to the development of the 5G ecosystem as a leading member of METIS (Mobile and wireless communications Enablers for the Twenty-Twenty Information Society) and 5G-PPP (5G Infrastructure Public-Private Partnership), both in the European Union; the 5G Innovation Centre (5GIC) with the University of Surrey in the United Kingdom; IMT-2020 in China; NYU WIRELESS in the United States; and the Fifth Generation Mobile Communications Promotion Forum (5GMF) in Japan. Huawei has also established partnerships with over 20 universities on joint research, including Harvard University, Stanford University, the Technical University of Munich, and Tsinghua University. The company has published more than 190 academic papers on 5G. Huawei was named the “Biggest Contributor to 5G Development” for its innovations and industry contributions, particularly for new air interface technologies, at the 5G World Summit 2015 held in Amsterdam, the Netherlands in June 2015. See <http://www.huawei.com/minisite/5g/en/>.

I. CRITERIA FOR EXAMINING SUITABLE SPECTRUM BANDS

The NPRM identifies four main criteria to guide the FCC's evaluation on the suitability of mmW bands for mobile services, namely, to focus on bands: with at least 500 MHz of contiguous spectrum; under consideration internationally for 5G mobile services; compatible with existing incumbent license assignments and uses; and for which the Commission can apply a flexible regulatory framework that accommodates a wide variety of services.¹⁴ Huawei generally supports each of the criteria set forth by the Commission for evaluating mmW spectrum bands and, to further elaborate on Huawei's views, offers the following additional supporting commentary.

In our comments responding to the FCC's October 2014 NOI on this matter, Huawei acknowledged the global consensus forming around the need for a minimum of 500 MHz to 1 GHz bandwidth to support 5G mobile services.¹⁵ Huawei believes that access to large blocks of spectrum is key to enabling the adoption of new ultra-high broadband wireless services. That is, the very high performance requirements for future 5G systems correspond to maximum delivered link data throughput of 1 gigabit per second ("Gb/s") or greater, coupled with low latency of 1 millisecond or less which can be achieved most practically and reliably with channel bandwidths of 1 GHz or more. Furthermore, the availability of wide channel bandwidths permits the statistical multiplexing of multiple users within the overall channel, thus efficiently accommodating high numbers of users with variable traffic needs and a high quality of service. Being able to employ significant bandwidths of contiguous spectrum to reach the 1 Gb/s goal is

¹⁴ See *Spectrum Frontiers NPRM* at ¶¶ 20-23.

¹⁵ See Huawei Comment at 15.

the principal reason for expanding 5G systems to include the mmW bands.¹⁶ However, Huawei observes that 500 MHz channels of contiguous bandwidth should be practical and sufficient in the lower mmW bands (e.g., the 28 GHz band), whereas 1 GHz channels are more suitable in the higher mmW frequencies (e.g., the 73 GHz band).

Given the need to provision wide bandwidth channels in support of future 5G services, Huawei also notes the potential for technical challenges attributable to existing band plans in certain mmW bands (i.e., 50 MHz channels in the 39 GHz band) and the compatibility of new mobile systems with incumbent operations in current channel usage plans. In light of these challenges, the Commission and stakeholders should give further consideration to an evolutionary plan that leads to the development of both new wideband channel plans in these bands and new commercial equipment standards. Indeed, Huawei believes common radio equipment standards will be required to ensure compatibility of mobile network equipment and services across multiple mmW bands.

Huawei's NOI comments also emphasized the beneficial effects of interoperability across geographic regions and economies-of-scale in equipment manufacturing achieved through globally harmonized spectrum bands.¹⁷ Huawei wholeheartedly endorses the views that global harmonization "is critical to getting the best benefit out of the available spectrum," that it "fosters global roaming and helps manufacturers to take advantage of the economies-of-scale in a global marketplace, resulting in lower prices and a wider range of broadband services and devices," and that it "helps prevent interference and facilitates coordination with neighboring

¹⁶ Huawei notes the potential practical compatibility limitations of smaller channels to support 5G services, for example, channels consistent with incumbent LMDS licensees of 50 MHz in bandwidth.

¹⁷ See Huawei Comments at 15.

countries.”¹⁸ In this respect, Huawei commends the United States government for its proposals¹⁹ to, and welcomes the outcome of, the International Telecommunications Union (“ITU”) World Radiocommunication Conference (“WRC”) held in November 2015 to study spectrum bands above 6 GHz for International Mobile Telecommunications (“IMT”) designation and consideration at WRC-19 in recognition of the advantages that harmonized worldwide bands and frequency arrangements will offer to users, service providers and equipment manufacturers.²⁰

Noting that not all WRC-15 proposals for the study of mobile broadband would likely be entirely consistent, the NPRM affirms the Commission’s intension to “work with relevant stakeholders to examine the suitability of [additional bands in light of international developments] for mobile and other uses.”²¹ Huawei appreciates the FCC’s willingness to consider other spectrum bands for mmW mobile use for purposes of achieving a greater degree of international harmonization of the bands allocated for 5G services. In this spirit, Huawei believes that the FCC should give immediate consideration to the 71-76 GHz and 81-86 GHz bands—the E-band—for which the FCC has not developed proposed rules notwithstanding identification of the E-band for study and inclusion on the agenda for WRC-19 as reflected in the final act of WRC-15.

Huawei notes that all of the mmW bands proposed in the NPRM currently are allocated in the ITU tables for primary mobile use. Consequently, Huawei believes that FCC final rules

¹⁸ See Remarks of FCC Chairman Tom Wheeler, International Institute of Communications Annual Conference, Washington, D.C. (Oct. 7, 2015).

¹⁹ See PROPOSALS FOR WORK OF THE CONFERENCE, Member States of the Inter-American Telecommunications Commission (CITEL), Proposed Agenda Item for WRC-2019 for consideration of identification of frequency bands for the terrestrial component of IMT in the frequency range 27.5-71 GHz, including appropriate mobile allocations if needed, to facilitate the development of mobile broadband applications, Doc. XXXX-E, July 31, 2015 (identifying spectrum bands at 24.25-27.5 GHz; 31.8-33.4 GHz; 37-43.5 GHz 45.5-50.2 GHz; 50.4-52.6 GHz; 66-76; and 81-86 GHz).

²⁰ See ITU News Release, “World Radiocommunication Conference Allocates Spectrum for Future Innovation” (Nov. 27 2015).

²¹ See *Spectrum Frontiers NPRM* at ¶ 14.

and licensing for mobile services in the mmW bands as proposed in the NPRM, along with the addition suggested herein, may proceed without awaiting further ITU activities.

II. PROPOSED mmW BANDS FOR 5G MOBILE SERVICES

Huawei acknowledges the NPRM’s proposal to allocate four proposed mmW spectrum bands—the Local Multipoint Distribution Service (LMDS) band (27.5-28.35 GHz, 29.10-29.25 GHz, and 31.075-31.225 GHz band or the “28 GHz band”); the 38.6-40 GHz band (“39 GHz band”); the 37-38.6 GHz band (“37 GHz band”); and the 64-71 GHz band—for 5G mobile services. Further, as stated, Huawei believes the Commission should consider the suitability of allocating the E-band for mobile use and enabling early licensing of this band for 5G mobile services.²² Huawei considers the E-band to be ideally suited for high-density licensed commercial mobile use and, in certain respects, has characteristics as favorable as the lower mmW bands proposed in the NPRM for future anticipated 5G mobile services.

Huawei offers more detailed comments with respect to the NPRM’s proposed bands and the E-band below. In the following subsections expanding upon Huawei’s views on these bands, Huawei aims to be helpful to the Commission in advancing the discussion and rulemaking with practical, detailed technical information about the suitability of these bands and their propagation characteristics. Hence, these comments are not meant to criticize or oppose the proposed selection of mmW bands for 5G mobile services.

A. Upper Microwave Flexible Use Service (28 GHz band and 39 GHz band)

Huawei acknowledges the NPRM’s identification of both the 28 GHz band and 39 GHz

²² See PROVISIONAL FINAL ACTS OF THE CONFERENCE, World Radiocommunication Conference (WRC-15), 2-27 November, 424 at 426 (setting forth Res. Comm6/20, “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”).

band²³ for mobile services and believes the combination of the two bands as the “Upper Microwave Flexible Use Service” will create a 3 GHz mobile spectrum zone that can be utilized productively for 5G mobile services. As both bands have a co-primary allocation for fixed and mobile services, Huawei agrees that these bands are technically suitable for mobile uses and that such uses would be consistent with current authorizations in these bands. Although co-existence of new mobile services in the two bands will require technical coordination with existing licensing schemes and incumbent operations uses in each band, Huawei believes the Commission’s intention to “leverage[e] market-based mechanisms to coordinate coexistence issues” is reasonable and achievable.²⁴ From a technical standpoint, Huawei believes the total 3 GHz mobile spectrum zone created with these bands is attractive for the delivery of wideband services; in addition, each sub-band is well within the approximately 10 percent of center frequency bandwidth constraint that often limits practical band filters for application in user equipment.

1. Rules For Licensed Operations in the Upper Microwave Flexible Use Service

The NPRM notes that the Local Multipoint Distribution Services (“LMDS”) are currently licensed by Basic Trading Area (“BTA”) in the 28 GHz band, with Fixed Satellite Services (“FSS”) Earth-to-space stations licensed on a secondary basis. As cited in the NPRM, the 39 GHz band is currently licensed by Economic Area for fixed services, with non-Federal FSS stations licensed on a co-primary basis and a Federal allocation in the 39.5-40 GHz portion of the band.²⁵ The NPRM proposes using a county-level geographic area licensing scheme for the two

²³ See *Spectrum Frontiers NPRM* at ¶ 30.

²⁴ See *Id.* at ¶ 126.

²⁵ See *Id.* at ¶¶ 25-25, 35-37.

bands and allowing licensees to provide any form of fixed or mobile service.²⁶

Huawei believes the use of geographic area licenses is consistent with the existing licensing arrangement in both bands. However, some coordination requirements may emerge at license boundaries if different standards have been, or are, newly adopted by different operators within adjacent areas. To the extent that LMDS licensees may desire to provide mobile coverage across geographic boundaries and engineer stronger signals at the edges, the licensing rules should incorporate such considerations.

In both bands, the NPRM proposes use of existing band plans. In the 28 GHz band, the FCC assigned two LMDS licenses per area: an "A" license with a total of 1,150 MHz bandwidth (consisting of the 27.5-28.35 GHz, 29.1-29.25 GHz and 31.075- 31.225 GHz bands); and a "B" license, 150 megahertz wide, covering the 31.0-31.075 GHz and 31.225 GHz-31.3 GHz bands).²⁷ The 39 GHz band is currently licensed in fourteen paired blocks of 50 x 50 MHz channels.²⁸ Huawei believes that, in principle, the single block area licensing scheme ensures self-compatibility of services (e.g. mobile/fixed) for sharing within the operator's territory. In order for mobile users to roam among various geographic areas, however, technologies and band plans used by individual licensees will need to be compatible. Huawei also notes the need for adopting common technical standards among all service areas.

Existing LMDS operations permit radiated power of +30 dBW/MHz for Hubs, +42 dBW/MHz for Subs and frequency coordination may be required when transmitters are within 20 km of a BTA boundary. Operations of new mobile equipment operating at levels of the order of 1-5 dBm/MHz (i.e. -30 dBW/MHz) may be integrated by the location of LMDS equipment with

²⁶ See *Id.* at ¶ 116.

²⁷ See *Id.* at ¶ 25.

²⁸ See *Id.* at ¶ 39.

directional antennas on rooftops and the mobile equipment located on the ground or indoors. Nonetheless, some channel planning may be needed by operators to ensure the coexistence of the two services. Further, Huawei notes the desirability of equipment compatibility across all the LMDS licensees for mobile services. With current mobile systems, operators have an incentive to adopt standardized systems and equipment to ensure roaming, uniformity of services and equipment costs commensurate with (global) economies of manufacturing scale.

Huawei believes that the Upper Microwave Flexible Use Service is most likely to succeed if there is a suitable degree of commonality among all the deployed systems and services, enabling spectrum compatibility, roaming and sufficient economies of scale to stimulate the development of new mobile equipment that satisfies service-appropriate price points. Huawei also believes that coordination among existing and new licensees in the bands will be necessary to the successful launch of new 5G services in these bands.

2. Granting Mobile Operating Rights to Existing Licensees

From a technical perspective, Huawei asserts that the LMDS bands and the 39 GHz band will be better served if the existing operators embrace mobile services or are able to market their spectrum to those that can coordinate with wider band mobile services. Huawei believes an overlay auction would cause conflicts among the radio systems at the various system levels (e.g., between existing LMDS operations and new mobile auction licensee in the same area). While spectrum sharing between two services alone presents sufficient challenges, the complexity intensifies as multiple different systems interact in the same space. Huawei advises against subdividing the band into smaller blocks to force frequency separation of two uses. That is, building practical equipment (particularly mobile equipment) to operate in the band and withstand both the high power LMDS and low power mobile signals in the same receiver band front end is challenging. Interference among multiple types of licensee and the potential for

incompatible standards dividing the market would reduce end user flexibility and equipment commonalty/economies of scale for both the fixed and mobile services.

3. Compatibility with Federal Operations in the 39 GHz band

The NPRM solicits detailed comment and analysis on the compatibility of mobile use with current and future Federal operations in the 39 GHz band.²⁹ In order to understand the interference potential between 5G mobile services and incumbent Federal operations, Huawei offers some general parameters of 5G mmW systems. The industry has not yet condensed a common technical view of future equipment details, but the following parameters may be helpful for initiating coordination studies with incumbent Federal systems.³⁰

When modeling for intersystem interference, Huawei notes that mobile service is a “cellular” system; channels are reused across an area. There is lower signal strength at the edges of cell coverage areas and channels are typically geographically reused with some repeating “reuse” patterns. Cell base stations usually will operate at reduced power as the cell density increases to prevent inter-cell interference. Most modern mobile radio systems are engineered to be self-interference-limited rather than basic noise-limited. Also within each cell, there is at most the equivalent of one user device occupying the spectrum band at any instant in time. This means that if there are multiple users within a cell coverage area, only one user will be able to transmit in an assigned subpart of the band during any time interval. In the mmW bands, it is expected that cell mobile coverage radii will be of the order of 100-400 meters in urban and suburban environments.

The propagation characteristics of the mmW bands, i.e., at 27 GHz and above, are a

²⁹ See *Id.* at ¶ 42.

³⁰ Huawei would be pleased to discuss details of system parameters at the request of Commissioners and/or FCC staff.

significant factor in the 5G mmW system deployment scenarios and the analysis of inter-system interference. Studies have shown that with typical antennas at low heights—for example, on building facades or lampposts—the probability of a line-of-sight (“LOS”) communications path at a distance of 70 meters is less than 50 percent for an outdoor Urban Macro cell (“UMa”) environment, such as along city or town streets. Similarly, for a distance of 50 meters in an outdoor Urban Micro cell (“UMi”) environment, such as within a city block or square, the probability of a LOS communication path is less than 50 percent.³¹

With these relatively short radio communication paths and both the regulatory and practical limitations of transmitter power, equipment is expected to rely on arrays of antenna elements for beam formation and beam steering to direct the signals at individual active user devices. The directional beams will focus power for sufficient communications signal strength while preventing interference to other systems. Although the details of 5G radio system operations are still in the formation stage, some high capacity systems are expected to make use of lower frequency channels (i.e., below 6 GHz) to assist with management and control of mmW transmissions. In many instances, the mmW channel assignments may be supplementary to and coordinated through signaling handled by other bands below 6 GHz. Huawei notes that such coordinated usage will help guarantee user connectivity in areas beyond the reach of mmW band coverage capabilities.

As a practical matter, when operating in the mmW bands, the user device will always be within visibility of the mmW fixed cell base stations (or access points) or other communications facilities. Because of the possibility of occultation of the radio mmW signal path by obstructions, such as passing vehicles or people, many high traffic areas will likely have

³¹ See, for example, 5G CHANNEL MODEL FOR BANDS UP TO 100 GHz, IEEE Globalcom2015 Industry White Paper, available at: http://www.5gworkshops.com/5G_Channel_Model_for_bands_up_to100_GHz (2015-12-6).pdf.

visibility to two or more cell base stations in order to ensure continuous connectivity. Most usage is expected to be indoors—in workplaces, homes and public markets. In areas of low traffic, where the density of people or things (as in the Internet-of-Things or “IoT”), there may be reduced mmW coverage requiring other layers of spectrum coverage to support mobile connections.

As to the parameters of base stations (i.e., fixed access points) that will operate in mmW bands, Huawei suggests the following:

- Antenna height: Huawei estimates antenna height will be 8-10 meters (above local terrain) or potentially slightly higher. In urban settings, the access points may be flush mounted on buildings or perhaps on rooftops at a height of approximately 3 meters. The typical high-density outdoor deployments will be suitable for urban settings and for mounting below rooftops and indoors.
- Effective Isotropic Radiated Power (“EIRP”): Huawei believes that up to 50 dBm is a practical number for use in outdoor non-line-of-sight (“NLOS”) environments. High gain (directional) antennas with up to 33 dBi may be used. Indoors, a maximum EIRP of up to 33 dBm is likely. As noted, these power levels will vary depending on local traffic and propagation conditions.
- Bandwidth: Overall bandwidth is likely to be as much as 5 GHz, but channel bandwidth will be narrower. Huawei anticipates that 50 MHz (or common local channel plan) in initial deployments is likely, evolving up to approximately 1 GHz.
- Typically, systems are power-controlled so that the minimum power needed for transmission is used in order to reduce intra- and inter-system interference and to minimize dynamic range in the receivers. For example, a [5 dB] average power reduction across the region is expected for this reason.

- For outdoor systems, the antennas will typically be pointed below the horizon to ensure local area coverage and avoid adjacent area interference.
- To service the bulk of the traffic indoors, most of the deployed mmW systems will be indoors with base-stations on walls and ceilings. Indoor deployments will typically use lower power (e.g., 33 dBm) and will be shielded from external systems by the building material loss, potentially well in excess of 40 dB depending on details of building construction.

As to the parameters for mobile devices and other user equipment, Huawei offers the following generic figures:

- Height: ~ 1.2 meters (i.e. the height of a person, plus the height of building if inside).
- EIRP: up to 24 dBm.
- The transmission is power-controlled so that the minimum power needed for communication is used in order to reduce intra- and inter-system interference and minimize dynamic range in the receivers.
- In modeling interference, Huawei notes that mobile devices do not operate their transmitters unless directed to do so by their subtending base station and then only in designated times and in designated frequency segments. Therefore, mobile devices will not operate in exclusion zones if there is no subtending base station with coverage in an area to be protected or a subtending base station does not authorize a mobile device to transmit because it is in a protected zone.

Huawei believes that sharing with Federal MSS ground-stations operating in the 39.5-40 GHz band³² may be accommodated through the use of exclusion zones if the Mobile Satellite Service (“MSS”) ground stations are at fixed locations. For example, commercial mobile operations can accommodate exclusion zones if terrestrial mobile system base stations are not licensed or deployed within interfering range of Federal receivers. Such a scenario reflects the principle advantage of developing a commercial equipment standard for the band—namely, that mobile operations can be controlled to ensure coordination with other systems.

The Shared Access Services (SAS) operational model adopted by the Commission for the 3.5 GHz band and currently under developed within the Wireless Innovation Forum also may be an appropriate method of shared usage in these bands.³³ Sharing mechanisms to ensure the protection of Federal systems in the 39.5-40 GHz band segment may also be devised using the approach recently developed for Advanced Wireless Service (“AWS”) in the 1695-1710 and 1755-1780 MHz bands.³⁴ For these AWS-3 bands, FCC and the National Telecommunications and Information Administration (“NTIA”) jointly established coordination procedures to enable shared access between Federal agencies that retain assignments in these bands and new non-Federal licensees to prevent harmful interference.³⁵ The procedures, which apply in designated Protection Zones where Federal agency users continue to operate in these bands, describes an informal pre-coordination discussions between Federal agency users and AWS-3 licensees and a

³² See *Spectrum Frontiers NPRM* at ¶ 168 (identifying the Federal allocation for FSS [space-to-Earth] and MSS [space-to-Earth] in the 39.4-40 GHz band).

³³ See *Amendment to the Commission’s Rules with Regard top Commercial Operations in the 3550-3650 MHz Band*, Report and Order and Second Further Notice of Proposed Rulemaking, 30 FCC Rcd. 311 (2015) (*Citizens Broadband Radio Service*). See also Wireless Innovation Forum, *Ex Parte Letter*, GN Docket No. 12-354 (filed Feb. 26, 2015).

³⁴ See The Federal Communications Commission and the National Telecommunications and Information Administration: Coordination Procedures in the 1695-1710 and 1755-1780 MHz, *Public Notice*, 29 FCC Rcd. 8527 (2014) (*Joint Public Notice*).

³⁵ See *Id.*

formal coordination process which entails “submitting coordination requests and receiving results from relevant agencies.”³⁶ The procedures also allow for the formation of a dispute resolution board at the request of the one of the parties if a dispute arises in the coordination process.³⁷

In the adjacent bands above 40 GHz, there are designations for operations of Earth Exploration Satellite Service (“EESS”), Fixed, FSS (space-to-Earth), MSS (space-to-Earth), Space Research (space-to-Earth).³⁸ Huawei believes that compatibility between operations in the adjacent band and mobile systems operating below 40 GHz may be achieved through the agreement of suitable out-of-band emissions limits and, possibly, with suitable geographic exclusion zones surrounding sensitive receiving stations and guard bands.

Huawei believes that these techniques attest to the importance of a central enabler of shared spectrum use—successful spectrum sharing requires all participants to be willing and able to adapt systems designs, parameters and operations to facilitate realistic and viable sharing arrangements. Indeed, the Commission likewise holds the view that incumbents and new licensees that will share access to spectrum must use “good faith” to “share information about their systems, agree to appropriate interference methodologies, and communicate results so as to facilitate commercial use of the band.”³⁹

B. 37 GHz band

Huawei also acknowledges the NPRM proposal to license the 37 GHz band for 5G mobile services. As noted in the NPRM, this band has a co-primary mobile allocation globally;

³⁶ *See Id.* at 8527-28. The procedures outlined in the Public Notice may be substituted with a “negotiated coordinated arrangement” agreed to by all involved parties. *See Id.* at 8535.

³⁷ *See Id.* at 8539-40.

³⁸ *See* U.S. Table of Allocations, 47 C.F.R. § 2.106.

³⁹ *See 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, 4693 (2014) (*recon. pending*).

it has no incumbent non-Federal terrestrial authorizations; and while it has a co-primary non-Federal FSS allocation, there are no satellite operations currently in the band.⁴⁰ Consisting of 1.6 GHz of contiguous spectrum, the 37 GHz band has the benefit of being adjacent to the 39 GHz band and, in combination with the 1.4 GHz of contiguous spectrum in the 39 GHz Band, could enable an aggregate of 3 GHz of spectrum for 5G mobile services.⁴¹

The NPRM proposes to establish rules for this band that would enable the deployment of private networks with ultra-high bandwidth connectivity for advanced enterprise and industrial applications.⁴² Huawei believes the concept of an operating right by private owners for indoor use, i.e., “tailored to physical facility boundaries,”⁴³ is constructive as it holds the potential of more secure and reliable services for critical operations among enterprise, industrial and public service-based (i.e., hospital) users. It may also be desirable that beyond building interior spaces, the property right includes areas and enclosures adjacent to buildings, such as machinery, service roadways and pedestrian walkways, which would facilitate common communication access, for example, throughout a building campus facility.

This concept of property-conferred spectrum ownership is an important facet of reliable broadband wireless service extensions, particularly for IoT applications. In Huawei’s view, however, a property right framework does not diminish the need for additional licensed spectrum resources for 5G services. Beyond just the pursuit of greater bandwidth and volume, Huawei believes that future networks will encompass a wide variety of applications and user experiences.

⁴⁰ See *Spectrum Frontiers NPRM* at ¶ 100.

⁴¹ See *Id.* at ¶ 51. The NPRM notes that the band is shared with Federal FSS and indicates that the Commission will coordinate with Federal users on technical parameters and sharing compatibility, and establish sharing arrangements to enable the deployment of 5G mobile services. See *Id.* at ¶ 166. Huawei is open to providing the Commission with technical parameters as it moves forward with developing a sharing mechanism(s). Some of these parameters and system behaviors are noted above in the 39 GHz Band discussion.

⁴² See *Id.* at ¶ 100.

⁴³ See *Id.*

Such a property rights license, Huawei submits, will increase the prospect of deploying local service-oriented networks to quickly and efficiently respond to user needs, as well as to offer consistent, high-quality services for different use cases. To the extent the Commission moves forward with this framework for this and/or other mmW bands, Huawei suggests that consideration be given to ensuring co-existence between indoor property owner and outdoor wider-area licensees.

In terms of a band plan for the 37 GHz band, the NPRM offers as alternatives subdividing the band into either three blocks of 533 megahertz each or four blocks of 400 megahertz each.⁴⁴ Although both options have advantages—533 MHz blocks would enable higher throughput potential as a consequence of greater bandwidth, whereas 400 MHz blocks would provide more simplified channel assignments for sharing and reuse—Huawei believes the more simplified, practical 400 MHz block scheme is appropriate at this early stage of the 5G spectrum allocation process.

C. 64-71 GHz band

The fourth spectrum band proposed in the NPRM for a 5G mobile services allocation, the 64-71 GHz Band, would be authorized for unlicensed operations under Part 15 of the Commission rules consistent with the adjacent 57-64 GHz Band.⁴⁵ Huawei acknowledges the proposal for the 64-71 GHz band to be used for unlicensed mobile communications. When combined, these bands will provide a significant amount of spectrum that has the potential to become utilized globally for unlicensed mobile services given its compatibility with other global assignments.⁴⁶ Huawei also notes the plan for future study by the ITU following WRC-15 of the

⁴⁴ See *Id.* at ¶ 118.

⁴⁵ See *Id.* at ¶ 58.

⁴⁶ As in the case of some other Part 15 unlicensed systems, the access point equipment will need to be able to

(continued...)

66-76 GHz and the 81-86 GHz bands, as well as others, for IMT2020 identification. As a multinational provider of wireless systems, Huawei strives for global spectrum harmonization whenever possible. According, Huawei suggest the Commission continue its involvement in the ITU study items of bands above 6 GHz for IMT2020 services.

Given the available contiguous bandwidth of this band, Huawei believes this band has the potential to become a vital communications resource for many users and should be given further protection along the lines of the de-facto operation of systems in other unlicensed spectrum bands. Rather than simply extending the existing Part 15 rules to this band, the Commission should give consideration to additional requirements that enhance service reliability consistent with current practice. Equipment should comply with established national (or international) standards and should be registered for location usage by users to minimize the probability of interference across multiple systems. Huawei believes that these two mechanisms, coupled together, may help to improve system reliability. Most deployed unlicensed systems in other bands, for example, already follow the IEEE 802.11 set of standards and are operated by the property owner or their designee. The mechanism proposed for the 37 GHz band to establish a property license right may be a viable option for the 64-71 GHz unlicensed band. Thus, because these constraints are already the de-facto operating condition for some unlicensed bands, the FCC should consider incorporating these standards into the rules for this band from the outset.

D. The E-Band

Among the other mmW bands discussed in the NPRM and deferred for consideration by the FCC to a later time are the 71-76 GHz and 81-86 GHz bands, or the E-Band. The reasons given in the NPRM for excluding the E-Band in this proceeding are: the lack of interest

(Continued from previous page) _____
identify its location to ensure use of proper bands across various national jurisdictions.

expressed in comments filed in response to the NOI; the coordination challenges with the large number of non-exclusive, nationwide licenses issued for fixed operations in the band; and the limits on mobile service operations that would be necessary to protect Federal Earth stations and radio astronomy locations.⁴⁷ Despite these conclusions, Huawei favors early action by the Commission in this proceeding or another to develop rules that permit coordinated mobile operations in the E-band.⁴⁸

As noted earlier, the E-band is among the list of bands identified at the WRC-15 for study and recommendations for WRC-19.⁴⁹ As the E-band already has an ITU primary designation for mobile services, it may be licensed for mobile services within the United States without delay. Huawei believe that the E-band is extremely suitable for high-density mobile services. Further, the sharing between indoor and outdoor applications is practical due to shielding effects of buildings. The E-band is also suitable for sharing by operators for backhaul and access needs. Indeed, significant synergies may be achieved by an operator that utilizes the E-band for mobile access traffic within a building or neighborhood, and also backhauls the traffic in the E-band using point-to-point links. Huawei submits that self-coordination by operators will enable more efficient use of the spectrum for such multiple purposes.

As noted earlier in discussion of the 28/37/39 GHz bands, the operation of mobile systems in the E-band is governed by the physics of mmW propagation and the practical limits of antenna sizes and RF power generation. Further, the low available transmit powers lead to the use of narrow-beam high-gain directional antennas that may be steered to direct the RF signals at

⁴⁷ See *Id.* at ¶ 86. The NPRM concludes that proponents of unlicensed use in the bands failed to provide a detailed showing that unlicensed devices would be compatible with fixed equipment operating in the bands. *Id.* at ¶ 87.

⁴⁸ See *Spectrum Frontiers NPRM* at ¶ 88 (suggesting that spectrum bands not addressed in the instant proceeding be considered in the context of FCC's proceeding on Wireless Backhaul, WT-10-153).

⁴⁹ See Provisional Acts of WRC-15, *supra* note 22.

the intended receivers. The radio systems will include capabilities to dynamically sample channel behavior, track users and direct antennas. Such dynamic, real-time tracking is facilitated, fundamentally, by the use of Time Division Duplexing (“TDD”) for the transmission links. As noted later in these comments, TDD with alternating up-and-down transmissions enables utilization of the measured received signal properties to aid in focusing subsequent transmissions in accommodating the instantaneous time variations of the channel. With these measured parameters, self-sharing with backhaul links is highly practical

Indoor system operations, along with co-ownership by an operator for backhaul and access, will facilitate fixed/mobile sharing by enabling the operator to assign spectrum resources in manner best suited their needs and traffic. If self-licensing coordination and online license mechanisms are adopted, these tools may be extended to mobile deployments as well. Assigning property right licenses as proposed in the NPRM for the 37 GHz band (at least for indoors and adjacent work areas), together with a registration database as employed for the current E-band system, may be a practical means to manage assignments and interference among fixed and mobile deployments. The mobile area licenses (on the ground) would be registered with the self-licensing database within a designated use area, just as the point-to-point links register their air-path links. Mobile system backhaul links may also be self-licensed using the registration database.

Geographically restricted license areas and indoor use may also help to ensure necessary protection of Federal earth stations and radio astronomy locations. This is equivalent to coordinating with the location and footprints of current systems with a fixed link, a solution that Huawei believes can be successfully duplicated.

III. SECURITY

In the NPRM, the Commission solicits comment on the most effective means to ensure that mmW bands assigned for 5G mobile services are secure with security features “built into key design principles for all mmW band communications devices and networks.”⁵⁰ Huawei commends the Commission for focusing on security at the 5G development stage rather than after network deployment. Further, Huawei agrees that the volume of data traffic, the number of mobile connections and the variety of services and applications that 5G will make possible requires that security is a key feature in system design. As articulated in a recent Huawei white paper, entitled *5G Security: Forward Thinking*, Huawei believes, “[s]ince the service and network architecture of 5G is going through dramatic remodeling, it will improve the feature and competitive strength for 5G if security protection and privacy consideration is included at an early stage.”⁵¹

Because 5G systems will be services oriented, Huawei believes that 5G security design must be all encompassing, with a special emphasis on security and privacy from a services perspective. Unlike earlier generations of wireless technology designed principally for one-to-one communications between users, 5G will serve vertical industries with a greater diversity of new services, faster speeds and minimal latency. As the IoT gains momentum, more people will be able to remotely operate or “talk” to networked objects and products, and the burgeoning Industrial Internet will enhance efficiencies in production processes through connectivity. Given this variety of embedded services, Huawei believes it is particularly important that 5G communications be reliable and secure.

⁵⁰ See *Spectrum Frontiers NPRM* at ¶ 261.

⁵¹ See Huawei White Paper, *5G SECURITY: FORWARD THINKING*, at 11 (Dec. 2015), available at: http://www.huawei.com/minisite/5g/img/5G_Security_Whitepaper_en.pdf.

In the context of vertical industries, security demands will vary significantly. The network-based hop-to-hop security approach used today to secure the path between communications users will not be sufficient for differentiated end-to-end security for certain 5G services. If the new paradigms in mobile connectivity are to succeed, wireless systems will require a secure architecture, stringent identity management and data protection, more rigorous authentication methods, and an array of system-level protections to defend against distributed denial of service (“DDOS”) attacks and other intrusions. Moreover, security and privacy features for 5G systems cannot be built on top of the system design; rather, they must be built into the system design.

As Huawei contemplates the challenges associated with 5G security, the following basic principles arise: security and privacy solutions must cover the service layer in addition to the access layer; the role of end-to-end protection mechanisms must extend from those of previous generations to include the endpoints; and the protection measures for identity and location must defend against active attackers. As Huawei continues its research and standards-related efforts, the company is committed to collaborating with all stakeholders—industry, governments, and civil society—to ensure that such requirements develop into effective and mutually assuring security solutions.

IV. TECHNICAL RULES

With the goal of authorizing as wide a variety of services as possible without mandating specific technologies or deployment models through a flexible set of rules, the NPRM includes proposals on certain technical matters.⁵² Supplementing the comments provided in response to

⁵² See *Spectrum Frontiers NPRM* at ¶ 266.

the October 2014 NOI,⁵³ Huawei offers the following views on proposed rules addressing duplexing, antennas and interoperability. While the proposal on duplexing is consistent with the stated goal, the proposal on interoperability endorses a specific mandated requirement. Huawei believes that a flexible approach to these technical matters is generally preferable given the early stage of development of technologies for mobile service operations in the mmW bands. Huawei appreciates and supports the Commission’s recognition that it should “create a set of technical rules that encourage, rather than inhibit the development” of technologies in a “nimble and flexible manner.”⁵⁴

A. Duplexing Rules & Antennas

The NPRM indicates a preference for avoiding rules that may preclude development of new forms of duplexing for the mmW bands and proposes instead to allow both Time Division Duplexing (“TDD”) and Frequency Division Duplexing (“FDD”) deployment.⁵⁵ However, the NPRM notes that the current channel plan for the 39 GHz band, with each channel pair consisting of 50 x 50 MHz and licensed on a geographic service area basis, likely favors FDD operations.⁵⁶ As a general matter, Huawei prefers that mobile operation in the mmW bands use TDD to take advantage of the reciprocity capable within a channel and consequent enabling of channel adaptation to improve performance.⁵⁷ That is, channel measurements made by a receiver during reception may be used to adjust and improve the subsequent transmission to the

⁵³ See Huawei Comments at pp. 5-13 (discussing antenna technologies for base stations and mobile stations, including transmitter power; operations; modulation schemes; and network architectures).

⁵⁴ See *Spectrum Frontiers NPRM* at ¶ 266.

⁵⁵ See *Id.* at ¶ 268.

⁵⁶ See *Id.* at ¶ 270.

⁵⁷ Huawei notes that TDD may introduce a synchronization requirement across license areas to avoid mobile-to-mobile interference at boundaries and that there may also be some possibility of interference to fixed links from mobiles that may be operating on shared channels. (i.e., a fixed link may be interfered with by either a co-channel mobile device or an access-point.) As noted by the FCC, this does tend to favor FDD so as to fit into the existing plans. See *Spectrum Frontiers NPRM* at ¶ 270.

device. While Huawei supports the Commission’s preference to “avoid adopting any rules that would preclude the development of new forms of duplexing that further technological advances might produce,”⁵⁸ the following comments provide additional factors Huawei believes should be considered on this issue.

Because of the short range propagation characteristics of the mmW band, the consequent smaller cell sizes permit the use of TDD because the time interval required by the channel turnaround time is not as significant a factor as with wide area networks.⁵⁹ TDD also offers the inherent reciprocal channel estimation process, which improves the system’s ability to dynamically adapt to channel conditions.

Furthermore, as noted earlier in the discussion of the mmW bands, the operation of these mobile systems is limited by the physics of mmW propagation and the practical limits of antenna size and RF power generation. As discussed earlier, the low available transmit powers lead to the use of narrow-beam high-gain directional antennas that are dynamically steered to direct the RF signals to the intended receivers. The radio systems will include capabilities to dynamically sample the channel behavior and to track users and direct the antennas. Such dynamic (real-time) tracking is facilitated, fundamentally, by the use of TDD for the transmission links.

As noted elsewhere herein, the TDD with alternating up-and-down transmissions enables the received signal properties to be used to aid the focusing of the subsequent transmission and accommodates the instantaneous time variations of the channel. The use of TDD for the mmW bands is thus indicated, especially for the higher frequency bands (e.g., the E-band), due to the need for dynamic tracking of directed focused beams the operation of which in a real, fluctuating

⁵⁸ See *Id.* at ¶ 269.

⁵⁹ The short transit times of the radio signal propagation in the small cells are a small portion of the overall system frame intervals.

environment is dependent upon rapid sampling of the channel that is available through the TDD format.

FDD is inappropriate for this capability as the use of separate frequency bands for up-and-down links means the channel parameters seen by the receiver in the receive channel are not the same as seen by the transmitters (and not appropriate for the transmitter's use) operating in a different channel. Particularly with the mmW bands, the propagation behavior of the transmission and reception channels are sufficiently different that measurement of one is not helpful in providing beam steering guidance or channel parameters for the other.

B. Interoperability

In the NPRM, the Commission notes its intent to require that mobile equipment operating in each of the proposed mmW bands be interoperable by the use of all air interfaces that will be utilized on a frequency.⁶⁰ An interoperability requirement, the NPRM suggests, will help to ensure both a “robust market for equipment” and the availability of equipment to all licensees on an equal basis.⁶¹ Huawei fully shares the Commission's interest in the development of equipment capable of operating across the mmW bands and firmly believes that creating an interoperability environment will enhance portability, transparency, reliability and accountability for all stakeholders. Huawei also believes that such an environment will instill confidence among vertical industries and consumers in their willingness to adopt services and applications enabled by 5G technologies.

However, Huawei believes that mandating interoperability of mobile equipment within each mmW band using all air interfaces that the equipment utilizes on a frequency may not be the most efficacious approach for the rollout of 5G services. As Huawei noted in comments

⁶⁰ See *Spectrum Frontiers NPRM* at ¶¶ 295-6.

⁶¹ See *Id.* at ¶ 296.

responding to the NOI in this proceeding, the dynamic adaptive capability of radio systems and the variety of services and levels of technological complexity that may be operating in the mmW bands should be taken into account in the applicable service rules.⁶² As expressed in a different context,⁶³ Huawei notes that the telecommunications industry has a well established open standards development processes that are essential to the harmonization of technical specifications, commercialization of new technologies and interoperability across platforms. Huawei believes that through these processes, industry participants and relevant standards bodies will take into account the importance of interoperability to next generation mobile services and develop appropriate standards and technologies that satisfy market demand.

V. CONCLUSION

Huawei views the development of 5G technologies and services to be more than just the next generation of mobile infrastructure. Huawei believes 5G is the most exciting innovation in the ICT industry, enabling a super-connected, intelligent digital world. The future of 5G is dependent a variety of factors, including new investments in 5G technologies and network architectures, cross-industry collaboration in standards development, and pilot networks to demonstrate capabilities and interoperability of 5G deployments. Equally important is the availability of sufficient spectrum resources to support the complex performance requirements necessary for 5G services and applications. The spectrum bands currently assigned to mobile network operators cannot meet all of these requirements even with additional spectrum efficiency improvements. Spectrum bands providing wide continuous bandwidths in the mmW

⁶² See Huawei Comments at 13.

⁶³ See Huawei, Comments, *Office of Engineering and Technology and Wireless Communications Bureau Seek Information on Current Trends in LTE-U and LAA Technology*, Public Notice, 30 FCC Rcd. 4457, at 2 (filed Jun 11, 2015). As noted in these comments, Huawei is committed to working with all stakeholders to facilitate win-win outcomes for all. *See Id.*

bands are essential to meet the expected performance requirements.

Huawei again commends the Commission for its early recognition and action in this proceeding and hopes these comments help facilitate the Commission's efforts in realizing the possibilities made possible by 5G networks and services. Huawei stands ready to clarify and/or supplement these comments as may be helpful to the Commission in achieving this goal.

Respectfully submitted,

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