

**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554**

In the Matter of)	
)	
Use of Spectrum Bands Above 24 GHz For Mobile Radio Services)	GN Docket No. 14-177
)	
Amendment of the Commission's Rules Regarding the 37.0-38.6 GHz and 38.6-40.0 GHz Bands)	ET Docket No. 95-183 (Terminated)
)	
Implementation of Section 309(j) of the Communications Act – Competitive Bidding, 37.0-38.6 GHz and 38.6-40.0 GHz Bands)	PP Docket No. 93-253 (Terminated)
)	
Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service Rules for the 42-43.5 GHz Band)	RM-11664
)	

COMMENTS OF STRAIGHT PATH COMMUNICATIONS, INC.

Russell H. Fox
Angela Y. Kung

MINTZ, LEVIN, COHN, FERRIS, GLOVSKY AND
POPEO, PC
701 Pennsylvania Ave., NW
Suite 900
Washington, DC 20004
(202) 434-7300

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APPENDIX A – EXAMPLES OF 39 GHz MOBILE NETWORK LINK BUDGET

SUMMARY

As one of the largest holders of spectrum in the 38.6-40 GHz (“39 GHz”) band and the 27.5-28.35 GHz, 29.1-29.25 GHz, and 31-31.3 GHz bands (together “Local Multipoint Distribution Service” or “LMDS band”), Straight Path Communications, Inc. (“Straight Path”) applauds the Commission’s efforts to examine how millimeter wave (“mmW”) frequencies can be utilized for flexible services, including next generation 5G mobile technologies. In order to most effectively unlock the value of the mmW bands, the Commission should adopt flexible technical requirements and a regulatory framework that recognizes the existence of incumbent licensees.

Straight Path supports flexible use of mmW frequencies for all potential applications, including mobile, fixed broadband, and backhaul services. Specifically, Straight Path recommends that the FCC allow mobile licensees in the 39 GHz and LMDS bands to deploy a variety of innovative antenna arrays as well as duplexing, modulation, and multiple access schemes. Straight Path provides, as an attachment to these comments, a link budget analysis that demonstrates the data rates and coverage that may be achieved by 5G systems, assuming certain performance metrics, and recommends that the FCC allow licensees the flexibility to use different technologies to accomplish these performance and coverage goals. Straight Path urges the Commission to adopt power limits that are consistent with the limits for other spectrum in which mobile services operate. Straight Path also supports applying the same out-of-band emission limits for fixed microwave services in the 39 GHz and LMDS bands to mobile services in this spectrum. Interference concerns should preferably be resolved through technical or operating arrangements, although power flux density (“PFD”) limits at the borders of license

areas could be established to limit co-channel interference for mobile services in the 39 GHz and LMDS bands.

The FCC specifically contemplated and anticipated allowing flexible services in the 39 GHz and LMDS bands. While Straight Path recognizes that portions of these bands have also been allocated domestically for other services such as fixed satellite operations, there is currently little use of that spectrum for those uses, and existing operations can otherwise be accommodated. There is no reason, therefore, why those allocations should impede mobile services in the mmW bands at this time.

Finally, Straight Path supports an exclusive licensing approach based on geographic service areas for flexible services in the 39 GHz and LMDS bands. In geographic service areas where an entity already has a license to provide fixed services, however, the FCC should authorize the incumbent to also provide flexible services. Straight Path would not oppose reasonable build-out requirements for mobile services, but an incumbent's failure to satisfy those requirements should not result in the loss of its authorization to provide fixed services.

To the extent the Commission desires to create additional unlicensed spectrum opportunities, it should consider doing so in the 60 GHz bands (57-64 GHz and 64-71 GHz) and 70/80 GHz bands (71-76 GHz and 81-86 GHz). Similarly, any hybrid approach that includes sharing between licensed and unlicensed operations would be more appropriate for the 37/42 GHz bands (37.0-38.6 GHz and 42.0-42.5 GHz).

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Straight Path Communications, Inc. (“Straight Path”) submits these comments in response to the Notice of Inquiry (“*NOI*”) issued by the Federal Communications Commission (“Commission” or “FCC”) in the above-referenced proceedings.^{1/} The *NOI* seeks comment on the suitability of spectrum above 24 GHz, known as the millimeter wave (“mmW”) bands, for mobile services and to develop a record on potential technical rules and a licensing framework for those bands. Straight Path applauds the FCC’s efforts to initiate this proceeding, particularly as recent advances in next generation communications technologies have made these frequencies increasingly attractive for mobile wireless services. Straight Path urges the Commission to proceed quickly to issue one or more notices of proposed rulemaking in order to adopt

^{1/} See *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, et al.*, Notice of Inquiry, GN Docket No. 14-177, *et al.*, FCC 14-154 (rel. Oct. 17, 2014) (“*NOI*”); *Wireless Telecommunications Bureau and Office of Engineering and Technology Extend Period to File Comments and Reply Comments in Response to Notice of Inquiry on Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, Public Notice, DA 14-1703 (rel. Nov. 25, 2014) (extending the comment and reply comment deadlines).

regulations that will enable the mmW bands to be used for flexible use, including mobile applications. The more stable regulatory environment that will be created by new rules will further spur development and innovation in the mmW bands, which will lead to use of the spectrum for 5G systems and further enhance the capacity and resiliency of the wireless ecosystem.

I. INTRODUCTION AND BACKGROUND

Straight Path holds a significant number of licenses in the mmW bands. In particular, it is one of the largest holders of spectrum in the 39 GHz band. Its 39 GHz spectrum licenses cover the entire continental United States with an average of 833 megahertz of bandwidth in the top 30 U.S. markets (measured by population according to the 2010 U.S. Census). It also holds licenses in the 27.5-28.35 GHz, 29.1-29.25 GHz, and 31-31.3 GHz LMDS bands. Today, Straight Path uses its spectrum to provide backhaul services to wireless internet service providers (“WISPs”) and mobile network operators (“MNOs”).

Nevertheless, Straight Path has been actively engaged in evaluating how it can maximize the full potential of its spectrum holdings for next generation mobile solutions such as 5G. Straight Path joined NYU WIRELESS,^{2/} the Nation’s leading 5G think tank, as an Industrial Affiliate to support and encourage the advances and commercialization of 5G mmW technology.^{3/} While many leading technology companies – e.g., Samsung, Intel, Ericsson,

^{2/} See Straight Path Communications, Inc., Annual Report (Form 10-K), at 5 (filed Oct. 14, 2014). The Commission has acknowledged the efforts by NYU WIRELESS and others to develop ways to provide mobile services in higher frequencies. See *NOI* ¶¶ 5, 12.

^{3/} Straight Path has also recently hired a leader in mmW technology as its Chief Technology Officer. In particular, it added Jerry Pi who, prior to joining Straight Path, was a Senior Director at Samsung Research America. He is at the forefront of the development of mmW 5G, both as co-inventor of one of the world’s first 5G related inventions and co-author of ground-breaking journal articles on mmW mobile communications. See Straight Path Press Release, *Straight Path Communications Hires CTO to Lead the Charge to 5G* (Sept. 3, 2014), available at <http://www.b2i.us/profiles/investor/ResLibraryView.asp?ResLibraryID=72236&GoToPage=1&Category=2120&BzID=2211&G=738>.

Nokia, Huawei, and others – are also Industrial Affiliates at NYU WIRELESS, Straight Path is the only mmW spectrum holder to become an Industrial Affiliate. Along with these technology companies and others, we expect to work collaboratively to highlight our assets for utilization for mmW mobility. Straight Path is also working cooperatively with these companies toward miniaturization and product development, which are key components of commercializing 5G mmW technologies. Finally, in addition to its efforts with NYU WIRELESS and directly with technology companies, Straight Path expects to participate in standards setting bodies for 5G in order to address, among other things, seamless mobility and interoperability among different radio access technologies including 4G, 5G, and Wi-Fi.

Based on its work so far in developing mmW spectrum for 5G applications, Straight Path expects that the technology will be a complement or overlay to existing mobile networks in the initial phase of deployment. Although it may not necessarily replace the long-term evolution (“LTE”) networks being deployed or existing 4G or 3G networks, it will inject into existing mobile networks the necessary capacity and throughput to meet the expanding demand for mobile broadband, while also making data plans more affordable. We are early in the process both domestically and internationally of moving to a world of interconnected devices (the so-called Internet of Things, or IoT), and the demand for connectivity, capacity, and interoperability – for multiple industries and applications – will require substantial bandwidth. As a substantial holder of mmW spectrum, Straight Path expects its spectrum to be used to promote a more intuitive, connected, and cost-effective world.

Straight Path does not currently contemplate competing with MNOs. Instead, it expects carriers will use Straight Path’s spectrum through leases, and potentially in select, ultra-dense areas, we may deploy a network of our own (providing a turnkey solution) and act as a carrier’s

carrier. As the market for mmW spectrum increases, Straight Path expects to continue to develop its capabilities as an end-to-end service provider.

Straight Path appreciates that the Commission, like it, recognizes the potential for unlocking greater value of the mmW bands and has initiated this proceeding as a first step towards changing the rules governing these bands to permit mobile applications. Accordingly, it is pleased to have the opportunity to submit the following comments.

II. TECHNOLOGY DEVELOPMENTS

A. Antenna Technology

Recognizing that the use of higher frequency bands for mobile services will likely be dependent upon new advanced antenna technologies, the FCC seeks comment on the current development of antenna technology in the mmW bands and the types of antenna arrays that may be available for base stations supporting advanced mobile services.^{4/} In addition, the FCC requests input on base station configurations, how base stations will manage transmitted effective isotropic radiated power (“EIRP”), what types of power amplifiers will be necessary to support various antenna array systems, and the typical antenna gain of antenna arrays in the mmW bands.^{5/}

Innovative antennas and antenna arrays are essential in enabling mobile services in the mmW bands. In order to foster this market and promote the effective and efficient delivery of a variety of services in, among others, the 39 GHz and LMDS bands, the Commission should, as it

^{4/} See *NOI* ¶¶ 18-19.

^{5/} See *id.* ¶¶ 20-21, 24.

has with other spectrum bands in which mobile services are permitted,^{6/} adopt a flexible regulatory regime that allows for innovation in antenna design.

First, the FCC should allow the deployment of a broad variety of advanced antennas and antenna arrays beyond traditional multi- or omni-directional antennas. This would allow entities to utilize devices like electronically steerable phased array antennas,^{7/} which can dynamically form beams that point in the direction of the intended mobile receivers. Such flexibility would encourage advances in massive multiple-input multiple-output (“Massive MIMO”) technologies, which allow 5G mobile broadband systems to utilize antenna arrays with a large number of elements to communicate with multiple mobile stations within a sector at a reduced level of interference. As the Commission points out, antenna arrays with a large number of elements and advanced MIMO technologies “may be among the key factors for overcoming some of the challenging propagation characteristics of mmW bands and could increase efficiency, allowing for higher data rates, and provide reasonable coverage for mobile broadband services.”^{8/}

Second, the Commission should clarify that antennas or antenna arrays for 39 GHz and LMDS mobile services will not be subject to the minimum gain requirement currently applicable to fixed microwave services – *i.e.*, 38 dB – in these bands.^{9/} A minimum antenna gain of 38 dB is impractical for mobile services in the 39 GHz and LMDS bands. Due to propagation characteristics, the 39 GHz and LMDS bands are best suited for small cells with radii not

^{6/} See 47 C.F.R. Parts 22, 24, 27 (including antenna height and power requirements for air navigation safety, but otherwise refraining from imposing antenna structure limitations for mobile services in the Cellular, Personal Communications Service (“PCS”), Advanced Wireless Service (“AWS”), Wireless Communications Service (“WCS”), and 700 MHz bands).

^{7/} See Lu Yang, *et al.*, “18-40-GHz Beam-Shaping/Steering Phased Antenna Array System Using Fermi Antenna,” MICROWAVE THEORY AND TECHNIQUES, IEEE TRANSACTIONS ON, at 767, 773 (Apr. 2008).

^{8/} NOI ¶ 18.

^{9/} See 47 C.F.R. § 101.115(b).

exceeding 1 kilometer. In that configuration, a 38 dB antenna gain at the transmitter is not needed to establish a good communication link. Moreover, high-gain antennas typically have large dimensions. For example, a 38 dB dish antenna in the 39 GHz band would have a diameter of about 12 inches. Lower gain antennas with more compact form factors and dynamic beam steering capability are more appropriate for the smaller coverage areas anticipated with mmW band systems. Requiring the use of high-gain antennas would limit innovation in antenna design, and result in bulky and expensive base station antennas that will significantly reduce the utility of the mmW bands

Further, a high antenna gain of 38 dB will not be able to provide adequate service to units in motion. The half-power beamwidth of a 38 dB antenna is about 2 degrees (assuming the same half-power beamwidth in azimuth and elevation), which covers about 3.5 meters at a 100-meter distance. For a mobile station passing a base station's coverage area with a speed of 120 kmph (approximately 75 mph) at a distance of 100 meters, it would only take 100 microseconds for the user to go out of the coverage area of that 38 dB beam. This would make mobility support at the system level very challenging, if not impossible.

Typical macro base station antennas for mobile communications below 3 GHz have a gain of around 13-17 dB in order to achieve the EIRP necessary to provide sufficient coverage. With the increased number of elements in mmW band antennas, we expect an antenna gain of 23-27 dB to be achievable with a compact form factor and dynamic beam steering capability. However, a base station may need to transmit certain signals (*e.g.*, system information, pilot, or control messages) with lower antenna gain (and thus wider beamwidth) to achieve coverage. Therefore, we recommend that the Commission refrain from imposing a minimum antenna gain requirement for mobile services in the mmW bands.

Third, the Commission should clarify that the restriction on the types of antenna polarization schemes currently applicable to fixed microwave services does not apply to 39 GHz or LMDS mobile services.^{10/} Polarization is an inherent part of antenna design and an important area for innovation. The link between the base station and the mobile station, particularly in urban environments, is typically non-line-of-sight. The reflection and diffraction along the propagation paths typically change the polarization of the waves in unpredictable ways, and the orientation of antennas on mobile devices can be unpredictable. Sophisticated antenna polarization schemes, however, can be designed in ways that will minimize the impact of these unpredictable propagation characteristics and maintain the quality of the link. The FCC should therefore ensure that these different types of schemes are permitted.

B. Bandwidth, Duplexing, Modulation, and Multiple Access

The FCC seeks comment on how much contiguous spectrum will be needed to support advanced mobile and other contemplated services in the bands above 24 GHz and whether technologies are available that will allow licensees to aggregate smaller, non-contiguous blocks of spectrum.^{11/} It also requests input on the advantages of using Time-Division Duplexing (“TDD”) over Frequency-Division Duplexing (“FDD”) in the mmW bands and asks whether systems incorporating these frequencies will employ simpler single carrier or more complex modulation and coding schemes.^{12/} In addition, the Commission seeks comment on the anticipated multiple access schemes for mmW mobile systems, noting that while it does not

^{10/} See *id.* § 101.117.

^{11/} See *NOI* ¶ 30.

^{12/} See *id.* ¶¶ 31-32.

contemplate mandating the use of specific schemes, the FCC seeks to develop a better understanding of emerging technologies.^{13/}

For optimal performance, 5G systems should have access to 100 megahertz to 1 gigahertz of contiguous spectrum. This would allow those systems to achieve data throughputs of about 100 Mbps – 1 Gbps at a cell edge, 1 – 10 Gbps on average, and 10 – 100 Gbps peak rate. As with 4G systems, 5G technologies are expected to support aggregation of non-contiguous carriers.

Straight Path envisions that TDD will be one of the primary duplexing mechanisms for the majority of 5G systems. As mobile services have moved from voice-centric to data-centric applications, the demand for downlink (base station to mobile station) capacity has increased dramatically. Many data applications, such as web browsing, audio and video streaming, and data downloading require intensive use of downlink. TDD better accommodates these applications than FDD because it allows the entire spectrum band to be utilized for both uplink and downlink operations and permits flexible configuration of the band through dynamic assignments of time slots to uplink and downlink transmissions. FDD, on the other hand, is more suitable for symmetric services such as voice where the uplink and downlink traffic are similar. In any case, the FCC should refrain from mandating any duplexing schemes for 5G systems and encourage the continued development of more advanced duplexing technologies.

5G systems will also likely be able to employ a variety of sophisticated coding and modulation techniques, including higher order modulation (16QAM, 64QAM, etc.); advanced forward error correction coding (turbo codes, low density parity check codes, etc.); Hybrid Automatic Repeat reQuest; adaptive modulation and coding; and a variety of MIMO precoding

^{13/} See *id.* ¶ 33.

techniques. Straight Path further expects that advanced modulation techniques such as Orthogonal Frequency Division Multiplexing, which can modulate the data of different users on different frequency subcarriers, as well as single carrier waveforms, will be used in 5G systems. The Commission should support these types of techniques and likewise foster the growth and development of more advanced coding and modulation technologies.

Finally, like 4G technologies, Straight Path expects 5G technologies to support a suite of multiple access schemes such as Orthogonal Frequency Division Multiple Access, Time Division Multiple Access, Single Carrier Frequency Division Multiple Access, and Spatial Division Multiple Access, among others. Code Division Multiple Access as well as Carrier Sense Multiple Access could also be utilized in certain use cases. Because any of these schemes, individually or in combination, can be used in 5G systems, Straight Path agrees that the FCC should refrain from mandating the use of any specific access schemes in the mmW bands.

C. Performance and Coverage

The FCC asks what specifications for data throughput, latency, and other performance metrics should be associated with advanced mobile services in the mmW bands.^{14/} Acknowledging that 5G systems are still under development, the FCC also asks about the likely or possible coverage areas of individual mmW base stations and whether they are sufficient to provide services outside of dense urban areas.^{15/}

Straight Path supports performance metrics that are technologically feasible and commercially practical within the anticipated timeframe for the full-scale commercial deployment of 5G technologies, *i.e.*, between 2020 and 2025. Moreover, any performance and coverage requirements must be sufficiently flexible to accommodate the range of services that

^{14/} See *id.* ¶ 34.

^{15/} See *id.* ¶ 35.

will be provided in the mmW bands. Nevertheless, in response to the Commission's questions, Straight Path anticipates that cell radius will be 100 meters – 1 kilometer; system bandwidth will be 100 megahertz – 1 gigahertz; cell-edge data rate will be 100 Mbps – 1 Gbps; average data rate will be 1 – 10 Gbps; peak data rate will be 10 – 100 Gbps; and average transmission latency will be 100 us – 1 ms. 5G systems with these performance metrics, once deployed, will not only mitigate network congestion related to the explosive growth of data traffic driven by applications and services mobile systems are experiencing today, but will also open the door for new applications, services, and businesses.

With the cell radius proposed above, 5G technologies should be able to provide sufficient coverage for different geographic areas – both urban and rural. As demonstrated in the attached link budget analysis, 5G systems can achieve data rates from a few Gbps to a few hundred Mbps for link distances from 100 meters to 500 meters, assuming a path loss model derived from mmW channel measurement data in New York City – one of the most challenging environments for mmW propagation.^{16/} Therefore, Straight Path envisions mobile service providers will be able to use mmW spectrum to provide sufficient coverage and meet different service requirements in different geographic areas. In any event, as noted below, the Commission should maintain consistency with how the bands are currently authorized and allow licensees to determine the best ways for them to achieve the performance and coverage for the services they intend to provide. Licensees can, and thus should be allowed to, continue to use currently permitted mechanisms such as spectrum leases as part of their coverage and performance strategies.

^{16/} See Appendix A.

D. Technical Rules

Although the FCC suggests that it is premature to seek comment on detailed technical rules at this time,^{17/} it nonetheless asks what maximum transmit power and/or EIRP limits would be appropriate for mobile services in the mmW bands, including whether the +55 dBW EIRP limit currently applicable in the 27.5-28.35 GHz band and 39 GHz band are appropriate.^{18/} The FCC also seeks comment on appropriate out-of-band emission (“OOBE”) limits and requests input on the means for reducing harmful interference to other licensees.^{19/}

I. Power Limits

As demonstrated by the attached link budget analysis,^{20/} Straight Path recommends that the FCC adopt an EIRP limit of 65 dBm (3160 Watts) for base stations operating in the 39 GHz and LMDS bands. This is consistent with the maximum power limit for other spectrum in which mobile services operate – *e.g.*, the Cellular,^{21/} Broadband PCS,^{22/} WCS,^{23/} AWS,^{24/} and 700 MHz bands.^{25/} This limit is also 100 times less than the current allowable maximum EIRP (55 dBW or 85 dBm per polarization) for 39 GHz and LMDS fixed microwave service stations.^{26/} Not only would this lower power limit reduce the potential for harmful interference to others, but it would also allow for better interference coordination among different licensees and between fixed and

^{17/} See *NOI* ¶ 40.

^{18/} See *id.* ¶ 41.

^{19/} See *id.* ¶¶ 42, 43.

^{20/} See Appendix A.

^{21/} See 47 C.F.R. § 22.913.

^{22/} See *id.* § 24.232.

^{23/} See *id.* § 27.50(a).

^{24/} See *id.* § 27.50(d).

^{25/} See *id.* §§ 27.50 (b), (c).

^{26/} See *id.* § 101.113.

mobile use. Straight Path's proposed EIRP limit, however, should not apply to fixed point-to-point or point-to-multi-point services. These services should continue to be subject to the current 55 dBW (85 dBm) maximum EIRP limit in the FCC's rules, which has been sufficient to allow the successful deployment of systems in the 39 GHz and LMDS bands.

For mobile stations, the FCC should adopt a 30 dBm maximum output power and 43 dBm maximum peak EIRP.^{27/} Like the proposed EIRP limit for base stations, these limits are consistent with the mobile station power limits for other mobile service bands as well as with the EIRP limits on portable and mobile Wi-Fi and 60 GHz devices.^{28/} Moreover, these limits account for the increased antenna gain that can be achieved by mobile devices operating in the mmW bands, which have shorter wavelengths than the electromagnetic waves below 3 GHz.

2. *OOBE Limits*

Straight Path generally supports the FCC's emission limits for fixed microwave services in the mmW bands and believes they may be applied to other flexible services, including mobile, in these bands.^{29/} The Commission should define the nominal bandwidth for calculating the spectral mask for the 39 GHz band (Straight Path suggests a value of 50 megahertz). Currently, the nominal bandwidth used in calculating the spectral mask is defined for the LMDS, 71-76, and 81-86 MHz bands.^{30/} The Commission should also clarify that the emission mask is only applied to the band edge of each block of spectrum in the 39 GHz band, as the Commission did for the 24 GHz, LMDS, and 71-76 and 81-86 GHz bands.^{31/} Unifying the spectral mask for the 39 GHz and LMDS bands along with other bands will save development costs and allow for

^{27/} See Appendix A.

^{28/} See 47 C.F.R. §§ 15.247, 15.255.

^{29/} See *id.* § 101.111 (a)(2)(ii).

^{30/} See *id.* § 101.111 (a)(2)(iv)-(v).

^{31/} See *id.*

more flexible deployments of systems with different bandwidth and better utilization of the spectrum.

3. *Interference Coordination*

The FCC should generally allow mobile service licensees in the 39 GHz and LMDS bands to resolve interference concerns through technical or operating arrangements as it currently permits for other mobile services.^{32/} Because 39 GHz and LMDS frequencies are generally licensed to a single entity in any service area, there is little risk of co-channel interference issues between different licensees within the same service area. Notably, the FCC's rules for fixed microwave service providers do not include specific co-channel interference protection criteria for either the 39 GHz or LMDS bands.^{33/} Straight Path supports a similar approach for mobile services in this band, particularly because there will be both mobile and fixed operations in the bands. To the extent that there are co-channel interference concerns between licensees in neighboring service areas, those licensees should be required to undergo the coordination procedures that are currently applicable to fixed microwave service providers.^{34/}

However, if the FCC determines that co-channel interference protection criteria are necessary, Straight Path suggests that the FCC adopt a field strength limit of 37 dBuV/m per megahertz for non-fixed services in the 39 GHz and LMDS bands. This field strength limit equates to -132 dBm per megahertz and -129 dBm per megahertz received power for an isotropic antenna in the 39 GHz and the LMDS bands, respectively, measured at the border of a geographic service area. Alternatively, the Commission could specify a PFD limitation of -109 dBW/m² per megahertz for the 39 GHz and LMDS mobile services, measured at the border of a

^{32/} See, e.g., *id.* §§ 22.352, 27.64.

^{33/} See *id.* § 101.105(a).

^{34/} See *id.* § 101.103.

geographic service area. While this level of co-channel interference may cause service degradation *at* the border, the level of interference should decline to a much lower level a few kilometers *away* from the border due to the propagation characteristics of mmW spectrum.

The FCC's rules include adjacent-channel interference protection criteria for the 39 GHz and LMDS bands.^{35/} However, there are no adjacent-channel interference criteria in other bands with flexible services like cellular, AWS, and PCS,^{36/} and spectrum in those bands can also be used to provide both fixed and mobile services.^{37/} Accordingly, to be consistent with its approach to other flexible service bands, the Commission should not adopt adjacent-channel interference limits for services in the 39 GHz and LMDS bands unless there is a demonstrated need to impose such limits.^{38/} Licensees that are operating consistent with the terms of their authorizations and the Commission's rules should be considered non-interfering to adjacent channels.

E. Alternative Uses, Including Backhaul

The FCC seeks input on the utility of the mmW bands for uses other than mobile services such as non-line-of-sight backhaul.^{39/} Straight Path encourages the flexible use of mmW frequencies at the operator's discretion – the same approach the Commission uses in other bands. As explained above, Straight Path currently utilizes its mmW frequencies to provide backhaul services for existing WISPs and MNOs. These wireless transport services are more cost effective for WISPs and MNOs than fiber backhaul services in many cases. As these and other

^{35/} See *id.* § 101.105.

^{36/} See, e.g., *id.* §§ 24.237, 27.1131.

^{37/} See, e.g., *id.* §§ 2.106, 24.3, 27.2.

^{38/} If necessary, the Commission could retain the current rules governing adjacent-channel protection criteria for *fixed* services, which generally employ coordination procedures between licensees. See *id.* § 101.105.

^{39/} See *NOI ¶¶* 44-45.

entities increasingly rely on small cells, their need for wireless backhaul capacity will continue to grow. Nevertheless, and as the Commission has recognized by initiating this proceeding, the mmW bands can also be used for other services, including mobile services. As the Commission observes, some systems may use the spectrum for both mobile and backhaul uses.^{40/} Others may continue to use the spectrum for backhaul, and still others may offer only mobile services. Service rules – such as those Straight Path recommends above – should flexibly accommodate all potential applications.

III. FREQUENCY BANDS ABOVE 24 GHz FOR MOBILE SERVICES

A. Status of Mobile Allocation and Rights

The FCC requests comment on the suitability of the 39 GHz and LMDS bands, among others, for advanced mobile services.^{41/} Straight Path strongly believes that now is the time for the Commission to amend its rules to permit a variety of services in the mmW bands in general and in the 39 GHz and LMDS bands in particular. As the Commission observes, until recently, the prevailing assumption was that flexible services such as mobile in higher frequency bands were infeasible because radio waves at those frequencies travel in straight lines and could provide only line-of-sight services.^{42/} In recent years, however, there have been significant developments in next generation mobile communication technologies, including Millimeter-wave Mobile Broadband, Massive MIMO, and small cell technologies, that can enable non-line-of-sight mobile services in higher frequency bands. In fact, researchers at NYU WIRELESS

^{40/} *See id.*

^{41/} *See id.* ¶¶ 46-50.

^{42/} *See id.* ¶ 5.

recently conducted testing and have reported that mmW frequencies “show great promise for the future of wireless communications.”^{43/}

Moreover, advances in Monolithic Millimeter-wave Integrated Circuits and Radio Frequency Integrated Circuits have resulted in more powerful and efficient, as well as smaller and cost-effective, mmW transceivers, allowing base stations and mobile devices to utilize mmW spectrum for mobile communications. As researchers at NYU WIRELESS have reported, “recent advances in integrated circuit and antenna technology have made it possible to inexpensively and reliably manufacture wireless devices that operate at millimeter wave frequencies.”^{44/} Improvements in Analog-to-Digital Converters and baseband modems have likewise developed in a manner that will be able to utilize the wide bandwidth (100 megahertz – 1 gigahertz) available in the mmW bands.

The Commission has already determined that the 39 GHz and LMDS bands can be used for mobile services. As the FCC points out, the 39 GHz band currently has a co-primary allocation for fixed and mobile services.^{45/} When the FCC allocated the spectrum for both services, it specifically left open the possibility of using the frequencies for mobile operations.^{46/} The Commission, however, postponed permitting mobile operations in the 39 GHz band until it

^{43/} Sijia Deng, *et al.*, “Small Wavelengths – Big Potential: Millimeter Wave Propagation Measurements for 5G,” MICROWAVE JOURNAL, at 1 (Nov. 13, 2014), available at <http://www.microwavejournal.com/articles/23274-small-wavelengths-big-potential-millimeter-wave-propagation-measurements-for-5g>.

^{44/} *Id.*

^{45/} See *NOI* ¶ 58; 47 C.F.R. § 101.101.

^{46/} See *Amendment of the Commission’s Rules Regarding the 37.0-38.6 GHz and 38.6-40.0 GHz Bands; Implementation of Section 309(j) of the Communications Act – Competitive Bidding, 37.0-38.6 GHz and 38.6-40.0 GHz*, Report and Order and Second Notice of Proposed Rulemaking, 12 FCC Rcd. 18600, ¶¶ 1, 18-23 (1997) (“39 GHz Order”) (“[W]e have decided to permit implementation of mobile operations in the 39 GHz band.”).

conducted a proceeding to resolve inter-licensee and inter-service interference issues.^{47/} The Commission also notes that it previously anticipated expanding the LMDS authorization to include mobile services if proposed and supported by the resulting record.^{48/} The Commission specifically observed that: “Although LMDS is allocated as a fixed service, we know of no reason why we would not allow mobile operations if they are proposed and we obtain a record in support of such an allocation.”^{49/}

This proceeding is exactly what the Commission and mmW licensees like Straight Path anticipated when the Commission created the mobile allocation in both the 39 GHz and LMDS bands. Now that technology has sufficiently advanced, it is time for the Commission to take the steps it said it would and adopt service rules that will permit mobile services in these bands. Moreover, as spectrum in frequencies below 6 GHz are becoming increasingly congested, it simply makes sense for the Commission to allocate spectrum for 5G technologies in the higher mmW bands.^{50/} As Chairman Wheeler recently noted, “[t]he fact that there is no low-hanging fruit in our spectrum inventory that can easily be repurposed for broadband means that the Commission needs to think creatively about how to make more spectrum available and increase the efficiency of its use.”^{51/}

^{47/} See *NOI* ¶ 58; *39 GHz Order* ¶¶ 24-26.

^{48/} See *NOI* ¶ 53.

^{49/} *Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission’s Rules to Redesignate the 27.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies For Local Multipoint Distribution Service and For Fixed Satellite Services*, Second Report and Order, Order on Reconsideration and Fifth Notice of Proposed Rulemaking, 12 FCC Rcd. 12545, ¶ 207 (1997).

^{50/} This would also be consistent with international efforts. The International Telecommunications Union’s (“ITU”) working group on International Mobile Telecommunications (“IMT”) recently suggested that use of higher frequencies will “be one of the key enabling components for the future of IMT.” ITU, Radiocommunications Study Groups, *Working Party 5D: Working Document Towards a Preliminary Draft, New Report ITU-R M. [IMT.Above 6 GHz]*, at 2 (Oct. 22 2014).

^{51/} Tom Wheeler, FCC Chairman, “Meeting the Mobile Moment” (Sept. 26, 2014), *available at* <http://www.fcc.gov/blog/meeting-mobile-moment>.

B. Other Authorized Services

The Commission observes that, in addition to fixed and mobile service allocations, both the 39 GHz and LMDS bands have satellite service allocations and seeks comment on the compatibility of such services with mobile services if they are permitted in these bands.^{52/} The FCC notes that there is a co-primary non-federal Fixed Satellite Service (“FSS”) (space-to-Earth) allocation throughout the 39 GHz band.^{53/} While there is also a federal allocation for FSS (space-to-Earth) as well as Mobile Satellite Service (“MSS”) (space-to-Earth) in the 500 megahertz between 39.5-40 GHz, both of which are on a co-primary basis, there is no federal service allocation in the remainder of the 39 GHz band – the 38.6-39.5 GHz band.^{54/} In the LMDS bands, both the 27.5-28.35 GHz and 29.1-29.25 GHz bands have a non-federal FSS (Earth-to-space) allocation that is co-primary with fixed and mobile services.^{55/} The 29.1-29.25 GHz band is also allocated for non-federal MSS feeder links on a co-primary basis with LMDS, which is limited to hub-to-subscriber transmissions.^{56/} The 31-31.3 GHz LMDS band includes a federal and non-federal allocation for space-to-Earth standard frequency and time signal operations, which is on a secondary basis to fixed and mobile services in the band.^{57/} None of the LMDS bands includes a primary federal allocation.^{58/}

Straight Path appreciates that portions of the 39 GHz and LMDS bands have also been allocated domestically for federal and non-federal satellite services. However, those allocations

^{52/} See *NOI* ¶¶ 55, 61.

^{53/} See *id.* ¶ 60.

^{54/} See *id.* ¶ 59.

^{55/} See *id.* ¶ 54. However, Section 25.202 of the FCC’s rules provides that FSS is secondary to LMDS in the 27.5-28.35 GHz band. See 47 C.F.R. § 25.202.

^{56/} See *NOI* ¶ 54.

^{57/} See *id.*

^{58/} See *id.*

should not impede the deployment of 5G mobile services in these bands. As the Commission recognizes, there is virtually no use of the 39 GHz band today by satellite operators.^{59/} The FCC reports that Hughes Network Systems, LLC (“Hughes”) holds a non-federal FSS authorization to provide space-to-Earth transmissions in the band,^{60/} but the FCC’s satellite licensing database indicates that Hughes surrendered its authorization in August 2014.^{61/}

The FCC also points out that FSS users in the 39 GHz band operate under a “soft segmentation” band plan, which, among other things, subjects them to lower PFD limits to accommodate high-density fixed terrestrial systems.^{62/} In a separate proceeding, the Commission is considering methods to increase the potential for sharing between terrestrial and satellite operations in the larger 37.5-42.5 GHz band (known as the “V-band”), which encompasses the 39 GHz band, including coordination procedures for FSS and fixed operations in the V-Band and procedures pursuant to which FSS licensees may raise their PFD levels to compensate for “rain fade.”^{63/} The better approach is for the Commission to remove the FSS allocation in the 39 GHz band altogether and focus on developing it for mobile use.^{64/}

^{59/} See *id.* ¶ 60.

^{60/} See *id.*

^{61/} See Letter from Jennifer A. Manner, Vice President, Regulatory Affairs, Hughes, to Ms. Marlene H. Dortch, Secretary, FCC, IBFS File No. SAT-LOA-20111223-00248 (filed Aug. 1, 2014).

^{62/} See *NOI* ¶ 60.

^{63/} See *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*, Third Notice of Proposed Rulemaking, 25 FCC Rcd. 15663 (2010) (“*V-Band Third NPRM*”).

^{64/} In order to accomplish that, Straight Path has asked, in a letter filed concurrently with these comments, that the Commission: (1) postpone action in the *V-Band Third NPRM* so that its decisions there may be consistent with any actions it takes in response to the *NOI* and any follow-up rulemaking proceedings; and (2) freeze applications for new satellite services in the V-Band, until it resolves outstanding issues raised in the *NOI*. See Letter from Russell H. Fox and Angela Y. Kung, Mintz, Levin,

Several reasons compel this result. *First*, it is not technically feasible for mobile services to coexist with FSS operations in the same geographic area due to the wide beamwidth of the mobile station antennas and large radii of satellite spot beams once they reach the Earth, particularly at the increased PFD limit that the Commission has proposed. Separating these two services would avoid any interference concerns and better maximize the utility of the spectrum. *Second*, as noted above, there is currently no non-federal satellite use in the V-band. In contrast, there is an expanding demand for terrestrial use of the spectrum. It is contrary to the public interest to continue to reserve spectrum for non-federal satellite use in the 39 GHz band where there is no demand and make that same spectrum unavailable for terrestrial services where demand exists. *Finally*, designation of the 39 GHz band for terrestrial use will still leave the remainder of the V-band (37.5-38.6 GHz and 40.0-42.0 GHz) available for satellite operations. Based on the limited use of the V-band by satellite operations since it was made available in 2003,^{65/} spectrum in the remainder of the V-band and in other bands, such as LMDS, will most likely be sufficient to meet current and projected needs of non-federal FSS.

Removing the FSS allocation in the 39 GHz band and designating it exclusively for fixed and mobile service operations would also be consistent with the FCC's V-band proceeding. As the Commission observed in that proceeding, one way to address the "rain fade" issue would be to limit FSS to a maximum of 1 gigahertz of downlink within the 2.5 gigahertz wide 37.5-40

Cohn, Ferris, Glovsky and Popeo, P.C., Counsel for Straight Path, to Ms. Marlene H. Dortch, Secretary, FCC, IB Docket No. 97-95, *et al.* (filed Jan. 15, 2015).

^{65/} See *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*, Second Report and Order, 18 FCC Rcd. 25428 (2003).

GHz downlink band.^{66/} If the Commission allocates the 39 GHz band exclusively for fixed and mobile services, it could limit FSS operations to the 37.5-38.5 GHz band as well as allow satellite operators to operate at increased PFD levels in that spectrum. Not only would this address the rain fade issue, but such action may also make the need to consider coordination procedures and increased PFD levels in the V-band proceeding unnecessary.

Federal satellite services in the 39.5-40 GHz portion of the 39 GHz band should not impede enhanced terrestrial use of the spectrum. For instance, federal FSS receive-only stations could be protected through “Protection Zones” or “Exclusion Zones” similar to those that are contemplated in the AWS-3 and 3.5 GHz proceedings.^{67/} Under this framework, commercial operations could be deployed freely outside of these zones as well as inside these zones, subject to successful coordination with federal operations. Conversely, because federal MSS stations are not entitled to claim protection from non-federal fixed or mobile operations in the 39.5-40 GHz band,^{68/} they would not require any additional protections if mobile operations are permitted in the 39 GHz band.

Similar to the 39 GHz band, there is currently little non-federal satellite use of the 27.5-28.35 GHz band and no non-federal satellite operations in the 31-31.3 GHz band. In any case, those satellite operations are only permitted on a secondary basis to LMDS operations pursuant to the FCC’s rules.^{69/} If mobile operations are permitted in these bands, those uses should remain secondary and should not require any additional protections. Straight Path recognizes

^{66/} See *V-Band Third NPRM* ¶ 55.

^{67/} 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, ¶¶ 11, 19 (2014); *Amendment of the Commission’s Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Further Notice of Proposed Rulemaking, 29 FCC Rcd. 4273, ¶ 5 (2014) (“3.5 GHz FNPRM”).

^{68/} See *NOI* ¶ 59.

^{69/} See 47 C.F.R. § 25.202.

that non-federal satellite operations in the 29.1-29.25 GHz LMDS band may make mobile wireless use of the band more complicated and require further analysis. However, any further study should not delay FCC action on the other LMDS bands or the 39 GHz band.

Finally, because there is no allocation for federal use of either the 27.5-28.35 GHz or 29.1-29.25 GHz band, the FCC need not consider federal satellite operations if it permits mobile services in these bands. While the 31-31.3 GHz band is allocated for certain federal satellite uses, those operations are only permitted on a secondary basis and thus do not require protection.

IV. LICENSING MECHANISMS

The FCC explains that there are two major models for wireless network deployments – a service provider model where a single operator deploys and manages a network and a decentralized Wi-Fi-like deployment model in which network elements are mostly deployed by end users.^{70/} It asks about the type of model commenters envision for mmW mobile services.^{71/} It similarly seeks comment on the appropriate licensing mechanism for mobile service operations in the mmW frequencies and on whether, and if so how, it should authorize incumbent licensees that are currently licensed to provide fixed service to begin mobile operations in these bands. It posits four alternative options for assigning new or unassigned mobile authorizations.^{72/}

A. Deployment Model

Straight Path believes a service provider model is the most appropriate for mobile services in the 39 GHz and LMDS bands and thus supports the FCC's first proposed option for licensing this spectrum. Under this approach, the Commission would auction and license exclusive authorizations in the mmW bands to entities for flexible services using geographic

^{70/} See *NOI* ¶¶ 36-37.

^{71/} See *id.* ¶ 39.

^{72/} See *id.* ¶¶ 88-102.

service areas – but only in areas where no such licensee exists today.^{73/} In areas where the Commission has already issued a license to provide fixed services, the FCC should authorize the incumbent to also provide flexible services like mobile. As the FCC points out, this approach is used for other mobile services in frequencies below 3 GHz and has the advantage of being a familiar, time-tested option that allows for flexible service deployment.^{74/}

The 39 GHz and LMDS bands are already licensed on an exclusive basis to a number of entities for fixed services. Those entities acquired their authorizations at auction and paid for the spectrum with the expectation that the Commission would, as noted above, make the frequencies available for mobile services in the future.^{75/} Equity dictates that the Commission should allow these mmW incumbents to realize the full value of the spectrum for which they paid and the benefits associated with FCC rule changes that would allow them to offer mobile services.

Moreover, authorizing mmW incumbents to provide mobile operations would ensure that their fixed operations are protected. As the Commission suggested in its AWS-4 proceeding,^{76/} it may be technologically impractical for different services to be operated separately in the same band. It therefore determined that such services should be managed by the same operator.^{77/} The Commission should find the same is true for the mmW bands. Indeed, while in the AWS-4 proceeding, the Commission considered separate satellite and terrestrial system licensees, in this case, licensees of both mobile and fixed systems would be operating terrestrial systems – creating an even greater potential for interference. A separate licensee providing mobile

^{73/} See *id.* ¶ 92.

^{74/} See *id.*

^{75/} See *39 GHz Order* ¶¶ 21-25.

^{76/} See, e.g., *Service Rules for Advanced Wireless Services in the 2000-2020 MHz and 2180-2200 MHz Bands, et al.*, Report and Order and Order of Proposed Modification, 27 FCC Rcd. 16102, ¶ 163 (2012) (“AWS-4 Order”).

^{77/} See *id.* ¶¶ 161-170.

operations in the same geographic service area would significantly harm Straight Path's and other incumbents' existing fixed operations. With respect to the 39 GHz band in particular, the FCC has already noted that "the issue of technical compatibility of fixed and mobile operations within a service area is one that can and should be resolved by the licensee."^{78/}

B. Build-Out Requirements

The FCC cautions that a potential concern related to its first option is that portions of "license areas outside of high-traffic areas could end up lying fallow."^{79/} However, any time the FCC licenses spectrum on a geographic area basis, that risk exists, and the Commission addresses the possibility, as it contemplates in the *NOI*, by performance requirements or other market forces.^{80/} Indeed, the Commission often adopts build-out requirements to ensure that service is provided and spectrum does not remain fallow.^{81/} AWS licensees, for example, are required to make a showing of "substantial service" in their license area by the end of their license term.^{82/} H Block licensees are also required to meet certain population-based build-out requirements during the middle and end of their license terms.^{83/} Similar performance obligations could be imposed on 39 GHz and LMDS licensees providing flexible services to prevent spectrum warehousing.

The Commission's questions presume that there would be a new licensee required to meet these performance requirements. However, as noted above, there are incumbent licensees

^{78/} 39 GHz Order ¶ 24.

^{79/} *NOI* ¶ 93.

^{80/} *See id.* ¶ 95.

^{81/} *See, e.g., Service Rules of the 698-746, 747-762 and 777-792 MHz Band, et al., Second Report and Order, 22 FCC Rcd. 15289, ¶ 154 (2002) (finding that build-out requirements ensure that "700 MHz Commercial Services licensees put this spectrum to use throughout the course of their license terms and serve the majority of the users in their license areas").*

^{82/} *See* 47 C.F.R. §§ 27.13, 27.14.

^{83/} *See id.* § 27.14.

in the 39 GHz and LMDS spectrum bands who should retain their authorizations and be able to take advantage of new rules permitting mobile wireless services. If incumbents are authorized to provide flexible services, Straight Path would not oppose reasonable and achievable build-out requirements for those services that are separate from incumbents' existing substantial service requirements. Similar to the FCC's determination in the AWS-4 proceeding, the failure to satisfy the performance requirements associated with an incumbent's additional authorization for mobile services should not result in the loss of the incumbent's license for fixed services.^{84/} In order to ensure the productive use of spectrum and re-authorization of any flexible service license that has been terminated, the Commission could declare that failure of an incumbent to meet its mobile build-out requirement will result in the loss of protection from future mobile service licensees in the areas covered by that license.^{85/}

The FCC should not, as the *NOI* suggests, establish smaller licensing areas to minimize the amount of unserved areas in any given license.^{86/} Requiring licensees to evaluate licenses based on Partial Economic Areas or potentially thousands of smaller census tracts would be burdensome and require a significant amount of resources. Allocating licenses using smaller geographic areas would also add unnecessary complexity to any auction process used to license spectrum not already authorized and increase the number of service area boundaries where licensees would be required to coordinate interference with neighbors. The simpler the process is for obtaining mobile licenses and the fewer number of boundaries for inter-licensee

^{84/} See *AWS-4 Order* ¶ 202 (holding that if a licensee fails to meet its final AWS-4 build-out requirement, its terrestrial authority for each area shall terminate).

^{85/} See *id.* ¶ 203.

^{86/} See *NOI* ¶ 94.

interference coordination in the mmW bands, the more likely parties will be encouraged to participate and deploy services in those bands.

C. Other Licensing Mechanisms

In any case, the Commission should refrain from adopting any licensing option that would involve a non-exclusive or unlicensed approach for spectrum that is already authorized on a licensed basis.^{87/} While both licensed and unlicensed spectrum are important to support mobile services, the current 39 GHz and LMDS bands are occupied by existing licensees. The FCC should protect the rights of these incumbents and ensure that their operations are not diminished by unlicensed users. When the 39 GHz and LMDS spectrum was auctioned, the Commission did not contemplate that it would be subject to shared use with unlicensed operations, and the FCC should not deviate from that now. Although the Commission is contemplating the shared use of spectrum between licensed and unlicensed services in other bands,^{88/} the sharing mechanisms are not yet tested, and in any case, there are no incumbent licensees in those bands who obtained their authorizations at auction. Spectrum licensed at auction should remain licensed on an exclusive basis after the Commission changes its rules to permit mobile use of that spectrum in addition to the fixed operations that are already allowed.

Straight Path agrees with recent statements by Chairman Wheeler that “efforts to expand the amount of unlicensed spectrum create[] alternative competitive pathways.”^{89/} Straight Path believes the FCC’s goals for creating additional unlicensed spectrum for mobile operations can

^{87/} See *id.* ¶¶ 97-101.

^{88/} See, e.g., *3.5 GHz FNPRM; Commission Seeks Comment on Licensing Models and Technical Requirements in the 3550-3650 MHz Band*, Public Notice, 28 FCC Rcd. 15300 (2013); *Amendment of the Commission’s Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Notice of Proposed Rulemaking, 12 FCC Rcd. 15594 (2012).

^{89/} Prepared Remarks of FCC Chairman Tom Wheeler, 1776 Headquarters, Washington, D.C., “The Facts and Future of Broadband Competition,” at 6 (Sept. 4, 2014), available at https://apps.fcc.gov/edocs_public/attachmatch/DOC-329161A1.pdf.

be accommodated by the 60 GHz bands (57-64 GHz and 64-71 GHz) and 70/80 GHz bands (71-76 GHz and 81-86 GHz). As the Commission observes, there are no licensed operations in the 60 GHz bands, and unlicensed operations within the 57-64 GHz band are specifically permitted under Part 15 of the FCC's rules.^{90/} Similarly, access to the 70/80 GHz bands have been authorized on a non-exclusive basis.^{91/} To the extent the FCC wishes to allocate mmW for unlicensed operations, it should do so in those spectrum bands.

Any hybrid approach involving sharing between licensed operations and either unlicensed operations or secondary licensed operations would also be more appropriate for the 37/42 GHz bands (37.0-38.6 GHz and 42.0-42.5 GHz). Like the 3.5 GHz band, there are currently no service rules or licenses for terrestrial operations in the 37/42 GHz bands.^{92/} Novel sharing regimes are better tested in cleared bands where there is little risk of disrupting the operations of existing licensees in the band.

^{90/} See *NOI* ¶ 71.

^{91/} See *id.* ¶ 76.

^{92/} See *id.* ¶ 63.

V. CONCLUSION

Straight Path appreciates the FCC's efforts to examine use of the mmW band frequencies for mobile services. To ensure the successful deployment of such services, the FCC should carefully consider Straight Path's proposals above and adopt flexible technical rules and a licensing regime that recognizes the importance of incumbents. Straight Path looks forward to working with the Commission as it adopts one or more notices of proposed rulemaking to implement a flexible regulatory scheme for wireless services in the bands above 24 GHz.

Respectfully submitted,

/s/ Russell H. Fox

Russell H. Fox
Angela Y. Kung

MINTZ, LEVIN, COHN, FERRIS, GLOVSKY AND
POPEO, PC
701 Pennsylvania Ave., NW
Suite 900
Washington, DC 20004
(202) 434-7300

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APPENDIX A

EXAMPLES OF 39 GHz MOBILE NETWORK LINK BUDGET

39 GHz mobile network link budget	Downlink cell edge	Uplink cell edge	Downlink cell center	Uplink cell center
PA output power (dBm)	20	18	20	18
Number of PAs	64	16	64	16
Total output power (dBm)	38	30	38	30
Number of Tx antenna element	256	16	256	16
Tx antenna element gain (dB)	6	6	6	6
Antenna & feed network loss (dB)	3	5	3	5
Total Tx antenna array gain (dB)	27	13	27	13
EIRP (dBm)	65.14	43.08	65.14	43.08
Distance (m)	500.00	500.00	100.00	100.00
Path loss = $72 + 29.2\log_{10}(d)$ (dB)^{93/}	150.81	150.81	130.40	130.40
Received power (dBm)	-85.67	-107.73	-65.26	-87.32
Bandwidth (MHz)	500.00	500.00	500.00	500.00
Thermal noise (dBm)	-87.01	-87.01	-87.01	-87.01
Noise Figure (dB)	7.00	5.00	7.00	5.00
SNR (dB) per Rx antenna element	-5.66	-25.72	14.75	-5.31
Number of Rx antenna element	16	256	16	256
Rx antenna element gain (dB)	6	6	6	6
Rx antenna feed network loss (dB)	5	3	5	3
Total Rx antenna array gain (dB)	13	27	13	27
SNR after beamforming (dB)	7.39	1.37	27.80	21.78
Implementation loss (dB)	3.00	3.00	3.00	3.00
Number of MIMO streams	1	1	8	8
Spectral efficiency (bit/channel use)	1.91	0.75	42.20	27.06
System overhead	40%	40%	40%	40%
Duty cycle	62.50%	37.50%	62.50%	37.50%
Throughput throughput (Mbps)	357.20	84.81	7912.07	3044.15

^{93/} See Akdeniz, M.R.; Yuanpeng Liu; Samimi, M.K.; Shu Sun; Rangan, S.; Rappaport, T.S.; Erkip, E., "Millimeter Wave Channel Modeling and Cellular Capacity Evaluation," *SELECTED AREAS IN COMMUNICATIONS, IEEE JOURNAL ON*, vol.32, no.6, at 1164, 1179 (June 2014).