
Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of) GN Docket No. 14-177
) IB Docket No. 15-256
Use of Spectrum Bands Above 24 GHz for) RM-11664
Mobile Radio Services, *et al.*) WT Docket No. 10-112
) IB Docket No. 97-95

To: The Commission

COMMENTS OF ERICSSON

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EXECUTIVE SUMMARY

Ericsson commends the Commission's timely moves to lead the way in making spectrum available for the next generation of mobile services, and in seeking to put higher frequency spectrum to its most productive use. Nations across the globe are working feverishly to develop 5G, and there is much to be learned about using millimeter wave spectrum for mobile services and in providing 5G services. The U.S., therefore, should move deftly and quickly.

In the new Upper Microwave Flexible Use Service, the Commission should:

- Grant mobile rights to incumbent fixed terrestrial licensees at 28 GHz and 39 GHz and auction exclusive, flexible use licenses in non-licensed areas in the 28 GHz and 39 GHz bands, and in the 37 GHz band as well.
- Permit secondary market transactions.
- Refrain from adopting "local area" licensing authorized by rule in the 37 GHz band and establish a single 37-40 GHz band instead, using 200 MHz license blocks.
- License the 28 GHz band using BTAs and the 39 GHz and 37 GHz bands using EAs.
- Exercise regulatory restraint regarding performance requirements.
- Raise the power limits for base stations from 62 dBm (65 dBm rural), when measured over 100 MHz, to 82 dBm (85 dBm rural), to allow comparable power spectral density to other mobile bands.
- Employ Total Radiated Power, rather than EIRP, for unwanted emission limits, given the advanced antenna designs that will be necessary for 5G arrays.
- Reject an interoperability mandate for any given air interface.
- Reexamine the RF exposure limits above 6 GHz in light of recent research.
- Support unlicensed and licensed use in separate parts of the 64–71 GHz band.
- Rely on market-based arrangements, rather than waivers or grants of automatic co-primary status to facilitate FSS gateway earth station operations.
- Refrain from enabling FSS user terminals in the 28 GHz and 39 GHz bands.
- Reject the rain-fade power increase proposal for FSS.

While prompt completion of this rulemaking is essential, it is also critical to look at other spectrum, especially below 30 GHz. Ericsson urges the Commission to promptly issue a further notice addressing bands below 30 GHz.

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Ericsson hereby submits its Comments in response to the Commission’s *Notice of Proposed Rulemaking* concerning the Use of Spectrum Bands Above 24 GHz for Mobile Radio Services.¹

I. INTRODUCTION

Ericsson commends the Commission’s timely moves to lead the way in making spectrum available for the next generation of mobile services, and in seeking to put higher frequency spectrum to its most productive use. This *NPRM*, coming on the heels of the 2014 *Notice of Inquiry*,² is an opportunity for the United States to foster the development and deployment of fifth generation mobile services (“5G”) and to evolve existing systems. 5G will continue extending and building on today’s 4G mobile data services, but it will also enable myriad new applications that benefit from key 5G capabilities: high data rate, low latency, and massive device density.

¹ *Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, GN Docket No. 14–177 *et al.*, *Notice of Proposed Rulemaking*, 30 FCC Rcd 11878 (2015) (*NPRM*).

² *Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, WT Docket No. 14-177, *Notice of Inquiry*, 29 FCC Rcd 13020 (2014) (*NOI*).

The U.S. has been a global leader in 4G deployment and is well-positioned to continue to lead in 5G as well. By allocating spectrum and adopting flexible-use rules, the Commission paved the way for early and expansive deployment of 4G LTE service. Today, 99.6% of the U.S. population has LTE coverage, and three or more providers offer LTE coverage to 91.5% of the U.S. population.³ As Ericsson recently reported, half of all mobile devices in North America use LTE today—the highest share in the world—and by 2021 95% of the mobile subscriptions in North America will be LTE 4G and/or 5G.⁴ 5G is a vital complement to, and growth path for, existing 4G systems. The current proceeding is so important, the Commission acknowledged, because 5G is necessary to accommodate “an eventual 1000-fold increase in traffic demand,” according to some projections.⁵

As the Commission is well aware, across the globe there is great interest in moving forward with 5G development and deployment as rapidly as possible. Korea and Japan, as hosts of the 2018 Winter Olympics and the 2020 Summer Olympics, respectively, have placed great emphasis on rolling out 5G wireless services as part of the Olympic experience.⁶ Of course, several wireless equipment and service vendors, including Ericsson, are working to

³ *Annual Report and Analysis of Competitive Market Conditions with respect to Mobile Wireless, Including Commercial Mobile Services*, Eighteenth Report, DA 15-1487, at 27-28, Chart III.A.3 (WTB Dec. 23, 2015).

⁴ ERICSSON MOBILITY REPORT NORTH AMERICA, at 2 (November 2015), <http://www.ericsson.com/res/docs/2015/mobility-report/emr-nov-2015-regional-report-north-america.pdf>; ERICSSON MOBILITY REPORT, at 9 (November 2015), <http://www.ericsson.com/res/docs/2015/mobility-report/ericsson-mobility-report-nov-2015.pdf>.

⁵ *NPRM*, 30 FCC Rcd at 1883 (¶ 8).

⁶ *See, e.g.*, Tim Skinner, *KT Targets 5G Rollout for 2018 Winter Olympics* (June 25, 2015), <http://telecoms.com/427991/kt-targets-5g-rollout-for-2018-winter-olympics/>; Marguerite Arnold, *Nokia, NTT DoCoMo Plan 5G Showcase at 2020 Olympic Games* (Mar. 2, 2015), <http://www.fiercewireless.com/europe/story/nokia-ntt-docomo-plan-5g-showcase-2020-olympic-games/2015-03-02>.

accommodate the rapid deployment of 5G for these events.⁷ These Olympic Games will only offer an early sampling of the promise of 5G. Ericsson is working with network operators in the U.S. and around the world to develop plans for rapid 5G development and deployment.⁸

Today there is an urgency to the regulatory process, because 5G is being developed and deployed worldwide at a breakneck pace, and the U.S. should move deftly and quickly. The millimeter wave (“mmW”) region holds tremendous promise for 5G services, despite its significant challenges. As the Commission recognizes, equipment design, and the effect of the physics of the environment as well as subsequent effects of design choices on propagation within high microwave frequencies, will be unlike what is currently applicable to mobile services at lower spectrum bands. There is much to be learned in the course of making use of mmW spectrum for 5G. Innovation and investment will be the watchwords, and the Commission must regulate with a very light touch to permit the necessary flexibility in adapting this spectrum to its highest and best use. To that end, regulating technical aspects of mmW usage based on the way mobile technology has been used in the past risks stifling the very innovation that the Commission should be seeking to foster.

⁷ See, e.g., Martha DeGrasse, *Ericsson Preps for Live 5G Trials* (Nov. 24, 2015), <http://www.rcrwireless.com/20151124/network-infrastructure/ericsson-preps-for-live-5g-trials-tag4>; Ericsson Press Release, *Ericsson 5G Radio Prototypes Prepped for Field Trials with NTT DOCOMO* (Nov. 24, 2014), <http://www.ericsson.com/news/1968743>; Ericsson Press Release, *Ericsson and KT Strengthen Collaboration to Develop 5G and IoT Technologies* (June 5, 2015), <http://www.ericsson.com/news/1926629>.

⁸ See, e.g. Ericsson Press Release, *Ericsson and China Mobile Launch 5G Collaboration* (Dec. 24, 2015), <http://www.ericsson.com/news/1975847>; Ericsson Press Release, *Ericsson, Telstra and Qualcomm Demonstrate 4x4 MIMO* (Dec. 22, 2015), http://www.ericsson.com/news/151222-ericsson-telstra-qualcomm-mimo_244069644_c; Ericsson Press Release, *Ericsson and SK Telecom Demonstrate 5G Network Slicing Technology* (Oct. 29, 2015), http://www.ericsson.com/news/151029-ericsson-and-sk-telecom_244069644_c; Ericsson Press Release, *Ericsson Showcases the Future to Swedish Industry and Society* (Oct. 8, 2015), http://www.ericsson.com/news/151008-ericsson-showcases-future-swedish-industry-society_244069644_c

Ericsson commends Chairman Wheeler for his statement that this rulemaking will be completed in the summer of 2016.⁹ Swift action is necessary to provide the industry with the proper signal and direction to enable innovation and investment, and to place a stake in the ground to establish U.S. leadership in the next generation of mobile wireless service. Ericsson looks forward to working with the Commission on developing a path to 5G mobile broadband deployment in the United States.

At the same time, it is essential to look at other bands, and in particular those below 30 GHz.¹⁰ The Chairman, commendably, committed to initiate a further notice to examine other bands for 5G deployment in the summer of 2016.¹¹ Ultimately, global harmonization and the adoption of similar flexible licensing structures around the world will give the U.S. the benefit of economies of scale. The U.S. has had a leadership role in the 700 MHz band—the FCC can take leadership here and help drive other regulators to harmonization in these new mmW bands by acting quickly on the rulemaking and enabling a 5G opportunity in the bands proposed here.

II. THE FCC SHOULD LICENSE THE 28 GHz, 39 GHz, AND 37 GHz BANDS AS UPPER MICROWAVE FLEXIBLE USE SERVICES

As the Commission recognized in the *NPRM*, millimeter-wave (“mmW”) frequencies, long considered unsuitable for mobile, hold much promise today due to technological advances

⁹ Testimony of Chairman Tom Wheeler at House E&C Subcommittee on Communications and Technology FCC Oversight Hearing, Transcript at 89 (Nov. 17, 2015) (“Wheeler Testimony”), Initial Transcript, <http://docs.house.gov/meetings/IF/IF16/20151117/104195/HHRG-114-IF16-Transcript-20151117.pdf>.

¹⁰ Commissioner O’Rielly has emphasized that the frequencies in the *NPRM* “are likely just the tip of the iceberg,” and stressed the need to “look even further and target additional bandwidth between 6 and 24 GHz, and even in the lower bands.” Separate Statement of Commissioner Michael O’Rielly, *NPRM*, 30 FCC Rcd at 12014.

¹¹ See Wheeler Testimony at 89; see also Separate Statement of Commissioner Michael O’Rielly, 30 FCC Rcd at 12014 (“[A] promise was made by the Chairman to reexamine the issue soon after the World Radiocommunication Conference.”)

including multiple MIMO, beamforming, and microcellular architecture. The large size of the mmW bands, moreover, enables much wider channels and massive throughput for a plethora of new services and applications. 5G in the mmW bands will support combinations of up to 1000 times higher data volume, 10–100 times the number of connected devices, 10–100 times higher user data rate, 10 times greater battery life, and 5 times reduced latency.¹² The most obvious initial use is to create additional capacity for high-bandwidth applications in areas of dense usage, but with the advent of massive Internet of Things (“IoT”) deployment, narrower-bandwidth applications will also be aided by 5G ubiquity.

A. The Commission Should Grant Mobile Rights to Incumbent Fixed Terrestrial Licensees in the 28 and 39 GHz Bands, Auction Flexible Use Rights in Non-Licensed Areas, and Support Secondary Markets

Ericsson fully supports licensing the 28 GHz, 39 GHz, and 37 GHz bands proposed for mobile broadband service in the *NPRM*. Accordingly, Ericsson supports the Commission’s creation of the Upper Microwave Flexible Use Service (“UMFUS”), under which new terrestrial licenses will be issued on a flexible-use basis for both fixed and mobile operations at 28 GHz and 39 GHz, as well as for 37 GHz.

Ericsson supports granting UMFUS licenses to the terrestrial incumbent licensees in these bands, coextensive with their existing licensed service areas. This would allow incumbents to provide mobile as well as fixed service on the same basis as new entrants. This is the most efficient way to move forward.

In the non-licensed portion of the UMFUS bands—*i.e.*, the portions of the 28 and 39 GHz band with no active licensee in a given geographic area and the entire 37 GHz band—the

¹² Comments of Ericsson Inc., GN Docket No. 14–177, at 8 (filed Jan. 15, 2015) (“*NOI* Comments”).

Commission should license the spectrum by auction, consistent with 47 U.S.C. § 309(j) and FCC policies that use competitive bidding to ensure that spectrum is put to its highest and best use.

The Commission should support secondary markets in the UMFUS bands. Secondary market transactions invariably assist in allowing spectrum to be put to its highest and best use. This is particularly important in any service where incumbent license holders are granted new rights, because allowing those incumbents to sell or lease their new rights gives them the flexibility to put these new spectrum usage rights to use or transfer them to a party eager to employ them productively. Further, in the mmW bands, the Commission should allow licensees full flexibility to aggregate and disaggregate spectrum, and to partition and combine service areas, to provide the coverage and capacity needed in their particular licensed markets. Spectrum leasing should be fully supported as well. In addition, the mmW bands should not be subject to the spectrum screen, which applies to spectrum below 3 GHz.¹³ There is much unknown about mobile broadband deployment in the mmW bands, and the Commission should refrain from imposing other constraints on investment and innovation in these higher frequency bands.

The Commission should move forward to finalize the rules for UMFUS quickly, and take a lead with respect to global harmonization so that development of technology and deployment of facilities can proceed and the nation can begin to receive the benefits of these large blocks of broadband spectrum from a competitive marketplace.

¹³ See generally *Policies Regarding Mobile Spectrum Holdings*, Report and Order, 29 FCC Rcd 6133 (2014).

B. The Commission Should Refrain from Adopting the Hybrid 37 GHz Licensing Model and Instead Combine the 37 GHz and 39 GHz Frequencies into a Single Band

1. Hybrid Licensing Should Not Be Adopted

The *NPRM* proposes a hybrid licensing scheme for 37 GHz, under which geographically defined wide-area licensees would coexist with non-exclusive “local area” networks licensed by rule, with “local area” perhaps limited to indoor use only or perhaps extending to outdoor areas such as campuses or courtyards.¹⁴ The Commission should not make any special provision for “local area” usage in this band. The 37 GHz band is essentially unoccupied, and it should be subject to policies that optimize its use and acknowledge its proximity to the 39 GHz band. The Commission should be cautious about adopting new schemes that could undermine investment in the 37 GHz band and limit the amount of spectrum available for intensive data services and ultimately complicate 5G rollouts.

First, it is noteworthy that the *NPRM* provides no basis to conclude that premises owners (or tenants) are the optimal parties to make well-managed and effective use of cutting edge spectrum. Nor does it cite any evidence of a nationwide demand among premises owners (or tenants) seeking to deploy 5G service. As Ericsson pointed out in response to a similar proposal in the 3.5 GHz proceeding, it would make more sense for those entities interested in a localized contained-facility network to work with a service provider to facilitate a customized network with a managed RF environment.¹⁵ There is no serious reason for considering the local-area hybrid licensing scheme.

¹⁴ *NPRM*, 30 FCC Rcd at 11910-11 (¶¶ 101-102, 105-06).

¹⁵ Comments of Ericsson, GN Docket No. 12–354, at 15-16 (filed July 24, 2014).

Second, a hybrid licensing proposal would add complexity where none is needed. There are no existing local area users to be accommodated. Authorizing premises-based local area users to share spectrum with geographic area licensees would require development of complex systems to avoid interference in both directions. And even more complex systems would be needed if outdoor local area use were to be permitted.

Finally, the Commission should be wary about mandating novel approaches to licensing before the success of other, newly adopted licensing experiments and innovations can be evaluated. For example, the Commission has adopted a licensing and interference-prevention system for 3.5 GHz that is not without challenges, and further consideration and possible refinements are already underway.¹⁶ Use of the mmW bands for mobile services will break new ground. The Commission would be served well by embracing flexible rules and refraining from imposing limits and restrictions that constrain the ability of the mobile industry to make productive use of the offered bands. Flexibility would provide the UMFUS the best opportunity to flourish.

2. A Combined 37–40 GHz Band Makes Sense and Should Be Licensed in 200 MHz Blocks, to the Extent Possible

The 37 and 39 GHz bands should be combined into a single 3-GHz-wide band, and not segregated into two bands with differing rules and eligibility restrictions. An unencumbered band of spectrum with uniformity of service and technical rules will facilitate the assignment of large contiguous blocks that are so important for 5G.

¹⁶ See, e.g., *Commercial Operations in the 3550-3650 MHz Band*, Report and Order and Second Further Notice of Proposed Rulemaking, 30 FCC Rcd 3959 (2015), *pets. for recon. pending*.

The licensing block size for spectrum in the combined 37–40 GHz band should be large enough to permit the provision of high data rate services, while at the same time providing sufficient blocks to allow competitive provision of service. Ericsson suggests that the Commission license this spectrum for wide-area usage in fifteen exclusively-licensed 200 MHz unpaired blocks, to the extent possible. The spectrum should be licensed unpaired, because time division duplex (“TDD”) is likely to be the technology selected at this frequency, given that it provides a high degree of flexibility and is especially appropriate at such high frequencies.¹⁷ However, the selection of an access methodology should be left to the licensee, subject to interference prevention constraints, so a licensee can choose unpaired TDD or FDD paired in the band or with other bands or as supplemental downlink as appropriate.

C. The Commission Should Adopt UMFUS Service Rules that Will Foster Investment and Innovation

1. Licensing UMFUS by Larger Geographical Areas Will Advance Investment

By implementing a broad geographic licensing approach, the Commission will create the best opportunity to direct investment into these new services and enable growth of a thriving mmW ecosystem in these bands.

The Commission should employ the same Basic Trading Areas (“BTAs”) and Economic Areas (“EAs”) that are already used in licensing the 28 GHz band and the 39 GHz bands, respectively (and the 37 GHz band should be subject to the same license areas as the 39 GHz band), rather than licensing by county as the *NPRM* proposes.¹⁸ Use of larger-sized geographic

¹⁷ As Ericsson has previously noted, TDD appears to be likely for the millimeter-wave region, because it has advantages in beamforming and for a variety of other reasons. *NOI Comments* at 27-28.

¹⁸ *NPRM*, 30 FCC Rcd at 11912 (¶ 110).

areas will facilitate frequency coordination among licensees, both new entrant and incumbent alike, while a move to county-based licensing would dramatically increase the need for frequency coordination among all licensees. Significantly, use of larger-sized geographic areas will also simplify the auction for non-licensed areas and, overall, will create a far more manageable licensing system.

Further, initial mobile service in the mmW bands will likely be offered to complement existing mobile services offered on a market basis, rather than county-by-county. It will be far more efficient to match up new UMFUS license areas with established license areas than create a new county-based licensing system, the benefits of which are not clear. While secondary market transactions will be needed under either scenario for service providers to develop optimal layouts, having license areas that resemble those used for other mobile services will minimize the number of transactions needed to cobble together geographically contiguous licensed areas with common frequencies.

2. Exercising Regulatory Restraint Regarding Performance Requirements Will Enable Innovation

The *NPRM* seeks comment on a variety of performance and buildout requirements for UMFUS licensees. Given that there is considerable uncertainty at this time as to how the mmW bands will be employed and how and where facilities should best be deployed, the best course of action would be to refrain from imposing strict performance requirements and exercise restraint.

Any performance metrics that are adopted need to be flexible to reflect the considerable diversity of 5G applications. This suggests the adoption of minimal and flexible rules. In particular, the rules should be more permissive than might be the case in a well-defined and well-understood service, where stricter rules might be justified based on the service's established track record. They should not force UMFUS licensees to prioritize use cases or deployments in order

to satisfy arbitrary rules. Aggressive performance requirements, on the other hand, will tend to be based on *a priori* assumptions about how this spectrum will and should be used. The result would be to turn those assumptions into self-fulfilling prophecies, driving these bands to those use cases for which equipment is available when performance must be shown, and on which the performance requirements were based, rather than the highest and best use.

To the extent the Commission deems it necessary to set performance benchmarks on the basis of the characteristics of specific use cases, Ericsson suggests that it build flexibility into the rules by establishing performance benchmarks oriented toward multiple use cases, rather than a single assumed use case. The Commission can make clear that it may reexamine the performance requirements in the future, should the approach warrant adjustment or prove to be inappropriate or invalid. Any initial performance regulations can be modified, and other requirements adopted, in response to the need for policies in the real world of 5G as the technology and the ecosystem develop.

III. TECHNICAL RULES SHOULD RECOGNIZE THE UNIQUE CHARACTERISTICS OF LARGE CHANNELIZATION AND HIGHER BAND SPECTRUM

The UMFUS rules should not be based on the expectations of what technical rules are traditionally appropriate, given the very significant differences between the mmW bands and traditional mobile bands. Simply put, in mmW frequencies, there is a great deal of uncertainty, and the services and technologies are certain to be at the cutting edge for a long time. We do not know how usage of this spectrum will evolve, and the Commission should take care not to restrict its use based on prior models. A light touch is essential to avoid discouraging or preventing innovative spectrum uses that have not yet been envisioned.

A. The Commission Should Raise the Power Limits to Be Consistent with Other Mobile Services

The *NPRM* proposed power limits of 1640 W (62 dBm) EIRP (doubled in rural areas to 3280 W or 65 dBm), measured over 100 MHz.¹⁹ While the Commission stated that it was seeking to apply a power density concept similar to what it applies in other mobile bands,²⁰ what it actually did was limit UMFUS licensees to a much lower power spectral density than is applicable in the other services. In the PCS and other mobile bands cited by the Commission, the 62 dBm limit applies to each MHz. Thus, the EIRP across the full 10 MHz will be 10 dB higher than the EIRP per MHz, or a total of 72 dBm total EIRP across the 10 MHz when operating at full utilization. By contrast, according to the proposed rules, UMFUS licensees would be subject to the 62 dBm limit across the entire 100 MHz bandwidth. Thus, if the bandwidth were fully utilized, the licensee would be limited to 42 dBm within any given MHz, a signal 20 dB, or 100 times, lower per MHz than allowed under PCS and similar rules.

In the *NPRM* there is no express indication that the Commission intended to propose a 20 dB disadvantage for UMFUS versus other services. Nor does it address the fact that its power proposal is significantly lower than the 85 dBm level proposed for point-to-point or point-to-multipoint fixed service²¹ or even the 82 dBm level permitted for unlicensed WiGig under Part 15 in the 60 GHz range.²²

Given that power is the most challenging and costly resource in mobile communications, neither developers nor operators has any incentive to use any more power than is necessary, and there is no need for the Commission to impose an arbitrarily low transmitted power level on

¹⁹ *NPRM*, 30 FCC Rcd at 11956-57 (¶ 275).

²⁰ *See id.*

²¹ *NPRM*, 30 FCC Rcd at 11957 (¶ 276).

²² *See* 47 C.F.R. § 15.255(b)(1)(ii).

equipment operating above 24 GHz. Vendors are incentivized to economize on power, using a variety of schemes to reduce the transmitted power budget, such as improving performance of power amplifiers, to ensure the minimum levels are used in 5G or any cellular networks.

Accordingly, Ericsson urges the Commission to give equipment manufacturers and network operators greater flexibility to manage power and engineer innovative technical improvements, in lieu of an overly restrictive ceiling. Ericsson suggests aligning the EIRP limits by 20 dB measured over 100 MHz, *i.e.*, 82 dBm/100MHz, to equalize the bands above 24 GHz with the PCS and similar bands.²³ Thus, we ask the Commission to set the EIRP to 82 dBm/100 MHz, or 85 dBm/100 MHz in rural areas.

In addition, the Commission should add a category of user equipment other than a handheld device, which would have higher power limits than handheld devices but lower power limits than base stations. Examples of use cases for this type of user equipment could be customer premises equipment for wireless broadband and user equipment built into vehicles (e.g. cars, buses, trains), among others.

B. Unwanted Emission Limits Should Be Based on Total Radiated Power, Rather than EIRP

For measuring the unwanted emissions, such as out-of-band emissions (“OOBE”), the Commission has provided an established level, *i.e.*, -13 dBm/MHz , also expressed as $43 + 10 \cdot \log_{10}(P)$, but measured as EIRP. EIRP could be an appropriate metric for systems employing fixed beam antennas, but is not a proper metric for capturing the unwanted emission in advanced antenna arrays necessary for 5G with multiple simultaneous users and beams.

²³ As discussed above, this would result in permissible power levels per MHz for UMFUS that are comparable to those employed in other cellular mobile services.

In addition, emission requirements expressed as EIRP with the same emission level as conducted emission requirements (e.g. -13 dBm/MHz) pose a significantly and unnecessarily stricter requirement on 5G antenna arrays. For example, a 62 dBm EIRP system with a -13 dBm/MHz emission requirement results in 19 dB more stringent attenuation than a 43 dBm system with a 19 dBi antenna gain and with the same -13 dBm/MHz emission requirements required as a conducted level, which is the case today for other cellular systems at lower frequencies. This is due to the significantly higher attenuation required for advanced antenna systems compared to systems where requirements apply as conducted. Moreover, at higher frequencies, due to higher propagation losses, the level of emission would pose less impact compared to the existing cellular bands and thus a higher level would not result in any benefit. Such requirements could severely affect the complexity, cost and availability of coming 5G systems.

EIRP as a metric for measuring unwanted emission would mean that for every single frequency—*e.g.*, ranging from a few kHz to possibly several hundred GHz—the radiation pattern of the equipment for each MHz within the extremely large frequency range applicable for unwanted emission would need to be measured. This is not only a complicated measurement but also extremely time consuming and costly. This would negatively affect the test complexity and cost, and would also delay the time-to-market and availability of 5G systems or could even be a factor that indirectly would impede introduction of 5G systems into the US market.

Instead of using EIRP, Ericsson suggests using Total Radiated Power (“TRP”) as the proper metric for advanced antenna array systems for 5G at higher frequencies, or in general for advanced antenna arrays when they are used at lower frequencies as well, consistent with recent

academic research.²⁴ TRP has the benefit of capturing all modes of operation including multi-beam. Moreover, unwanted emissions can have a slightly different spatial distribution compared to the wanted signal, while having very little compatibility impact. In addition, TRP as a metric requires that the sum of all emissions from all transceivers in the advanced antenna array should be kept below the required unwanted emission level, and in practice the level of unwanted emissions would need to be kept $10 \cdot \log_{10}(n)$ dB lower (where n is the number of transceivers) which is also fully in line with FCC MIMO/Multiple transmitter requirements.²⁵

At this stage of development of 5G systems, it is too early to exclude the conducted requirements and thus, we also would urge FCC to allow for “conducted” requirements where the multiple transmitter output directive should be made applicable. Adopting the TRP as radiated requirement would also be fully aligned with the allowance of conducted measurement and applicability of the multiple transmitter output directive. Accordingly, Ericsson urges FCC to use TRP instead of EIRP for purposes of OOBE and other undesired emissions. With TRP as metric for unwanted emission, the proposed attenuation of $43 + 10 \cdot \log_{10}(P)$ or -13 dBm/ MHz would be feasible.

Additionally, Ericsson urges the Commission to reconsider the bandwidth-dependent unwanted emission requirements at the first MHz adjacent to the licensed block, because this unnecessarily and unreasonably discriminates against broadband systems. At higher frequencies, the possible carrier bandwidth could be on the order of several hundred MHz. For example, when comparing the unwanted emission requirements for a 10 MHz carrier and 100 MHz carrier,

²⁴ See Christopher Mollén, *et al.*, *Out-of-Band Radiation Measure for MIMO Arrays with Beamformed Transmission* (Oct. 19, 2015), <http://arxiv.org/pdf/1510.05513>.

²⁵ OET Knowledge Database, Document 662911 D01, *Multiple Transmitter Output* (v.02 r.01), https://apps.fcc.gov/kdb/GetAttachment.html?id=B0ZQiTBTVsn3P3wZ2WdqhQ==&desc=662911%20D01%20Multiple%20Transmitter%20Output%20v02r01&tracking_number=49466.

the 100 MHz carrier would get 10 dB more stringent requirements than the smaller one. Surely this cannot be the Commission's intention, given that the power spectral density per MHz is the same. This would discriminate against broadband systems in favor of narrow band systems and specifically against using frequencies above 24 GHz with a possible OFDM system that comprises wider sub-carriers. These systems have different characteristics over the transition slopes (waveform) and would be unnecessarily constrained with a bandwidth-dependent unwanted emission requirement at the first MHz adjacent to the licensed block. Also such a requirement could pose a serious challenge on the equipment beyond the physics of the modulation spectrum of OFDM systems with large sub-carrier spacing. Accordingly, Ericsson urges the FCC to consider bandwidth-independent unwanted emission requirements.

To reduce the number of test points for higher frequencies, and mmW frequencies in particular, Ericsson also proposes that the Commission consider a differentiation in the measurement bandwidth for unwanted emission. As described above, unwanted emission requirements for higher frequencies could range from a few kHz to several hundred GHz, and a measurement bandwidth of 1 MHz would imply 1000 measurement points per GHz—which would add to the complexity and cost of the test significantly and increase the test time, endangering the time to market for such system. Thus, the Commission should consider varying the resolution bandwidth for measurements as frequency range increases,—*e.g.*, starting with 1 MHz and progressively increase to 10 MHz and then 100 MHz. The progressively increased resolution bandwidth would also require linear scaling of the unwanted emission requirement levels—*e.g.*, a -13 dBm/MHz would correspond to -3 dBm/10 MHz, *etc.*

C. The Commission Should Not Mandate Interoperability

The *NPRM* asks whether the Commission should require “interoperability” within any given mmW band, “using all air interfaces that the equipment utilizes” on those frequencies.²⁶ It is unclear what the Commission intended by this, or what purpose it would serve.

Air interfaces can be broadly defined arrays of standards, with myriad features and options. A given device or node will generally include only those features and options that are deemed necessary. Thus, a given device may access spectrum using a particular air interface, such as LTE or a future 5G interface, that provides a wide variety of options with regard to bandwidth, speed, latency, etc., and the device designer can choose the most appropriate features and options and omit those that are unneeded. Ericsson also believes that the Commission’s long-established policy in favor of technology neutrality should continue to guide policy for the future. There is no need for mandated interoperability.

Given the uncertainty regarding how the technology and its applications will develop, the Commission should avoid imposing any interoperability requirements unless and until there is a solid basis for doing so under well-defined circumstances.

D. The Commission Should Consider Recalibration of RF Exposure Limits Given Recent Research

The use of frequency bands above 6 GHz brings new challenges in terms of RF exposure assessment and measurement, because the fundamental exposure metrics change from maximum permissible exposure (“MPE”) based on specific absorption rate (“SAR”) below 6 GHz, to

²⁶ *NPRM*, 30 FCC Rcd at 11964 (¶ 296).

power density (“PD”) above 6 GHz.²⁷ The Commission should consider recent research, which suggests the need for a recalibration of the RF exposure rules at the higher frequencies.

A recently published paper by Foster *et al.* has questioned the current limits at the high frequencies, as they appear to be designed with extremely large safety margins—much larger than those adopted for the basic restrictions at lower frequencies.²⁸ Another publication by Colombi *et al.* has demonstrated that there are differences between the International Commission on Non-Ionizing Radiation Protection (“ICNIRP”), the Institute of Electrical and Electronics Engineers (“IEEE”) and the FCC with respect to RF exposure standards in this area, particularly the point at which the exposure limits change from specific absorption rate to free-space power density.²⁹ The differences, however, also raise issues for device design, particularly the findings that for a device used in close proximity to the body at the transition frequency where the exposure metric changes from SAR to PD, compliance with current FCC RF exposure limits would see a discontinuity of several dB such that the estimated maximum output power in uplink for such devices would be much lower compared to what is used today below 6 GHz. The impact this discontinuity would have on network capacity and coverage would be significant and would limit some of the benefits that 5G promises let alone the unnecessary cost implications that would necessarily follow, particularly for network roll-out. Finally, both the Colombi *et al.*

²⁷ See 47 C.F.R. § 1.1310(d).

²⁸ K.R. Foster, H. Zhang, and J.M. Osepchuk, *Thermal Response of Tissues to Millimeter Waves: Implications for Setting Exposure Guidelines*, 99 HEALTH PHYSICS 806 (Dec. 2010).

²⁹ D. Colombi, B. Thors, and C. Tornevik, *Implications of EMF Exposure Limits on Output Power Levels for 5G Devices above 6 GHz*, 14 IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS 1247 (Feb. 2015) http://www.ericsson.com/news/151126-implications-of-emf-exposure-limits_244069644_c.

research above and Wu *et al.*³⁰ point out that under IEEE C95.131, the discontinuity in the maximum transmit power appears to be basically negligible.

Ericsson believes that the better basis for the limits in the range of frequencies being considered would be those from IEEE C95.1-2005 and C95.1a-2010 and invites the Commission to consider the adoption of such limits.

IV. THE COMMISSION SHOULD SUPPORT BOTH UNLICENSED AND LICENSED USE OF 64-71 GHz SPECTRUM, SEPARATELY

The Commission should divide the 64–71 GHz band into licensed and unlicensed use bands, to allow both approaches to be undertaken as a spur to innovation. Specifically, the lower segment, 64–66 GHz, should be reserved for Part 15 unlicensed use, which would facilitate the aggregation of spectrum from this block with the adjacent 57–64 GHz band, which is already subject to Part 15 unlicensed use, providing a contiguous block of 9 GHz for unlicensed device and application development. Following a licensed approach for 66–71 GHz would provide a 5 GHz contiguous band that could support multiple licensed carriers employing very large contiguous blocks of spectrum on the order of 500 MHz. The proximity of licensed and unlicensed bands would also benefit the development of RF semiconductor technology in the band more rapidly and with greater focus than has been possible with current rules. Employing licensed usage in the 66–71 GHz band would position the U.S. for a leadership role in

³⁰ T. Wu, T. S. Rappaport, and C. M. Collins, *The Human Body and Millimeter-Wave Wireless Communication Systems: Interactions and Implications*, accepted in 2015 IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS (ICC) (Jun. 2015), <http://arxiv.org/pdf/1503.05944v2>.

³¹ IEEE C95.1-2005, SAFETY LEVELS WITH RESPECT TO HUMAN EXPOSURE TO RADIO FREQUENCY ELECTROMAGNETIC FIELDS, 3 KHz TO 300 GHz (April 2006); IEEE C95.1a-2010, Amendment 1: SPECIFIES CEILING LIMITS FOR INDUCED AND CONTACT CURRENT, CLARIFIES DISTINCTIONS BETWEEN LOCALIZED EXPOSURE AND SPATIAL PEAK POWER DENSITY (March 2010).

developing innovative applications and services that would benefit from a large allocation of licensed spectrum, which, in turn, would give the U.S. the ability to support international consideration of this band, consistent with the WRC–15 decision to conduct and complete studies of the 66–76 GHz band.³²

V. THE COMMISSION SHOULD RELY ON MARKET-BASED SOLUTIONS FOR SATELLITE GATEWAY STATION PROTECTIONS AND REFRAIN FROM INTRODUCING SATELLITE USER TERMINALS

A. Reliance on Market-Based Arrangements for Satellite Gateway Operations at 28 GHz Is Preferable to Granting Co-Primary Status or Automatic Upgrades to Terrestrial Licenses

As the *NPRM* recognizes, gateway fixed satellite service (“FSS”) earth stations in the 28 GHz band are currently secondary to terrestrial Local Multipoint Distribution Service (“LMDS”) operations, which have primary status.³³ The *NPRM* seeks comment on various ways to allow satellite earth stations to acquire primary status in order to accommodate gateway earth stations in this band, including market mechanisms and upgrades of existing licenses.³⁴

Ericsson agrees with the *NPRM*’s tentative conclusion that it would not serve the public interest to automatically grant co-primary status for FSS operations in the 27.5-28.35 GHz band at this time, and that such status, or equivalent protection, is achievable instead through private agreements or by purchasing a terrestrial UMFUS license at auction or in the secondary market.

³² See, e.g., Presentation to the FCC Open Meeting, *World Radiocommunication Conference (WRC–15)*, at 7 (Dec. 17, 2015), http://transition.fcc.gov/Daily_Releases/Daily_Business/2015/db1217/DOC-336915A1.pdf.

³³ *NPRM*, 30 FCC Rcd at 11916-17 (¶¶ 124, 127).

³⁴ *Id.* at 11918-22 (¶¶ 129-146).

As the Commission observed, automatically granting co-primary status “could be inconsistent with the development of terrestrial Mobile Service in the band.”³⁵

These market-based mechanisms for accommodating gateway earth stations in the 28 GHz band will facilitate determination of the highest and best use of the spectrum in a given area. Thus, FSS gateway licensees could acquire co-primary status through auctions to acquire a terrestrial license, or by acquiring terrestrial licenses from UMFUS licensees, where their owners believe that such a level of protection is necessary. An FSS provider taking advantage of this flexibility would be acquiring a terrestrial license, for terrestrial operations, that also has the effect of protecting a gateway in the service area by virtue of the right to exclude conferred through the license. A UMFUS license would not authorize operations of the FSS earth stations. Existing FSS licensees not acquiring a terrestrial license would maintain their secondary status, but they would be free to negotiate with the primary UMFUS licensees for arrangements short of acquisition of a license that would provide any additional needed protection. LMDS licensees (who would become UMFUS licensees) purchased their licenses at auction with the understanding that their fixed and point-to-multipoint operations would have priority over FSS operations. Issues of coexistence can be resolved through direct discussions between the terrestrial licensees and FSS operators as they are today.

This market-based approach should apply both to FSS earth stations located within an existing LMDS licensee’s license area and to those located outside such a license area. With respect to those located outside the license area of an LMDS licensee, the public interest would not be served by awarding those earth stations an automatic upgrade to co-primary status. Granting co-primary status to an FSS earth station located outside of an LMDS license area

³⁵ *Id.* at 11918 (¶ 130)

could hinder future terrestrial deployment in the 28 GHz band, because there is no guarantee that the FSS licensee will invest in the primary service based on the upgraded status. As a result, a market-based mechanism would provide a more optimal outcome—in areas where there is no existing terrestrial licensee, auction of a terrestrial UMFUS license is the best method for the FSS gateway to acquire primary status (or private agreement with the UMFUS licensee). Because the spectrum offers new 5G opportunities, access to the spectrum under UMFUS should be available where no LMDS license has been deployed.

B. The Commission Should Refrain from Enabling FSS User Equipment at 28 GHz

The *NPRM* discusses several proposals for possibly facilitating spectrum sharing between terrestrial and FSS user terminals (*e.g.*, spectrum access system, beaconing, or active signal cancelling requirements on terrestrial licensees) in the 28 GHz band.³⁶ Ericsson submits that FSS use of the 28 GHz band should remain limited to gateway earth stations.

Allowing deployment of fixed FSS user equipment on a secondary basis would subject primary terrestrial service to greater complexity and reduced availability and reliability. The approaches raised in the *NPRM* would likely impose unnecessary burdens on terrestrial licensees. There is no need for an SAS or other such complex, top-down mechanisms. The Commission should allow the introduction of one ubiquitous service in the band—flexible terrestrial operations—and avoid the complexity and risks of introducing two such services.

³⁶ *NPRM*, 30 FCC Rcd at 11922-26 (¶¶ 147-159).

C. The Commission Should Not Adopt Regulations for 39 GHz FSS Usage That Would Disadvantage Terrestrial Service

The *NPRM* also seeks comment on several issues relating to FSS use of the 39 GHz band. As discussed in the following paragraphs, Ericsson urges the Commission not to adopt rule changes that would disadvantage terrestrial UMFUS service.

First, the Commission asks whether it should change its rules that currently permit deployment of gateway earth stations in this band only if the FSS licensee either obtains a 39 GHz license or enters into an agreement with a licensee, due to the creation of the UMFUS.³⁷ The Commission should not adopt a rule change that would substantively change the current requirements. However, since the UMFUS will be in a different rule part than the existing service in this band, the Commission should change the relevant cross-reference in Section 25.201(a)(1) note 3. No other changes to the rules are warranted.

Second, the Commission asks whether it should establish a waiver process that would allow FSS earth station licensees in this band to gain co-primary status.³⁸ For the same reasons discussed above in connection with 28 MHz, Ericsson urges the Commission to avoid any automatic upgrade and rely on market mechanisms (*i.e.*, auctions, secondary market transactions, and private agreements) that can facilitate the highest and best use of the spectrum.

Third, the Commission asks whether it should facilitate opportunistic space-to-earth use of the 39 GHz band by allowing ubiquitous stationary FSS user equipment.³⁹ As in the 28 GHz band, Ericsson does not support the provision of FSS user equipment in the 39 GHz band. Terrestrial operations could nonetheless interfere with satellite user equipment in the band,

³⁷ *Id.* at 11926 (¶ 161).

³⁸ *Id.* (¶ 162).

³⁹ *Id.* (¶¶ 163-64).

potentially leading to complaints regarding interference to secondary spectrum usage in widely-employed customer equipment. Such disputes have the potential to create claims of equitable rights on behalf of secondary users that would diminish the rights of the primary licensee. Moreover, any regime that would provide FSS operators with sufficient information about terrestrial stations in an attempt to avoid interference would create a regulatory burden for terrestrial operators and create uncertainty in the band.

Finally, the Commission seeks comment on a proposal to allow satellite operators to increase their power flux density (“PFD”) in the 39 GHz band to overcome rain fade.⁴⁰ Ericsson opposes this proposal, which would significantly reduce terrestrial coverage and needlessly complicate coordination between terrestrial and satellite operations.

The bottom line with respect to the 39 GHz FSS proposals is that they are very complex, and the introduction of terrestrial mobile communications into this band is sufficiently complex in and of itself, with many unknowns. The uncertainty counsels against complicating the process by introducing new potential impediments, such as satellite user terminals.

VI. THE COMMISSION SHOULD ACT PROMPTLY ON A FURTHER NOTICE PROPOSING ADDITIONAL BANDS BELOW 30 GHz

Ericsson commends the Chairman for his commitment to conduct a further proceeding to consider additional bands for 5G, starting this summer.⁴¹ As part of the *NPRM*, the Commission committed to work with stakeholders to consider not only the bands proposed therein, but also

⁴⁰ *Id.* at 11927 (¶ 165).

⁴¹ Wheeler Testimony at 89.

other bands worthy of consideration “in light of international developments.”⁴² Ericsson is eager to assist the FCC in this endeavor.

It is also critically important for the Commission to continue exploring additional spectrum opportunities for mobile broadband *below* 30 GHz, including bands below 6 GHz and those between 10 GHz and 30 GHz. While global harmonization is critical, we are at a stage before global harmonization will occur, and, as a result, U.S. leadership in providing spectrum opportunities for 5G both above and below 30 GHz will inevitably play a role in consideration of global spectrum usage at WRC–19 and beyond.⁴³ While WRC–15 did not identify spectrum between 6 and 20 GHz for mobile broadband, continued efforts to identify such spectrum in the U.S. remain crucial to the deployment of new 5G services, especially those requiring transmissions between outdoor and indoor points, for which higher bands face greater challenges.⁴⁴ Given the differing design choices on propagation within high microwave frequencies, the Commission needs to pay continued attention to lower frequencies as well as higher.

There is a role for a variety of spectrum assets so that adequate balance can be created with the better coverage of lower frequencies and the improved indoor penetration characteristics. The mmW bands require antenna systems with significantly higher complexity to boost the radiated power high enough to overcome the propagation effects. Moreover, bands above 30 GHz will likely need high antenna directivity on the end-user equipment as well,

⁴² *NPRM*, 30 FCC Rcd at 11885 (¶ 14).

⁴³ The *NPRM* acknowledged this, noting that the U.S., at WRC–15, was supporting the study of harmonized mobile spectrum below 6 GHz as well as in higher bands. *Id.* at 11885 (¶ 13).

⁴⁴ See Eliane Semaan, Fredrik Harrysson, Anders Furuskär, and Henrik Asplund, *Outdoor-to-Indoor Coverage in High-Frequency Bands* (Nov. 24, 2015), <http://www.ericsson.com/res/docs/2015/outdoor-to-indoor-coverage-in-high-frequency-bands.pdf>.

whereas the lower bands with improved propagation characteristics can operate with lower antenna complexity at the user equipment. Continued exploration of sharing scenarios in the spectrum between 6 and 20 GHz may yield technologies that will allow mobile broadband to share with fixed services, and the Commission should consider seeking comments on such approaches.

In considering new bands for 5G, global harmonization of both the bands and the licensing structure will give the U.S. ecosystem the benefit of economies of scale. Accordingly, an effort should be made to select bands that can be matched with bands in other parts of the world to facilitate future harmonization. One example of such a development comes out of WRC-15, namely the need for study of bands below 30 GHz for 5G, specifically bands that are considered international ranges like the 24-29.5 GHz, where products are implementable and portions of which are available in various regions, as this will secure availability of affordable equipment and devices to the benefit of consumers. In doing so, it is, of course, important to maintain the flexibility to form allocations that provide operators with adequate flexibility to provision offerings that serve high bandwidth services.

If the Commission ensures that the U.S. remains a world leader on 5G spectrum allocation, regulatory approach, and deployment, that will allow the U.S. to continue to influence the global approach to 5G as additional bands are considered.

VII. CONCLUSION

Based on the foregoing, the Commission should act promptly in this proceeding to allow the United States to move ahead with 5G in the mmW bands with a light regulatory touch, in order to promote innovation and investment in an ecosystem that is the subject of warp-speed development worldwide. The Commission should also quickly adopt a further notice to seek comment on additional bands, including bands below 30 GHz.

Respectfully submitted,

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