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

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

REPORT AND ORDER AND FURTHER NOTICE OF PROPOSED RULEMAKING

Adopted: July 14, 2016 **Released: July 14, 2016**

Comment Date: September 30, 2016
Reply Comment Date: October 31, 2016

By the Commission: Chairman Wheeler and Commissioners Clyburn and Rosenworcel issuing separate statements; Commissioner Pai approving in part, concurring in part and issuing a statement; Commissioner O'Reilly approving in part, dissenting in part and issuing a statement.

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I. INTRODUCTION

1. Today, we take a significant step towards securing the Nation's future in the next generational evolution of wireless technology to so-called 5G.[1] We build upon years of successful spectrum policy – including flexible use, unlicensed, and sharing policies – to create service rules for using four spectrum bands above 24 GHz. These high frequencies previously have been best suited for satellite or fixed microwave applications; however, recent technological breakthroughs have newly enabled advanced mobile services in these bands, notably including very high speed and low latency

[1] We note that we do not intend to define what qualifies as "5G". Standard bodies like 3GPP and the International Telecommunication Union (ITU) plan to develop the requirements by early 2017. *See* 3rd Generation Partnership Project (3GPP), *Tentative 3GPP Timeline for 5G,* http://www.3gpp.org/news-events/3gpp-news/1674-timeline_5g

services. To promote the deployment of these highly beneficial technologies, we are acting quickly – more quickly than most of our counterparts around the world – to establish a coherent framework built on a robust public record. In addition to this significant step forward, we will also continue to explore new opportunities to make additional bands available and to explore other issues, including robust Federal sharing, raised in the accompanying *Further Notice of Proposed Rulemaking*.

2. We recognize that as we continue to explore millimeter wave (mmW) bands for flexible services, including mobile services, some bands have incumbent rights and may present complex sharing issues. We are committed to working with industry, incumbent licensees, our Federal government partners, and other interested stakeholders to resolve those issues. In particular, we find that these bands offer inherent opportunities stemming from the physical characteristics of the spectrum to facilitate robust shared access. As described herein, we today move forward with the creation of a new paradigm for Federal and non-Federal sharing in the 37 GHz band, with the goal of fully developing a powerful new model for efficiently sharing high-frequency spectrum can be applied to other such bands in the future.

3. Our actions today will establish a framework that will help ensure continued American leadership in wireless broadband by facilitating access to spectrum, maximizing flexibility, and encouraging wireless innovation. At the same time, we adopt rules that will allow these bands to be shared with a variety of other uses, including fixed, satellite, and Federal government uses.

II. EXECUTIVE SUMMARY

4. In the *Report and Order*, we take the following actions:

- Upper Microwave Flexible Use Licensing: We adopt a general framework applied across three licensed bands to make a substantial amount of spectrum available with similar rules tailored to the characteristics of each band. This framework will serve as the basis for how we will pursue flexible use licensing in additional mmW bands going forward.
- 27.5-28.35 GHz and 38.6-40 GHz bands: We create new upper microwave flexible use licenses authorizing mobile operations in these bands using geographic area licensing. In the 27.5-28.35 GHz band (28 GHz band), we adopt county-sized geographic area licenses. In the 38.6-40 GHz band (39 GHz band), we adopt Partial Economic Area (PEA) licenses. We maintain the co-primary Federal FSS and MSS allocations in the 39.5-40 GHz band, limited to military systems.
- 37-38.6 GHz band: We adopt a band plan that allows for continuity of commercial operations between the 37 and 39 GHz bands. We also protect a limited number of Federal military sites across the full 37 GHz band and maintain the existing Federal fixed and mobile allocations throughout the band. In the 37-37.6 GHz band, we create a space for coordinated co-primary shared access between Federal and non-Federal users. Through this structure, additional proposals in the *FNPRM*, and the collaborative industry/government process that will take place will further define the sharing process. We will take substantial strides to advance Federal and non-Federal sharing in the 37 GHz band while also making a significant amount of spectrum available for wireless broadband.
- 64-71 GHz band: We authorize operations in the 64-71 GHz band under Part 15 of our rules based on the rules we recently adopted for the adjacent 57-64 GHz band. This action will provide more spectrum for unlicensed uses such as Wi-Fi-like "WiGig" operations and short-range devices for interactive motion sensing.
- Incumbent Operations: We adopt rules that facilitate incumbent terrestrial use of the spectrum and permit expansion of satellite operations with certain limitations.
- We grant mobile operating rights to existing Local Multipoint Distribution Service and 39 GHz band licensees, while subdividing their existing licenses to either the county or

PEA level.

- In the 28 GHz, 39 GHz, and part of the 37 GHz bands, we adopt rules that will provide various mechanisms for Fixed-Satellite Service licensees to upgrade the status of their earth stations without significantly impacting terrestrial operations.
- We revise the band plan for the 38.6-40 GHz band to provide licensees with wider blocks of contiguous spectrum and allow existing licensees to move into the new band plan.
- We implement rules to protect incumbent Federal operations and adopt a sharing paradigm to ensure Federal access to the 37 GHz band.
- We adopt spectrum holdings policies for the 28 GHz, 37 GHz, and 39 GHz bands that will apply to licenses acquired through auctions and the secondary market.
- We adopt a variety of other service and technical rules to facilitate the use of these bands.
- We help promote an environment that encourages early and ongoing consideration of security issues by requiring licensees to submit a statement describing its security plans and related information prior to commencing operations.
- In order to meet our statutory duty to ensure that spectrum is being placed in use, we adopt performance requirements that are flexible to allow multiple use cases to evolve over time.
- We adopt technical rules to facilitate licensed operation and mitigation methods so that incumbent operations are protected in the 28 GHz and 39 GHz bands.
- We delete the broadcasting and broadcasting-satellite service allocations from the 42-42.5 GHz band (42 GHz band) and we decline to allocate the band to the fixed-satellite service (space-to-Earth).

5. In the *Further Notice of Proposed Rulemaking*, we seek comment on the following proposals:

- We seek comment on authorizing fixed and mobile use of the following bands: 24.25-24.45 GHz together with 24.75-25.25 GHz (24 GHz band), 31.8-33 GHz (32 GHz band), 42-42.5 GHz (42 GHz band), the 47.2-50.2 GHz (47 GHz band), 50.4-52.6 GHz (50 GHz band), and the 71-76 GHz band together with the 81-86 GHz bands (70/80 GHz bands). We also seek comment on use of bands above 95 GHz.
- We seek to further develop the sharing framework we adopted today for the 37-37.6 GHz band, both among non-Federal operators and with the Federal government. We also seek comment on circumstances under which Federal government users can gain coordinated access to spectrum in the 37.6-38.6 GHz band (in addition to the protected sites) in the future.
- We seek comment on establishing performance requirements for innovative uses associated with the Internet of Things (IoT) such as machine-to-machine communications, healthcare devices, autonomous driving cars, and home and office automation. We also seek comment on supplementing our performance requirements with a use-or-share obligation.
- We seek comment on implementing the spectrum holdings policies adopted today for the 28 GHz, 37 GHz, and 39 GHz bands, and to further develop the record on spectrum holdings policies as new "frontier" spectrum bands become available.
- We seek comment whether it would be possible for satellites in the 37.5-40 GHz band to radiate a higher Power Flux Density and to have their transmissions also received by user terminals.

- We seek comment on the feasibility and desirability of a digital station identification requirement in the Upper Microwave Flexible Use Service.
- We seek comment on refining our technical rules for these bands.

III. BACKGROUND

A. The Millimeter Wave Mobile Opportunity

6. Millimeter wave frequencies have historically been considered unsuitable for mobile applications because of propagation losses at such high frequencies and the inability of mmW signals to propagate around obstacles. Technological advances hold promise for potentially unlocking mmW bands for mobile and other operations in a way that meets the need for flexible access to spectrum to improve bandwidth in constrained geographies. As discussed further below, short transmission paths and high propagation losses can facilitate spectrum re-use in microcellular deployments by limiting the amount of interference between adjacent cells. In addition, where longer paths are desired, the extremely short wavelengths of mmW signals make it feasible for very small antennas to concentrate signals into highly focused beams with enough gain to overcome propagation losses. The short wavelengths of mmW signals also make it possible to build multi-element, dynamic beam-forming antennas that will be small enough to fit into handsets – a feat that might never be possible at the lower, longer, wavelength frequencies below 6 GHz where cell phones operate today.

7. While the discussion concerning a possible fifth generation of mobile wireless technology includes a wide variety of ideas and technological developments, the possible use of mmW bands for mobile use and other high-bandwidth uses is a key concept within that discussion. Many commenters point to the increasing demand for data from consumers using an ever wider variety of devices.[2] The mmW bands could be particularly useful in supporting very high capacity networks in areas that require such capacity. The record also shows that the mmW bands can be used for backhaul and machine-to-machine communication. Several commenters also highlighted that the low latency of 5G technology will enable various IoT applications including wearables, fitness and healthcare devices, autonomous driving cars, and home and office automation.[3] In addition to the advanced antenna system, other enabling technologies for 5G include distributed network architecture, adaptive coding and modulation, multi-radio access technology, and advanced small cell technology.[4] Moving quickly to make this spectrum available in the near term will best enable potential users, technology developers, and innovators to have relative certainty about the spectrum structure in the mmW bands for these new uses.

B. Notice of Inquiry

8. In October 2014, acting on advice from the Commission's Technological Advisory Council, the Commission issued a *Notice of Inquiry* seeking comment on the prospects for operating mobile radio services in the frequency bands above 24 GHz.[5] The *Notice of Inquiry* acknowledged the longstanding presumption that it would be infeasible to provide mobile services at such high frequencies but also took note of recent field trials in New York City and Austin, Texas, funded by the U.S. Army and Samsung,

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[2] *See* CTA Comments at 4-5, CTIA Comments at 4-5.

[3] 5G Americas Comments Attach., 5G Technology Evolution Recommendations White Paper at 3-6 (2015), http://www.4gamericas.org/files/2414/4431/9312/4G_Americas_5G_Technology_Evolution_Recommendations_-_10.5.15_2.pdf, AT&T Comments at 2,Verizon Comments at 1, CTIA Reply Attach. A, Thomas K. Sawanobori, The Next Generation of Wireless: 5G Leadership in the U.S., at 7-12 (2016), http://www.ctia.org/docs/default-source/default-document-library/5g_white-paperweb.pdf, Sprint Reply at 3-4.

[4] *See* DMC R&D Center, Samsung Electronics Co., Ltd., *5G Vision*, http://www.samsung.com/global/business-images/insights/2015/Samsung-5G-Vision-0.pdf.

[5] *In the Matter of Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, Notice of Inquiry, 29 FCC Rcd 13020, 13021, para. 2 (2014) (*Notice of Inquiry*).

which appeared to demonstrate that non-line-of-sight services can be provided in the mmW bands by capturing reflections of signals that would otherwise be blocked by intervening obstructions.[6] Based on those and other developments, the Commission foresaw "a potential coalescence of technologies that could lead to the emergence of a new and radically more capable generation of wireless mobile service that can capitalize on use of the millimeter wave region of the spectrum around the year 2020."[7]

9. The Commission also noted that significant momentum was starting to build among diverse countries and regions around the idea of a fifth generation of mobile and fixed services, that some envision as accommodating an eventual 1000-fold increase in traffic demand for mobile services; high-bandwidth content with speeds in excess of 10 gigabits per second (GB/s); end-to-end transmission delays (latency) of less than one-thousandth of a second, and, in the same networks, sporadic, low-data-rate transmissions among an "Internet of things"—all of this to be accomplished with substantially improved spectral and energy efficiency.[8] In that context, bands above 24 GHz were typically being considered not for stand-alone mobile services but as supplementary channels to deliver ultra-high speed data in specific places, as one component of service packages that will likely include continued use of lower bands to ensure ubiquitous coverage and continuous system-wide coordination.[9]

10. The *Notice of Inquiry* sought comment on the technologies underlying the development of mmW mobile services using bands above 24 GHz, the frequency bands that would be suitable for advanced mobile services, and the best ways to manage interference among operators and other licensees operating in the same or adjacent bands. Finally, the Commission sought comment on licensing and authorization schemes for mobile operations above 24 GHz.[10]

C. Notice of Proposed Rulemaking

11. On October 22, 2015, the Commission adopted and released the *Notice of Proposed Rulemaking* in this proceeding.[11] The Commission proposed to authorize mobile services in the 28 GHz, 39 GHz, 64-71 GHz, and 37 GHz bands. In the 28 GHz and 39 GHz bands, the Commission proposed to license the spectrum by geographic area licensing using county-sized licenses. In the 64-71 GHz band, we proposed to authorize unlicensed operations pursuant to our Part 15 rules that were recently adopted for the adjacent 57-64 GHz band. For the 37 GHz band, we proposed a hybrid licensing mechanism that would grant operating rights by rule to property owners, while establishing geographic area licenses based on counties for outdoor use. This licensing mechanism was designed to facilitate the deployment of advanced enterprise and industrial applications not suited to unlicensed spectrum or public network services, while also providing additional spectrum for more traditional cellular deployments.[12]

12. The Commission further proposed to grant mobile operating rights to existing fixed Local Multipoint Distribution Service (LMDS) and 39 GHz band licensees, although it also sought comment on utilizing an overlay auction as an alternative method of awarding mobile operating rights. Recognizing that the 28 GHz, 39 GHz, and 37 GHz bands were shared with the Fixed-Satellite Service, we proposed

[6] *Notice of Inquiry*, 29 FCC Rcd at 13022, 13024 paras. 5, 11. Those trials found that 39 GHz mobile base stations can sustain 100 percent coverage in cells with a 200-meter radius in high-density urban areas. Receivers equipped with highly directional, steerable antennas were able to capture and combine as many as 14 links with rooftop-mounted transmitters despite obstructions in propagation paths. *Id.*

[7] *Notice of Inquiry,* 29 FCC Rcd at 13025, para. 13.

[8] *Notice of Inquiry,* 29 FCC Rcd at 13023, paras. 7, 9.

[9] *Notice of Inquiry,* 29 FCC Rcd at 13023, para. 7.

[10] *See Notice of Inquiry,* 29 FCC Rcd at 13026-27, para. 16.

[11] *In the Matter of Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, Notice of Proposed Rulemaking, 30 FCC Rcd 11878 (2015) (*NPRM*).

[12] *See generally NPRM*, 30 FCC Rcd at 11881-82, para. 4.

market-based rules that could facilitate greater satellite use of those bands without unduly limiting terrestrial use of those bands. We also sought comment on various licensing rules, including performance requirements. In addition, we sought comment on technical rules needed to facilitate licensed operation and mitigation methods to protect incumbent operations in the 28 GHz, 37 GHz, and 39 GHz bands. We also recognized the importance of preventing interference between Federal uses and new mobile use of these bands, and sought comment on any rules that would be necessary to facilitate coexistence with Federal systems. Finally, we asked for comment on how to ensure that effective security features are built into key design principles for communications devices and networks that will use these bands.[13]

13. Comments on the *NPRM* were due January 26, 2016, and reply comments were due February 26, 2016.[14] We received 55 comments and 38 reply comments.[15] A list of commenters, reply commenters, and *ex parte* filings is contained in Appendix F.[16]

14. On March 10, 2016, the Commission held a workshop on the use of bands above 24 GHz.[17] The workshop explored the concepts raised in this proceeding and the state of technological developments in the mmW bands. In parallel to the workshop, the Commission hosted equipment demonstrations illustrating some of the technologies enabling advanced wireless services in the mmW bands.

D. Recent Technological Developments

15. Momentum continues to build for developing technologies that can leverage mmW bands, including for so-called 5G services. Both Verizon and AT&T announced their road maps to develop 5G services and their intent to have field trials in 2016.[18] On February 16, 2016, the NYU Wireless Center stated that it has developed an open source downloadable 5G channel simulator software.[19] Over the last twelve months, the Office of Engineering and Technology has issued at least 40 experimental authorizations for tests of technologies that are related to so-called 5G services, including in the mmW bands. This is but some of the current and ongoing work on 5G technologies across the world.

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[13] *See generally NPRM*, 30 FCC Rcd at 11881-82, para. 4.

[14] *See Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*; Proposed Rules, 81 FR 1802 (Jan. 13, 2016); *Office of Engineering and Technology and Wireless Telecommunications Bureau Extend Period to File Reply Comments for Use of Spectrum Bands Above 24 GHz for Mobile Radio Services Notice of Proposed Rulemaking*, Public Notice, 31 FCC Rcd 1135 (OET WTB 2016).

[15] United States Cellular Corporation and Sprint Corporation filed their reply comments on February 29, 2016. There was an outage of the Electronic Comment Filing System on the evening of February 26, 2016. On our own motion, we will consider those reply comments to be timely filed.

[16] When citing comments, we will use the short name of the commenter contained in Appendix E, followed by the words "Comments" or "Reply." Similarly, for *ex parte* filings, we will use the name of the commenter along with the date the *ex parte* was filed as listed in ECFS (this date may be different from the date on the actual *ex parte* letter).

[17] *Office of Engineering and Technology, Wireless Telecommunications Bureau, and International Bureau Announce Agenda for Workshop and Tech Demonstration on Spectrum Frontiers and Technological Developments in the Millimeter Wave Bands*, Public Notice, 31 FCC Rcd 1865 (OET WTB IB 2016). *See also* https://www.fcc.gov/news-events/events/2016/03/spectrum-frontiers-workshop.

[18] *See Verizon sets roadmap to 5G technology in U.S.; Field trials to start in 2016*, News Release (Sep. 8, 2015), *available at* http://www.verizon.com/about/news/verizon-sets-roadmap-5g-technology-us-field-trials-start-2016; *AT&T Unveils 5G Roadmap Including Trials In 2016*, News Release (Feb. 12, 2016), *available at* http://about.att.com/story/unveils_5g_roadmap_including_trials.html.

[19] *See* NYU Wireless at New York University Tandon School of Engineering (NYU Wireless), *Open Source 5G Channel Model Simulator Software,* http://wireless.engineering.nyu.edu/5g-millimeter-wave-channel-modeling-software/. The NYU Wireless Center has been leading the research in mmW technology, including the propagation measurements and models, radiation and biological health effects, mmW MAC layer design and other component technology development. NYU Wireless, *Research*, http://nyuwireless.com/research/.

E. World Radio Conference

16. The International Telecommunication Union's World Radiocommunication Conference (WRC) 2015 (WRC-15) was held from November 2-27, 2015 in Geneva, Switzerland.[20] One of the tasks of that conference was to set the agenda for the next WRC, which is expected to take place in 2019 (WRC-19). In that regard, WRC-15 adopted Resolution 238, entitled "Studies on frequency-related matters for International Mobile Telecommunications identification including possible additional allocations to the mobile services on a primary basis in portion(s) of the frequency range between 24.25 and 86 GHz for the future development of International Mobile Telecommunication for 2020 and beyond." In that resolution, the ITU's Radiocommunication Bureau was directed "to conduct and complete in time for WRC-19 the appropriate studies to determine the spectrum needs for the terrestrial component of IMT in the frequency range between 24.25 GHz and 86 GHz for 2020 and beyond."[21] ITU-R was also directed "to conduct and complete in time for WRC-19 the appropriate sharing and compatibility studies, taking into account the protection of services to which the band is allocated on a primary basis, for the frequency bands: 24.25-27.5 GHz, 37-40.5 GHz, 42.5-43.5 GHz, 45.5-47 GHz, 47.2-50.2 GHz, 50.4-52.6 GHz, 66-76 GHz and 81-86 GHz, which have allocations to the mobile service on a primary basis; and 31.8-33.4 GHz, 40.5-42.5 GHz and 47-47.2 GHz, which may require additional allocations to the mobile service on a primary basis."[22] Despite strong support from the United States, The Republic of South Korea, Japan, and other countries, Resolution COM6/20 does not include the 27.5-28.35 MHz band. Nonetheless, we, along with South Korea and Japan, have made a commitment to pursue authorizing mobile operations in these bands domestically.

IV. REPORT AND ORDER

17. In this *Report and Order* we adopt new licensing, service, and technical rules for three bands. In so doing, we attempt to follow a consistent framework across all of the bands that can serve as a template for additional bands in the future. We adopt 10 year license terms and performance requirements that are flexible to allow multiple use cases to evolve over time. These basic building blocks are modified in order to meet the specific characteristics of a particular band.

18. We also take significant steps forward on solutions to spectrum sharing in the mmW bands. We adopt rules that will allow both satellite and terrestrial networks to continue to expand in a flexible manner. We continue to facilitate co-primary shared access to the 39.5-40 GHz band for Federal and non-Federal users, and building off of recent policy developments in spectrum sharing, we also create a new approach to Federal sharing in the 37 GHz band. Specifically, instead of relying on static exclusion zones, we create a space for both Federal and non-Federal users to share on a coequal basis and set out a process for defining how that sharing will be implemented. Finally, we substantially increase the amount of unlicensed spectrum available by adding another seven gigahertz to the existing 57-64 GHz band, and adopting flexible technical rules.

A. 28 GHz Band (27.5-28.35 GHz)

19. *Background*. In 1997, the Commission developed a band plan making 1,300 megahertz of LMDS spectrum available in each basic trading area (BTA) across the United States.[23] Specifically, the

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[20] *See* International Telecommunication Union, *World Radiocommunication Conference 2015 (WRC-15), Geneva Switzerland, 2-27 November 2015,* http://www.itu.int/en/ITU-R/conferences/wrc/2015/Pages/default.aspx.

[21] The World Radiocommunication Conference (WRC-15), *Resolution COM6/20: Studies on frequency-related matters for International Mobile Telecommunications identification including possible additional allocations to the mobile services on a primary basis in portion(s) of the frequency range between 24.25 and 86 GHz for the future development of International Mobile Telecommunications for 2020 and beyond*, at 3 (Geneva, Switzerland 2015).

[22] *Id.*

[23] *See 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*

(continued….)

Commission allocated two LMDS licenses per BTA—an "A Block" and a "B Block" in each.[24] The A Block license is comprised of 1,150 megahertz of total bandwidth, and the B Block license is comprised of 150 megahertz of total bandwidth.[25] The A Block consists of the sub bands 27.50-28.35 GHz (the A1 Band); 29.10-29.25 GHz (the A2 Band); and 31.075-31.225 GHz (the A3 Band).[26] The B Block consists of the sub bands 31.00-31.075 (the B1 Band) and 31.225-31.30 GHz (the B2 Band).[27] Of the 986 designated license areas (493 BTAs times two licenses per BTA), 412 areas have active licenses, which cover about 75 percent of the U.S. population.

20. LMDS operates in two frequency bands that are allocated to the fixed and mobile services on a primary basis for non-Federal use.[28] While the Commission has not, to date, authorized any specific service (including LMDS) to provide mobile service in those bands, it previously expressed an expectation that it would expand the LMDS authorization to include the mobile service if proposed and supported by the resulting record.[29] The U.S. Table of Frequency Allocations includes a primary Fixed-Satellite Service (FSS) allocation limited to the Earth-to-space direction across the LMDS band,[30] however, Section 25.202 of the Commission's rules provides that FSS is secondary to LMDS.[31] Forty-one stations are licensed for Earth-to-space transmissions on a secondary basis in the 28 GHz band, and there are twelve pending applications for new earth station operations in this band.[32]

21. The *NPRM* proposed to authorize mobile operations in the contiguous 850 megahertz of spectrum at 27.5-28.35 GHz, which is in the A1 Band of the LMDS A Block.[33] The Commission concluded that research conducted by industry and academic groups had demonstrated that mobile technologies can work in that band.[34] We also acknowledged some opposition to our proposal but found

(Continued from previous page)
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, 12605, para. 136 (1997) ("*Second LMDS Report and Order*"); *see also* Rand McNally Commercial Atlas & Marketing Guide 36-39 (123rd ed. 1992). Rand McNally is the copyright owner of the Major Trading Area (MTA) and BTA Listings, which list the BTAs contained in each MTA and the counties within each BTA, as embodied in Rand McNally's Trading Area System MTA/BTA Diskette, and geographically represented in the map contained in Rand McNally's Commercial Atlas & Marketing Guide. The conditional use of Rand McNally copyrighted material by interested persons is authorized under a blanket license agreement dated February 10, 1994 and covers use by LMDS applicants. This agreement requires authorized users of the material to include a legend on reproductions (as specified in the license agreement) indicating Rand McNally ownership. The Commission has allocated the LMDS for operations in a total of 493 BTAs throughout the nation.

[24] *See Second LMDS Report and Order*, 12 FCC Rcd at 12600, para. 125.

[25] *See id.*

[26] *See* 47 CFR § 101.1005.

[27] *See id*.

[28] LMDS operates in the 28 GHz and 31-31.3 GHz bands. The 28 GHz band is part of the larger 27.5-29.5 GHz band, which is allocated to the fixed, fixed-satellite (Earth-to-space), and mobile services on a primary basis for non-Federal use. There are no Federal allocations in the 28 GHz band. The 31-31.3 GHz band is allocated to the fixed and mobile services on a primary basis for non-Federal use and to the standard frequency and time signal-satellite service (space-to-Earth) on a secondary basis for Federal and non-Federal use. *See* 47 CFR § 2.106.

[29] *Second LMDS Report and Order,* 12 FCC Rcd at 12637, para. 207.

[30] *See* 47 CFR § 2.106.

[31] 47 CFR § 25.202(a)(1) n.2.

[32] On July 8, 2016, the Commission's IBFS database listed 36 Fixed-Satellite Service (FSS) Earth-to-space licenses for the 27.5-28.35 GHz band and 47 pending applications.

[33] *See NPRM*, 30 FCC Rcd at 11892, para. 30.

[34] *NPRM*, 30 FCC Rcd at 11891-92*,* para. 30.

that the prospect of mobile service in the band should not thwart any reasonable expectations of satellite operators: their use of the band is secondary with respect to LMDS under Commission rules, and the *Second LMDS Report and Order* had put them on notice that mobile service might eventually be authorized in the 28 GHz band.[35] While not every country is planning to use the 28 GHz band for mobile service, we noted that the 28 GHz band has a co-primary mobile allocation throughout the world.[36] Most importantly, we expressed the expectation that satellite and mobile operators would be able to coexist in the 28 GHz band if a well-crafted regulatory framework were adopted.[37]

1. Suitability for Mobile Use

22. Some satellite operators, satellite equipment suppliers and satellite-focused trade associations urge the Commission not to authorize terrestrial mobile services in the 28 GHz band.[38] This perspective is by no means unanimous or unqualified even among that group, however.[39] SES, for example, says that it expects to support terrestrial mobile services in bands above 24 GHz by providing video distribution, providing backhaul services, and by extending terrestrial network coverage to sea, air, and remote land masses.[40] EchoStar says that satellite operators could coexist with mobile services in the band by avoiding deployment of gateway earth stations in large urban centers.[41] ViaSat estimates that the compatibility distance between satellite earth stations and terrestrial mobile in the 28 GHz band would be in the range of 160 meters, and could be further reduced by additional mitigation techniques.[42] Nearly all other commenters who address the topic emphatically support mobile service authorization in the 28 GHz band.[43]

23. Perhaps more so than other mmW bands, the 28 GHz band has been the focus of academic research and industry prototyping efforts to develop mobile service technologies.[44] The 28 GHz band is attractive for research on enabling mobility in mmW bands because, with 850 megahertz of contiguous bandwidth, it has ample capacity to accommodate a wide range of high data-rate applications, and it has global co-primary allocations for fixed and mobile services.[45] There are no Federal allocations in the band.[46] Further, because this is an active service with LMDS licenses covering about 75 percent of the U.S. population, it can be quickly repurposed for new flexible uses, including mobile.[47] The ready availability of the spectrum will also help drive the development of a robust ecosystem at a large scale.

[35] *NPRM*, 30 FCC Rcd at 11889, 11892, paras. 26, 31.

[36] *NPRM*, 30 FCC Rcd at 11892, para. 32.

[37] *NPRM*, 30 FCC Rcd at 11892*, para.* 33.

[38] *See, e.g.*, Avanti Comments at 2, Boeing Comments at ii, 4, ESOA Comments at 4-5, O3b Comments at 12-14.

[39] *See* EchoStar Comments at 14 (supporting the Commission's proposal to award mobile operating rights to existing LMDS licensees for geographic areas in which they currently hold 28 GHz licenses); SES Comments at 5 ("SES does not oppose the development of 5G services in . . . the bands that have been proposed in the NPRM").

[40] SES Americom Comments at 5.

[41] EchoStar Reply at 18-19.

[42] ViaSat Reply at 12.

[43] *See, e.g.*, Cisco Comments at 4-5, Huawei Comments at 8-9, ITIC Comments at 3-4, Intel Comments at 3, Mobile Future Comments at 8, Samsung Comments at 10-11, TIA Comments at 6-7, Nokia Reply at 3, Samsung Reply at 4, Sprint Reply at 3, WISPA Reply at 2.

[44] Intel Comments at 3.

[45] Samsung Comments at 12.

[46] *NPRM*, 30 FCC Rcd at 11891, para. 27.

[47] *NPRM*, 30 FCC Rcd at 11890, para. 25. By comparison, licenses in the 39 GHz band cover about 49 percent of the U.S. population, and the 37 GHz band is not yet licensed. *NPRM*, 30 FCC Rcd at 11893, 11896, paras. 35, 47.

24. Opponents of authorizing new flexible and mobile use in the 28 GHz band raise three basic objections: (1) that there is no international consensus to authorize mobile services in the band; (2) that LMDS operators do not have an equitable expectation of mobile rights in the band; and (3) that mobile services in the 28 GHz band would impair vital satellite services. We discuss the first of those issues below, reserving discussion of the second and third issues for Section IV.A.4.c (Aggregate Interference to Satellite Receivers).

25. Regarding the alleged absence of international consensus expressed by some of the commenting parties,[48] we note that the 28 GHz band already has a primary worldwide mobile service allocation, which embodies a previously agreed consensus among ITU members.[49] Although WRC-15 omitted 27.5-28.35 GHz from a list of mmW bands that it invited ITU-R to study for mobile service,[50] the record in this proceeding makes it abundantly clear that there are significant benefits to authorizing mobile use in the 28 GHz band regardless of that international decision.

26. Administrations and wireless industry representatives that have been major leaders in the mobile industry support authorization of mobile services in the 27.5-28.35 GHz band. Verizon notes that countries supporting mobile use in the band include South Korea, Japan, Sweden, Finland, and Singapore – "technology powerhouses with their sights set on 5G" – and argues that this Commission should not delay repurposing the 28 GHz band while its counterparts in those countries support their industries' efforts to develop mobile technologies for the band.[51] Intel says that major markets like the U.S., Japan, and Korea are moving expeditiously, "blazing the trail for mobile 5G services in the 28 GHz band, in spite of the WRC-15 decision not to study the 28 GHz band leading up to WRC-19."[52] Ericsson contends that, regardless of the outcome of WRC-15, spectrum from this general range very likely will be used for 5G around the world, as evidenced by the fact that Japan and Korea appear to be pressing ahead to use frequencies in this range for their Olympic Game deployments.[53] Nokia expresses disappointment with the outcome of WRC-15, sees "great potential" for the 28 GHz band and urges the Commission to "unlock the promise of that band for mobile use."[54] Internationally, Huawei and Alcatel-Lucent are also focusing on the 28 GHz band as key spectrum for mobile use.[55] T-Mobile USA, whose majority owner is the flagship German telecommunications company, Deutsche Telekom, filed comments in this proceeding expressing its support for mobile services in the 28 GHz band.[56] Other comments reflect near-unanimous support among carriers, equipment suppliers, and associations that represent them.[57]

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[48] *See* Avanti Comments at 2-5, Boeing Comments at 5-9, ESOA Comments at 2-3, 8, Global VSAT Forum Comments at 2, O3b Comments at 12, 15-17, ESOA Comments at 7-8.

[49] *See NPRM*, 30 FCC Rcd at 11895, para. 42.

[50] *See* WRC-15 Final Acts, Resolution 238 (Resolution 238), at 298 and 298 n.1.

[51] *See* Verizon Reply at 3.

[52] Intel Reply at 8.

[53] Ericsson Reply at 2, n.4, *citing* Cheon Tai-Un, 5G Mobile to Be Commercialized for the World's First Time by 2020, Korea IT Times, July 15, 2014, http://www.koreaittimes.com/story/38950/5g-mobile-becommercialized-worlds-first-time-2020; NTT Docomo Press Release, DOCOMO Successfully Conducts 5G Trials in Actual-use Environments—Trials carried out with Nokia Networks, Samsung, Ericsson, Fujitsu and Huawei (Nov. 26, 2015), https://www.nttdocomo.co.jp/english/info/media_center/pr/2015/1126_00.html.

[54] Nokia Comments at 10.

[55] Huawei Comments at 8-9, XO Comments at 15 n.30.

[56] T-Mobile Comments at 9-11.

[57] *See, e.g.*, AT&T Comments at 12, Cisco Comments at 4-5, CTIA Comments at 14-15, Intel Comments at 3-5, ITI Comments at 3-4, Samsung Comments at 12, TIA Comments at 7, Verizon Comments at 5-6, Nokia Reply at 3, Samsung Reply at 4, Sprint Reply at 3, and WISPA Reply at 2.

27. We acknowledge the comments of parties that emphasize the importance of international harmonization,[58] but in this case, it appears there is sufficient international interest (including from Japan and South Korea) for using the 28 GHz band and adjacent bands to justify making the 28 GHz band available for mobile use. Intel and Ericsson both state that the mobile industry could readily create integrated circuits with tuning ranges for various bands in that part of the spectrum, and the Republic of Korea submitted a proposal to WRC-15 stating that the "frequency range from 24.25 GHz to 29.5 GHz proposed from regional groups could be implemented by one single device to facilitate global roaming around the year 2020."[59] These kinds of capabilities are already being reflected in standards development. Microsoft explains that 3GPP release 13 will allow for carrier aggregation of multiple bands of spectrum, both licensed and unlicensed, in the 5 GHz band, and it says that, once 5G service is defined, the committee will likely extend its standards to encompass the millimeter wave bands. Microsoft argues that carriers should ultimately be able to aggregate low-, medium-, and high-band spectrum.[60] The significant domestic and international interest in making the 28 GHz band available for new mobile uses clearly supports taking action in this *Report and Order* to create new flexible use licenses.

2. Licensing the 28 GHz Band

a. Use of Geographic Area Licensing

28. *Background.* We proposed to use geographic area licensing for the 28 GHz band for a number of reasons, including the fact that issuing a single license including both fixed and mobile service rights would allow the licensee to coordinate fixed and mobile uses within its geographic area. Such an approach would be consistent with the Commission's prior decision to use geographic area licensing for LMDS. In addition, we noted that geographic licensing is consistent with the Commission's licensing approach for flexible use bands, such as bands licensed under Part 27 of the Commission's rules.[61]

29. The majority of commenters addressing this issue supported using geographic area licensing with each resulting license having the flexibly to provide fixed or mobile services.[62] In addition to the advantages noted by the Commission, commenters argued that exclusive rights will promote investment and expedite the deployment of mobile and other advanced services.[63] Public Knowledge/OTI, Federated Wireless, and Google urge the Commission to adopt a licensing scheme based on the Spectrum Access System (SAS) and concepts adopted by the Commission for the 3.5 GHz band.[64] Microsoft asks the Commission to limit geographic area licensing to the 28-28.35 GHz band and make the 27.5-28 GHz band available for unlicensed use.[65]

[58] *See, e.g.*, Avanti Comments at 5, Boeing Comments at 8-9, ESOA Comments at 2.

[59] Proposal of the Republic of Korea to the Plenary Meeting of the World Radiocommunication Conference (WRC-15), Revision 1 to Addendum 24 to Document 102-E, 10 November 2015, Agenda Item 10, at 1-2.

[60] Microsoft Comments at 17.

[61] *NPRM*, 30 FCC Rcd at 11907-08, para. 93.

[62] 5G Americas Comments at 3-4, AT&T Comments at 12, Cisco Comments at 4-5, CTA Comments at 10, CTIA Comments at 11, Ericsson Comments at 5-6, EchoStar Comments at 14-15, FiberTower Comments at 2-3, FWCC Comments at 4, HTSC Comments at 5, Huawei Comments at 8-10, Intel Comments at 4, ITIC Comments at 4, Mobile Future Comments at 10, 13, Nokia Comments at 14-15, Qualcomm Comments at 6-7, Samsung Comments at 11, Straight Path Comments at 5, T-Mobile Comments at 9-10, Verizon Comments at 5, XO Comments at 8. *See also* FiberTower Reply at 4, Mobile Future Reply at 8.

[63] 5G Americas Comments at 3-4, CTIA Comments at 11, Qualcomm Comments at 7.

[64] Federated Wireless Comments at 5-16, Google Comments at 3-5, OTI and Public Knowledge Comments at 7-10.

[65] Microsoft Comments at 14-18.

30. *Discussion.* We adopt our proposal to implement geographic area licensing throughout the 28 GHz band because geographic area licensing will expedite deployment, provide licensees with the flexibility to provide a variety of services, and is consistent with the existing licensing scheme. One significant advantage to this approach is that we can expedite use of the band for advanced services because it is consistent with the existing framework in this band.

31. In contrast, if we adopted a separate framework for mobile use of the band, we would need to develop a SAS, define the specific rights held by the existing licensees, and work out rules for coordination with the existing licensees. Adopting geographic area licensing for this band is also consistent with our goal of adopting a balanced licensing approach that includes licensed, unlicensed, and innovative sharing approaches across a variety of bands. For these reasons, we are not adopting a 3.5 GHz-style SAS framework for this band.

32. Similarly, we decline to adopt Microsoft's proposal to create an unlicensed portion of the band. We believe splitting the band into unlicensed and licensed segments would potentially hinder deployment by making it more difficult for licensees to use the full 850 megahertz of spectrum. We nonetheless agree that a balance between licensed and unlicensed usage is important, and as described below, we are also making seven gigahertz of spectrum available for use by unlicensed devices in the 64-71 GHz band, and create an opportunity for shared access in the 37-37.6 GHz band segment.

b. License Area Size

33. *Background*. In the *NPRM*, we proposed to use counties as the base geographic area unit for licenses in the 28 GHz band. As we explained:

> We believe there may be several advantages to county-based licenses. First, we believe county licenses best fit the localized types of services we expect to be offered in the mmW bands. These bands do not propagate well over long distances, and when used in mobile applications, are expected to provide coverage of areas measured in meters, not kilometers. Second, establishing smaller licenses could provide licensees with additional flexibility to target their deployments to those areas where they need the capacity. Under the existing framework in 28 GHz and 39 GHz, a licensee must meet buildout for its entire BTA or EA or lose its license. Establishing smaller license areas will allow licensees to base their deployment decisions on market forces and customer demand. If it does not make business sense for a licensee to build in a particular county, it can sell or lease the license for that county. Third, smaller license areas reduce the potential for warehousing spectrum; again, licensees will be more likely to acquire and hold only the licenses they need to meet their customers' demand. Fourth, county based licenses could equally facilitate access by both small carriers and large carriers. Smaller license areas allow smaller carriers to better tailor their spectrum acquisitions to the locations for which they need it the most. Smaller license areas would facilitate access by larger carriers because such carriers could both narrowly target the areas in which they need the additional spectrum or aggregate the counties—which serve as the building blocks for traditional license areas —into larger license areas, thus achieving economies of scale.[66]

34. The majority of commenters support using Rand McNally BTAs, which, as explained, is the license area unit used by existing LMDS licensees.[67] They raise four concerns about using counties: (1) counties do not fit the contemplated services to be offered using mmW spectrum; (2) counties will result in more borders, which will make it more difficult for licensees to coordinate with each other; (3) a larger number of small licenses will increase the administrative burdens on licensees and the Commission (e.g.,

[66] *NPRM*, 30 FCC Rcd at 11912, para. 111.

[67] 5G Americas Comments at 5-9, AT&T Comments at 17-19, Cisco Comments at 11, CTA Comments at 11-12, Ericsson Comments at 9-10, Intel Comments at 4, Mobile Future Comments at 13, Nokia Comments at 18, Verizon Comments at 10-12.

more buildout showings are required); and (4) that requiring buildout to be made on a county-by-county basis would increase licensee's costs and would be unfair to licensees who paid for spectrum.[68] FiberTower and US Cellular, on the other hand, support using counties.[69] US Cellular believes that smaller license areas will facilitate access to spectrum by smaller carriers, allow larger carriers to more precisely target the spectrum they need, and reduce the potential for warehousing spectrum.[70]

35. *Discussion.* We will adopt counties as the license area size for Upper Microwave Flexible Use Service (UMFUS) licenses in the 28 GHz band. We also adopt our proposal to subdivide existing LMDS licenses on a county basis.[71] As we explained in the *NPRM*, a county-based license affords a licensee the flexibility to develop localized services, allows for targeted deployments based on market forces and customer demand, and facilitates access by both smaller and larger carriers.[72] In our view, the claims of certain commenters that larger license areas will better fit the services contemplated for these bands lack specificity and do not take into account the potential need for targeted deployment.[73] It is unclear that providers need to – or will want to – aggregate nationwide licenses, as mobile operations in the band may initially be deployed. On a mobile basis, this band is envisioned for mobile operations in denser population centers or around highway corridors. While it is true that county-sized licenses will result in more borders, we adopt a power flux density limit at the border that will facilitate coordination between licensees. Furthermore, no party offered evidence that there have been problems providing service near existing BTA borders. We note that licensees in other services regularly coordinate their operations along shared borders and have well established procedures for conducting this coordination. We expect that licensees will be able to apply these same procedures in this band without any undue burden. To the extent existing BTA licensees do not believe it is economically viable to build within certain counties of a BTA, we believe it would be appropriate to give other interested parties an opportunity to license and to make use of the spectrum. Finally, establishing smaller license areas is fair to existing licensees because those licensees are also obtaining valuable new rights and they are keeping the same bundle of rights they had previously. Overall, we believe the benefits of smaller license areas for this specific band outweigh any administrative burden on licensees and the Commission.

36. In this proceeding, we are endeavoring to create a regulatory scheme that will suit the development of innovative wireless services for years to come. The Commission in recent years has sought greater consistency in its approach to geographic license area sizes to help providers aggregate licenses in a more targeted and efficient manner, gravitating toward license areas that are derived from Economic Area (EA) units.[74] BTAs have only been used as the license area for a few commercial wireless services. Counties, however, are the base unit that make up common commercial wireless license sizes, including EAs and the new Partial Economic Area (PEA) license areas.[75] There is also a practical advantage to issuing county-based licenses. Specifically, the Commission would be required to

[68] *See* Nextlink June 3, *Ex Parte* Letter (a detailed discussion of the costs involved in building out mmW licenses).

[69] FiberTower Comments at 3, US Cellular Reply at 4-9.

[70] US Cellular Reply at 5-9.

[71] *NPRM*, 30 FCC Rcd at 11913-14, para. 115.

[72] *NPRM*, 30 FCC Rcd at 11912, para. 111.

[73] *See* Straight Path Comments at 8-13.

[74] The EA license areas the Commission uses are based upon a definition established by U.S Department of Commerce's Bureau of Economic Analysis. See *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, XX FCC Rcd 6567, 6595, n.193(2014) (*Incentive Auction Report and Order*).

[75] S*ee* Bureau of Economic Analysis, Final Redefinition of the BEA 60 Fed. Reg. 13114 (March 10, 1995); Areas; *Wireless Telecommunications Bureau Provides Details About Partial Economic Areas*, GN Docket No. 12-268, Public Notice, DA 14-759, App. B (WTB 21014).

negotiate a new licensing agreement with Rand McNally to use BTAs in UMFUS. In recent years, the Commission has avoided using license areas controlled by third parties in order to eliminate the time and expense involved in negotiating such agreements.

3. Mobile Rights for Incumbents

37. *Background*. The 27.5-29.5 GHz band has had long-standing allocations for fixed, mobile, and Fixed-Satellite Service (Earth-to-space) allocations.[76] In the 1996 *LMDS First Report and Order,* the Commission designated the 27.5-28.35 GHz band for LMDS on a primary basis and determined that satellite services would be permitted in that band on a non-interference basis to LMDS systems, and only for the purpose of providing limited gateway-type services.[77] The following year, in the 1997 *Second LMDS Report and Order*, the Commission expressed an expectation that it would expand the LMDS authorization for Fixed Service to include Mobile Service if proposed and supported by the resulting record. In the *Second LMDS Report and Order*, the Commission stated:

> 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. We believe this would be consistent with our goal of providing LMDS licensees with maximum flexibility in designing their systems.[78]

The technology of the time did not enable the use of these frequencies for advanced mobile services and, therefore, the Commission did not authorize mobile service in the band. However, the band retained its mobile allocation and, in the intervening period, the Commission has authorized some satellite services in the band for the purpose of providing limited gateway-type services.

38. Recently, technological advances have enabled the development of viable mobile networks in the mmW bands. Accordingly, in the *NPRM*, we proposed to permit existing LMDS and 39 GHz licensees to exercise the full extent of their rights – including mobile rights – for geographic areas and bands in which they currently hold licenses. We noted three likely advantages to this proposal. First, this approach would minimize transaction costs and provide the fastest transition to expanded use of the band, which would benefit consumers. We opined that it would be particularly important to take actions that expedite service because of the great benefits these new technologies could bring to consumers and because of the technical and logistical challenges licensees will face. Second, we noted that given the technical characteristics of this band and the nature of the services that may be developed for it, the differences between fixed and mobile operation are increasingly blurred. We therefore suggested that attempting to define separate bundles of "fixed" and "mobile" rights might create unnecessary complexity and be inconsistent with the underlying technologies, in which case it would be more efficient to have both the fixed and mobile usage rights contained within the same license. Third, the existence of separate licenses for fixed and mobile operation might create unusually large challenges related to interference. For example, one point-to-point link could preclude mobile use of the spectrum in a downtown region. We noted that a single license that combines both fixed and mobile rights avoids this issue and provides the licensee with the appropriate incentives to evaluate the tradeoffs between different uses.[79]

39. As an alternative, however, we also sought comment in the *NPRM* on the costs and benefits of using an overlay auction that would separately license the mobile rights associated with certain accompanying fixed rights on the same frequency – as long as the overlay licensee obtaining the mobile

[76] *In the Matter of Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 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*, First Report and Order and Fourth Notice of Proposed Rulemaking, 11 FCC Rcd 19005, 19008, para. 6 (1996) (*LMDS First Report and Order*).

[77] *LMDS First Report and Order,* 11 FCC Rcd at 19025, para. 45.

[78] *Second LMDS Report and Order,* 12 FCC Rcd at 12637, para. 207.

[79] *NPRM*, 30 FCC Rcd at 11908, para. 95.

rights did not interfere with the incumbent's fixed use.[80] We noted several possible advantages to overlay licenses. First, an overlay auction would assign these rights to the user that values the set of rights most highly, whether it be an incumbent licensee or a new potential user. Second, the use of an auction, rather than a direct grant of additional rights to existing licensees, would ensure that a portion of the value associated with these additional rights will accrue to the United States Treasury. Third, we noted that the Commission has relevant experience in the application of overlay rights in other bands.[81]

40. Most commenters support granting mobile rights to incumbent LMDS licensees and oppose the grant of overlay licenses.[82] AT&T, on the other hand, suggests that incumbent licenses be modified to limit their authorizations to protecting existing operations, both by frequency and by area of operations, and that overlay licenses be issued for the remaining rights.[83]

41. *Discussion.* We adopt our proposal to grant mobile operating rights to existing active LMDS licensees. This grant is in fulfillment of the Commission's original mobile allocation for 28 GHz and its stated expectation of allowing mobile use in the band in "providing LMDS licensees with maximum flexibility in designing their systems."[84] Once the rules we adopt today take effect, existing licensees will be able to provide mobile services consistent with Part 30 licensing and technical rules. Granting mobile operating rights to existing licensees will expedite the deployment of service, minimize the difficulties involved in coordinating fixed and mobile deployments, and provide a uniform licensing scheme throughout the United States. We remain concerned that awarding fixed and mobile rights separately would lead to disputes between fixed and mobile licensees that could make it more difficult for both licensees to provide service.

42. We recognize that awarding mobile rights to incumbent licensees could be viewed as a windfall to those licensees, although the Commission contemplated granting mobile rights when it first created LMDS. Here, the benefits of expediting service and ease of coordinating fixed and mobile service outweigh any foreseeable disadvantages of granting mobile rights to incumbents. In this instance, we find that expedition is particularly important because of the need to make mmW spectrum available for innovative and novel issues.

4. Satellite Terrestrial Sharing

a. Sharing with FSS Earth Stations

43. *Background.* The U.S. Table of Frequency Allocations includes a primary Fixed-Satellite Service (FSS) allocation limited to the Earth-to-space direction across the 28 GHz band.[85] Twenty years ago, in the *LMDS First Report and Order,*[86] the Commission designated 850 megahertz at 27.5-28.35 GHz for LMDS on a primary basis, along with other band segments, and permitted geostationary Fixed-Satellite Service (GSO/FSS) or non-geostationary Fixed-Satellite Service (NGSO/FSS) systems to provide links in that band segment on a non-interference basis to LMDS systems, but only for the purpose

[80] *NPRM*, 30 FCC Rcd at 11909, para. 97.

[81] *NPRM*, 30 FCC Rcd at 11909, para. 97.

[82] 5G Americas Comments at 3-4, Cisco Comments at 4-5, CTA Comments at 10, CTIA Comments at 14, Ericsson Comments at 5-6, EchoStar Comments at, FiberTower Comments at 2-3, FWCC Comments at 4, HTSC Comments at 4, Huawei Comments at 11-12, Intel Comments at 4, ITIC Comments at 4, Mobile Future Comments at 10, Nokia Comments at 15-16, Qualcomm Comments at 6-7, Straight Path Comments at 14-16, T-Mobile Comments at 10-12, Verizon Comments at 5-6, XO Comments at 8-11. *See also* FiberTower Reply at 4-5, Mobile Future Reply at 5.

[83] AT&T Reply at 14-15.

[84] *Second LMDS Report and Order,* 12 FCC Rcd at 12637, para. 207.

[85] *See* 47 CFR § 2.106.

[86] *LMDS First Report and Order*.

of providing limited Earth-to-space gateway-type services.[87] The Commission also rejected a proposal from GE Americom to offer limited protection to FSS gateways operating in the 27.5-28.35 band segment, stating that gateway links would operate on a non-interference basis with respect to LMDS operators.[88] The Commission found that co-frequency sharing between LMDS and ubiquitously deployed satellite earth stations was not yet feasible, but said that it would consider revisiting that conclusion if future technology became available to facilitate that type of sharing.[89] The *NPRM* expressed the Commission's intention to review its policies with respect to accommodating gateway earth stations in the 28 GHz band.[90]

44. Initially, some parties contended that any mobile use of the 28 GHz band would be inconsistent with continued satellite use of the band.[91] Following the *NPRM*, two main issues emerged between proponents of terrestrial use of the band and satellite industry representatives: (1) how can the size of the interference zone where FSS earth stations may cause interference to terrestrial receivers be limited; and (2) should the Commission limit the aggregate skyward interference caused by terrestrial systems to radio receivers on satellites.[92]

45. *Discussion*. The record demonstrates that FSS earth stations in the 28 GHz band can share the band with minimal impact on terrestrial operations. For example, EchoStar argues that 28 GHz Earth-to-space stations would not curtail the deployment of 5G systems outside a few very small non-urban areas.[93] EchoStar and ViaSat both estimate that terrestrial mobile stations could be deployed as close as 170 meters to their Earth-to-space transmitters in the 28 GHz band.[94] SES Americom suggests "carving out some rural areas where future gateway earth stations can be licensed for use in the 28 GHz band."[95] With respect to terrestrial operations, AT&T, Nokia, Samsung, T-Mobile, and Verizon estimate that the necessary separation distances between FSS earth stations and terrestrial deployments are between 50 and 400 meters depending on the type of earth stations.[96] Therefore, we find that it is in the public interest to create rules that allow for continued and expanded sharing between terrestrial operations and FSS earth stations in the 28 GHz band.

46. We recognize that sharing may be more difficult for non-geostationary satellite systems, such as the system operated by O3b. While O3b argues that it needs multiple sites in a county in order to serve

[87] *LMDS First Report and Order*, 11 FCC Rcd at 19025, para. 45.

[88] *LMDS First Report and Order,* 11 FCC Rcd at 19026, para. 48. That restriction is codified at 47 CFR § 25.202(a)(1), n.2 ("FSS is secondary to LMDS in this band").

[89] *LMDS First Report and Order*, 11 FCC Rcd at 19015-16, para. 27.

[90] *NPRM*, 30 FCC Rcd at 11918, para. 130.

[91] *See, e.g.*, Boeing Comments at 6, Avanti Reply at 8, ESOA Reply at 4 n.4, and Inmarsat Reply at 7-8.

[92] *See*, *e.g.*, SIA May 10, *Ex Parte* Presentation at 2 ("In the mmW bands, UMFU and satellite services can operate on a co-primary basis with clear operating rules.").

[93] *See* EchoStar Feb. 19, *Ex Parte* Letter at 4 ("There is no technological barrier that prevents terrestrial operators from deploying 5G networks while protecting existing and planned satellite uses of the 28 GHz . . . band."). We discuss EchoStar's proposals to allow 28 GHz Earth-to-space operations in greater detail in Section IV.A.4.b (Licensing of FSS Earth Stations), below.

[94] *See* EchoStar Comments at 16 (5G parameters submitted by Samsung in this proceeding imply that the required coordination distance between a transmitting gateway and a mobile base station in the 28 GHz band would be approximately 170 meters), ViaSat Comments at i-ii, 13-14, Exhibit 1 (if the 5G interference threshold were set at the 47 dBuV/m specified in Part 27 of the Commission's rules, any areas of incompatibility would likely occur in an area no more than about 160 meters from the earth station, and that area could be further reduced by shielding).

[95] SES Americom Comments at 13.

[96] *See* AT&T, Nokia, Samsung, T-Mobile, and Verizon May 6, *Ex Parte* Letter at 4.

customer locations,[97] it ignores the Commission's decision that it was allowing FSS to access the 28 GHz band solely for the purpose of providing limited Earth-to-space gateway-type services.[98] O3b had no reasonable expectation that the Commission would grant earth stations designed to serve customer locations priority over fixed LMDS services and mobile services that the Commission contemplated would become part of LMDS. O3b estimates that the preclusive distance for its gateway earth stations with respect to mmW mobile stations is between 1.2 and 13.8 kilometers.[99] Nonetheless, we believe that sharing is feasible for O3b. First, as discussed below, we are grandfathering O3b's existing earth stations in Texas and Hawaii. Second, O3b has the option of locating future earth stations in relatively remote areas. Third, O3b can obtain protection by purchasing an exclusive use terrestrial license at auction or by working with a licensee in the secondary market to partition a license area with sufficient size to allow it to deploy additional earth stations without impacting terrestrial operations, or enter into a different type of negotiated sharing arrangement. Fourth, O3b can take advantage of shielding or other mitigation techniques.[100] Comsearch characterizes satellite operators' use of naturally occurring terrain features as follows:

> Before the great explosion of satellite communications for all types of uses, earth station sites were carefully selected with protection from interference the primary consideration. Most locations were many miles from the cities that they were serving, with the ideal earth station site being naturally shielded by terrain at a spot, which was calculated to be virtually free of interfering signals. For most types of communication, this type of isolation is not required, although it is still true that the most important aspect of a site is its shielding.[101]

There are many naturally occurring terrain features that are capable of providing terrain shielding for NGSO gateway stations and shielding can also be provided by creating berms or other man-made barriers.[102]

47. In short, while allowing new earth stations in the 28 GHz band is not without cost to terrestrial licensees, we believe that the small area encumbered by a new earth station (with the limits noted below) will minimize such costs and will allow both satellite and terrestrial services to expand and coexist. Furthermore, satellite operators deployed in this band knowing that they were secondary licensees with respect to LMDS, that the Commission had chosen to allow only limited satellite use, and that the Commission had long envisioned allowing mobile use in the band. Despite these facts, below we create a path to further expand satellite gateways that could add thousands of new sites because we believe the relatively small protection zones will have little impact on terrestrial use.

b. Licensing of FSS Earth Stations

48. *Background*. In the *NPRM,* the Commission said that it was disinclined to automatically grant co-primary status for all FSS operations in the 27.5-28.35 GHz band, principally because it would be inconsistent with the development of terrestrial mobile service in the band.[103] With respect to

[97] *See* O3b May 31, *Ex Parte* Letter at 8.

[98] *See LMDS First Report and Order*, 11 FCC Rcd at 19025, para. 45.

[99] O3b March 24, *Ex Parte* Letter, Attach. at 1.

[100] Site-shielding of earth station antennas is a well-established technique.

[101] Comsearch White Paper, *Fundamentals of Earth Station Frequency Coordination,* at 7 (http://www.comsearch.com/articles/es_coordination_guide.pdf).

[102] *See* S.A. Bokhari, et al., *Site Shielding of Earth-Station Antennas,* IEEE Antennas and Propagation Magazine, Vol. 37, No. 1, Feb. 1995, at 7 (IEEE accession number 1045-9243/93) (http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=370577&newsearch=true&searchWithin=%22Publication%20Title%22:antennas%20and%20propagation%20magazine&searchWithin=%22Volume%22:37&searchWithin=%22Issue%22:1) (last visited July 3, 2016). This information is provided for illustrative purposes only.

[103] *NPRM*, 30 FCC Rcd at 11918, para. 130.

gateways, however, the Commission proposed that satellite operators could acquire terrestrial flexible use licenses enabling them to exclude terrestrial operators that might be subject to interference from within the license area. The *NPRM* proposed that satellite operators be allowed to take advantage of four market-oriented mechanisms to operate their earth stations without the obligation to protect terrestrial stations: purchase geographic area licenses at auction, acquire such licenses from existing licensees, obtain partitioned segments of existing geographic area licenses from existing licensees, or enter into contractual agreements with nearby licensees.[104] With regard to existing 28 GHz FSS earth stations, the Commission proposed that they retain their existing secondary status relative to terrestrial use if situated in the licensed areas of existing licensees, subject to whatever contractual arrangements satellite operators might have entered into with terrestrial licensees.[105] With respect to FSS earth stations located outside the territories of existing LMDS licenses, the Commission proposed the following:

> Prior to holding an auction, the Commission would open a closed filing window for Upper Microwave Flexible Use licenses. The filing window would be restricted to FSS licensees with an earth station within the census tract (or other area we may adopt) of the proposed license. The FSS earth station licensee would have the opportunity to apply for a license including the license area where the earth station was located. Because the filing window would be restricted to the FSS operator, there would be no mutual exclusivity. Once the FSS operator was issued the Upper Microwave Flexible Use license, it would have co-primary status.[106]

The *NPRM* also sought comment on alternative mechanisms for upgrading both existing and future FSS earth stations.[107]

49. Satellite interests contend that county-sized geographic service areas are far too large for their needs and that terrestrial license holders will be reluctant to sell them access to smaller, partitioned areas, either because they see satellite operators as competitors or because their own needs in the evolving 5G landscape are difficult to foresee.[108] They also contend that requiring satellite operators to participate in spectrum auctions would violate the Open-market Reorganization for the Betterment of International Telecommunication Act (ORBIT Act).[109] Terrestrial wireless interests and their equipment suppliers generally favor the Commission's market-oriented proposals,[110] though AT&T and Verizon recommend that we take the pragmatic step of grandfathering existing satellite gateway stations.[111]

50. *Discussion.* We maintain the current status of FSS, and as described below, create new opportunities for continued expansion of FSS earth stations on a protected basis. Upgrading the FSS designation to co-primary status, even if limited to individually licensed earth stations, would be inconsistent with terrestrial use of this band and the Commission's decision to facilitate expanded

[104] *NPRM*, 30 FCC Rcd at 11918-11919, paras. 132-134.

[105] *NPRM*, 30 FCC Rcd at 11920, para. 137.

[106] *NPRM*, 30 FCC Rcd at 11920, para. 140.

[107] *NPRM*, 30 FCC Rcd at 11921-22, paras. 142, 146.

[108] *See, e.g.*, EchoStar Comments at 23-24, 33, O3b Comments at 18-19, 26, SES Americom Comments at 14, SIA Comments at 15-16, ViaSat Comments at ii, 16, EchoStar Reply at 14-17, O3b Reply at 16-17, SES Americom Reply at 7-8, ViaSat Reply at 12-14.

[109] 47 U.S.C. § 765(f). *See, e.g.*,, EchoStar Comments at iii, 34-35, O3b Comments at 18, EchoStar Reply at 13-14.

[110] CTA Comments at 16-17, CTIA Comments at 31-32, Ericsson Comments at 20-22, Intel Comments at 5-6, ITIC Comments at 5-6, Mobile Future Comments at 14, Nokia Comments at 24, Samsung Comments at 22, Straight Path Comments at 37-38, TIA Comments at 11-13, T-Mobile Comments at 16, Verizon Comments at 22-23, XO Comments at 34, ITIC Reply at 4, Nokia Reply at 6, Samsung Reply at 8-9, Verizon Reply at 10-11.

[111] AT&T Comments at 12, Verizon Reply at 10.

terrestrial use, and would not effectively facilitate sharing in the band.[112] We believe the 28 GHz band will play a vital role in the deployment of advanced mmW services, and fully upgrading FSS under our service rules to co-primary status would be inconsistent with this goal and would be unnecessary to meet the FSS community's needs.

51. We recognize, however, that FSS operators rely on this band for gateway connectivity and have invested significant capital in the band and will continue to do so in the future.[113] We believe there is value in creating meaningful, targeted opportunities to deploy additional FSS earth stations in the band without harming terrestrial operations. The *NPRM*'s proposals encouraging satellite operators to participate in county-sized (or smaller) market transactions were predicated in part on the vast protection zones that satellite operators have traditionally claimed were necessary, either to protect their operations or to protect others from them.[114] Here, there is a consensus that much smaller protection zones are needed. As stated above, EchoStar and ViaSat have both estimated that terrestrial mobile stations could be deployed as close as 170 meters to their Earth-to-space transmitters in the 28 GHz band.[115] Most other satellite operators either support those specific calculations,[116] agree in general terms that the necessary preclusive zones can be very small,[117] or state that gateway earth stations can be located in rural areas far away from the urban cores where mmW mobile operations will be most viable.[118]

52. The ability of satellite earth stations and terrestrial operations to coexist in close proximity to each other has two significant ramifications. First, it should be possible for satellite and terrestrial services to share the 28 GHz band with *de minimis* impairment of each other's operations. Second, the disparity between the county-sized license areas we have established for 28 GHz UMFUS licensees and the extremely small areas required for FSS earth stations makes it inappropriate for us to rely exclusively on a market-based mechanism for assigning rights to FSS earth stations, although we retain this option as one means through which FSS operators may expand.

53. In addition to acquiring the terrestrial license rights, we also conclude that it would be efficient to continue to authorize gateway satellite earth stations under the existing Part 25 first-come, first-served basis. We adopt a mechanism under which FSS earth stations will, so long as they comply with conditions noted below, be able to deploy new gateways in limited circumstances without being

[112] FSS has exclusive use of several spectrum bands that lack terrestrial service rules, but the 28 GHz, 37 GHz, and 39 GHz bands are all shared with terrestrial services.

[113] We note that these investment decisions have been made with the explicit understanding the FSS is secondary in this band domestically.

[114] *See, e.g.*, *In the Matter of Wireless Operations in the 3650-3700 MHz Band*, Report and Order and Memorandum Opinion and Order, 20 FCC Rcd 6502, 6525-26, para. 63 (2005) (SIA calculated that fixed stations must be located at least 313 km away from an FSS earth station to ensure adequate protection). *See also* FWCC Comments at 11-13 (band-sharing between the Fixed Service and Fixed-Satellite Service has always been highly asymmetric in favor of the FSS).

[115] *See* EchoStar Comments at 16 (5G parameters submitted by Samsung in this proceeding imply that the required coordination distance between a transmitting gateway and a mobile base station in the 28 GHz band would be approximately 170 meters) and ViaSat Comments at i-ii, 13-14, Exhibit 1 (if the 5G interference threshold were set at the 47 dBuV/m specified in Part 27 of the Commission's rules, any areas of incompatibility would likely occur in an area no more than about 160 meters from the earth station, and that area could be further reduced by shielding).

[116] EchoStar Comments at i, 33.

[117] SES Americom Comments at 14.

[118] *See* EchoStar Comments at I, 20, SES Americom Comments at 14, SES Americom Reply at 4-5. A qualified exception is O3b, which operates a non-geosynchronous middle-earth-orbit constellation that is atypical of the industry. *See* O3b Comments at 17-18 (in most cases the interference footprint will be small, but that can vary depending on the type of satellite system, the type of earth station, surrounding terrain, typical rain cell density, and many other factors).

required to take any additional actions to provide interference protection to UMFUS licensees. We build this upon record support for several different approaches to sharing in the 28 GHz band.

54. The authorization of FSS earth stations in the 27.5-28.35 GHz band that will not be required to take any additional actions to provide interference protection to UMFUS licenses is subject to the following conditions. First, we will authorize no more than three locations in each county where FSS may deploy earth stations on a protected basis. Second, an FSS applicant must demonstrate in its license application that the permitted interference zone around its earth station, which we will define as the contour within which FSS licensees generate a power flux density (PFD), at 10 meters above ground level, of no more than -77.6 dBm/m^2/MHz, together with any preexisting earth stations located in the same county on a protected basis, will, in the aggregate, cover no more than 0.1 percent[119] of the population of the county license area where the earth station is located.[120] Third, the applicant must show that the permitted interference zone does not infringe upon any major event venue, arterial street, interstate or U.S. highway, urban mass transit route, passenger railroad, or cruise ship port. We note that Verizon supports prohibiting siting earth stations near athletic and/or entertainment venues, interstate and U.S. highways, and port facilities.[121] We believe the other locations we have identified are similarly areas where we could expect to have high demand for wireless services. Fourth, prior to filing its application, if there is an existing 28 GHz UMFUS licensee in the county where it is proposing to locate its earth station, the earth station applicant must coordinate its operation with the existing UMFUS licensees using the coordination procedures contained in Section 101.103(d) of the Commission's rules.[122] The purpose of the coordination is to ensure that the earth station will not interfere with existing facilities operating under the UMFUS license. We expect that UMFUS licensees will cooperate in good faith in the coordination process and only raise objections if there is a legitimate concern about interference to existing UMFUS facilities or failure to comply with the criteria listed above.

55. These conditions are designed to provide FSS licensees with substantial opportunities to expand their limited use of the 28 GHz band to deploy earth stations that do not have to protect terrestrial services, while minimizing the impact on terrestrial operations. Since there are over 3,000 counties in the United States, with a potential for up to three locations in each county, FSS licensees would have many choices for earth station locations. Furthermore, even with the conditions we have imposed, FSS operators will have great flexibility in selecting earth station locations that meet their needs. Taking ViaSat's 160-meter radius estimate as a point of departure, the typical interference zone for terrestrial operations around a gateway earth station would cover about 0.08 square kilometers. As ViaSat notes, this zone could be reduced further by reducing the preclusive distance around the earth station,[123] using mitigation techniques such as shielding.[124] Even without such reductions, the interference zone would represent only about 0.0033 percent of the area of an average U.S. county.[125] If one were to assume an even population distribution throughout every county, ViaSat's interference zone would cover no more than 0.1 percent of the population of any county that covers more than 80 square kilometers. There are

[119] For further discussion of the 0.1 percent population limit, *see* para. 55, *infra*.

[120] The International Bureau will issue a public notice seeking comment on the appropriate methodology to calculate the 0.1 percent population limit and further details regarding earth station interference zone calculation (including propagation models, *e.g.* free space versus probabilistic), and will also seek comment on best practices for earth station siting to minimize the impact on UMFU services, colocation of earth stations, and accommodating multiple earth station interference zones without exceeding 0.1 percent of population in a given county.

[121] See Verizon June 14, *Ex Parte* Letter at 2-3.

[122] *See* 47 CFR § 101.103(d).

[123] ViaSat Comments at 13-14.

[124] ViaSat Reply at 12.

[125] ViaSat Comments at 16.

only four counties in the United States that cover less than 80 square kilometers.[126] In addition, any interference zone will be allowed to accommodate multiple FSS earth stations that could, for instance, be serving different satellites in the geostationary orbit, as long as these earth stations, in the aggregate, do not cause the interference zone to exceed the limits we adopt today.[127]

56. Conversely, we believe that allowing FSS earth stations to share the 28 GHz band under these conditions will not unduly hinder terrestrial deployment in the band. We note that existing LMDS licensees are obtaining valuable mobile rights today, and the value of those rights far outweighs any impairment imposed by this sharing mechanism. In addition, under the rules we adopt today, we believe that FSS operations will encumber only a small geographic area and a small portion of the population of the license area. While we maintain flexibility for FSS operators to choose the areas that fit within these conditions, current and future licensees will have some ability to predict the potential impact on the license area.

57. Other than applying those conditions, we do not propose to designate the locations of any county's satellite permitted interference zones in advance – i.e., we will leave the choices of locations to the discretion of the satellite operators, conditional upon the licensees constructing and activating their earth stations within 12 months, pursuant to Section 25.133 of our rules.[128]

58. We also note that FSS operators will have other mechanisms available to deploy earth stations that do not have to protect terrestrial services. We will adopt our proposal to grant such rights to any FSS earth stations for which the FSS operator also holds the UMFUS license that covers the earth station's permitted interference zone. To the extent FSS operators and UMFUS licensees enter into private agreements, their relationship will be governed by those agreements. Finally, FSS earth stations may continue to be authorized without the benefit of an interference zone.[129] In this respect, taking into account the small size of the area around an earth station where terrestrial operations would not be protected, we encourage UMFUS licensees to be flexible in providing certainty to the operation of FSS earth stations in areas where they do not intend to deploy terrestrial services. We emphasize that these FSS earth stations will have no expectation of interfering rights and will have to cease operation if requested by UMFUS licensees at any time on the basis of harmful interference to their services.

59. We also modify our proposal in the *NPRM* for treatment of existing FSS gateway earth stations.[130] Since we are no longer requiring FSS operators to obtain an UMFUS license in order to obtain the right to interfere, we will not grant UMFUS licenses to existing FSS earth station holders. Instead, we will grandfather all existing 28 GHz FSS earth stations authorized as of the adoption date of this *Report and Order* and grant them the right to operate under the terms of their existing authorizations without taking into account possible interference to UMFUS operations. We will also grandfather pending applications for 28 GHz earth stations filed prior to the adoption date of this *Report and Order* if such applications are subsequently granted pursuant to the existing Part 25 rules (i.e., without regard to the criteria we adopt today). We note that in many instances, these earth stations are used to provide valuable services to customers. In areas where there is no existing LMDS licensee, a new UMFUS licensee will have the ability to take the existing FSS earth station into account before it acquires the license or plans deployment. Even in areas where there is an existing LMDS licensee, Samsung's analysis demonstrates

[126] *See* United States Census Bureau, *2010 Census Gazetteer Files*, http://www.census.gov/geo/maps-data/data/gazetteer2010.html.

[127] *See* Boeing Reply at 9-10.

[128] *See* 47 CFR § 25.133.

[129] Earth stations authorized on a secondary basis will be subject to immediate shutdown if harmful interference to an UMFUS station occurs.

[130] *See* AT&T Comments at 12, Verizon Reply at 10.

that existing earth stations will have a small impact on the terrestrial licensee.[131] Finally, we note that AT&T and Verizon support grandfathering existing earth stations.[132]

60. In adopting these rules, we acknowledge with appreciation the efforts that AT&T and EchoStar have made to forge a compromise proposal that would be acceptable to other parties.[133] We decline to adopt their compromise proposal because it would have provided less predictability regarding the locations of future earth stations, and it would have limited the ability of FSS to deploy near population centers even if the deployment affected a small percentage (or even none) of the population. By contrast, the sharing mechanism that we adopt today will provide predictability to terrestrial licensees while giving FSS the opportunity to greatly expand their operations to over 9,500 locations. We believe the rules that we adopt today will encourage intensive use of the band by both UMFUS and FSS licensees.

c. Aggregate Interference to Satellite Receivers

61. The second issue that must be considered with respect to satellite-terrestrial system coexistence is aggregate skyward interference to satellite receivers. There is a concern on the record that upward transmissions from large numbers of terrestrial stations will, in the aggregate, generate enough power to be received at the satellite's receiver, thus degrading the satellite's performance. The most detailed concerns about aggregate interference are raised in *ex parte* presentations by O3b, SES, ViaSat, and a group referring to themselves as Satellite Operators.[134] For the reasons noted below, we conclude that the potential for aggregate interference rising to the level of harmful interference is unlikely and thus is not a basis for refusing to authorize mobile service in the 28 GHz band, and we decline to establish any regulatory limit on aggregate power levels.

62. Under our rules, FSS is secondary to LMDS fixed and mobile operations in the 28 GHz band. Our rules specifically state, "FSS is secondary to LMDS in [the 27.5-28.35 GHz] band."[135] We reject ViaSat's argument that the Commission granted FSS primary status over mobile operations. ViaSat relies in part on the following passage from the *LMDS First Report and Order*:

> We are designating discrete spectrum bands for specific types of systems. Services designated for domestic licensing priority are specified in capital letters in the graphic depiction of the band plan. These services have licensing priority vis-à-vis any other type of service allocated domestically or internationally in the band. Lower-case letters indicate services in a particular band segment which also have licensing priority vis-à-vis

[131] Samsung May 9, *Ex Parte* Letter.

[132] AT&T Comments at 12, Verizon Reply at 10.

[133] *See* AT&T and Echostar May 19, *Ex Parte* Letter, AT&T and EchoStar April 6, *Ex Parte* Letter.

[134] *See* O3b Mar. 24, *Ex Parte* Letter, Attachment at 2-3; Satellite Operators May 12, *Ex Parte* Letter; SES Americom May 5, *Ex Parte* Letter, and ViaSat Apr. 21, July 1, and July 7, *Ex Parte* Letters. Satellite Operators include representatives of EchoStar, Inmarsat, Intelsat, O3b, OneWeb, SES, and ViaSat.

[135] 47 CFR § 25.202(a)(1) n.2. Internationally, this band is allocated to the fixed-satellite service (FSS) and the fixed and mobile services on a co-primary basis. We recognize that there are non-U.S. licensed FSS networks in this band, and that the United States needs to protect those systems consistent with its relevant international obligations. This framework exists in other bands where FSS shares spectrum with terrestrial services internationally, such as the C-band. Contrary to Lockheed Martin's assertions, the Commission is not violating U.S. international treaty obligations by adopting rules that will enable the provision of UMFUS in the 28 GHz band without first resolving potential aggregate interference issues. *See* Lockheed Martin June 24, *Ex Parte* Letter. As discussed below, we conclude that the risk of aggregate interference is low. In the event, however, that there is an instance where a non-U.S.-licensed FSS network receives harmful interference, we intend to address such interference in accordance with applicable U.S. international treaties, and will monitor industry developments to that end. *See* para. 69, *infra*.

> any third service allocated domestically or internationally in the band, but have no licensing priority over the service in capital letters in the band segment and must operate on a non-interference basis and must accept interference vis-à-vis that service.[136]

Contrary to ViaSat's view, the Commission can, and in fact did, establish priority for mobile services through its service rules. ViaSat claims that FSS retains primary status over any new mobile service, because the Commission established priority only for LMDS. This argument fails because mobile service is part of LMDS, and is not a "third service" or a "new service." The mobile allocation already existed at the time of the *LMDS First Report and Order*, but the Commission made no distinction between fixed and mobile service in terms of priority – it established priority for a terrestrial service over a satellite service.[137] As noted above, the Commission contemplated that LMDS, the designated primary service, could eventually obtain mobile rights.[138] Indeed, it "kn[e]w of no reason why we would not allow mobile operations if they are proposed and we obtain a record in support" thereof.[139] It declined to authorize mobile operations "for now,"[140] not because of concerns about coexistence with FSS (which it had already designated a secondary due to the infeasibility of sharing at that time), but because it was unclear that the technology existed to facilitate mobile operations and whether mobile operations could share with fixed operations. The actions we are taking today are precisely the actions the Commission contemplated when it established service rules for LMDS – adding mobile rights to existing LMDS licenses.[141]

63. We also note that if the Commission had intended to make mobile operations secondary to FSS, it could have very clearly done so by explicitly stating that FSS had priority over the mobile allocation. In the *LMDS First Report and Order*, when the Commission intended to discuss the mobile allocation, it specifically referred to the mobile allocation.[142] If the Commission intended to make mobile secondary to FSS, it could have specifically referred to mobile instead of a "third service." Indeed, when the Commission talked of mobile services in the 28 GHz band, it said that authorizing such services "would be consistent with our goal of providing LMDS licensees with maximum flexibility in designing their systems."[143] If the Commission intended to treat mobile services independently of LMDS, it would not have referred to providing flexibility to LMDS licensees.

64. FSS operators received multiple notices of their secondary status. Indeed, in the *LMDS First Report and Order*, the Commission specifically rejected a request from GE Americom to provide some protection to FSS gateways as "inconsistent with the designation of FSS for secondary licensing priority in the 27.5-28.35 GHz band."[144] As ViaSat recognizes, FSS license conditions in the 28 GHz band explicitly state that FSS operations in the 28 GHz band are on an "unprotected, non-harmful interference

[136] *LMDS First Report and Order*, 11 FCC Rcd at 19024, para. 44. *See* ViaSat Comments at 11; ViaSat July 1 *Ex Parte* at 7.

[137] *LMDS First Report and Order*, 11 FCC Rcd at 19008, para. 6.

[138] *Second LMDS Report and Order,* 12 FCC Rcd at 12637, para. 207.

[139] *Id.*

[140] *Id.*

[141] ViaSat relies on the fact that the LMDS service rules did not authorize mobile operations for issued LMDS licenses. ViaSat July 1 *Ex Parte* at 8-9. That fact, while correct, does not support ViaSat's position. For purposes of assigning priority, the pertinent consideration is that the Commission explicitly contemplated that potential future mobile rights would be made available as part of LMDS.

[142] *LMDS First Report and Order*, 11 FCC Rcd at 19008, para. 6 ("The 27.5-29.5 GHz frequency band is allocated for fixed service, fixed-satellite service uplinks and mobile service.")

[143] *Second LMDS Report and Order,* 12 FCC Rcd at 12637, para. 207.

[144] *LMDS First Report and Order*, 11 FCC Rcd at 19026, para. 48.

basis relative to LMDS."[145] The *NPRM* in this proceeding noted, "Twenty stations are licensed for Earth-to-space transmissions on a secondary basis in the 28 GHz band. . . ."[146] That much being said, we recognize that FSS operators use the 28 GHz band to provide services today and intend to provide additional services in the future.

65. However, the record in this proceeding does not demonstrate that the rules that we adopt today would significantly risk harmful interference to satellite operations because of aggregate interference received at the satellite receiver. Under the existing rules, LMDS stations have a maximum authorized transmit power of 55 dBW (85 dBm), versus the 75 dBm we adopt today.[147] Furthermore, LMDS can operate in either point-to-point or point-to-multipoint mode, and there are no existing limits on upward emissions. In contrast, we are adopting lower power limits for base-station and mobile operations in UMFUS. Furthermore, the systems contemplated for these bands have several characteristics that will tend to limit transmissions towards satellite receivers. As noted in the *NPRM*, most industry evaluations of potential mmW mobile base station deployments appear to assume that such stations' antennas will be tilted downward at a slight angle, typically from a street lamp pole or a location on a building at a similar height.[148] Intel explains that this configuration is necessary not only to direct transmissions toward user equipment but also to limit interference between adjacent cellular base stations. In fact, says Intel, failure to adopt this downtilt configuration would impair throughput to users at cell edges by about 60 percent.[149] Although ViaSat expresses concern that in some limited locations mobile base stations might be directed skyward to provide coverage to users in the upper floors of tall buildings, because of this need for downward coverage such mobile providers can rely on wired in-building facilities where necessary. Mobile base stations in this band will probably use antenna systems that employ dynamic beamforming techniques to produce beams as narrow as 1.0 degree,[150] which will substantially reduce the likelihood that such beams will point directly at satellite receivers.[151] User equipment will also employ antenna arrays to generate dynamic beamforming, varying both azimuth and

[145] *See* ViaSat July 1 *Ex Parte* Letter at 11 n.51.

[146] *NPRM*, 30 FCC Rcd at 11891, para. 27.

[147] *See* 47 CFR § 101.113(a).

[148] *NPRM*, 30 FCC Rcd at 11925, para. 156, *citing* Young-Han Nam, et al., of Samsung Telecommunications America, *Full-Dimension MIMO (FD-MIMO) for Next Generation Cellular Technology,* IEEE Communications Magazine, Vol. 51, No. 6, June 2013, 172 at 174 (http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6525612&filter%3DAND%28p_IS_Number%3A6525582%29%26rowsPerPage%3D50) (last visited July 3, 2016).

[149] Intel May 24, *Ex Parte* Letter, Attach. at 2.

[150] *See* IEEE Globecom '16 White Paper prepared by Aalto University, AT&T, BUPT, CMCC, Ericsson Huawei, Intel, KT Corp., Nokia, NTT Docomo, New York University, Qualcomm, Samsung, University of Bristol, and University of Southern California, *5G Channel Model for Bands up to 100 GHz*, (May 2016, revised version 2.1) (http://www.5gworkshops.com/5GCM.html) (5G Channel Model) at 7. *See also* Robert W. Heath, Jr., and Tianyang Bai, Cockrell School of Engineering, University of Texas at Austin, *Coverage and Capacity Analysis of mmWave Cellular Systems*, (June 15, 2013), at 17 (64-element MIMO base station capable of 1.6-degree beamwidth when communicating with mobile units equipped with 16 antenna elements) (http://users.ece.utexas.edu/~rheath/presentations/2013/mmWave_coverage_heath.pdf). *See also* Tianyang Bai, Ahmed Alkhateeb, and R. W. Heath, Jr.,*Coverage and Capacity of Millimeter Wave Cellular Networks*, IEEE Communications Magazine (2014 vol. 52, no. 9) at 70-77; Tianyang Bai and R. W. Heath, Jr., *Coverage and Rate Analysis for Millimeter Wave Cellular Networks*, IEEE Transactions on Wireless Communications, (2015 vol. 14, no. 2) at 1100-1114 (http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6894455&searchWithin=%22Publication%20Title%22:communications%20magazine&searchWithin=%22Volume%22:52&searchWithin=%22Issue%22:9&searchWithin=%22Start%20Page%22:70&newsearch=true).

[151] Intel May 24, *Ex Parte* Letter, Attach. at 4.

elevation in order to maintain signal connections with their base stations.[152] Again, terrestrial operators are likely to deploy this technology of their own accord: by Intel's analysis, choosing not to use dynamic beamforming technology would reduce throughput at cell edges by about 70 percent.[153] Base stations and user equipment will also likely employ dynamic power control, both to avoid draining batteries and to limit intersystem interference.[154] In fact, both base stations and user equipment could be entirely silent much of the time; terrestrial operators report that, in current deployments, network loading rarely exceeds 30 percent.[155] All of these features will limit the extent of skyward transmissions from terrestrial mobile systems.[156]

66. In addition, it is important to recognize that most mmW transmissions will likely not occur in environments that have line of sight to satellites. By some estimates, as much as 80 percent of smartphone use occurs indoors, with much of the remainder occurring in vehicles.[157] Because mmW signals are heavily attenuated by exterior walls, roofs and windows, signals originating from handheld smartphones will be largely confined within any buildings or vehicles where they are used, and would need to be relayed to mobile base stations by other devices with exterior antennas that will likely have sufficient beamforming ability to limit skyward transmissions.[158] In principle, spilling signal power uselessly into outer space would represent a source of inefficiency, so it is likely that dynamically beamformed signals will be aimed at receivers on the ground or not far above it. The most vulnerable satellites – those situated at elevations close to the horizon – will be protected further by the path losses that terrestrial signals will encounter in the cluttered environments of street canyons, suburban foliage, and other obstacles.[159]

67. We have reviewed the studies submitted by the various parties, including the satellite operators. As discussed in the Technical Rules section, *infra*, we conclude that the various studies submitted by the parties do not support establishment of an aggregate interference limit. From the satellite operators' perspective, part of the challenge is that mmW mobile is a new, rapidly evolving technology, and the terrestrial mobile industry is still developing system designs and propagation models. Even so, there has been substantial progress in that regard,[160] and the interference models submitted by satellite operators in this proceeding do not take into account prospective features of mmW mobile systems that are readily accessible on the public record, as recounted above. O3b, for example, assumes that mmW mobile user equipment will employ no beamforming at all, and will generate omnidirectional signals.[161] Interference models submitted by other parties do not adequately account for, and in some cases do not take into account at all, antenna beamwidths, downtilts, beamforming, power control, traffic

[152] *See* 5G Channel Model at 7.

[153] Intel May 24, *Ex Parte* Letter, Attach. at 2.

[154] Intel May 24, *Ex Parte* Letter, Attach. at 2-3.

[155] *See, e.g.*, AT&T, Nokia, T-Mobile, Samsung and Verizon May 6, *Ex Parte* Letter at 5.

[156] *See NPRM*, 30 FCC Rcd at 11964, para. 298.

[157] *See* FCC Acts to Help Emergency Responders Respond to Wireless 911 Calls, FCC News Release, Feb. 20, 2014.

[158] *See 5G Channel Model*. *See also NPRM*, 30 FCC Rcd at 11910, para. 101.

[159] *See* ITU Radiocommunication Sector, *Technical Feasibility of IMT in Bands Above 6 GHz*, (July 2015) (ITU-R Report M.2376-0) at 14-17 (http://www.itu.int/pub/R-REP-M.2376).

[160] *See, e.g.*, AT&T, Nokia, T-Mobile, Samsung and Verizon May 6 and 12, *Ex Parte* Letters; *5G Channel Model*; *ITU-R Report M.2376-0*; National Institute of Science and Technology, Communications Technology Laboratory, *5G mmWave Channel Model Alliance* (http://www.nist.gov/ctl/wireless-networks/5gmillimeterwavechannelmodel.cfm).

[161] O3b March 24, *Ex Parte* Letter at 3.

patterns, number of simultaneously transmitting stations, the obstruction losses that terrestrial signals are likely to encounter before reaching satellites at low elevations, and the fact that the majority of transmissions will occur indoors.[162] Terrestrial operators have every incentive to design networks that direct the signals they are transmitting to the locations of the receivers – either another fixed point on a vertical structure, or a mobile unit within a couple of meters of the ground – especially given the propagation characteristics of these frequencies. Furthermore, mobile units, which are likely to be transmitting at angles more skyward, are operating at powers significantly lower than base stations. These are both true regardless of the types of systems that are ultimately deployed in these bands. Nonetheless, given the wide variety of deployments and uses we expect to see in these bands, it would be inappropriate to universally mandate these design features in every deployment, in the absence of more credible support for the proposition that satellite systems will receive harmful interference from mmW mobile systems.

68. Our decision not to set specific limits on aggregate interference is consistent with our treatment of that issue in other bands. In AWS-3, we declined to establish aggregate power limits to protect Federal satellites in the 1761-1780 MHz band because it was unlikely that aggregate interference was likely to occur.[163] Similarly, in the 10.7-11.7 GHz band, which is shared between FSS and Fixed Service (FS), the Commission held with respect to concerns regarding a different type of aggregate interference: "[W]e view rule changes that would allow greater FS use of the 11 GHz band as beneficial to the public interest, so long as existing users would not be harmed."[164] Similarly, we see great public benefit to more intensive terrestrial use of the 28 GHz band where terrestrial use is the primary designated service in the band.

69. For the reasons stated above, we have concluded that the satellite industry has not shown that it has a legal right to protection from aggregate interference or that harmful aggregate interference is likely to occur from the mobile operations now being authorized for LMDS. We also recognize that SES, EchoStar, and ViaSat believe that satellite and mobile operations can coexist.[165] Nonetheless, we are sensitive to the concerns raised. We note that the satellite and wireless industries have begun the process of modeling the terrestrial systems under consideration for this band to provide further information concerning their potential impact on satellites. We encourage both industries to continue working cooperatively on this issue, including by submitting any relevant data demonstrating changes in the amount of aggregate interference on record as UMFU services are deployed. We direct the International Bureau, the Office of Engineering and Technology, and the Wireless Telecommunications Bureau to jointly establish a separate docket that parties can use to file the relevant data and analyses, and we reserve the right to revisit this issue should additional information or other circumstances warrant further Commission review or action.[166]

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[162] *See* Intel May 24, *Ex Parte* Letter at 8-9; Satellite Operators May 12, *Ex Parte* Letter; SES Americom May 5, *Ex Parte* Letter, and ViaSat Apr. 21, *Ex Parte* Letter.

[163] *See Amendment of the Commission's Rules with Regard to Commercial Operations in the 1695-1710 Mhz, 1755-1780 Mhz, & 2155-2180 Mhz Bands*, 29 FCC Rcd 4610, 4645, para. 92 (2014) (*AWS-3 Report and Order*).

[164] *Amendment of Part 101 of the Commission's Rules to Modify Antenna Requirements for the 10.7 – 11.7 GHz Band*, Report and Order, 22 FCC Rcd 17153, 17176, para. 48 (2007).

[165] *See* para. 22, *supra*.

[166] In the *NPRM*, we also sought comment on the possibility of repealing the prohibition on FSS user equipment in the 28 GHz band. *NPRM*, 30 FCC Rcd at 11922-26, paras. 147-159. While there has been considerable comment on this issue, in light of the evolving nature of technology and deployment in the band, we do not believe the issue is ripe for action at this time. Accordingly, we will consider this issue in the future, either in this proceeding or in a separate proceeding.

5. Band Plan

70. *Background.* In the *NPRM*, we proposed to license the 28 GHz band as a single 850 megahertz channel, as it is currently licensed.[167] We expressed the belief "that continuing to license this band as a single block would be in the public interest because it would provide a wide band (850 megahertz) of contiguous spectrum that could be used to provide high-speed service."[168]

71. Commenters were split on this issue. Intel, Nokia, Samsung, Straight Path, and TIA support licensing the 28 GHz band as a single block.[169] 5G Americas, AT&T, and T-Mobile support dividing the band into multiple blocks.[170] In particular, T-Mobile cites a competitive interest in having multiple operators in the 28 GHz band.[171]

72. *Discussion*. We will license the 28 GHz band as two 425 megahertz blocks. We believe 425 megahertz channels will be sufficient for a licensee to provide the type of high data rate services and other innovative uses and applications contemplated for this spectrum. The fact that several carriers support dividing the bands into multiple blocks supports that conclusion. We also agree with T-Mobile that there are benefits to competition in allowing multiple licensees to provide service in the 28 GHz band. We emphasize that existing LMDS Channel A1 licensees will receive licenses for both channels, so they will maintain their existing license rights. To the extent licensees are interested in having a contiguous block of 850 megahertz of spectrum, they are free to acquire both licenses, subject to compliance with our spectrum aggregation policies.

B. 39 GHz Band (38.6-40 GHz)

73. In the *NPRM,* the Commission proposed to develop service rules for mobile operations in the 38.6-40 GHz band (the "39 GHz Band"). This band is currently allocated to the fixed, fixed satellite (space-to-Earth), and mobile services on a primary basis for non-Federal use.[172] There are Federal FSS (space-to-earth) and MSS (space-to-Earth) allocations in the 39.5-40 GHz band, limited to military systems.[173]

74. The 39 GHz band is licensed by Economic Area (EA) and consists of 14 blocks of 50 by 50 megahertz channels.[174] Out of the 2,464 possible terrestrial fixed service EA licenses available in this band (14 channel pairs for each of 176 EAs) only 870 licenses currently exist. Other licenses were voluntarily cancelled or terminated for failure to meet substantial service requirements.[175] In addition, there are currently 229 active Rectangular Service Area (RSA) licenses that predate the creation of the EA licenses in which the licensees self-defined their service area, and where they retain the exclusive right to

[167] *NPRM*, 30 FCC Rcd at 11914, para. 116.

[168] *NPRM*, 30 FCC Rcd at 11914, para. 116.

[169] Intel Comments at 4, Nokia Comments at 21, Samsung Comments at 14, Straight Path Comments at 22, TIA Comments at 30. *See also* Nokia Comments at 21 (As an alternative, Nokia could also support licensing the band in blocks of 400 and 450 megahertz).

[170] 5G Americas Comments at 15 (three 200 megahertz blocks and one 250 megahertz block), AT&T Comments at 12 (channels of 200 megahertz each). T-Mobile Comments at 11 (supports smaller license blocks in general)

[171] T-Mobile Comments at 11.

[172] *See* 47 CFR § 2.106.

[173] Federal MSS earth stations may not claim protection from non-Federal fixed and mobile stations. The 38.6-39.5 GHz band is not allocated for Federal use. 47 CFR § 2.106 n.US382, G117.

[174] *See* 47 CFR § 101.147(v)(1); *see also NPRM*, 30 FCC Rcd at paras. 35.

[175] *See* 47 CFR § 101.17.

operate.[176] The populations in licensed areas (both EA and RSA licenses) vary by channel, but in aggregate they cover about 49 percent of the U.S. population. The Commission has previously indicated that licensees of the band could have the flexibility to provide mobile service and stated the belief 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."[177] The Commission declined, however, to permit mobile operations until it conducted a separate proceeding to resolve any inter-service and inter-licensee interference issues. As a result, no mobile operations currently exist in the 39 GHz band.[178] To accommodate high-density fixed terrestrial systems under a "soft segmentation" band plan, the Commission has established lower power flux density limits for satellite transmissions in the 37.5-40 GHz band than in other satellite bands.[179] We note that there are no commercial satellite operations in the band.

1. Suitability for Mobile Service

75. *Background.* Commenters, including incumbent terrestrial licensees, overwhelmingly support opening the band for mobile use.[180] The only commenters opposing mobile use of the 39 GHz band are certain satellite interests who argue that mobile and satellite uses are incompatible with each other, despite the fact that this band is currently unused by satellite operators.[181] Not all satellite interests view mobile and satellite uses as being incompatible, however.[182]

76. *Discussion.* We will authorize mobile operation in the 39 GHz band (38.6-40 GHz), as discussed below, and we will issue new licenses granting existing and new 39 GHz licensees both fixed and mobile rights. We believe that the significant bandwidth available in this band will help to accommodate the expected continued rise in demand for mobile data.[183] Commenters, including

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[176] *See Amendment of the Commission's Rules Regarding the 37.0 - 38.6 GHz and 38.6 - 40 GHz Bands*, Report and Order and Second Notice of Proposed Rulemaking, 12 FCC Rcd 18600, at 18637, para. 79. (1997) ("*39 GHz Report and Order*").

[177] *See 39 GHz Report and Order*, 12 FCC Rcd at 18615, para. 24.

[178] *See 39 GHz Report and Order*, 12 FCC Rcd at 18615, para. 25.

[179] *See* 47 CFR § 2.106; *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, 25438, para. 24 (2003) ("*V-Band Second Report and Order*"). *See also* 47 CFR § 25.208(r). The Commission has pending a proposal to establish procedures pursuant to which FSS licensees may raise their power flux density levels if necessary to compensate for "rain fade." *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 Further Notice of Proposed Rulemaking, 25 FCC Rcd 15663 (2010) ("*V-Band Third NPRM*").

[180] AT&T Comments at 3, 14, Cisco Comments at 4-5, CTA Comments at 10, CTIA Comments at 14, Ericsson Comments at 5, Facebook Comments at 2, FiberTower Comments at 2-3, FWCC Comments at 4, HTSC Comments at 4, Huawei Comments at 8-9, Intel Comments at 3, ITIC Comments at 4, Mobile Future Comments at 10, Nokia Comments at 14-15, Qualcomm Comments at 6-7, Samsung Comments at 11, Straight Path Comments at 5, T-Mobile Comments at 9, Verizon Comments at 5, XO Comments at 8, CCA Reply at 4-5.

[181] *See* Boeing Comments at 7-9, Inmarsat Comments at 9-10, SIA Comments at 17.

[182] *See*, *e.g.*, ViaSat Comments at 19-21, Boeing May 9, *Ex Parte Letter*.

[183] Cisco estimates the global mobile data traffic grew 74 percent in 2015, and 563 million mobile devices and connections were added in 2015. *See* Cisco, *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2015–2020* (Feb. 3, 2016), http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-

(continued….)

incumbent terrestrial licensees, overwhelmingly support opening the band for mobile use and expanding their reach to mobile.[184] We agree and believe the band can be used by both mobile and satellite because satellite use can be accommodated with minimal impact on terrestrial service.[185] Accordingly, in the paragraphs that follow, we create the service rules to enable such mobile use and we detail the means by which satellite must cooperate with new mobile services in these bands to reduce interference and improve service.

2. Licensing the 39 GHz Band

a. Use of Geographic Area Licensing

77. *Background.* In the *NPRM*, the Commission sought comment on applying a geographic area licensing scheme to the 39 GHz band.[186] We proposed issuing new licenses to current incumbent fixed operators in these bands, which would allow the flexibility to provide fixed and mobile operations. For areas with no existing 28 GHz or 39 GHz licensees, we proposed to use geographic area licensing, which will permit the filing and acceptance of mutually exclusive license applications that must be resolved by competitive bidding.[187] We sought comment on various factors we identified in support of this plan. For example, we noted that allowing the same licensee to coordinate fixed and mobile uses within its geographic area would minimize transaction costs and provide the fastest transition to expanded use of the band.[188] The Commission recognized that given the convergence between fixed and mobile technologies, attempting to define separate bundles of fixed and mobile rights might create unnecessary complexity and be inconsistent with the underlying technologies.[189] Furthermore, we contemplated that LMDS and 39 GHz licensees would have the opportunity to engage in mobile operations if the associated technical issues could be solved.

78. Most commenters took the same position on geographic area licensing in both the 28 GHz and 39 GHz bands. The majority of commenters addressing the issue agreed with using geographic area licensing to flexibly permit fixed or mobile services by each licensee.[190] In addition to the advantages noted by the Commission, commenters argued that exclusive rights will promote investment and expedite the deployment of mobile and other advanced services.[191] Public Knowledge/OTI, Federated Wireless,

(Continued from previous page)
networking-index-vni/mobile-white-paper-c11-520862.html; *see also* Presentation of Theodore (Ted) Rappaport, David Lee/Ernst Weber professor of electrical engineering at NYU, and founding Director of NYU Wireless, FCC Spectrum Frontiers Workshop (March 10, 2016) (https://www.fcc.gov/news-events/events/2016/03/spectrum-frontiers-workshop).

[184] AT&T Comments at 3, 14, Cisco Comments at 4-5, CTA Comments at 10, CTIA Comments at 14-15, Ericsson Comments at 5, Facebook Comments at 2, FiberTower Comments at 2-3, FWCC Comments at 4, HTSC Comments at 4, Huawei Comments at 8-9, Intel Comments at 3, ITIC Comments at 4, Mobile Future Comments at 10, Nokia Comments at 14-15, Qualcomm Comments at 6-7, Samsung Comments at 17, Straight Path Comments at 5, 14, T-Mobile Comments at 9, Verizon Comments at 5, XO Comments at 8.

[185] *See* Section IV.B.4 (Non-Federal Satellite Terrestrial Sharing – Licensing of Gateway Earth Stations), *infra*.

[186] *NPRM*, 30 FCC Rcd at 11907-11909, paras. 93-98.

[187] *See NPRM*, 30 FCC Rcd at 11907-11908, para. 93.

[188] *NPRM*, 30 FCC Rcd at 11908, paras. 94-95.

[189] *See NPRM*, 30 FCC Rcd at 11908, paras. 95.

[190] *See* 5G Americas Comments at 2, AT&T Comments at 12, 14, 19, Cisco Comments at 11, CTA Comments at 10, CTIA Comments at 14-15, Ericsson Comments at 5-6, FiberTower Comments at 2-3, FWCC Comments at 4-5, HTSC Comments at 4-5, Huawei Comments at 8-9, 9-10, Intel Comments at 3-4, 7-8, ITIC Comments at 4, Mobile Future Comments at 10, Nokia Comment at 14-15, Qualcomm Comments at 6-7, Samsung Comments at 11-12, Straight Path Comments at 14, T-Mobile Comments at 9-10, Verizon Comments at 5, XO Comments at 7-8.

[191] 5G Americas Comments at 3-4, CTIA Comments at 14, Qualcomm Comments at 7-8.

and Google urge us to adopt a licensing scheme based on using Spectrum Access System (SAS) and concepts adopted by the Commission for use in the 3.5 GHz band.[192] They contend that an SAS would facilitate access to spectrum by a wide range of users.

79. *Discussion.* We adopt geographic area licenses that will grant licensees the flexibility to provide fixed and mobile services. As with the 28 GHz band, we find that in this band, geographic area licensing will expedite deployment, provide licensees with the flexibility to provide a variety of services, and is consistent with the existing licensing scheme in the band. We will maintain the current co-primary Federal FSS and MSS allocations and associated regulations in this band. We also find that the presence of incumbent geographic area licenses in a large part of the country renders the 39 GHz band a poor candidate for implementing an SAS-based sharing model.

b. License Area Size

80. *Background*. In the *NPRM*, we proposed to use counties as the base geographic area unit for licenses in the 39 GHz band. As noted with respect to the 28 GHz band, we saw several advantages to counties.[193] We also sought comment on alternative licensing areas, PEAs, census blocks, or block groups.[194]

81. The majority of commenters addressing this issue support using Economic Areas (EAs), which is the license area unit used by existing 39 GHz licensees.[195] They raise three concerns about the use of counties: (1) counties do not fit the contemplated services to be offered using mmW spectrum, (2) counties will result in more license areas, which will make it more difficult for licensees to coordinate border areas with each other, and (3) issuing a larger number of small licenses will increase administrative burdens on licensees and the Commission (e.g., more buildout showings are required).[196] In contrast, FiberTower and US Cellular support the use of counties.[197]

82. *Discussion.* We will license the 39 GHz band using PEAs, because we find that use of this license area size will facilitate access to spectrum and the rapid deployment of service in the band. PEAs are smaller than BTAs or EAs, and therefore are more realistically obtainable by smaller bidders, yet are larger than counties which various commenters deem too small. Licensing the 39 GHz band on a PEA basis strikes the appropriate balance between facilitating access to spectrum by both large and small providers and simplifying frequency coordination while incentivizing investment in, and rapid deployment of, new technologies. PEAs also nest into EAs but can also be broken down into counties, allowing operators to combine or partition their PEAs into the license areas of their choice.[198] We believe that the size and ability to combine/partition will aid in the rapid deployment of these licenses. Our decision to license the 39 GHz band on a PEA basis is distinguishable from our decision to use counties

[192] *See* OTI and Public Knowledge Comments at 7-12, Federated Wireless Comments at 5-13, Google Comments at 4.

[193] *NPRM*, 30 FCC Rcd at 11912, para. 111.

[194] *NPRM*, 30 FCC Rcd at 11913, para. 113.

[195] 5G Americas Comments at 5-9, AT&T Comments at 17-19, Cisco Comments at 11, CTA Comments at 11-12, Ericsson Comments at 9-10, Intel Comments at 2-3, Mobile Future Comments at 13, Nokia Comments at 18, Verizon Comments at 10.

[196] *See* 5G Americas Comments at 6-9, AT&T Comments at 18-19, CTA Comments at 12, Verizon Comments at 10-12.

[197] FiberTower Comments at 3, US Cellular Reply at 5-10.

[198] *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Report and Order, 29 FCC Rcd 6567, 6595-6604, paras. 68-80 (2014) (*Incentive Auction Report and Order*). *See* 47 C.F.R. § 27.6(l); *see also Wireless Telecommunications Bureau Provides Details About Partial Economic Areas*, Public Notice, 29 FCC Rcd 6491 (WTB 2014).

as the license area in the 28 GHz band, because, as previously discussed, the latter band is currently licensed by BTAs and cannot readily be reformed into either EAs or PEAs.

3. Mobile Rights for Incumbents

83. When the Commission established rules for the 39 GHz band, it contemplated that 39 GHz licensees would have the opportunity to engage in mobile operations if the associated technical issues could be resolved.[199] Accordingly, in the *NPRM*, we proposed to permit existing 39 GHz licensees to exercise the full extent of these rights – including mobile rights – for geographic areas and bands in which they currently hold licenses.[200] We noted three likely advantages to this proposal. First, this approach would minimize transaction costs and provide the fastest transition to expanded use of the band, which would benefit consumers. We opined that it would be particularly important to expedite service because of the great benefits these new technologies could bring to consumers and because of the technical and logistical challenges licensees will face. Second, we noted that given the technical characteristics of this band and the nature of the services that may be developed for it, the differences between fixed and mobile operation are increasingly blurred. We therefore suggested that attempting to define separate bundles of "fixed" and "mobile" rights might create unnecessary complexity and be inconsistent with the underlying technologies, in which case it would be more efficient to have both the fixed and mobile usage rights contained within the same license. Third, the existence of separate licenses for fixed and mobile operation might create unusually large challenges related to interference. For example, one point-to-point link could preclude mobile use of the spectrum in a downtown region. We noted that a single license that combines both fixed and mobile rights avoids this issue and provides the licensee with the appropriate incentives to evaluate the tradeoffs between different uses.[201]

84. As an alternative, we also sought comment on the use of an 'overlay auction to separately license the mobile rights in the 39 GHz frequencies – as long as the overlay licensee obtaining the mobile rights did not interfere with the incumbent's fixed use of the same frequencies.[202] We noted several possible advantages to overlay licenses. First, an overlay auction would assign these rights to the user that values the set of rights most highly, whether it is an incumbent licensee or a new potential user. Second, the use of an auction, rather than a direct grant of additional rights to existing licensees, would ensure that a portion of the value associated with these additional rights will accrue to the United States Treasury. Third, we noted that the Commission has relevant experience in the application of overlay rights in other bands.[203]

85. The majority of commenters addressing this issue support granting mobile rights to incumbent 39 GHz licensees[204] and most of these commenters oppose an overlay auction.[205] AT&T

[199] *See 39 GHz Report and Order*, 12 FCC Rcd at 18615, para. 24.

[200] *NPRM*, 30 FCC Rcd at 11908, para. 95.

[201] *See NPRM*, 30 FCC Rcd at 11908, para. 95.

[202] *See NPRM*, 30 FCC Rcd at 11909, para. 97.

[203] *See NPRM*, 30 FCC Rcd at 11909, para. 97.

[204] *See* 5G Americas Comments at 3-4, Cisco Comments at 4-5, CTA Comments at 10, CTIA Comments at 14, Ericsson Comments at 5-6, FiberTower Comments at 2-3, FWCC Comments at 4, HTSC Comments at 4, Huawei Comments at 11, Intel Comments at 4, ITIC Comments at 4, Mobile Future Comments at 10, Nokia Comments at 15, Qualcomm Comments at 7, Samsung Comments at 11-12, Straight Path Comments at 14-16, T-Mobile Comments at 9, Verizon Comments at 5, XO Comments at 8.

[205] *See* 5G Americas Comments at 4, Cisco Comments at 5 n.11, Huawei Comments at 11, Intel Comments at 4, Mobile Future Comments at 10, Nokia Comments at 15, Qualcomm Comments at 7, Samsung Comments at 11-12, Straight Path Comments at 14-16, T-Mobile Comments at 9, Verizon Comments at 6, XO Comments at 9.

suggests that incumbent licenses be modified to limit their authorizations to protection of existing operations, both by frequency and by area of operations.[206]

86. *Discussion.* We adopt our proposal to grant mobile operating rights to existing active 39 GHz licensees for the same reasons we granted mobile operating rights to LMDS incumbent licensees. Granting mobile operating rights to existing licensees will expedite the deployment of service, minimize the difficulties involved in coordinating fixed and mobile deployments, and provide a uniform licensing scheme throughout the United States. In contrast, separating fixed and mobile rights through assignment of overlay licenses would delay the implementation of mobile service. We remain concerned that awarding fixed and mobile rights separately would lead to disputes between fixed and mobile licensees that could make it more difficult for both licensees to provide service.

87. We recognize that awarding mobile rights to incumbent licensees could be viewed as a windfall to those licensees, although the Commission contemplated granting mobile rights when it first created LMDS. Here, the benefits of expediting service and facilitating the coordination of fixed and mobile service outweigh any potential disadvantages of granting mobile rights to incumbents.

4. Non-Federal Satellite Terrestrial Sharing – Licensing of Gateway Earth Stations

88. The *NPRM* invited comments on three issues relating to FSS use of the radiofrequency spectrum from 37.5 GHz to 40 GHz, encompassing both the 38.6-40 GHz (39 GHz) band and the 37-38.6 GHz (37 GHz) band.[207] The first question was whether we should make any changes to our treatment of gateway earth station applications; the second, whether it would be reasonable to eliminate the prohibition against ubiquitous deployment of user equipment; and the third question, whether it would be feasible to allow satellite operators to increase their power flux densities (PFDs) above existing limits during heavy rain storms.[208] In none of those cases did the Commission foresee any reason to differentiate between the 37 GHz and 39 GHz bands with respect to satellite sharing issues.

89. The U.S. Table of Frequency Allocations accords co-primary status to FSS earth stations in the 37.5-40 GHz frequencies,[209] but Commission rules provide that gateway earth stations in the 39 GHz band may be deployed only if the FSS licensee obtains a 39 GHz license for the area where the earth station will be located, or if it enters into an agreement with the corresponding 39 GHz licensee.[210] The Commission mentioned the changes that the *NPRM* was proposing for the licensing of satellite operations in the 28 GHz band and sought comment on whether similar changes should be adopted for the 37.5-40 GHz channel groups.[211] The *NPRM* asked whether the Commission should establish a waiver process by which non-Federal FSS earth stations in the 37.5-40 GHz bands could acquire co-primary status in areas where there is no geographic service area licensee, if they can demonstrate that doing so would not have a negative impact on future terrestrial service.[212] The Commission asked if the fact that 37.5-40 GHz FSS operations are space-to-Earth, rather than Earth-to-space as in the 28 GHz band, should lead to different

[206] AT&T Reply at 14; *see also* Cisco Comments at 5 n.11.

[207] *See NPRM*, 30 FCC Rcd at 11926, para. 160.

[208] *See NPRM*, 30 FCC Rcd at 11926, para. 160.

[209] 47 CFR § 2.106.

[210] *See* 47 CFR § 25.202(a)(1) n.3. There is no corresponding rule for the 37 GHz band because the Commission has not yet adopted service rules for that band.

[211] *See NPRM*, 30 FCC Rcd at 11926, para. 161.

[212] *See NPRM*, 30 FCC Rcd at 11926, para. 162.

answers to these questions.[213] The Commission also sought comment on any other changes it should make to the existing rules.[214]

90. Commenters acknowledge that the space-to-Earth nature of satellite operations in the 37.5-40 GHz bands means that it is earth stations that need protection against interfering signals from terrestrial operations rather than the opposite situation that applies for Earth-to-space operations in the 28 GHz band.[215] EchoStar calculates that satellite earth stations in the 37.5-40 GHz band will need exclusion zones with radii extending no more than about two kilometers.[216] EchoStar states this radius in the 37.5-40 GHz bands is about 12 times the radius (170 meters) circumscribing the exclusion zone that EchoStar says is required for earth stations in the 28 GHz band. The areas required for the resulting exclusion zones would be about 138 times as large – 12.6 square kilometers (4.9 square miles) for the 37.5-40 GHz bands versus 0.09 square kilometers (0.03 square miles) for the 28 GHz band. By comparison with the 28 GHz band, therefore, accommodating satellite earth stations in the 39 GHz band is approximately two orders of magnitude more difficult.

91. The smallest counties mentioned in our discussion of satellite interference zones for the 28 GHz band each cover about 80 square kilometers. The exclusion area that EchoStar says is required for the 37.5-40 GHz frequencies would cover about 16 percent of such a county -- a proportion that could seriously impair the growth prospects for mmW mobile. The challenge is less daunting when we consider the possibility of authorizing earth station sites on a Partial Economic Area basis rather than a county basis. The average PEA in the 48 contiguous U.S. states covers about 18,692 square kilometers (7,217 square miles).[217] Therefore, the requisite exclusion zone would cover about 0.0674 percent of the average PEA's land mass in the contiguous U.S. If people were evenly distributed across this hypothetical average PEA, substantially less than 0.1 percent of its population would fall in the earth station's exclusion zone.[218]

92. These calculations show that some PEAs should be able to host a 39 GHz earth station without placing more than 0.1 percent of the PEA's population in the earth station's exclusion zone. Most PEAs cover substantially less territory than the average PEA does; i.e., even for some PEAs, a five square-mile exclusion zone might affect an unacceptably high proportion of their populations. But satellite operators will not necessarily need to deploy 39 GHz earth stations in the smaller, more densely populated PEAs. For satellite gateway earth stations in particular, the *sine qua non* is not proximity to population centers, *per se*, but access to long-haul, high data-rate Internet facilities. As Figure 1 shows, direct access to long-haul Internet nodes is available not just in major population centers but also in some of the more remote parts of the U.S.[219] The table in Appendix B confirms that many of those nodes are in

[213] *See NPRM*, 30 FCC Rcd at 11926, para. 162.

[214] *NPRM*, 30 FCC Rcd at 11926, para. 161.

[215] *See, e.g.*, EchoStar Reply at 20-21.

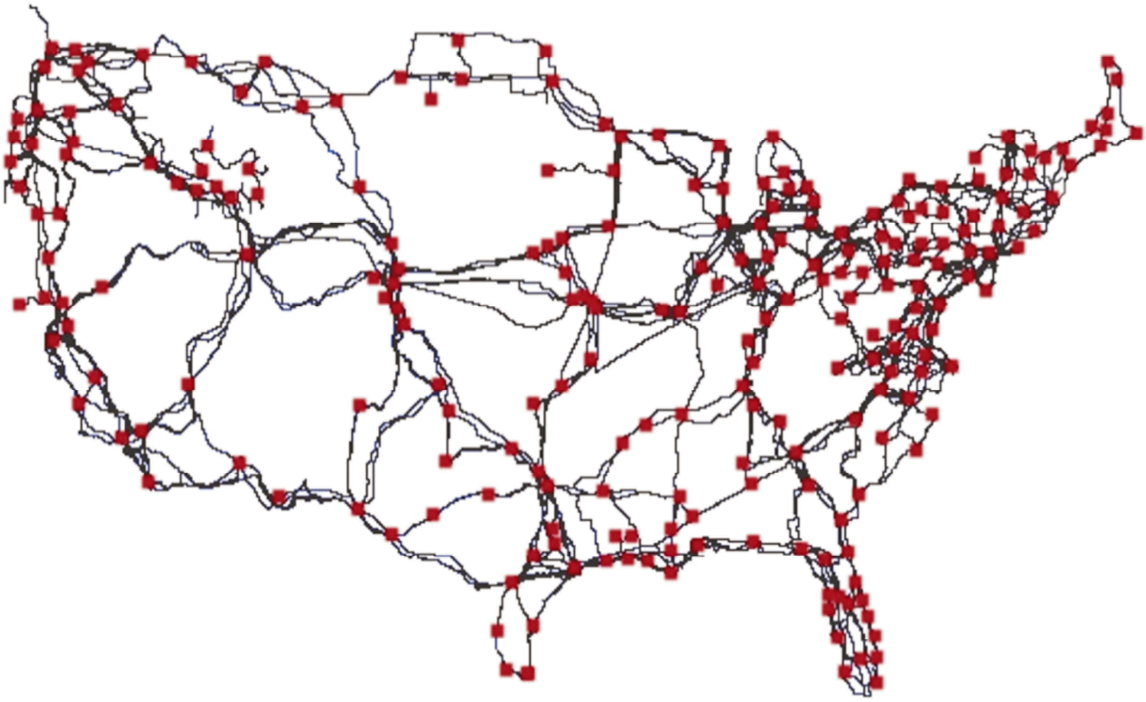
[216] EchoStar Comments at 33.

[217] The combined land area (not including water area) of the contiguous 48 U.S. states is 2,954,841 square miles). United States Census Bureau, *2010 Census Gazetteer Files*, http://www.census.gov/geo/maps-data/data/gazetteer2010.html (last visited June 16, 2016). There are 410 Partial Economic Areas in the contiguous 48 U.S. states. *See Wireless Telecommunications Bureau Provides Details About Partial Economic Areas*, GN Docket No. 12-268, Public Notice, DA 14-759 (WTB June 2, 2014).

[218] As of July 2015, the official estimate for the population of the contiguous 48 states was 311,654,056. United States Census Bureau, Population Estimates (http://www.census.gov/popest/data/national/totals/2015/index.html).

[219] R. Durairajan, P. Barford, J.Sommers and W. Willinger. *InterTubes: A Study of the US Long-haul Fiber-optic Infrastructure*, in Proceedings of ACM SIGCOMM, 2015 (http://www.sigcomm.org/node/3852); R. Durairajan, S. Ghosh, X. Tang, P. Barford, and B. Eriksson, *Internet Atlas: A Geographic Database of the Internet*, in Proceedings (continued….)

Figure 1: Long-Haul Internet Connections



places with comparatively low population densities – i.e., near areas where it should be possible to deploy earth stations without creating exclusion zones that affect unacceptably high proportions of the population. In addition, as we suggested for the 28 GHz band, satellite operators can substantially reduce the sizes of the exclusion zones that they require by constructing artificial site shields or by taking advantage of naturally occurring terrain features.[220] Figure 2 illustrates how spatial analysis software can process digital elevation data to identify geographic depressions, which are capable of providing natural site-shielding in all directions.[221] For earth stations that communicate only with geosynchronous

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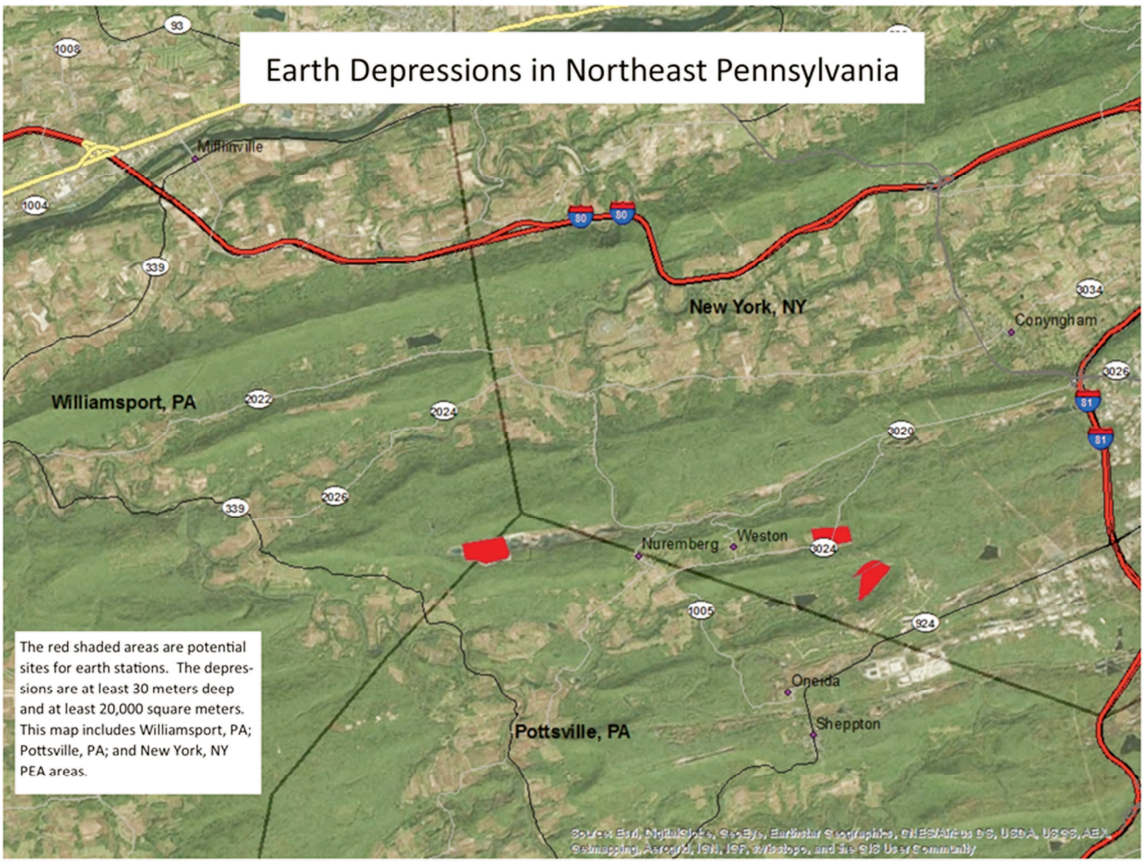
of the 5th ACM Workshop on HotPlanet, August 2013 (https://www.researchgate.net/publication/262247359_Internet_atlas_A_geographic_database_of_the_internet).

[220] *See* S.A. Bokhari, et al., *Site Shielding of Earth-Station Antennas,* IEEE Antennas and Propagation Magazine, Vol. 37, No. 1, Feb. 1995, at 7 (IEEE accession number 1045-9243/93) (http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=370577&newsearch=true&searchWithin=%22Publication%20Title%22:antennas%20and%20propagation%20magazine&searchWithin=%22Volume%22:37&searchWithin=%22Issue%22:1).

[221] The sources and methods used to generate this map are described in Appendix C.

Figure 2



satellites, more limited site shielding would typically suffice. In addition, satellite operators may continue to protect their earth stations from interference using any of four market-oriented mechanisms: purchasing geographic area licenses at auction, acquiring licenses from existing licensees, obtaining partitioned segments of existing geographic area licenses from existing licensees, or obtaining contractual agreements from nearby licensees not to interfere into their earth station operations.

93. Based on those considerations, we will authorize non-Federal satellite earth stations in the 39 GHz band on a first-come, first-served basis that will entitle them to protection from terrestrial transmissions subject to the following conditions.[222] First, the earth station applicant must define a protection zone in its application around its earth station where no terrestrial operations may be located. The FSS applicant may self-define this protection zone, but it must demonstrate using reasonable engineering methods that the designated protection zone is no larger than necessary to protect its earth station. Second, we will authorize a maximum of three protection zones in each PEA, so the applicant must demonstrate that there are no more than two existing protection zones in the PEA or demonstrate that its protection zone will be contiguous to any preexisting satellite protection zone. Third, the applicant must demonstrate the existing and proposed protection zones, in the aggregate, will not cover more than 0.1 percent of the PEA's population.[223] Fourth, the applicant must show that the protection

[222] We adopt a new footnote, NG63, to the Allocation Table that reflects the existing limitation to gateway earth stations. *See* 47 CFR § 25.202(a)(1) n.3.

[223] The International Bureau will issue a public notice seeking comment on the appropriate methodology to calculate the 0.1 percent population limit and will also seek comment on best practices for earth station siting to minimize

(continued….)

zone does not infringe upon any major event venue, arterial street, interstate or U.S. highway, urban mass transit route, passenger railroad, or cruise ship port. Finally, the earth station applicant must coordinate with terrestrial fixed and mobile licensees whose license areas overlap with the protection zone, in order to ensure that the protection zone does not encompass existing terrestrial operations. The coordination requirements will be based on our existing requirements contained in Section 101.103(d) of the Commission's rules.[224] If the earth station is authorized, UMFUS licensees will be prohibited from placing facilities within the protection zone absent consent from the FSS operator, and the FSS operator must respond in good faith to requests to place facilities within a protection zone.

5. Band Plan

94. *Background.* Having decided on PEAs as the appropriate geographic area for the 39 GHz band, our next objective is to determine the appropriate bandwidth or channel size in these areas. The *NPRM* sought comment on retaining the existing band plan, which consists of 14 channel pairs of 50 MHz by 50 MHz (totaling 1.4 gigahertz) licensed by EA.[225] The *NPRM* proposed keeping the existing band plan to expedite deployment while maintaining national uniformity. We also sought comment on expanding the channel size and any costs the licensee could incur if the channel plan were changed.[226] Commenters also argue that 200 MHz blocks are necessary to attain the data speeds and meet the capacity requirements of wireless 5G uses, with such larger channel bandwidths optimizing traffic management and improving system performance.[227] Many commenters supporting 200 megahertz channels for the 39 GHz band envision the channels as part of a larger 3 gigahertz band that combines the 37 GHz and 39 GHz bands.[228] The allocation of 3 gigahertz of contiguous spectrum above 24 GHz for mobile operations is viewed as one of the best way to spark investment in 5G and significantly support deployment of new technologies that can enable high-data rate transmissions.[229] Only a few incumbent licensees express a preference for maintaining the current paired 50 MHz band plan[230] (though one has recently changed its position and is open to a rebanding if an appropriate transition plan enables it to continue serving its customers[231]). Alternatively, some commenters argue for channels larger than 200 megahertz, suggesting two 500 megahertz channels and one 400 megahertz channel for the band.[232]

(Continued from previous page)
impact on UMFU services, colocation of earth stations, and accommodating multiple earth station interference zones without exceeding 0.1 percent of population in a given PEA..

[224] 47 CFR § 101.103(d).

[225] *NPRM*, 30 FCC Rcd at 11914, para. 117.

[226] *See* 5G Americas Comments at 14-15, AT&T Comments at 14, CTA Comments at 12, CTIA Comments at 21-22, Ericsson Comments at 9, Qualcomm Comments at 11, Samsung Comments at 14, TIA Comments at 30-31, T-Mobile Comments at 11-12, Verizon Comments at 7, Intel Reply at 8, Verizon Reply at 7,.

[227] AT&T Comments at 10, Samsung Comments at 14.

[228] *See* 5G Americas Comments at 15, AT&T Comments at 14-16, CTA Comments at 12, CTIA Comments at 21-22, Ericsson Comments at 8-9, AT&T Reply at 19, 21-22, CTIA Reply at 12-14, EchoStar Reply at 20, Verizon Reply at 4, 7.

[229] *See* 5G Americas Comments at 15, AT&T Comments at 15-16, CTA Comments at 12, CTIA Comments at 21-22, Ericsson Comments at 8, Huawei Comments at 5-6, Intel Comments at 7, Straight Path Comments at 6, T-Mobile Comments at 13, Verizon Comments at 6-7, AT&T Reply at 21-22, CCA Reply at 5, Mobile Future Reply at 6-7, Samsung Reply at 6-7.

[230] FiberTower Comments at 6 (arguing that licensees should be free to swap with other licensees and that both TDD and FDD should be supported), XO Comments at 24 (arguing that its existing FDD links would be jeopardized).

[231] XO Reply at 12.

[232] *See* 5G Americas Comments at 15 (suggesting that combinations of 200 and 500 MHz could be used), Nokia Comments at 5, 21-22 (recommending dividing the 39 GHz band into three channels with 400 megahertz, 500
(continued….)

95. *Discussion.* The Commission will create seven 200 megahertz bands out of the 39 GHz band (38.6-40 GHz). We find that this channel size is large enough to take advantage of the data throughput capacity of these bands yet yields a sufficient quantity of channels in the band to provide access to multiple operators simultaneously. We agree with the comment that next generation 5G networks are expected to depend in part on higher frequencies, increased spectral efficiency and greater density of cell deployments and that these factors alone may be insufficient to meet the expected tenfold increases in peak data rates and user throughput without using ultra-wide channel bandwidths of at least 200 MHz.[233] These wider channels available at higher frequencies could allow for higher data rates in environments constrained by power or signal-to-noise ratios.[234] By facilitating higher throughput, wideband channels will thereby permit more users to simultaneously use the band.

96. We also modify the current band plan that is based on paired spectrum blocks in favor of larger, unpaired channels to enable Time Division Duplexing (TDD) which commenters believe will best enable a 5G mobile service environment.[235] Straight Path asserts that TDD is preferable in these frequencies given the current lack of adequate frequency duplexers capable of meeting the performance, cost or form factor requirements necessary to facilitate Frequency Division Duplexing (FDD) at these higher wavelengths.[236] TDD does not require a frequency duplexer and allows flexible downlink-uplink ratios that depend on traffic and result in efficient utilization of spectrum.[237] While these and other commenters note the benefits of TDD in the context of 5G, commenters overwhelmingly support rules that allow for flexible duplexing schemes,[238] and the rules we adopt will allow any type of duplexing. Licensees may also continue to offer FDD service by acquiring and pairing multiple spectrum blocks. Because the existing channel plan favors FDD operation and limits flexibility to accommodate other duplexing schemes, reconfiguring the channel plan will remove obstacles to TDD schemes while still allowing for flexibility to accommodate FDD. Furthermore, larger bandwidths may optimize traffic management and improve system performance because a single, wide carrier permits centralized spectrum management whereas aggregation and use of various narrow bandwidth channels requires greater power consumption and equipment complexity.[239] Finally, as discussed below, 200 megahertz channels will potentially create several empty channels for new entrants after incumbent licensees swap or repack their existing systems into consecutive or adjacent channels.[240] Given all of the considerations above, we find that 200 MHz channels are the best band size for 39 GHz.

6. Pre-Auction License Reconfiguration

97. *Background.* One concern we wish to address before licensing the unassigned 39 GHz frequencies concerns the fragmentation of the band. A large number of the 28 50 megahertz available channel pairs at 39 GHz are interspersed among free, unassigned channels in noncontiguous batches

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megahertz, and 500 megahertz each), Straight Path Comments at 23 (recommending dividing the 39 GHz band into three channels with 400 megahertz, 500 megahertz, and 500 megahertz each); *see also* Straight Path Reply at 9-12.

[233] *See* AT&T Comments at 9-10.

[234] Google Comments at 5.

[235] Ericsson Comments at 9, Straight Path Comments at 23.

[236] Straight Path Comments at 23-24.

[237] Straight Path Comments at 24. Straight Path also noted that with smaller bandwidths, other barriers to efficient use could include guard bands as well as more expensive transceivers and front end devices. *Id.* at 24. Verizon also argues channels in these bands should be auctioned unpaired to permit TDD. Verizon Comments at 7; *see also* Ericsson Comments at 9, TIA Comments at 31.

[238] *See infra* Section IV.G.1 (Flexible Duplexing Rules).

[239] *See* AT&T Comments at 10.

[240] *See* Section IV.B.6 (Pre-Auction License Configuration), *infra*..

throughout the existing EAs. Holding any auction based on this fragmented band would likely be inefficient, as bidders would reasonably expect to incur significant transaction costs in assembling contiguous spectrum post-auction.[241] The *NPRM* sought comment on Straight Path's proposal to allow incumbent licensees to exchange their licenses pre-auction.[242] Straight Path recommends that the Commission conduct a voluntary, pre-auction license swap or exchange which would give licensees the opportunity to consolidate their licensed blocks into larger tranches of contiguous spectrum thereby leaving more valuable empty contiguous channel blocks for the Commission to auction.[243] Nearly 65% of all 39 GHz fixed terrestrial licenses are unassigned, Straight Path holds nearly 34% of the licenses, and less than 2% of the licenses are held by a few other entities.[244] While not all licensees may choose to participate in such swaps, just the participation of Straight Path and the Commission alone could yield a significant improvement in the available unencumbered spectrum.[245]

98. *Discussion.* Straight Path's proposal contains the clearest delineation of rules and steps necessary to align adjacent spectrum tranches to create contiguous bands – the goal advocated by commenters.[246] We agree with Straight Path that in EAs where only it holds licenses, the Commission should accept any exchange application in which Straight Path or others propose to acquire the same amount of spectrum in the market that it proposes to relinquish as long as it meets the end goal of creating a contiguous block or blocks of spectrum.[247] In instances where there are multiple geographic area licensees, Straight Path advocates that the Commission should first accept any band plan mutually acceptable to the various licensees as long as it also increases the amount of contiguous spectrum for at least one of the licensees.[248] If licensees do not agree on a band plan, Straight Path argues the Commission should accept applications in which an incumbent geographic area licensee seeks to acquire any contiguous spectrum blocks adjacent to spectrum blocks it already holds subject to two limitations (i) the target spectrum block is not already occupied by another incumbent geographic area licensee; and (ii) the target spectrum block could not be requested by another incumbent geographic area licensee on the grounds that it is adjacent to a block it holds or that it could hold. A licensee should be able to continue to add contiguous unused blocks in a row until it reaches a prohibited block—i.e., a spectrum block that

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[241] *See* Intel Reply at 10.

[242] *NPRM*, 30 FCC Rcd at 11914, para. 117.

[243] Straight Path Reply at 12.

[244] Other licenses are held by FiberTower, T-Mobile, NextLink(XO), SmartCity LLC, and SureWest. *See* Intel Reply at 8 n.27, 9, Figure A; *see also* Straight Path April 4 *Ex Parte* Letter.

[245] Intel Reply at 12. Straight Path currently holds licenses in each of the existing 175 EAs and in most EAs Straight Path is the only licensee with the remaining 39 GHz channel blocks unoccupied. Straight Path April 4 *Ex Parte* Letter Attach. 1, at 1.

[246] *See* Intel Comments at 12, Nokia Comments at 24, Skyriver Comments at 17, T-Mobile Reply at 16; *see also* Iridium Reply at 5.

[247] Straight Path April 4, *Ex Parte* Letter Attach. 1, at 1. For example, treating the 14 channel pairs as 28 independent channels,

> in EA13, channel blocks 1, 6, 10, 14, 15, 20, 24, and 28 are vacant, and Straight Path holds channel blocks 2-5, 7-9, 11-13, 16-19, 21-23, and 25-27 for a total of twenty channel blocks. Under Straight Path's proposal, it would relinquish its authorizations for blocks 21-23 and 25-27 in exchange for the vacant blocks 1, 6, 10, 14, 15, and 20, giving it twenty contiguous channel blocks, with the Commission holding eight contiguous channel blocks (21-28). Similarly, in EA12, channel blocks 1, 2, 4, 6, 8, 12, 14-16, 18, 20, 22, 26, and 28 are vacant, and Straight Path holds channel blocks 3, 5, 7, 9-11, 13, 17, 19, 21, 23-25, and 27 for a total of fourteen channel blocks. In this example, Straight Path would relinquish its authorizations for blocks 17, 19, 21, 23-25, and 27 in exchange for the vacant blocks 1, 2, 4, 6, 8, 12, and 14, giving both Straight Path and the Commission fourteen contiguous channel blocks.

Id. at 1.

[248] Straight Path April 4, *Ex Parte* Letter Attach. 1, at 1.

could also be claimed by another incumbent licensee.[249] Straight Path suggests that in this way, contiguous occupied bands could be aligned starting at the lower edge of the band – at 38.6 GHz – and moving up toward 40 GHz. Because we are adopting a band plan for the 37 GHz band that provides for continuity of commercial operations across the 37 GHz and 39 GHz bands, when the bands are viewed together, Straight Path's swapping plan results in occupied spectrum in the middle of the combined bands. One alternative might be to push incumbents to the upper end of the band near 39.5 GHz, in order to create larger available swathes of spectrum by combining the lower frequencies with the open bands in the 37 GHz band. However, in the interest of addressing mobile data demand as quickly as possible, 39 GHz licensees at the bottom of the band will provide the first market for mmW mobile equipment as soon as it becomes available, and this will further the goal of interoperability by allowing fixed licensees to more rapidly foster the development of mobile in their bands.

99. Some of the 200 MHz spectrum blocks offered at auction will also contain at least one incumbent RSA licensee occupying some portion of the spectrum.[250] Straight Path argues that where the incumbent geographic license holder is also the RSA licensee, the RSA license will be deemed not to exist and will be cancelled upon an exchange.[251] Otherwise, incumbent licensees will only be permitted to elect to add contiguous channels with greater encumbrances than *vice versa*; accordingly, a geographic area licensee can always opt to exchange a block without an RSA for an adjacent block with an RSA whose operations it will have to protect, and similarly it can always opt to take a license area with a more encumbered RSA over a block it holds with a less encumbered RSA, but it cannot "upgrade" to an RSA-free block or a license with an embedded RSA that is less encumbered.[252] Overall, although Intel and Straight Path have argued that EAs are the appropriate geographic area for new licenses given their historical use and the complexity of the swap process,[253] as discussed above, our preferred license area size for the 39 GHz band are PEAs, and such PEAs neatly fit into the EAs they comprise. Accordingly, once incumbents' spectrum swapping has run its course at the EA level, the resulting license area/band combinations should be further broken down into PEAs, which 'nest' into EAs.

100. We believe this reconfiguration process will yield a band, and licenses, that are more useable by incumbents as well as new entrants for the new flexible use services, including mobile broadband that we are authorizing in this *Report and Order*. Straight Path currently holds 931 licenses

[249] Straight Path April 4, *Ex Parte* Letter Attach. 1, at 2.

> By way of illustration, in EA30, there is an incumbent geographic area licensee on channel blocks 6 and 20; channel blocks 4, 5, 7, 9, 12, 13, 18, 19, 21, 23, 26, and 27 are vacant; and Straight Path holds licenses for channel blocks 1-3, 8, 10, 11, 14-17, 22, 24, 25, and 28, for a total of fourteen channel blocks. Because of the presence of an incumbent, Straight Path would not be eligible to apply for the channels occupied by the incumbent or channels adjacent to those occupied by the incumbent—in this case, channel blocks 5-7 and 19-21. Instead, Straight Path would be permitted to acquire blocks 4 (adjacent to its current blocks 1-3), 9 (adjacent to its current blocks 8 and 10), 12 (adjacent to its current block 11) and 13 (adjacent to its current block 14) and relinquish channel blocks 22, 24, 25, and 28 in exchange. As a result, Straight Path would hold channel blocks 1-4 and 8-17 for a total of fourteen channel blocks, and—assuming the other incumbent does not apply for any channel swaps—the Commission would hold channel blocks 5, 7, 18, 19, and 21-28 to auction. Similarly, in EA56, there is a second incumbent geographic area licensee on channel blocks 5, 6, 19, and 20; channel blocks 1-4, 7, 8, 14-18, 21, 22, and 28 are vacant; and Straight Path holds the licenses for channel blocks 9-13 and 23-27 for a total of ten channel blocks. In this scenario, Straight Path would be prohibited from applying for (i) channel blocks 5, 6, 19, and 20, which are occupied by the other incumbent licensee; (ii) blocks 4, 7, 18, and 21, which are immediately adjacent to blocks held by the other licensee; and (iii) block 17, which could be subject to competing claims as contiguously adjacent to blocks held by both licensees. Instead, Straight Path would be permitted to acquire channel blocks 8 (adjacent to its channel block 9), and 14-16 (with channel block 14 adjacent to its current channel block 13 and with continuing adjacency, without the presence of a prohibited channel, through channel block 16). It would retain channels 9-13 and 23 for a total of ten channel blocks. *Id.*

[250] *See* Straight Path April 4, *Ex Parte* Letter Attach. 1, at 3.

[251] Straight Path April 4, *Ex Parte* Letter Attach. 1, at 3.

[252] *See* Straight Path April 4, *Ex Parte* Letter Attach. 1, at 3.

[253] *See* Intel Reply at 13; Straight Path April 4, *Ex Parte* Letter Attach. 1, at 1.

out of 1,098.[254] If Straight Path voluntarily reconfigures its rights as it has advocated, this will substantially reduce encumbrances (i.e., remaining RSAs or blocks within EAs that have not been reconfigured) that might exist in new license areas before a future auction. While we adopt a voluntary reconfiguration approach, it is our hope and expectation that all licensees will take advantage of this opportunity to convert their licenses to the new flexible use licensing scheme and band plan. Furthermore, while we adopt a voluntary approach, we note that under Section 316 of the Act we retain the right to modify any license consistent with the public interest.[255]

C. 37 GHz Band (37-38.6 GHz)

101. The 37 GHz band presents a number of opportunities because, other than a limited number of existing Federal uses that need protection, the band is a greenfield– there are no existing non-federal operations, terrestrial or mobile. In addition, it is adjacent to the 39 GHz band, which presents an opportunity to create a larger, contiguous 37/39 GHz band, subject to similar technical and operational rules. Also, the Federal fixed and mobile service allocations are lightly used. The approach we adopt today takes full advantage of these opportunities.

102. Specifically, we can meet the twin goals of expanding commercial access in this band while facilitating continued and expanded Federal use. Because there are both Federal and non-Federal fixed and mobile rights and there are minimal incumbency issues (or an installed base of equipment), the approach we adopt in this band can significantly further the regulatory, policy, and technical approaches to Federal and non-Federal sharing. As discussed in greater detail below, we adopt a band plan that allows for continuity of commercial operations between the 37 and 39 GHz bands, we protect a limited number of Federal military sites across the full 37 GHz band, and we identify 600 megahertz of spectrum that will be available for coordinated coequal shared access between Federal and non-Federal users. Through this structure, additional proposals in the *FNPRM*, and the collaborative industry/government process that will take place to further define the sharing process and paradigm, we will take substantial strides forward on Federal and non-Federal sharing in the mmW bands while also making a significant amount of spectrum available for wireless broadband.

1. Suitability for Mobile Use

103. *Background*. In the *NPRM,* the Commission proposed to develop service rules for mobile operation in the 37 GHz band.[256] In undertaking this task, the Commission indicated that because the band has both Federal and non-Federal allocations and is located adjacent to a passive services band, developing rules to permit mobile operation in the 37 GHz band will be challenging.[257] The Federal and non-Federal allocations of the 37 band are as follows: The entire 37 GHz band is allocated to the fixed and mobile services on a primary basis for Federal and non-Federal use.[258] Portions of the 37 GHz band are also allocated to the Space Research Service (SRS) (space-to-Earth) on a primary basis for Federal use (37-38 GHz) and to the Fixed-Satellite Service (FSS) (space-to-Earth) on a primary basis for non-Federal

[254] These numbers include both EA and RSA licenses.

[255] 47 U.S.C. § 316.

[256] *NPRM*, 30 FCC Rcd at 11897-98, paras. 51-53.

[257] *NPRM*, 30 FCC Rcd at 11897-98, paras. 52-53.

[258] The Commission proposed to modify the mobile service allocation in the 37-38 GHz band by excluding the aeronautical mobile service, i.e., the 37-38 GHz band would be allocated to the mobile except aeronautical mobile service. *See Amendment of Parts 1, 2, 15, 25, 27, 74, 78, 80, 87, 90, 97, and 101 of the Commission's Rules Regarding Implementation of the Final Acts of the World Radiocommunication Conference (Geneva, 2007) (WRC-07), Other Allocation Issues, and Related Rule Updates*, *Amendment of Parts 2, 15, 80, 90, 97, and 101 of the Commission's Rules Regarding Implementation of the Final Acts of the World Radiocommunication Conference (Geneva, 2012)(WRC-12), Other Allocation Issues, and Related Rule Updates*, Report and Order, Order, and Notice of Proposed Rulemaking, 30 FCC Rcd 4183, 4268 para. 244 (2015).

use (37.5-38.6 GHz).[259] The use of this FSS downlink allocation is subject to the soft-segmentation plan adopted by the Commission in the *V-Band Second Report and Order*.[260] And finally, the 37 GHz band is adjacent to the 36-37 GHz band, where passive sensors in the Earth exploration satellite service (EESS) and SRS are located.[261] To accommodate the needs and characteristics of these different uses, the Commission stated that it intended to develop a flexible rules framework for the 37 GHz band that would enable as wide a range of services as possible.[262] The Commission also committed to working with the National Telecommunications and Information Administration (NTIA) to ensure that Federal operations are protected while maximizing the use of the 37 GHz band for commercial operations.[263] Since the Commission released the *NPRM*, the ITU in WRC-15 committed to study the use of the 37-40.5 GHz band for terrestrial services.[264]

104. Many commenters support the development of service rules to permit fixed and mobile terrestrial operations in the 37 GHz band.[265] Other commenters express reservations. For instance, Boeing asks the Commission to ensure that any identification of spectrum for 5G services protects the growth of existing and near-term satellite communications services and specifically requests that the Commission not authorize 5G technologies in the 37-38.6 GHz band until the international community has completed the studies called for by the 2015 World Radiocommunication Conference on the potential use of the 37 GHz band for satellite.[266] Also, Cisco urges the Commission to proceed with caution because potential enterprise or industrial users have not yet organized or amassed sufficient interest in the mmW bands to initiate the necessary technological development.[267]

105. *Discussion*. Today we adopt rules to permit fixed and mobile terrestrial operation in the 37 GHz band to enable as wide a range of services as possible. We find that there are several important characteristics of the 37 GHz band that make the provision of fixed and mobile terrestrial operations especially promising: it contains 1.6 gigahertz of contiguous spectrum, which could support ultra-high data rates; it is contiguous with the 39 GHz band, which will permit operators to aggregate spectrum across both bands; and it has global co-primary fixed and mobile allocations, which could enable operators to achieve economies of scale.[268] Although, as discussed above, Cisco urges us to proceed cautiously,[269] and Boeing urges us to wait until the studies called for by the WRC-15 are completed,[270] we are persuaded that fixed and mobile terrestrial services can be provided in the 37 GHz band.[271] In this regard, in analyzing the suitability of the 37 GHz band for mobile service, the band is very similar to the

[259] The existing rules limit the FSS use of the 37.5-40 GHz band to gateway earth stations. *See* 47 CFR § 25.202(a)(1) n.3.

[260] *NPRM*, 30 FCC Rcd at 11897, paras. 49 (*citing V-Band Second Report and Order,* 18 FCC Rcd at 25438 paras. 23-24). *See also* 47 CFR § 2.106.

[261] *NPRM*, 30 FCC Rcd at 11897-11898, paras. 52-53. *See* U.S. Table of Frequency Allocations, 47 CFR § 2.106.

[262] *NPRM*, 30 FCC Rcd at 11897-11898, para. 52.

[263] *NPRM*, 30 FCC Rcd at 11898, para. 53.

[264] Boeing Comments at 8.

[265] Mobile Future Comments at 8-9, Nokia Comments at 9-10, Samsung Comments at 11-13, Straight Path Comments at 5.

[266] Boeing Comments at ii.

[267] Cisco Comments at i.

[268] *NPRM*, 30 FCC Rcd at 11897 para. 51.

[269] Cisco Comments at i.

[270] Boeing Comments at ii.

[271] Samsung Comments at 11-13.

39 GHz band. It has an existing mobile allocation, the propagation characteristics are very similar to the 39 GHz band, and we do not see any inconsistency with other allocations that would make the band unsuitable for mobile service. In terms of timing of our action, considering the potential benefit for 5G services and the significant lead time that will be necessary to develop the services in this band, we believe that we should move forward and develop fixed and mobile terrestrial services rules for the 37 GHz band. Moreover, as discussed more fully below, the rules we adopt today accommodate the needs of NASA, NSF, the military, and FSS operations in the 37 GHz band as well as EESS (passive) and SRS (passive) operations in the adjacent 36-37 GHz band.[272]

2. Licensing the 37 GHz Band

106. *Background.* In the *NPRM*, the Commission proposed to adopt a hybrid authorization, licensing scheme that would convey licensed local area operating rights to premises occupants, and separately, geographic area licenses for wide area use.[273] The Commission proposed to license local area operating rights by rule, under Section 307(e) of the Communications Act of 1934, as amended (the Communications Act), and to license wide area rights by auction.[274] The Commission proposed to use counties as the geographical size for the wide-area licenses.[275]

107. The Commission also sought comment on an alternative licensing scheme in which the 37 GHz band would be divided into several blocks; some of which would be assigned by rule for local area uses.[276] Under this proposal, the band could be divided into three 533 megahertz or four 400 megahertz blocks and one or two blocks could be assigned by rule to local areas uses and the others could be assigned on a geographic area basis and assigned though an auction process.[277]

108. In addition, the Commission sought comment on a second alternative licensing scheme in which the entire 37 GHz band would be licensed geographically, but the geographic areas would be small enough to accommodate local area users without extensive partitioning of large licenses.[278]

109. As discussed below, most commenters oppose the hybrid authorization proposal.[279] Instead, many commenters favor a licensing scheme based on geographic area licensing with geographic areas larger than counties, such as BTAs, EAs, or PEAs.[280] Public Knowledge and Starry, Inc. favor adopting a scheme similar to the one that the Commission adopted in the 3.5 GHz Citizens Broadband

[272] Since the considerations for satellite sharing in the 37.5-40 GHz band are identical to the considerations present in the 39 GHz band, we will adopt the same rules for terrestrial sharing for both bands. *See supra* Section IV.B.4 (Non-Federal Satellite Terrestrial Sharing). For additional discussion of Federal sharing in the band, see Section IV.E (Federal Sharing Issues), *infra*.

[273] *NPRM*, 30 FCC Rcd at 11909-10, para. 100.

[274] *NPRM*, 30 FCC Rcd at 11910, paras. 102-103.

[275] *NPRM*, 30 FCC Rcd at 11912, para. 110.

[276] *NPRM*, 30 FCC Rcd at 11911, para. 105.

[277] *NPRM*, 30 FCC Rcd at 11911, para. 105.

[278] *NPRM*, 30 FCC Rcd at 11911, para. 106.

[279] 5G Americas Comments at 14, AT&T Comments at 16, CTA Comments at 10-11, CTIA Comments at 11, Ericsson Comments at 7, Intel Comments at 13-14, ITIC Comments at 5, Mobile Future Comments at 11-12, NCTA Comments at 13-16, Nokia Comments at 16, PCIA Comments at 10-11, Qualcomm Comments at 8, Samsung Comments at 13, TIA Comments at 18-21, T-Mobile Comments at 12-13, Verizon Comments at 6.

[280] 5G Americas Comments at 8-9, CTA Comments at 11-12, Mobile Future Comments at 13, Qualcomm Comments at 9, TIA Comments at 22-23.

Radio Service.[281] Finally, several commenters urge us to combine the 37 GHz band with the 39 GHz band and license both under the same geographic area licensing framework.[282]

110. In 2016, NTIA sent a letter to the Commission addressing issues raised in the *NPRM*, regarding, in part, licensing the 37-38.6 GHz.[283] NTIA recommends that the Commission adopt a modified version of their Alternative Proposal in the *NPRM*, creating a band plan with a 600 megahertz shared block in the 37-37.6 GHz band.[284]

111. *Discussion*. We adopt a licensing approach that makes five 200 megahertz blocks available on a geographic area-licensed basis in the 37.6-38.6 GHz portion of the band (upper band segment). We will make the 37-37.6 GHz block (lower band segment) available for coordinated co-primary sharing between Federal and non-Federal users, where non-Federal rights are granted by rule. We note that the entire band is subject to Federal co-primary fixed and mobile allocations. We decline to adopt the hybrid authorization licensing scheme because it is unsupported by the record.[285] Specifically, commenters oppose it because they do not believe that the 37 GHz band is appropriate for this particular scheme, though it could be used for other bands.[286] In addition, the satellite industry expresses concern that the hybrid licensing approach does not provide satellite operators with any meaningful certainty that they will be able to expand into the 37 GHz band.[287]

112. Of the three licensing options that the Commission sought comment on in the *NPRM*, we find that a variation of our alternative proposal best enables the band to be used for new commercial uses while simultaneously allowing fixed and mobile Federal use to expand. Although there is support in the record to license the entire 37 GHz band by geographic area, we find that it is in the public interest to license a portion of this band on a non-exclusive shared basis, and to license the remainder of the band by geographic area to give potential licensees additional opportunity to access large blocks of spectrum or to use 37 GHz spectrum in combination with, and similarly to, 39 GHz spectrum. Allowing part of the band to be made available on a non-exclusive, shared basis will promote access to spectrum by a wide variety of entities, support innovative uses of the band, and help ensure that spectrum is widely utilized. Adopting geographic area licensing for the other portion of the band will expeditiously make spectrum available and allow common development of the 37 GHz and 39 GHz bands. Furthermore, users in the shared portion of the band will benefit from efforts by equipment manufacturers and licensees to develop equipment for the portion of the band licensed on a geographic area basis. Thus, we find that adopting the alternative proposal, as modified below, should promote investment and deployment in both bands. As explained below, we agree that there are benefits to adopting the same geographic area licensing framework for the 37 GHz and 39 GHz spectrum bands. Also, we find that adopting the alternative proposal, in addition to other decisions made by the Commission today, provides satellite operators the certainty they need to be able to expand their operations into the 37 GHz band in the future.

[281] OTI and Public Knowledge Comments at 5-6, Starry May 5, *Ex Parte* Letter.

[282] 5G Americas Comments at 15, AT&T Comments at 15-16, Intel Comments at 7-8, T-Mobile Comments at 13, Verizon Comments at 6-7.

[283] Letter from Paige R. Atkins, Associate Administrator, Office of Spectrum Management, NTIA, dated July 12, 2016, to Mr. Julius Knapp, Chief, Office of Engineering and Technology, FCC (*2016 NTIA Letter*).

[284] *2016 NTIA Letter* at 4.

[285] 5G Americas Comments at 14, AT&T Comments at 16, CTA Comments at 10-11, CTIA Comments at 11, Ericsson Comments at 7, Intel Comments at 13-14, ITIC Comments at 5, Mobile Future Comments at 11-12, NCTA Comments at 13-14, Nokia Comments at 16, PCIA Comments at 10-11, Qualcomm Comments at 8, Samsung Comments at 13, TIA Comments at 18-19, T-Mobile Comments at 12, Verizon Comments at 6.

[286] Intel Comments at 14-15.

[287] SIA Comments at 17-18.

113. We adopt a modified version of the alternative proposal as follows: we will create a band plan with a 600 megahertz shared block in 37-37.6 GHz and a geographically-licensed portion in 37.6-38.6 GHz. The lower band segment will be fully available for use by both Federal and non-Federal users on a coordinated co-equal basis. Non-Federal users, which we will identify as Shared Access Licensees (SAL), will be authorized by rule. Federal and non-Federal users will access the band through a coordination mechanism, including exploration of potential dynamic sharing through technology in the lower 600 megahertz, which we will more fully develop through the *FNPRM* and through government/industry collaboration. We envision this segment serving as a proving ground for Federal and non-Federal sharing in the mmW bands, as a way to facilitate expanded Federal use in the band, an opportunity to facilitate lower-cost access to mmW bands, and a means for all providers to gain additional capacity where and when it is needed.

114. As described below, we adopt the same technical rules for the shared band segment as we do for the rest of the 37 GHz band.[288] These technical rules are also consistent with the 39 GHz band. We also adopt an operability requirement that will ensure equipment developed for the 37 and 39 GHz bands is able to operate across the entire 37-40 GHz band.[289] This will help drive scale in the development and access to the equipment, and allow users in the shared portion of the band, including Federal users, to benefit. In order to ensure a sharing environment in 37-37.6 GHz that is predictable, manageable, and efficient, we strongly encourage Federal users to comply with the same technical rules, and will work with NTIA to explore establishment of guidance in its regulations.

115. Following the adoption of this *Report and Order*, the Wireless Bureau and Office of Engineering and Technology will, in collaboration with NTIA and Federal stakeholders, work with industry stakeholders and other interested parties to further define the sharing framework. We will hold one or more public meetings to examine the state of innovative sharing techniques and technologies and to have an open dialogue about how sharing can best be implemented and achieved in the 37-37.6 GHz band. We strongly encourage both industry and Federal stakeholders to use new and existing experimental testbeds to develop sharing approaches and technologies. Based on stakeholder feedback, the Wireless Bureau and the Office of Engineering and Technology may, jointly with NTIA, issue a public notice seeking comment on a refined and detailed 37 GHz sharing framework. In response to the record developed, the Commission, jointly with NTIA, will establish the 37 GHz sharing mechanism. We believe this inclusive and collaborative process ensures that all parties' needs are met and that an effective and robust sharing mechanism will be developed.

116. In the upper band segment (37.6-38.6 GHz), we will use geographic area licensing with PEAs as the licensing unit, which is consistent with the licenses in the 39 GHz band. In this band, there will be Federal co-primary use coordination zones around 14 military sites where the military will have the right to operate fixed and mobile operations, and the three Space Research Service sites as described below.[290] Non-Federal users will be able to access these locations through a coordination mechanism that will be developed and established by WTB and OET in conjunction with NTIA and announced via Public Notice. We also recognize that there are existing Federal and non-Federal fixed and mobile allocations in the upper band segment, and in the *FNPRM*, we seek comment on developing additional criteria under which Federal users can obtain access to the upper band segment.[291]

117. We believe licensing the 37 GHz band in this manner has many benefits. In the lower band segment, we are creating an innovative shared space that can be used by a wide variety of Federal and non-Federal users. SALs will be widely available to provide easy access to spectrum, including for

[288] *See infra* Section IV.G (Technical Rules).

[289] *See infra* Section IV.G.5 (Operability).

[290] *See infra* Section IV.E.2 (Federal Sharing Issues, 37-38.6 GHz).

[291] *See infra* Section V.B.7 (Use It or Share It and Federal Sharing in the Upper Band Segment).

new innovative uses and for targeted access where and when providers need additional capacity. It will help further efforts to facilitate sharing between Federal and non-Federal users, and will give Federal users and consumers an opportunity to take advantage of speed-to-market and lower cost of broadly deployed commercial technologies, and provide Federal users opportunities for current use and future growth. In the upper band segment, we note that the 37 GHz band and the 39 GHz band will be licensed under the same framework, with identical technical and licensing rules. They will both be licensed by PEAs, which will allow licensees in the 37 GHz and 39 GHz bands to aggregate blocks of spectrum or to pair blocks of spectrum.

118. Below, we discuss in further detail some of the decisions we have made concerning the 37 GHz band. In the *FNPRM*, we seek comment on refining the sharing framework we are adopting today.[292]

3. License Area Size

119. *Background*. In the *NPRM*, we proposed to use counties as the base geographic area unit for licenses in the 37 GHz band and gave four reasons for doing so.[293] First, the Commission explained that because 37 GHz signals do not propagate well over long distances, when it is used for mobile applications coverage will be measured in meters, not kilometers.[294] Second, the Commission further explained that small license areas could provide licensees with additional flexibility to target their deployments where they need capacity.[295] Third, smaller license areas reduce the potential for warehousing spectrum. Fourth, county based licenses could equally facilitate access by both small carriers and large carriers.[296]

120. Unlike in the 28 GHz and 39 GHz bands, there are no incumbent non-Federal licensees in the 37 GHz band. Therefore, we do not need to take incumbent licensees into account in setting a license area size.

121. *Discussion.* We are presented with a unique opportunity to adopt a licensing scheme that will apply to 2,400 megahertz of contiguous spectrum, the upper segment from 37.6-38.6 GHz together with the 38.6-40 GHz band. In the shared band segment, we will authorize fixed and mobile users on a site-based coordinated basis. We believe this approach will allow users to access spectrum where and when it is needed, which will help maximize spectrum by providing opportunities for each user to target just the areas it needs. As discussed above, we are licensing the 39 GHz band by PEA. Our reasons for adopting PEAs as the geographic area for the 39 GHz band apply here as well.[297] Specifically, as we noted with respect to the 39 GHz band, after reviewing the record, we now believe that PEAs strike the appropriate balance between facilitating access to spectrum by both large and small providers and simplifying frequency coordination while incentivizing investment in, and rapid deployment of, new technologies.[298] Thus, we adopt the same geographic license structure for both the upper band segment of the 37 GHz band and the 39 GHz band. This decision will give licensees the flexibility that they need and will encourage investment in a wide variety of services and technologies.

[292] *See infra* Section V.B (Federal Sharing Issues—37-38.6 GHz Band (37 GHz band)).

[293] *NPRM*, 30 FCC Rcd at 11912, paras. 110-111.

[294] *NPRM*, 30 FCC Rcd at 11912, para. 111.

[295] *NPRM*, 30 FCC Rcd at 11912, para. 111.

[296] *NPRM*, 30 FCC Rcd at 11912, para. 111.

[297] *See supra* Section IV.B.2 (Licensing the 39 GHz band).

[298] *See* para. 82, *supra*.

4. Band Plan for Upper Band Segment

122. *Background*. In the *NPRM*, the Commission sought comment on two possible channelization plans.[299] Under the first possibility, the 37 GHz band would be divided into three equal blocks of 533 megahertz.[300] Under the second possibility the band would be divided into four blocks of 400 megahertz each.[301] Commenters generally recommend that the Commission establish large blocks, with a minimum block size of 200 megahertz.[302] As mentioned above, several commenters recommend that the Commission combine the 37 GHz and 39 GHz bands under one licensing framework.[303]

123. *Discussion.* We will divide the upper band segment into five blocks of 200 megahertz each for non-Federal users. As explained in this *Report and Order*, we are attempting to create a consistent and coherent licensing framework that can be applied throughout the mmW bands, with modifications based on the characteristics of a particular band. Our decision to choose 200 megahertz channels rather than 533 megahertz channels also stems, in part, from our previous decision to create two licensing segments for the 37 GHz band: a 600 megahertz lower band segment licensed by rule, and a 1,000 megahertz upper segment, which will be licensed geographically by PEA. Adopting 200 megahertz channel sizes for the upper band segment is consistent with the 200 megahertz channels we adopt for the 39 GHz band. Because we license the upper band segment of the 37 GHz band and the 39 GHz band by PEA, licensees will have the flexibility to pair their 37 GHz license with a 39 GHz license.

124. In addition, the provision of fixed and mobile terrestrial operations at this frequency will depend upon large blocks of spectrum and a single 200 megahertz block provides a sufficient amount of spectrum for the provision of high-capacity wireless broadband. Those licensees needing more spectrum than a 200 megahertz channel can combine channels to create contiguous blocks of 200 megahertz channels, either within the 37 GHz band or by combining 37 GHz spectrum with 39 GHz spectrum. Licensees also have the option of acquiring 425 megahertz channels in the 28 GHz band.

D. 64-71 GHz Band

125. We are making available the 64-71 GHz frequency band for use by unlicensed devices pursuant to the same technical standards as in the 57-64 GHz frequency band under Section 15.255 of our rules, with slight modifications.[304] As the Commission has consistently stated, it is optimal to include a balance of licensed rights and opportunities to operate on an unlicensed basis in order to meet the country's wireless broadband needs. Our action here creates a 14-gigahertz segment of contiguous spectrum in these frequency bands to encourage the development of new and innovative unlicensed applications, and promote next-generation high-speed wireless links with higher connectivity and

[299] *NPRM*, 30 FCC Rcd at 11914-15, para. 118.

[300] *NPRM*, 30 FCC Rcd at 11914-15, para. 118.

[301] *NPRM*, 30 FCC Rcd at 11914-15, para. 118.

[302] 5G Americas Comments at 14 (supporting 200 megahertz channels), CTA Comments at 12-13 (supporting 200 megahertz channels), CTIA Comments at 22 (supporting 200 megahertz channels), Huawei Comments at 19 (supporting 400 megahertz channels), Nokia Comments at 21-22 (supporting 400 megahertz channels), Samsung Comments at 14 (supporting 200 megahertz channels), TIA Comments at 29-30 (supporting 200 megahertz channels).

[303] 5G Americas Comments at 15, AT&T Comments at 15-16, Intel Comments at 7-8, T-Mobile Comments at 13, Verizon Comments at 6-7.

[304] 47 CFR § 15.255.

throughput, while alleviating spectrum congestion from carrier networks by enabling mobile data off-loading[305] through Wi-Fi and other unlicensed connections.[306]

126. *Background.* In the *NPRM*, the Commission proposed to amend its rules to allow unlicensed Part 15 operations in the 64-71 GHz band.[307] Part 15 of the Commission's regulations permits the operation of radio frequency (RF) devices without an individual license from the Commission or the need for frequency coordination.[308] The technical standards contained in Part 15 are designed to ensure that there is a low probability that such devices will cause harmful interference to other users of the radio spectrum.[309] Unlicensed operations within the 57-64 GHz band are currently permitted under Section 15.255 of our rules.[310] Any type of unlicensed operation within the 57-64 GHz band is permitted under these rules, with the exception of operation on-board aircraft or satellites, and in mobile field disturbance sensor applications.[311]

127. Several commenters support the Commission's proposal and recommend that the Commission proceed expeditiously to extend the provisions of Section 15.255 to cover 57 GHz to 71 GHz.[312] These parties argue that the way consumers use wireless devices today creates a disproportionate demand on unlicensed wireless capacity, and that most of the Internet traffic today – which drives wireless demand – originates and/or ends using unlicensed devices.[313]

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[305] Mobile data offloading is the use of complementary network technologies for delivering data originally targeted for cellular networks to reduce the amount of data being carried on the cellular bands, freeing bandwidth or allowing users to obtain better connectivity via wired services in situations where local cell reception may be poor.

[306] *See* Cisco, *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2015–2020 White Paper* (Feb. 1, 2016), *available at* http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html ("Fifty-one percent of total mobile data traffic was offloaded onto the fixed network through Wi-Fi or femtocell in 2015.")

[307] *NPRM*, 30 FCC Rcd at 11965, para. 303.

[308] 47 CFR §§ 15.1 *et seq*.

[309] The primary operating conditions under Part 15 are that the operator of a Part 15 device must accept whatever interference is received and must correct whatever harmful interference is caused. Should harmful interference occur, the operator is required to immediately correct the interference problem, even if correction of the problem requires ceasing operation of the Part 15 equipment causing interference. *See* 47 CFR § 15.5.

[310] 47 CFR § 15.255. *See Amendment of Parts 2, 15, and 97 of the Commission's Rules to Permit Use of Frequencies Above 40 GHz for New Radio Applications,* First Report and Order and Second Notice of Proposed Rulemaking, 11 FCC Rcd 4481 (1995) (*Above 40 GHz First Report and Order and Second FNPRM*); *Memorandum Opinion and Order and Fourth Notice of Proposed Rule Making*, 12 FCC Rcd 12212 (1997) (*Above 40 GHz MO&O and Fourth NPRM*); *Third Report and Order,* 13 FCC Rcd 15074 (1998); *Amendment of Part 2 of the Commission's Rules to Allocate Additional Spectrum to the Inter-Satellite, Fixed, and Mobile Services and to Permit Unlicensed Devices to Use Certain Segments in the 50.2-50.4 GHz and 51.4-71.0 GHz Bands*, Report and Order, 15 FCC Rcd 25264 (2000); *Revision of Part 15 of the Commission's Rules Regarding Operation in the 57-64 GHz Band*, Report and Order, 28 FCC Rcd 12517 (2013).

[311] 47 CFR § 15.3(l) defines a field disturbance sensor as "a device that establishes a radio frequency field in its vicinity and detects changes in that field resulting from the movement of persons or objects within its range." Examples of field disturbance sensors include radars operating under 47 CFR §§ 15.252 or 15.256; and perimeter protection systems operating under 47 CFR §§ 15.209(g) or 15.229.

[312] *See, e.g.*, Boeing Comments at 11, CTA Comments at 8, DSA Comments at 2, Facebook Comments at 5, FWCC Comments at 3, Google Comments at 6, Intel Comments at 17, Microsoft Comments at 5, NCTA Comments at 3, OTI and Public Knowledge Comments at 27, Qualcomm Comments at 14, Straight Path Comments at 6, ViaSat Comments at 21-22, Vubiq Networks Comments at 3, Wi-Fi Alliance Comments at 5.

[313] *See e.g.*, NCTA Comments at 3-5; Wi-Fi Alliance Reply at 4.

128. Additionally, among the proponents of unlicensed operations, Microsoft, New America Open Technology Institute & Public Knowledge (OTI & PK) and the Information Technology Industry Council (ITIC) (hereinafter Microsoft *et al*) request extending the band even further, to 72.5 GHz rather than just to 71.0 GHz, in order to make the most efficient use of the spectrum, given the IEEE standard[314] for channel size and ITU-R[315] recommended channel plan.[316] These parties argue that extending the band will provide seven non-overlapping channels of 2.16 gigahertz instead of six as proposed. Microsoft further requests that the Commission allow indoor Part 15 operations between 72.5 GHz and 76 GHz because it will not conflict with the lightly-licensed outdoor use.[317] The Wi-Fi Alliance and the Dynamic Spectrum Alliance (DSA) also recommend that the Commission maximize the available spectrum for unlicensed uses by opening up the 71-76 GHz, 81-86 GHz, and 92-95 GHz bands to both indoor and outdoor unlicensed operations.[318] In contrast, the Fixed Wireless Communications Coalition (FWCC) strongly opposes these requests, contending that mobile or unlicensed operation at 71-76/81-86 GHz would threaten interference to the many thousands of fixed links in these bands.[319]

129. On the other hand, a number of commenters disagree with the Commission's proposal, suggesting instead that the Commission provide only the 64-66 GHz band for unlicensed operations and reserving the 66-71 GHz band for licensed use.[320] These parties argue that the 66-76 GHz band has been selected to be studied for globally harmonized services, based on the recommendations of World Radio Conference (WRC) 2015 for international mobile telecommunication (IMT) 2020 services, and that the Commission should license this spectrum for exclusive use to be consistent with international efforts.[321] These parties also contend that there is a great imbalance in the Commission's proposals for licensed and unlicensed uses of the mmW spectrum because only 3.85 gigahertz of spectrum is proposed to be made available for licensed services while 14 gigahertz of spectrum (in the 57-71 GHz band) would be accessible for unlicensed uses.[322]

130. *Discussion.* We are adopting rules to allow for unlicensed operations in the 64-71 GHz band, subject to the technical standards in Section 15.255, thus creating a contiguous spectrum segment

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[314] *See* Institute of Electrical and Electronics Engineers, *Standard 802.11ad-2012, IEEE Standard for Information technology - Telecommunications and information exchange between systems--Local and metropolitan area networks--Specific requirements-Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, Amendment 3: Enhancements for Very High Throughput in the 60 GHz Band* (https://standards.ieee.org/findstds/standard/802.11ad-2012.html).

[315] *See* International Telecommunication Union, Radiocommunication Sector, Report M.2227 *Multiple Gigabit Wireless Systems in frequencies around 60 GHz* (2011) (ITU-R Report M.2227) (http://www.itu.int/pub/R-REP-M.2227).

[316] ITIC Comments at 7, Microsoft Comments at 5-7, OTI and Public Knowledge Commentsat 29, DSA Reply at 3, Qualcomm Reply at 2, ZII Reply at 2.

[317] Microsoft Comments at 18, Microsoft Reply at 10-11.

[318] Wi-Fi Alliance Comments at 9-10, DSA Comments at 1.

[319] FWCC Reply at 9. FWCC also indicates that there are pending rulemaking and waiver requests in these bands. *See Wireless Telecommunications Bureau Seeks Comment on Requests of Aviat Networks and CBF Networks, Inc. D/B/A Fastback Networks for Waiver of Certain Antenna Requirements in the 71-76 and 81-86 GHz Bands*, Public Notice, 30 FCC Rcd 10961 (2015).

[320] *See e.g.*, AT&T Comments at 17, CTIA Comments at 17-19, Ericsson Comments at 19-20, Giganets Comments at 2, Mobile Future Comments at 16-17, Nokia Comments at 17-18, T-Mobile Comments at -1415, Verizon Comments at 13.

[321] AT&T Comments at 17, Huawei Comments at 19-20, Nokia Comments at 4, T-Mobile Comments at 14-15.

[322] CTIA Comments at 17-19, Verizon Comments at 13. In reality, in this proceeding, we are only making available 7 gigahertz of spectrum for unlicensed use in the 64-71 GHz band; unlicensed operations in the 57-64 GHz adjacent band is already permitted in Section 15.255 of the rules.

with the 57-64 GHz band. We observe that unlicensed WiGig devices using the 57-64 GHz band are just beginning to be marketed and these products are standardized pursuant to an internationally harmonized channelization scheme,[323] which should promote their growth and usage.[324] Making available additional spectrum contiguous to the existing 57-64 GHz band may enable higher throughputs and enhanced use of present spectrum, as well as to permit an increase in the number of simultaneous high-bandwidth users. We agree with Intel that a lesser amount of spectrum would limit the growth potential of 60 GHz applications.[325] We also agree with the WISPA that "because ITU may study a band is an insufficient reason for the Commission to delay making a valuable spectrum resource available for unlicensed use."[326] We acknowledge that eventual harmonization with international requirements will benefit consumers by promoting a global marketplace and enhancing the international competitiveness of U.S. manufacturers. However, notwithstanding a desire for harmonization with international standards, we determine to make these frequencies available for unlicensed use based on our analysis of U.S.-specific factors. Here, we determine that we should not wait for the outcome of the ITU study of this band, contrary to what T-Mobile advocates,[327] because that could take years, leaving 5 gigahertz of spectrum to lie fallow in the meantime, when unlicensed applications are ready in the very near future to make use of this spectrum, given current planned deployments of WiGig products in the adjacent 57-64 GHz band.[328] In addition, we note that spectrum characteristics vary at different frequencies, due to different propagation losses and other atmospheric and sharing conditions, thus a strict linear comparison per frequency unit of spectrum amount in different frequency bands as "gigahertz parity" (e.g., 3.85 gigahertz of spectrum in lower bands vs. 14 gigahertz of spectrum in upper bands) is not a valid comparison. Based on the above, we are permitting use of the 57-71 GHz band by unlicensed devices pursuant to the technical rules in Section 15.255, as amended today.

131. With respect to the additional requests from Microsoft *et al* to extend the band up to 72.5 GHz, and to allow indoor use of the 72.5-76 GHz band by unlicensed devices,[329] we do not find that additional spectrum above and beyond the very large 14-gigahertz of contiguous spectrum in the 57-71 GHz band that we are providing for unlicensed operations herein is warranted at this time, due to the presence of the numerous existing fixed links in the 71-76/81-86 GHz bands.[330] When the Commission adopted rules for licensed operations in these bands in 2003, it did not permit unlicensed

[323] *See* notes 303-04, *supra*.

[324] *See* Wi-Fi Alliance, *Wi-Fi Certified WiGig,* http://www.wi-fi.org/discover-wi-fi/wigig-certified. WiGig products certified by the Wi-Fi Alliance operate over unlicensed spectrum in the 60 GHz band and are designed to deliver multi-gigabit speeds, low latency, and security-protected connectivity between nearby devices. *See also*, 60-GHz standards at notes 303-04, *supra*.

[325] Intel Comments at 17-18.

[326] WISPA Reply at 9.

[327] T-Mobile Comments at 14-15.

[328] We also note that the "study" of a frequency band by the ITU does not mean necessarily that the band will be automatically designated for licensed use, because licensing of spectrum is deferred to "the sovereign right of each State to regulate its telecommunication". *See* International Telecommunication Union, *Constitution and Convention* (http://www.itu.int/en/history/Pages/ConstitutionAndConvention.aspx).

[329] ITIC Comments at 7, Microsoft Comments at 18, OTI and Public Knowledge Comments at 29.

[330] *See* FWCC Reply at 9. For example, as of June 17, 2016, there were 407 active non-exclusive nationwide licenses for fixed service in the 71-76 GHz band with 12,994 coordinated, registered point-to-point links. *See* the Commission's Universal Licensing System database under the Millimeter Wave 70/80/90 GHz Service, available at Federal Communications Commission, *License Search*, http://wireless2.fcc.gov/UlsApp/UlsSearch/searchLicense.jsp. All links are registered with third party database managers. The public can obtain information about registered links through the Third Party Database System. *See* http://wireless.fcc.gov/services/index.htm?job=licensing_4&id=millimeter_wave.

sharing of these bands because "an underlay of unlicensed devices in the bands could detrimentally affect the quality and buildout of service."[331] In addition, the fixed point-to-point equipment that has been developed for deployment in the 71-76 GHz and 81-86 GHz bands were not engineered to operate in a Part 15 unlicensed environment. Subsequently, in 2014, the Commission adopted Part 15 rules[332] to permit a special type of unlicensed device, level probing radars (LPR), to share the 75-85 GHz band; these devices, however, must be operated in a vertically downward position at fixed locations with severe limitations on antenna beamwidth.[333] In contrast, the 5G unlicensed transmitters envisioned here would be both mobile and fixed and would not have such limitations. We find that parties requesting to extend the band beyond 71 GHz for unlicensed operation did not submit any persuasive technical arguments to prove that unlicensed sharing with the 71-76/81-86 GHz licensed services is feasible at this time. Accordingly, we deny these requests at this time. However, we are seeking further information on this topic in the *FNPRM*. Specifically, we request comments on unlicensed use of this spectrum indoors and we invite parties to submit additional information, studies and technical data concerning this issue.[334]

E. Federal Sharing Issues

132. Many bands above 24 GHz have Federal allocations on a primary basis. As we continue to increase flexibility in the non-Federal use of these bands, we must consider appropriate mechanisms and tools to share these bands that recognize the co-primary rights in these bands. In this *Report and Order*, we facilitate sharing in the 39.5-40 GHz band and 37-38.6 GHz band, including through new sharing schemes that promote dynamic and flexible access in the 37-37.6 GHz band. We also continue to explore sharing requirements in many bands in the *FNPRM*. In order to continue to evolve spectrum access and sharing regimes that meet both Federal and non-Federal needs, it will be imperative for all stakeholders, including wireless and satellite industries, to engage proactively to help shape these solutions.

1. 39.5-40 GHz

133. *Background*. The 39.5-40 GHz portion of the 39 GHz band is allocated to the Federal FSS and MSS a primary basis, limited to space-to-Earth (downlink) operations.[335] However, Federal MSS earth stations in this band may not claim protection from non-Federal fixed and mobile stations in this band.[336]

134. In the *NPRM*, the Commission explained that when the *39 GHz Report and Order* was adopted, Federal use of the band was limited to military systems in the 39.5-40 GHz band segment, that the Department of Defense (DoD) stated that it had plans to implement satellite downlinks at 39.5-40 GHz in the future, and that the National Aeronautics and Space Administration (NASA) identified 39.5-40 GHz as a possible space research band to accommodate future Earth-to-space wideband data requirements.[337] The *39 GHz Report and Order* expressed optimism that such plans would not affect the continued development of the 39 GHz band for non-Federal use, but the Commission said that it intended to address those interference issues in a future, separate proceeding that would focus on developing inter-

[331] *See Allocations and Service Rules for the 71-76 GHz, 81-86 GHz and 92-95 GHz Bands*, Report and Order, 18 FCC Rcd 23318, 23336, para. 41 (2003).

[332] 47 CFR § 15.256.

[333] *Amendment of Part 15 of the Commission's Rules To Establish Regulations for Level Probing Radars and Tank Level Probing Radars in the Frequency Bands 5.925-7.250 GHz, 24.05-29.00 GHz and 75-85 GHz*, Report and Order, 29 FCC Rcd 761 (2014).

[334] *See* Section V.A.7 (70/80 GHz Bands (71-76 GHz and 81-86 GHz)), *infra*.

[335] 47 CFR § 2.106.

[336] 47 CFR § 2.106 n.US382.

[337] *NPRM*, 30 FCC Rcd at 11928, para. 168 *citing 39 GHz Report and Order*, 12 FCC Rcd at 18615, para. 25.

licensee and inter-service standards and criteria.[338] At present, the U.S. Table of Frequency Allocations provides that Federal satellite services in the 39.5-40 GHz band are limited to military systems.[339]

135. Although only four commenters responded to our questions on these issues, all four agreed that it is possible for Federal and non-Federal operations to share the 39 GHz band. They also agreed that the Commission should adopt coordination zones to mitigate interference between Federal and non-Federal operations. For instance, AT&T argues that the Commission should adopt coordination zones rather than novel spectrum sharing techniques because coordination zones balance the twin goals of efficient spectrum utilization and the prevention of harmful interference to incumbents.[340] Intel argues that portions of the band that are strictly Federal use could be separated from those for commercial use.[341] Cisco states that while coordination will have to be done by the Commission staff and their counterparts at NTIA, co-existence is achievable.[342] Finally, Nokia argues that the Commission should continue work with NTIA and other Federal agencies to minimize Federal coordination zones, which would maximize the value of the spectrum.[343]

136. In 2016, NTIA sent a letter to the Commission addressing issues raised in the *NPRM*, regarding, in part, military operations in the 39.5-40 GHz portion of the 38.6-40 GHz band.[344] NTIA explained that the 39.5-40 GHz band is allocated to military mobile-satellite service (MSS) and fixed-satellite service (FSS) earth stations.[345] Federal MSS earth stations cannot claim protection from non-Federal fixed and mobile stations as specified in footnote US382 of the table of frequency allocations.[346] However, Federal earth stations in the MSS are not required to protect non-Federal fixed and mobile services.[347] NTIA stated that given the existing regulatory constraints in the 39.5-40 GHz band, the *NPRM's* proposed non-Federal fixed and mobile operations will not impact Federal satellite operations in the 39.5-40 GHz band.[348]

137. *Discussion*. We conclude that it is possible for Federal operations to share the band with non-Federal fixed and mobile terrestrial operations because the protections offered by footnote US382 are sufficient to protect both Federal and non-Federal operations in this band.[349] Thus, no changes to our rules are necessary.

2. 37-38.6 GHz

138. *Background*. Developing flexible licensing rules for the 37 GHz band is challenging, in part, because the 37-38.6 GHz band is also allocated for primary Federal use, and thus, the band must be shared between Federal and non-Federal operations. The 37 GHz band is allocated to the Federal fixed

[338] *NPRM*, 30 FCC Rcd at 11928, para. 168 *citing 39 GHz Report and Order*, 12 FCC Rcd at 18615, para. 25.

[339] *NPRM*, 30 FCC Rcd at 11928, para. 168 *citing* 47 CFR § 2.106 n.G117.

[340] AT&T Comments at 3-4, 15. Within a coordination zone, licensees would be permitted to provide service to the extent that they have successfully coordinated operations with a Federal incumbent. AT&T Comments at 15.

[341] Intel Comments at 11.

[342] Cisco Comments at 6-7.

[343] Nokia Comments at 25.

[344] *2016 NTIA Letter*.

[345] *2016 NTIA Letter* at 5.

[346] *2016 NTIA Letter* at 5.

[347] *2016 NTIA Letter* at 5.

[348] *2016 NTIA Letter* at 4-5.

[349] *See* 47 CFR § 2.106 n.US382.

and mobile services, and the 37-38 GHz portion of the band is also allocated to the Federal space research service (SRS), limited to space-to-Earth (downlink) operations.[350]

139. The Commission explained that there are a number of Federal sites that utilize the 37-38.6 GHz band. In 2004, NTIA identified the following NASA receiving earth stations in the Space Research Service (SRS): Goldstone, California; Guam, Pacific Ocean; Merritt Island, Florida; Wallops Island, Virginia; and White Sands, New Mexico.[351] NTIA subsequently identified the NASA receiving earth station at Blossom Point, Maryland.[352] NTIA also identified Green Bank, West Virginia; and Socorro, New Mexico, which the National Science Foundation (NSF) cites as supporting its Very Long Baseline Interferometry (VLBI) earth station operations. The Commission further explained that NTIA recommended in 2004 that coordination with Federal operations should be performed within the Interdepartment Radio Advisory Committee (IRAC) process.[353] NTIA noted the importance of the 37-38 GHz band to support a permanent manned presence in earth orbit (on or near the moon), to initiate manned exploration of Mars, and to support VLBI by satellite.[354] In addition, NTIA identified 14 military sites in the 37-38.6 GHz band that require protection.[355]

140. In 2006, NTIA sent a follow-up letter to the FCC reaffirming the need to protect NASA, NSF, and military operations from non-Federal terrestrial and FSS operations in the 37-38 GHz band.[356] NTIA requested Federal operations be protected by establishing a footnote to the U.S. Table of Frequency Allocations specifying the Federal sites and the coordination areas.[357] NTIA also recommended that because of the potential for interference from airborne systems, the aeronautical mobile service allocation should be deleted from the 37-38 GHz band.[358]

141. In 2016, NTIA sent a letter to the Commission addressing issues raised in the *NPRM*, regarding, in part, protection of Federal space research operations in the 37-38.6 GHz band and the 14 military sites in the 37-38.6 GHz band that it originally identified in its 2004 letter.[359]

142. With regard to the protection of Federal space research operations, NTIA states that it identified a number of NASA and National Science Foundation (NSF) earth station receive locations that would likely be subject to protection and coordination if the Commission authorized non-Federal fixed and mobile operations in the 37-38.6 GHz band.[360] NTIA further states that the 37-38.6 GHz band is important to support U.S. goals to provide permanent manned presence in Earth's orbit (on or near the

[350] *NPRM*, 30 FCC Rcd at 11928, para. 170.

[351] *NPRM*, 30 FCC Rcd at 11896-11897, para. 48. *See* Letter from Fredrick R. Wentland, Associate Administrator, Office of Spectrum Management, NTIA, dated March 24, 2004, to Mr. Edmond J. Thomas, Chief, Office of Engineering and Technology, FCC.

[352] *NPRM*, 30 FCC Rcd at 11896-11897 para. 48. *See* Letter from Karl B. Nebbia, Associate Administrator, Office of Spectrum Management, to Julius Knapp, Chief, Office of Engineering and Technology, *Re: Notification of Pending Status of Tracking and Data Relay Satellite System (TDRSS) Earth Station* (Mar. 20, 2014).

[353] *NPRM*, 30 FCC Rcd at 11896-11897, para. 48.

[354] *NPRM*, 30 FCC Rcd at 11896-11897, para. 48.

[355] *NPRM*, 30 FCC Rcd at 11896-11897, para. 48.

[356] *NPRM*, 30 FCC Rcd at 11896-11897, para. 48. *See* Letter from Fredrick R. Wentland, Associate Administrator, Office of Spectrum Management, NTIA, dated Sept. 13, 2006, to Mr. Julius Knapp, Chief, Office of Engineering and Technology, FCC.

[357] *NPRM*, 30 FCC Rcd at 11896-11897, para. 48.

[358] *NPRM*, 30 FCC Rcd at 11896-11897, para. 48.

[359] *2016 NTIA Letter*. For a list of the 14 military sites see *2004 NTIA* Letter at Enclosure 2.

[360] *2016 NTIA Letter* at 3.

moon), initiate manned exploration of the planet Mars, and support data return links to the very long baseline interferometer.[361] NTIA also states that after consultation with NASA and NSF, it has determined that only three sites would need specific protection and coordination in connection with this proceeding: the NASA Deep Space Communications Complex in Goldstone, California; the NASA Tracking Station in White Sands, New Mexico; and the National Radio Astronomy Observatory in Socorro, New Mexico.[362] NTIA also provides the coordination areas for the Goldstone, White Sands, and Socorro sites,[363] and requests that the Commission require all fixed and mobile stations operating in the 37-38.6 GHz band located within the geographic areas listed in Enclosure 2 to its 2016 letter be coordinated with NTIA.[364] NTIA states that operation within the coordination areas will be possible if the non-federal proponent shows NTIA that its deployment can adequately protect the earth stations.[365] NTIA states that it, in coordination with NASA, NSF, and the Commission, may conduct additional analysis and testing to determine the extent to which the recommended coordination areas in Enclosure 2 can be reduced.[366]

143. With regard to the NSF Green Bank, WV site, NTIA noted that it is within an existing Quiet Zone in which any fixed or mobile stations operating in the 37-38.6 GHz band are subject to the requirements set forth in Section 1.924(a) of the Commission's rules.[367]

144. With regard to the 14 military sites that it originally identified in its 2004 letter,[368] NTIA states that after consultation with DoD, it has determined that these 14 sites, which are listed in Enclosure 3, are still representative of where the military plans to operate systems consistent with the current allocation.[369] To protect DoD operations, NTIA recommends that non-Federal fixed and mobile stations operating in the 37-38.6 GHz band within the geographic areas listed in Enclosure 3 to its 2016 letter be coordinated with NTIA.[370] NTIA notes that operation within the coordination areas is possible if the non-Federal proponent can show NTIA that its proposed deployment can adequately protect the existing and planned DoD operations.[371]

145. As discussed above, NTIA recommends that the FCC adopt a modified version of their Alternative Proposal in the Spectrum Frontiers NPRM, creating a band plan with a 600 megahertz shared block in the 37-37.6 GHz band. NTIA notes that this 600 megahertz band segment will be fully available for use by Federal and non-Federal users on a coordinated co-equal basis outside of the coordination zones until improved coordination mechanisms are developed.[372] NTIA states that Federal and non-Federal users will access the band through a coordination mechanism, including exploration of potential dynamic sharing through technology in the lower 600 megahertz that can be developed through a process with Federal and industry collaboration.[373] In the 37.6-38.6 GHz band segment, NTIA recommends

[361] *2016 NTIA Letter* at 3.

[362] *2016 NTIA Letter* at 3-4.

[363] *2016 NTIA Letter* at Enclosure 2.

[364] *2016 NTIA Letter* at 4.

[365] *2016 NTIA Letter* at 4.

[366] *2016 NTIA Letter* at 4.

[367] 2016 NTIA Letter at 4,n.12 *citing* 49 CFR § 1.924(a)(1).

[368] *2004 NTIA* Letter at Enclosure 2.

[369] *2016 NTIA Letter* at 5.

[370] *2016 NTIA Letter* at 5 and Enclosure 2.

[371] *2016 NTIA Letter* at 6.

[372] *2016 NTIA Letter* at 4.

[373] *2016 NTIA Letter* at 4.

Federal co-primary use coordination zones around the 14 military installations where the Federal agencies will have the right to operate fixed and mobile operations and the three SRS sites will be protected from interference.[374] NTIA states that it will work with the Commission to develop and establish a coordination process that can allow non-Federal users to access these locations.[375]

146. In response to the *NPRM*, the National Academy of Sciences' Committee on Radio Frequency (CORF) indicated that because DoD's existing weather satellites will continue to use the 37-37.5 GHz band until at least 2020,[376] the Commission should coordinate the rollout of any new 37-37.5 GHz regulations with DoD.[377]

147. CTIA recommends that the Commission can best balance the needs of Federal and commercial users by adopting stringent, but small, coordination zones.[378] CTIA argues that the adoption of overly conservative coordination zones will inhibit the value of licensed spectrum rights and diminish the investment incentives and certainty associate with those rights.[379] CTIA also recommends that the Commission consider deferring consideration of bi-directional sharing issues until NTIA's Commerce Spectrum Managements Advisory's subcommittee makes a recommendation on that issue sometime in 2016.[380] Mobile Future urges the Commission work with NTIA to ensure that commercial users are able to fully utilize their spectrum holdings at all times in a manner that meets the needs of their customers.[381]

148. *Discussion.* We conclude that non-Federal fixed and mobile operations can share the 37-38 GHz band with SRS downlink operations under certain conditions. First, as a result of discussions between NTIA and the Commission, NTIA indicated that it would request protection for only three SRS earth station sites: Goldstone, California; White Sands, New Mexico; and Socorro, New Mexico. Second, to address NTIA's recommendations, we will establish coordination zones for these three sites by adding a footnote to the US Table of Allocations listing the locations to be protected and their respective coordination zones.[382] Third, with respect to operations, at Green Bank, West Virginia, NTIA indicated that since Green Bank, West Virginia is located in an existing quiet zone, any new or modified stations including in the fixed and mobile services, within the zone are required by § 1.924(a) of the Commission's rules to notify the National Radio Astronomy Observatory, and thus Green Bank would not be included in the footnote. Therefore, we adopt footnote US151, which requires that, in the 37-38 GHz band, fixed and mobile stations not cause harmful interference to Federal SRS earth station at three sites and that non-Federal applications for such use be coordinated with NTIA in accordance with new Section 30.205 of the Commission's rules.

149. We conclude that non-Federal fixed and mobile operations can share the 37-38.6 GHz band with DoD operations. With regard to Federal co-primary access to the 37 GHz band, we will adopt rules that entail the coordination zones recommended by NTIA for the 14 military sites, and the ability for

[374] *2016 NTIA Letter* at 4-5.

[375] *2016 NTIA Letter* at 5.

[376] CORF Comments at 10.

[377] CORF Comments at 7 n.2.

[378] CTIA Comments at 33.

[379] CTIA Comments at 33.

[380] CTIA Comments at 34.

[381] Mobile Future Comments at 14-15.

[382] The coordination zones are described in Appendix D – Coordination Contours for NASA and NSF sites in the 37-38.6 GHz band. The Commission and NTIA may coordinate with NASA and the NSF to conduct an additional analysis based upon the rules adopted today to determine the extent to which these coordination zones might be reduced in the future. The Wireless Telecommunications Bureau and Office of Engineering and Technology will announce any reduced protection zones via public notice.

Federal agencies to add future sites on a coordinated basis.[383] As discussed above, we will make the 37-37.6 GHz block (lower band segment) available for coordinated co-primary sharing between Federal and non-Federal users, where non-Federal rights are granted by rule.[384] This framework will facilitate access by DoD and other Federal users. In the *FNPRM*, we seek comment on defining the sharing framework in greater detail.[385] In the upper band segment, we seek comment on facilitating Federal coordination with licensees for access to licensed areas.

150. We also do not believe that it is necessary to take action to protect the weather satellites, which according to CORF, will operate above 37 GHz until at least 2020 because it will take a significant amount of time for mmW devices to be developed and deployed in the 37 GHz band. Therefore, we expect that relatively few mmW devices will be operating in the band while the weather satellites are still in use.[386]

151. Under the plan we adopt today, we enable the deployment of new commercial services while protecting Federal agency missions. This balances the needs of commercial operators with the needs of Federal agencies for protection and future growth by creating an environment where Federal and non-Federal users can share the band on a co-primary basis and providing enough certainty to future commercial users to stimulate investment in the spectrum.

3. Passive Services Below 37 GHz

152. *Background*. There are Federal and non-Federal allocations for the Earth Exploration-satellite Service (passive) and Space Research Service (passive) in the 36-37 GHz band. Also, footnote US342 specifies that all practicable steps must be taken to protect radio astronomy in the 36.43-36.5 GHz band.[387] Several other allocations around 40 GHz also permit radio astronomy use.[388]

153. The *NPRM* sought comment on whether any special protections are necessary or appropriate for passive services below 37 GHz.[389] While noting that EESS and space research operations are not entitled to interference protection from Fixed and Mobile Services,[390] the *NPRM* sought comment on whether we could take steps to protect these passive operations without unduly limiting 37 GHz band operations. Specifically, the *NPRM* asked about creating a 100 megahertz guard band at the lower end of the 37 GHz band or adopting a stricter out-of-band emission limit. The *NPRM* also sought comment on

[383] The coordination zones are described in Appendix A– Rule 30.205(b).

[384] *See supra* Section IV.C.2 (37 GHz Band (37-38.6 GHz); Licensing the 37 GHz Band).

[385] *See infra* Section V.B (Federal Sharing Issues-37-38.6 GHz band (37 GHz band)).

[386] *See* 3rd Generation Partnership Project (3GPP), *Tentative 3GPP Timeline for 5G*, http://www.3gpp.org/news-events/3gpp-news/1674-timeline 5G.

[387] 47 CFR § 2.106 n.US342.

[388] Very Large Array receivers use the frequency ranges of 26.5-40 GHz (Ka-band), and 40-50 GHz (Q-band). VLBA receivers cover 21.7-24.1 GHz and 41.0-45.0 GHz. Similarly, the Green Bank Telescope has a sensitive receiver and specialized wideband (continuum as well as spectrometric) back-ends for observations over the 26-40 GHz range.

[389] *NPRM*, 30 FCC Rcd at 11930, para. 176.

[390] The U.S. Table of Frequency Allocations footnote that specified that the EESS and space research service are not entitled to interference protection from Fixed and Mobile Services that was in effect when the *NPRM* was issued has subsequently been repealed. *Amendment of Parts 1, 2, 15, 25, 27, 74, 78, 80, 87, 90, 97, and 101 of the Commission's Rules Regarding Implementation of the Final Acts of the World Radiocommunication Conference (Geneva, 2007) (WRC-07), Other Allocation Issues, and Related Rule Updates*, Report and Order, Order, and Notice of Proposed Rulemaking, 30 FCC Rcd 4183, 4232-33, para. 135 (2015).

whether any special protections are needed to protect radio astronomy operations in the 36.43-36.5 GHz band.[391]

154. CORF explains that the 36-37 GHz band is used for global weather forecasting and the study of ocean surface topography, ocean winds, and sea ice.[392] CORF recommends that the Commission consider a guard band greater than 100 MHz at 37 GHz to account for aggregate interference into the 36-37 GHz band.[393] According to CORF, a 100 MHz guard band will provide adequate protection from interference from a single 1 watt transmitter, but multiple interferers may require a wider guard band.[394] CORF claims that because the EESS satellites are only overhead for a short period of time, timesharing arrangements could protect EESS applications.[395] CORF also recommends protecting radio astronomy at three sites by exclusion or coordination of transmitters within 30 kilometers of line-of-sight of these locations and by adopting limits on spurious emissions and/or exclusions zones to meet ITU recommendation 769.[396] The IEEE Technical Committee on Frequency Allocations in Remote Sensing (IEEE FARS) notes that the band is used by four different satellite based remote sensing systems and requests that the technical rules we adopt ensure that these systems are protected from harmful interference.[397] IEEE FARS supports adopting a guard band at 37 GHz, but believes further study is needed to determine the appropriate size of the guard band.[398]

155. T-Mobile argues that CORF's "proposals are overly conservative and will hinder growth and innovation in the millimeter wave bands."[399] According to T-Mobile, we should defer action on protecting EESS and radio astronomy until after a subcommittee of NTIA's Commerce Spectrum Management Advisory Committee provides its recommendations on bi-directional sharing.[400] Huawei comments that compatibility may be achieved by agreeing to of suitable out-of-band emission limits and, possibly, exclusion zones around sensitive receiving sites and adopting guard bands.[401] NTIA states that the proposed out-of-band emission limit for non-Federal fixed and mobile stations is lower than the power level specified in footnote US550A, which limits mobile stations and fixed stations that are not hubs of point-to-multi-point systems to a transmitted power of -10dBW in the 36-37 GHz band.[402] As a result, NTIA asserts that fixed and mobile stations complying with the proposed out-of-band emission limit in the *NPRM* should not cause interference to the passive sensors in the 36-37 GHz band.

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[391] *NPRM*, 30 FCC Rcd at 11930, para. 176.

[392] CORF Comments at 6-7.

[393] CORF Comments at 19.

[394] CORF Comments at 9-10. CORF suggest an out-of-band emission limit of -166 dBW/GHz to protect the passive operations. *Id*. at 10.

[395] CORF Comments at 10.

[396] These observatories are located at Green Bank Telescope (West Virginia), the Very Large Array (Socorro, New Mexico), and the Owens Valley Radio Observatory (California). CORF Comments at 11.

[397] IEEE FARS Reply at 2-3. According to IEEE FARS, two of these remote sensing systems operate above 37 GHz. *Id*. at 3.

[398] IEEE FARS Reply Comments at 4. IEEE FARS presents calculations showing that a guard band of 200 MHz at 37 GHz is needed to protect one of the sensor systems from ten mmW devices transmitting at 1 watt of power. *Id*. at 3-4.

[399] T-Mobile Reply at 17-18.

[400] *See* CTIA Comments at 33-34.

[401] Huawei Comments at 17.

[402] *See 2016 NTIA Letter* at 4; 47 CFR § 2.106 n.US550A.

156. *Discussion.* We believe that the out-of-band emission limit that we adopt in this *Report and Order* will provide adequate protection to the passive sensors in the adjacent 36-37 GHz band. The out-of-band emission limit will keep emissions from an UMFUS device into the 36-37 GHz band well below the -10 dBW level specified by footnote US550A. We note that the -10dBW power limit was adopted to protect passive sensors in the 36-37 GHz band in accordance with ITU Resolution 752 (WRC-07).[403] Because this limit was adopted by the ITU to protect passive sensors from harmful interference from fixed and mobile transmitters in the 36-37 GHz band, we conclude that it will provide appropriate protection to the passive sensors from transmitters in the adjacent band.

157. We will not adopt a guard band at 37 GHz to protect the EESS and SRS in the 36-37 GHz band as suggested by CORF and IEEE FARS. Neither CORF nor IEEE FARS make a specific recommendation on the necessary size of the guard band, although CORF requests a guard band of at least 100 MHz. Because a guard band will reduce the spectrum available for mmW devices, we do not want to take this step without compelling evidence that it is necessary. No one has provided information on the specific benefits and necessity of adopting a guard band of at least 100 MHz to protect EESS and SRS. Given the lack of data supporting adoption of a guard band, we believe that the out-of-band emission limit that we have adopted will provide adequate protection to the EESS and SRS without the need for a guard band at 37 GHz.

158. With regard to protecting radio astronomy at the three locations specified by CORF, we are not convinced that additional measures are needed to protect radio astronomy. The radio astronomy observations that CORF is concerned about will be conducted in the 36.43-36.5 GHz band, which is 500 megahertz from the 37 GHz band,[404] so the emission limits that we are adopting for mmW devices should sufficiently protect radio astronomy.

F. Licensing, Operating, and Regulatory Issues

1. Creation of New Rule Service and Part

159. *Background*. LMDS and the 39 GHz service are currently regulated under Part 101 of the Commission's rules, which governs fixed microwave services.[405] In light of the additional flexibility we are providing to LMDS and 39 GHz licensees, including mobile operating rights, we proposed in the *NPRM* to create a new radio service, the Upper Microwave Flexible Use Service, and to regulate that new service under a new Part 30 of the Commission's rules.[406] We also proposed to include the contemplated new 37 GHz band as part of the Upper Microwave Flexible Use Service.[407]

160. Comments on our proposal were mixed. CTA and FiberTower support creating a new service rule in Part 30 to provide all licenses with the appropriate degree of flexibility.[408] CTIA suggests that Part 27 would be sufficient to accommodate the new service and would provide simplicity and

[403] *Amendment of Parts 1, 2, 15, 25, 27, 74, 78, 80, 87, 90, 97, and 101 of the Commission's Rules Regarding Implementation of the Final Acts of the World Radiocommunication Conference (Geneva, 2007) (WRC-07), Other Allocation Issues, and Related Rule Updates*, Report and Order, Order, and Notice of Proposed Rulemaking, 30 FCC Rcd 4183, 4232, para. 135 (2015).

[404] One of these radio astronomy sites is located in the quiet zone specified in 47 CFR § 1.924(a). Licensees planning to operate a base station in this zone are required to notify the radio observatory, and if the radio observatory objects, the Commission may "take whatever action is deemed appropriate."

[405] 47 CFR § 101.1 *et seq*.

[406] *NPRM*, 30 FCC Rcd at 11930, para. 177.

[407] *NPRM*, 30 FCC Rcd at 11930, para. 177.

[408] CTA Comments at 16, FiberTower Comments at 2-3.

consistency for mobile licensees[409] while Google believes that the bands should be licensed under Part 96, as part of an enhanced sharing regime.[410] No other commenters discuss this issue.

161. *Discussion.* We adopt our proposal to create a new service, the Upper Microwave Flexible Use Service (UMFUS) under a new Part 30 of our rules to include the 28 GHz, 39 GHz, and 37 GHz bands. Licensing the millimeter wave bands under Part 27, as CTIA suggests,[411] would produce a less flexible regime than we intend while the rules we adopt in Part 30 will provide much of the flexibility present in the Part 27 rules. Part 27 would be a poor fit for the point-to-point services currently operating in the 28 and 39 GHz bands, and for the backhaul uses other licensees may wish to include in their services. Part 96, which Google suggests,[412] is designed for a specific regime of intensive, three-tier sharing.[413] As we are not adopting this type of sharing regime for these bands at this time, using this rule part would be inappropriate. We conclude that establishing a new rule part will allow us to have one unified set of rules governing the various types of operations we contemplate licensees will offer, which will provide more clarity to licensees and more accurately reflect the nature of these licenses.

2. Regulatory Status

162. *Background.* For LMDS, the Commission has previously determined that applicants could provide common-carrier service, non-common carrier service, or both, and also enabled licensees to later amend their applications or modify that status.[414] The Commission permitted LMDS to be licensed to allow both common carrier and non-common carrier services in a single license.[415] In other words, the Commission permitted LMDS licensees to provide all services anywhere within its licensed area at any time, consistent with the statutory and regulatory requirements that are imposed on the respective operations.[416] In adopting this rule, the Commission expressly rejected the application of a presumption of common carrier status to an application.[417]

163. Similarly, in the 39 GHz band, the Commission concluded that licensees should be permitted to serve as a common carrier or as a private licensee.[418] It determined that licensees who select common-carrier regulatory status would be able to provide private service, and those licensees who select private service provider regulatory status could share the use of their facilities on a non-profit basis or could offer service on a for-profit, private carrier basis, subject to Section 101.135 of the Commission's

[409] CTIA Comments at 19-20.

[410] Google Comments at 4.

[411] CTIA Comments at 19-20.

[412] Google Comments at 4.

[413] *See In the Matter of Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Report and Order and Second Further Notice of Proposed Rulemaking, 30 FCC Rcd 3959, 3975, para. 45 (2015) (*3.5 GHz Report and Order*).

[414] *Second LMDS Report and Order*, 12 FCC Rcd at 12643-45, 12652-54, paras. 221-26, 245-51.

[415] *Id.* at 12651, para. 244.

[416] *Id.* at 12643-44, para 222.

[417] *Id.* at 12643, para. 222. The Commission did specify that "[a]n LMDS licensee may be required to adhere to the following filing or authorization requirements in modifying a station: (1) in Section 1.1301 through 101. 5239 concerning actions that may have a significant impact on the quality of the human environment, (2) in Sections 22.369 and 101.123 concerning radio frequency quiet zones, (3) Part 17 of our rules concerning antenna structure clearance procedures and the obligation under Section 17.4 to register with the Commission prior to construction, (4) any restrictions regarding border areas under international agreements, and (5) any applicable technical rules in this part." *Id.* at 12643-44, para. 222.

[418] *39 GHz Report and Order*, 12 FCC Rcd at 18635, para. 76.

rules.[419] Under this approach, licensees would elect the status of the services they wish to offer and be governed by the rules applicable to their status.[420]

164. The open and flexible approach the Commission took to regulatory status in Part 101 is also consistent with the Commission's approach to other wireless services, such as the Part 27 rules for terrestrial wireless service. The Commission permits Part 27 applicants who may wish to provide both common carrier and non-common carrier services (or to switch between them) under a single license to request status as both a common carrier and a non-common carrier.[421] Such licensees are able to provide all allowable services anywhere within their licensed area at any time, consistent with their regulatory status. Applicants are required to indicate regulatory status for any services they choose to provide, but apart from that designation, they are not generally required to describe the services they seek to provide.[422] Further, licensees must notify the Commission if they change the service or services they offer such that it would be inconsistent with their regulatory status.[423]

165. In the *NPRM*, we proposed to maintain this open and flexible regulatory framework for the Upper Microwave Flexible Use Service.[424] Specifically, we proposed to permit applicants and licensees to request common carrier status, non-common carrier status, private internal communications status, or a combination of these options, for authorization in a single license (or to switch between them).[425] This would allow, but not require, applicants in these bands to choose between providing common carrier and non-common carrier services. Alternatively, the applicant may wish to limit its operations to common carrier or non-common services, in which case it would apply only for authorization on a common carrier or a non-common carrier basis, and the license would be issued for the status specified. The licensee would be able to provide all Fixed and Mobile Services anywhere within its licensed area at any time, consistent with the statutory and regulatory requirements that are imposed on its respective operations. We also proposed to rely on the applicant's self-designation to determine its status (common carrier or non-common carrier) for the purpose of enabling us to fulfill our obligations to enforce the common carrier requirements contained in statutes and our regulations.[426]

166. CTA, Qualcomm, and XO support our proposal.[427] TIA also supports a flexible regulatory framework generally.[428] No commenters oppose our proposal, and no commenters address the issue of whether to rely on the applicant's determination of its status as a common carrier or non-common carrier.

167. *Discussion.* We adopt our proposal from the *NPRM* to implement a flexible regulatory framework for the Upper Microwave Flexible Use Service. As we proposed, UMFUS licensees in the 28, 39, and 37 GHz bands will be able to choose the regulatory status (common carrier, non-common carrier,

[419] *Id.*

[420] *Id.*

[421] *See* 47 CFR § 27.10; *Amendment of the Commission's Rules to Establish Part 27, the Wireless Communications Service* ("WCS"), Report and Order, 12 FCC Rcd 10785, 10846-48, para. 119-22 (1997) (*Part 27 Report and Order*).

[422] *See Part 27 Report and Order*, 12 FCC Rcd at 10848, para. 121*; see also LMDS Second Report and Order*, 12 FCC Rcd at 12644, para. 223; 47 CFR § 101.1013.

[423] *See* 47 CFR § 27.10(d); *see also* 47 CFR § 27.66.

[424] *NPRM*, 30 FCC Rcd at 11931, para. 182.

[425] *NPRM*, 30 FCC Rcd at 11932, para. 183.

[426] *NPRM*, 30 FCC Rcd at 11932, para. 184.

[427] CTA Comments at 13, Qualcomm Comments at 6-7, XO Comments at 23.

[428] TIA Comments at 6.

or both) that best fits their business models and the services they seek to provide.[429] This approach will maintain an open and flexible framework that will allow the business judgments of individual applicants and licensees in these bands to shape the nature of the services offered pursuant to their licenses.

168. We also adopt our proposal to rely on the applicant's designation of its common carrier or non-common carrier status, to enable us to fulfill our obligations to enforce the common carrier requirements contained in statutes and our regulations.[430] An election to provide service on a common carrier basis requires that the elements of common carriage be present, and the applicant is in the best position to ascertain the presence of these elements. This approach is consistent with the Commission's past decisions regarding the classification of mobile services.

3. Foreign Ownership Reporting

169. *Background.* Certain foreign ownership and citizenship requirements are imposed by subsections (a) and (b) of Section 310 of the Act, as modified by the 1996 Act.[431] These provisions prohibit the issuance of licenses to certain applicants. For current LMDS, 37 GHz, and 39 GHz licensees, these statutory provisions are adopted in Part 101 of the Commission's rules at Section 101.7 of the Commission's rules.[432] Specifically, Section 101.7(a) prohibits the granting of any license to be held by a foreign government or its representative.[433] Section 101.7(b) prohibits the granting of any common carrier license to be held by individuals that fail any of the four citizenship requirements listed.[434]

170. In the *NPRM*, we tentatively concluded that the Section 310 requirements would apply to any applicants in the Upper Microwave Flexible Use Service.[435] Based on this interpretation of the requirements of Section 310, we proposed in the *NPRM* to include a provision in the new Part 30 that would mirror the current Section 101.7 of our rules.[436] In addition, we proposed that all applicants for Part 30 licenses be required to report the same foreign ownership information, regardless of the specific type of service they sought to provide.[437] An applicant requesting authorization for broadcast, common carrier, aeronautical en route, or aeronautical Fixed Services, alone or in combination with other services, would be prohibited from holding a license if it met any of the criteria in Section 310(b). If the applicant requested authorization for services other than for broadcast, common carrier, aeronautical en route, or aeronautical Fixed Services, it could hold a license if it met the single alien ownership requirement in Section 310(a), regardless of whether it would otherwise be disqualified for a common carrier authorization. No commenters addressed the issue of foreign ownership reporting requirements, or opposed our proposals.

171. *Discussion*. We adopt our proposals from the *NPRM* to require the same foreign ownership reporting from all applicants for Part 30 licenses, regardless of the specific type of service they seek to provide, and to implement this requirement by including a provision in Part 30 that mirrors Section 101.7 of our current rules.[438] This approach will properly implement the restrictions contained in

[429] *NPRM*, 30 FCC Rcd at 11932, para. 183.

[430] *NPRM*, 30 FCC Rcd at 11932, para. 184.

[431] 47 U.S.C. § 310.

[432] 47 CFR § 101.7.

[433] 47 CFR § 101.7.

[434] 47 CFR § 101.7.

[435] *NPRM*, 30 FCC Rcd at 11932, para. 186.

[436] *NPRM*, 30 FCC Rcd at 11933, para. 188.

[437] *See NPRM*, 30 FCC Rcd at 11933, para. 187.

[438] *NPRM*, 30 FCC Rcd at 11933, paras. 187-88; 47 CFR § 101.7.

Section 310(a) and (b) of the Act, and is consistent with our treatment of flexible use services regulated under Part 27 of the Commission's rules.[439]

4. Eligibility

172. In the *NPRM*, we proposed to adopt an open eligibility standard for the Upper Microwave Flexible Use Service.[440] We noted that an open eligibility approach would not affect citizenship, character, or other generally applicable qualifications that may apply under our rules. Cisco and CTA support this proposal, citing uncertainty as to how the UMFUS bands will develop,[441] and the need to allow innovation from all parties.[442] No commenters oppose our proposal.

173. We adopt our proposal to implement an open eligibility standard for the Upper Microwave Flexible Use Service.[443] This approach is in keeping with the flexibility of the other licensing rules we adopt in this *Report and Order*,[444] as well as our treatment of other flexible use services, and will encourage innovation and efficient use of spectrum in these bands.

5. License Term

174. *Background*. In the *NPRM*, we proposed to establish a 10-year license term for all UMFUS licenses.[445] We noted that existing LMDS and 39 GHz license terms have 10-year license terms, and we opined that a 10-year license term would help maintain consistency.[446] We also sought comment on whether licensees should receive a renewal expectancy for subsequent license terms if they continue to provide at least the level of service required at the end of their initial license terms through the end of any subsequent license terms.[447]

175. The majority of commenters who address this proposal support a 10-year license term, although a few of those commenters suggest that a longer license term may be appropriate.[448] XO asks for an initial license term of 15 years.[449] Those commenters, plus XO, also support the Commission's proposal concerning renewal expectancy. In contrast, Public Knowledge believes a three-year license term is more appropriate in connection with its proposal to use the licensing framework adopted for the 3.5 GHz band.[450]

176. *Discussion*. We adopt our proposal to establish a 10-year license term for all UMFUS licenses, and our proposal to award a renewal expectancy for subsequent license terms if the licensee

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[439] *See* 47 CFR § 27.12(a).

[440] *NPRM*, 30 FCC Rcd at 11933, para. 189.

[441] Cisco Comments at 11.

[442] CTA Comments at 13-14.

[443] *See NPRM*, 30 FCC Rcd at 11933, para. 189.

[444] *See supra* Section IV.F.1 (Creation of New Rule Service and Part).

[445] *NPRM*, 30 FCC Rcd at 11915, para. 121.

[446] *NPRM*, 30 FCC Rcd at 11915, para. 119.

[447] *NPRM*, 30 FCC Rcd at 11915, para. 122.

[448] AT&T Comments at 20, Cisco Comments at 10 (minimum term of 10 years), CTIA Comments at 22-23, HTSC Comments at 4, Intel Comments at 23, Mobile Future Comments at 13-14, Nokia Comments at 19, PCIA Comments at 11, Qualcomm Comments at 11-12, TIA Comments at 25, T-Mobile Comments at 10 n.40, Verizon Comments at 10 (at least 10 years).

[449] XO Comments at 22.

[450] OTI and Public Knowledge Comments at 23-24.

continues to provide at least the initially-required level of service.[451] While we have pursued shorter license terms and non-renewable licenses in other bands, and continue to believe there are circumstances where those structures are appropriate, here we adopt a 10 year license term that can be renewed. We believe a 10-year license term will give licensees sufficient certainty to invest in their systems, particularly as the new technology is still nascent and will require time to fully develop. If the standards for mobile service in the mmW bands are established by, at the latest, 2020, new licensees would still have the majority of the license term after that point to plan and to deploy service. Neither XO nor any other commenter has presented facts that would justify a longer license term. A 10-year license term is also consistent with existing license terms in a wide variety of services.

177. We also adopt our proposal to award a renewal expectancy for subsequent license terms if the licensee continues to provide at least the initially-required level of service through the end of any subsequent license terms.[452] That treatment is consistent with our treatment of many other licensed services and will provides incentives for licensees to continue to provide service.

6. Mobile Spectrum Holdings Policies

178. *Background*. Spectrum is an essential input for the provision of mobile wireless services, and ensuring access to and the availability of sufficient spectrum is crucial to promoting competition, innovation, and investment.[453] In prior rulemakings, the Commission has developed policies to ensure that spectrum is assigned in a manner that promotes competition, innovation and the efficient use of spectrum.[454] In so doing, its spectrum policies have applied both to the acquisition of spectrum through auction as well as through secondary market transactions. In the *Mobile Spectrum Holdings Report and Order*, the Commission established a market-based spectrum reserve in the Incentive Auction designed to ensure against excessive concentration of low-band spectrum holdings,[455] and to facilitate access by multiple service providers to such spectrum.[456] The Commission also found it in the public interest to continue to use its spectrum screen and case-by-case review[457] and, in addition, to require that any

[451] *NPRM*, 30 FCC Rcd at 11915, paras. 121-22.

[452] *NPRM*, 30 FCC Rcd at 11915, para. 122.

[453] *NPRM*, 30 FCC Rcd at 11933, n.340.

[454] The Communications Act requires the Commission to examine closely the impact of spectrum aggregation on competition, innovation, and the efficient use of spectrum to ensure that spectrum is assigned in a manner that serves the public interest, convenience, and necessity. Section 309(j)(3) of the Act provides that, in designing systems of competitive bidding, the Commission must "include safeguards to protect the public interest in the use of the spectrum," and must seek to promote various objectives, including "promoting economic opportunity and competition and ensuring that new and innovative technologies are readily accessible to the American people by avoiding excessive concentration of licenses and by disseminating licenses among a wide variety of applicants," and promoting the "efficient and intensive use" of spectrum. *Act*, § 309(j)(3) *codified at* 47 U.S.C. § 309(j)(3).

[455] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6192-93, paras. 139-43. The Commission replaced its post-auction case-by-case analysis of the licensing of spectrum bands through competitive bidding with a determination of whether a band-specific mobile spectrum holding limit is necessary and, if so, to establish that limit *ex ante*. *Id.* at 6156, 6168, 6190, paras. 45, 68, 135. The Commission declined to adopt any mobile spectrum holding limits for the licensing of the AWS-3 bands through competitive bidding. *Id.* at 6190, para 135.

[456] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6204, para. 174. To qualify to bid on reserved spectrum, an entity must not have an attributable interest in 45 megahertz or more, or approximately one-third or more, of suitable and available below-1-GHz spectrum. The 45 megahertz threshold is consistent with the approximately one-third threshold for total spectrum that we use to identify those holdings in local markets that may raise particular competitive concerns in the context of secondary market transactions. *Id.* at 6204-05, paras. 175-76.

[457] *Id.* at 6223-24, para. 231.

increase in spectrum holdings of below 1 GHz be treated as an "enhanced factor" in its review if post-transaction the acquiring entity would hold approximately one-third or more of such spectrum.[458]

179. In the *NPRM*, we sought comment on how to address mobile spectrum holdings issues for the bands proposed for this new radio service.[459] In particular, we sought comment on whether to adopt a band-specific spectrum holding limit in the licensing of these spectrum bands through competitive bidding, either for individual bands or a combination of these bands, and asked commenters to consider the costs and benefits of any such limits.[460] In addition, we proposed to exclude these bands from the Commission's spectrum screen, which applies to secondary market transactions, because it is not clear that these bands would be suitable and available for the provision of mobile telephony/broadband services in the near term.[461]

180. With respect to the existing spectrum screen, the majority of commenters agree with our proposal not to include mmW bands in the spectrum screen, given the unique technical characteristics of the spectrum available in these three bands.[462] Commenters argue that mmW spectrum is likely to be used as a supplement to low-bandwidth spectrum to enhance bandwidth and capacity, characteristics that will be increasingly important with the development of 5G services.[463] Mobile Future, TIA, Verizon, and XO agree that the Commission should refrain from including these bands in the spectrum screen because there is no basis to conclude that they are suitable for providing mobile service in the same manner as other spectrum bands that currently are included in the spectrum screen.[464] On the other hand, CCA proposes that upon a determination that this spectrum is suitable and available in the near term, the Commission should consider how to add these bands to the spectrum screen on a per-band basis to prevent the largest service providers from aggregating this spectrum to the detriment of competition and consumers.[465] O3b argues that if the Commission authorizes mobile service in the 28 GHz band, it should include that spectrum in the spectrum screen and for all purposes in calculating each licensee's mobile spectrum holdings.[466]

181. On the issue of spectrum aggregation limits in the mmW bands, Verizon, XO, and TIA oppose any band-specific aggregation limits. Verizon claims that arbitrary band-specific aggregation limits for mmW spectrum would quash the development of nascent technologies that require operators to aggregate substantial amounts of spectrum.467 Verizon proposes that the Commission should provide

[458] *Id.* at 6240, paras. 286-88.

[459] *NPRM*, 30 FCC Rcd at 11934, para. 191.

[460] *Id.* at 11934, para. 191.

[461] *Id.* at 11934, para. 192.

[462] Ericsson Comments at 6, Mobile Future Comments at 15, TIA Comments at 28, Verizon Comments at 14, XO Comments at 19.

[463] AT&T Reply at 5 (noting that the mmW bands are not a "stand-alone solution" and serve as a complement to lower-bandwidth spectrum); *see also* CTIA Reply at 5 (noting that "While the NPRM focuses on spectrum above 24 GHz, the wireless industry will require access to high-, mid-, and low-frequency spectrum to deliver the next generation of broadband. The high-frequency bands highlighted by the Commission in the NPRM will provide significant bandwidth and capacity to 5G services. Meanwhile, lower-frequency bands have better propagation characteristics that will be more advantageous for macro network coverage and capacity.").

[464] Mobile Future Comments at 15, TIA Comments at 28, Verizon Comments at 14, XO Comments at 19.

[465] CCA Reply at 13-14.

[466] O3b Reply at 7-8, n.17.

[467] Verizon Comments at 3, 15. Verizon states that "If any competition issues arise in the future, the Commission and the antitrust authorities can address them as the industry develops: doing so now would be premature." *Id*. at 15. *See also* Verizon June 20, *Ex Parte* Letter at 1.

companies with the flexibility required to transfer, share, and acquire mmW spectrum to meet the large bandwidths that will likely be necessary for 5G deployment,[468] and, in response to recent *ex parte* filings, argues that adopting any spectrum aggregation limits ignores the large amounts of mmW spectrum that will be available as 5G technologies and services develop.[469] XO also argues that as technology continues to evolve, additional high frequency spectrum will become conducive to 5G mobile use, further weighing against the need for band-specific limits.[470] TIA expresses concern that limiting a single licensee to no more than 1250 megahertz of spectrum could curtail technology developments in the bands.[471]

182. AT&T initially argued that adopting spectrum aggregation caps would undermine the potential of next generation services and threaten the commercial viability of the spectrum.[472] However, in its recent *ex parte* filing, AT&T supports a proposed overall aggregation threshold of 1250 megahertz applied *ex ante* that would trigger additional scrutiny and review should it be exceeded, as well as an approach that would result in two distinct licensees of the 425 megahertz licenses in the 28 GHz band given the importance of that band to emerging 5G development efforts.[473] CCA argues that the Commission must incorporate protections to ensure that this spectrum is not dominated by AT&T and Verizon – as they allege the below-1-GHz bands currently are today.[474] CCA argues that the Commission should establish a clear spectrum aggregation policy,[475] and in recent *ex parte* filings, proposes a two-tiered approach – a one-third screen for all licensed mmW spectrum and a one-half screen for licensed spectrum in a particular band, like 28 GHz – both with respect to secondary market transactions and as an *ex ante* auction mechanism.[476] T-Mobile proposes that the Commission should monitor future spectrum aggregation to ensure that there is a competitive marketplace for mmW band spectrum and to take action if necessary to ensure reasonable access to the spectrum.[477] In recent *ex parte* filings, T-Mobile has also advocated for a one-third screen applicable to all mmW spectrum, as well as a one-half screen in individual bands.[478]

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[468] Verizon June 20, *Ex Parte* Letter at 1.

[469] Verizon (Gregory M. Romano) July 7, *Ex Parte* Letter at 1-2. *See also* Verizon (Charla M. Rath) July 7, *Ex Parte* Letter at 1 (arguing that there is no evidence of actual or tangible harm to warrant a mmW spectrum limit, and no basis for band-specific limits).

[470] XO Comments at 20.

[471] TIA July 7, *Ex Parte* Letter at 2-3.

[472] AT&T Reply at 12.

[473] AT&T June 29, *Ex Parte* Letter at 1-3 (arguing that the 37-39 GHz bands "stand in a slightly different posture" than the 28 GHz band and that given the performance differences moving from 28 GHz to 37-39 GHz, any aggregation approach to the 37-39 GHz band, including any intraband limits, should take that into consideration such that 5G deployments in 37-39 GHz have an opportunity to compete on par with deployments in 28 GHz). *See also* AT&T July 7, *Ex Parte* Letter at 3 (arguing that licensees would need 44%-66% more spectrum in the 39 GHz band to provide the same cell edge data rate with the same cell radius as compared to 28 GHz).

[474] CCA Reply at 13. *See also* CCA June 7, *Ex Parte* Letter at 3 (arguing that pending transactions demonstrate a need to monitor consolidation of high-band spectrum and urging the Commission to implement a separate screen for each band to avoid harmful aggregation).

[475] CCA June 15 *Ex Parte* Letter at 2.

[476] CCA June 15, *Ex Parte* Letter at 2; CCA June 29, *Ex Parte* Letter at 2; CCA June 30, *Ex Parte* Letter at 4; CCA July 7, *Ex Parte* Letter at 2.

[477] T-Mobile Reply at 11. *See also* T-Mobile May 9, *Ex Parte* Letter, Attach. at 2 (advocating for a "competitive playing field" in the mmW bands).

[478] T-Mobile June 20, *Ex Parte* Letter at 4-5 (arguing that although several mmW bands have similar characteristics, they are not identical and their utility may be different). *See also* T-Mobile June 30, *Ex Parte* Letter at 6 (T-Mobile notes that one-third of 3250 megahertz is 1083 megahertz. Further, T-Mobile argues that that there are technical

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183. *Discussion*. We find it essential today to establish clear and transparent mobile spectrum holdings policies that will promote competition in the future, including competition in the development of 5G services, as well as promote the efficient use of mmW spectrum, and avoid an excessive concentration of licenses. As mentioned in the *NPRM*, demand for mobile service that mmW spectrum is expected to enhance and improve has been increasing,[479] and our predictive judgment is that interest in the spectrum will be high.[480] Thus, we find that it would provide regulatory certainty, flexibility in planning, and expedited deployment if we supply guidance on application of these policies at this stage when we authorize mobile service in these bands and adopt related rules governing the terms of service, rather than at some later stage.[481] In our consideration of whether to adopt a mobile spectrum holdings limit for the licensing spectrum through competitive bidding and, if so, what type of limit to apply, our evaluation includes, among other things, the promotion of competition in relevant markets, the acceleration of private sector deployment of advanced services, and generally managing the spectrum in the public interest.[482] We evaluate how a limit would likely affect the quality of communications services or result in the provision of new or additional services to consumers, as well as any other statutory goals and directives applicable to a particular spectrum band being licensed by competitive bidding.[483]

184. As the Commission noted in the *Mobile Spectrum Holdings Report and Orde*r, the mobile wireless marketplace is highly concentrated, and with continually increasing consumer demand for mobile broadband, "in order for there to be robust competition, multiple competing service providers must have access to or hold sufficient spectrum to be able to enter a marketplace or expand output rapidly in response to any price increase or reduction in quality, or other change that would harm consumer welfare."[484] In addition, we have found that holding a mix of spectrum bands is advantageous to providers and that consumers benefit when multiple providers have access to a mix of spectrum bands.[485] We conclude here that with, the rapid rate of technological advance, mmW spectrum is likely to be a critical component in the development of 5G, and we must take steps today to ensure its optimal use to the benefit of all American consumers. For these reasons, we adopt an *ex ante* spectrum aggregation limit of 1250 megahertz that will apply to licensees acquiring spectrum in the 28 GHz, 37 GHz, and/or 39 GHz bands, through competitive bidding in auction. We also adopt today for these same reasons a spectrum threshold of 1250 megahertz for proposed secondary market transactions in these three bands.[486]

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distinctions in the bands – notably an approximately 20% difference in propagation capacity); T-Mobile July 7, *Ex Parte* Letter at 3.

[479] *NPRM*, 30 FCC Rcd at 11882, para. 6.

[480] *See, e.g., Application of Cellco Partnership d/b/a Verizon Wireless and Nextlink Wireless, LLC for Long-Term De Facto Transfer Spectrum Leasing Arrangement*, ULS File No. 0007162285 (filed Mar. 3, 2016).

[481] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6190, para. 135.

[482] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6192-93, para. 143. *See also generally* 47 U.S.C. § 309(j).

[483] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6192-93, para. 143. *See also generally* 47 U.S.C. § 309(j).

[484] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6143-44, 6146-47, 6157, paras. 17-18, 23-25, 47.

[485] *Id.* at 6163-64, para. 59. As the Commission stated, "The continually evolving marketplace makes having a mix of low- and high-band spectrum more important for the deployment of robust high quality networks by multiple service providers, which in turn can increase competition, drive down prices, and ensure continued innovation and investment." *Id*.

[486] We note that this 1250 megahertz spectrum threshold helps to identify those markets that provide particular reason for further competitive analysis, but that our consideration of potential competitive harms would not be limited solely to those markets identified by the threshold.

185. Historically, mmW frequencies have been considered unsuitable for mobile applications because of propagation losses at such high frequencies and the inability of mmW signals to propagate around obstacles.[487] As noted in the NPRM, bands above 24 GHz were not typically considered for stand-alone mobile services but rather as supplementary channels to deliver ultra-high speed data in specific places.[488] Due to technological advances, the mmW bands could potentially be used for mobile broadband and are likely to serve as an important supplement to lower-band spectrum. Specifically, the mmW bands potentially will be used for supporting very high capacity networks in areas that require such capacity, as well as for machine-to-machine communications,[489] and in the development of various Internet of Things applications including wearables, fitness and healthcare devices, autonomous driving cars, and home and office automation.[490]

186. We find that grouping the 28 GHz, 37 GHz, and 39 GHz bands together for purposes of applying these spectrum holdings policies, either at auction or in the secondary market, is appropriate in view of the interchangeability of the spectrum in these bands, i.e., similar technical characteristics and potential uses of this spectrum that are unique to the mmW bands. While certain differences across the mmW bands exist, we find these technical differences are not sufficient to significantly affect how these spectrum bands might be used and to require separate band-specific limits. This approach mirrors our existing CMRS spectrum screen, which applies across a number of bands that do not have the same technical characteristics and not on a band-specific basis.[491] Even assuming that more 37 GHz to 39 GHz spectrum would be needed to provide the same performance, there will be 2400 megahertz of 37 GHz and 39 GHz spectrum available for service providers' use, almost three times as much as in the 28 GHz band. And, in any event, all the particular facts of any proposed secondary market transaction will be carefully evaluated on a case-by-case basis to ensure that the public interest is served. For these reasons, we do not find that adopting a band-specific spectrum aggregation limit is necessary, and we find that the spectrum holdings policies we adopt today will best support our objective of ensuring that multiple providers have access to this high band spectrum that is likely to be critically important in the development of 5G services moving forward. We anticipate, as discussed below in the FNPRM that applying these spectrum holdings policies to spectrum with similar technical characteristics that may become available in the future is also likely to be appropriate.

187. *Competitive Bidding*. We conclude that an approach based on limiting an entity's holding to approximately one-third of the relevant spectrum will help to ensure that multiple providers are able to access a sufficient amount of spectrum to the benefit of consumers.[492] In our consideration of the appropriate limit to set at auction, we note that as a result of the various license sizes in these bands, setting a limit at approximately one-third would as a practical matter result in a limit notably lower than a one-third limit.[493] Given the varied license sizes of spectrum blocks in each band, as well as the total

[487] *NPRM*, 30 FCC Rcd at 11882, para. 5.

[488] *Id.* at 11883, para 8.

[489] *Id.* at 11882-3, paras. 6-7. The short transmission paths and high propagation losses unique to mmW spectrum can facilitate spectrum re-use in microcellular deployments by limiting the amount of interference between adjacent cells. In addition, the short wavelengths of mmW signals make it feasible to beam signals with enough gain to overcome propagation losses and, unlike longer-wavelength spectrum below 6 GHz, to accommodate antennas small enough to fit into handsets to beam such signals. *Id*. at para 5.

[490] *See supra* Section III (Background).

[491] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6169-70, paras. 71-72.

[492] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6205, para. 176.

[493] The total available amount of the mmW spectrum in the 28 GHz, 37 GHz, and 39 GHz bands today is equal to 3250 megahertz, approximately one-third of which is 1100 megahertz. Given the sizes of the spectrum blocks in these bands, however, no entity could hold more than 1050 megahertz, and an entity interested in holding only licenses in the 37 and 39 MHz bands could hold no more than 1000 megahertz. More specifically, the latter entity

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amount of mmW spectrum available, we find that permitting licensees to acquire somewhat more than one-third of the spectrum available in these bands at auction is appropriate. We therefore will not permit licensees to acquire more than 1250 megahertz across the three bands at auction.[494] We find that the spectrum aggregation limit we adopt today will help ensure that multiple providers will be able to access a sufficient amount of mmW spectrum to facilitate the deployment of new services and innovation that will benefit consumers, while guarding against the excessive concentration of licenses.[495] We ask for comment below on how this limit might be implemented.[496]

188. *Secondary Market*. We adopt our proposal to exclude mmW spectrum from the current spectrum screen that includes those spectrum bands that the Commission has determined are suitable and available for the provision of mobile telephony/broadband services. As the Commission has previously explained, spectrum is considered "available" if it is "fairly certain that it will meet the criteria for suitable spectrum in the near term, an assessment that can be made at the time the spectrum is licensed or at later times after changes in technology or regulation that affect the consideration."[497] We do not find that the mmW bands are suitable and available for the provision of mobile telephony/broadband services in the same manner as other spectrum bands that are currently included in the Commission's spectrum screen as applied to secondary market transactions. We make this finding based on the unique characteristics of these bands as described above. Accordingly, we do not include the mmW bands in the spectrum screen.

189. However, we recognize that this frontier spectrum is likely to become increasingly valuable to the advent of 5G services. In its competitive analysis of wireless transactions, the spectrum screen applicable to lower-band spectrum has been one tool used to help identify particular markets for further competitive analysis; it is applied on a county-by-county basis and identifies local markets where an entity would hold approximately one-third or more of the total spectrum suitable and available for the provision of mobile telephony/broadband services, post-transaction.[498] Similarly, for proposed secondary market transactions that would result in an entity holding 1250 megahertz or more of the total spectrum in the 28 GHz, 37 GHz, and 39 GHz bands, we will apply our threshold on a county-by-county basis, and

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would be able to hold no more than five licenses of 200 megahertz each across the 37 GHz and 39 GHz bands for a total of 1000 megahertz. An entity interested in holding some 28 GHz spectrum could hold either two 28 GHz licenses and one license of 200 megahertz for a total of 1050 megahertz, or one 425 megahertz license in the 28 GHz band and three licenses of 200 megahertz for a total of 1025 megahertz.

[494] We recognize that there are incumbent licensees in the 28 GHz and 39 GHz bands that currently hold varying amounts of spectrum. These licensees would be able to bid in the auction to an amount that would be no more than 1250 megahertz in total, taking existing spectrum holdings into account. Service providers' existing spectrum holdings across the 28 GHz, 37 GHz, and 39 GHz bands therefore will be counted for purposes of our application of the 1250 megahertz limit.

[495] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6193, para. 176. *See also Auction 1000 Bidding Procedures PN*, 30 FCC Rcd at 9063, para. 172. In view of the block sizes we adopt today, we anticipate that the 1250 megahertz spectrum holdings limit will allow acquisition of spectrum in more than one of the available bands. We further note that, in applying our mobile spectrum holding policies, we do not include the 600 megahertz of spectrum in the 37 GHz band that we designate for application of a Federal access paradigm.

[496] *See infra* Section V.D (Mobile Spectrum Holdings Policies).

[497] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6169, para. 71. (Suitability is determined by whether the spectrum is capable of supporting mobile service given its physical properties and the state of equipment technology, whether the spectrum is licensed with a mobile allocation and corresponding service rules, and whether the spectrum is committed to another use that effectively precludes its uses for mobile services). *Id.*

[498] *See, e.g.*, *Applications of AT&T Inc., E.N.M.R. Telephone Cooperative, Plateau Telecommunications, Inc., New Mexico RSA 4 East Limited Partnership, and Texas RSA 3 Limited Partnership for Consent To Assign Licenses and Authorizations*, Memorandum Opinion and Order, 30 FCC Rcd 5107, 5118, para. 24 (2015).

subject such transactions to our case-by-case review in order to ensure that the public interest is served. As noted above, while this 1250 megahertz spectrum threshold helps to identify those markets that provide particular reason for further competitive analysis, our consideration of potential competitive harms will not be limited solely to those markets identified by the threshold. Establishing this spectrum aggregation threshold in the secondary market context recognizes the specific characteristics of the spectrum while helping to ensure that multiple entities have an opportunity to obtain mmW spectrum for deployment of innovative mobile technologies.

190. *Summary.* We find, on balance, that the potential public interest benefits of adopting a 1250 megahertz limit for auctions of this spectrum, and a 1250 megahertz threshold for secondary market transactions for these unique spectrum bands outweigh any potential public interest harms. Further, adopting these spectrum holdings policies is consistent with our previous determination that an "approximately one-third threshold for total spectrum that we use to identify those holdings in local markets that may raise particular competitive concerns" is an effective analytical tool in the secondary market context.[499] We anticipate that the potential costs of adopting such spectrum holdings policies will be low. We disagree with commenters who argue that it is premature for the Commission to establish any spectrum aggregation policies in these bands and that such policies will undermine the potential use of this spectrum. On the contrary, as noted above, we find that establishing such policies that will apply as mmW spectrum is introduced into the marketplace will help promote competition from the outset. We have explained that mmW spectrum holds the potential for a range of uses from supporting high capacity networks to use with various Internet of Things applications. While we cannot be certain at this time how this spectrum will be used, we find that its anticipated value to the future of 5G makes it critical that multiple providers have access to it. The spectrum holdings policies we adopt today will guard against consolidation of this spectrum by one or two providers and will encourage the development of innovative services to the benefit of the American consumer.

7. Performance Requirements

a. Introduction

191. *Background.* The Commission establishes performance requirements to promote the productive use of spectrum, to encourage licensees to provide service to customers in a timely manner, and to promote the provision of innovative services in unserved areas, particularly rural ones. Our overriding purpose in establishing performance requirements is to provide "a clear and expeditious accounting of spectrum use by licensees to ensure that service is indeed being provided to the public."[500] In doing so, we must strike an appropriate balance between providing licensees with operational flexibility and ensuring that spectrum does not lie fallow.

192. Over the years, the Commission has tailored performance requirements with an eye to the unique characteristics of individual frequency bands and the types of services expected, among many other factors. In the case of Part 101 services, such as 24 GHz, LMDS, and 39 GHz, licensees are required to demonstrate that they are providing "substantial service" at the end of their first license period in order to obtain renewal.[501] The Commission has generally defined substantial service as "service

[499] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6205, para. 176.

[500] *39 GHz Report and Order*, 12 FCC Rcd at 18623 para. 42. *See also Amendment of Part 101 of the Commission's Rules to Facilitate the Use of Microwave for Wireless Backhaul and Other Uses and to Provide Additional Flexibility to Broadcast Auxiliary Service and Operational Fixed Microwave Licensees*, Second Report and Order, Second Further Notice of Proposed Rulemaking, Second Notice of Inquiry, Order on Reconsideration, and Memorandum Opinion and Order, 27 FCC Rcd 9735, 9772, para. 101 (2012) ("*Wireless Backhaul Second Report and Order*").

[501] 47 CFR § 101.1413; *39 GHz Report and Order*, 12 FCC Rcd at 18623.

which is sound, favorable, and substantially above a level of mediocre service which might minimally warrant renewal."[502]

193. For existing geographically-licensed Part 101 services, including the LMDS and 39 GHz services, the Commission has generally specified safe harbors that will satisfy the substantial service requirement.[503] It has also emphasized that safe harbors are merely one means of demonstrating substantial service, and that given an appropriate showing, a level of service that does not meet a safe harbor may still constitute substantial service.[504] It has also determined that all substantial service showings that do not meet an established safe harbor would be evaluated on a case-by-case basis.[505]

194. In connection with its Wireless Backhaul proceeding, the Commission rejected an argument from the National Spectrum Managers Association (NSMA) that the Commission should credit antecedent activities such as developing equipment, offering spectrum leases, and submitting proposals to potential customers towards a finding of substantial service.[506] The Commission has stated that it would consider possible revisions to buildout policies in upper microwave services in WT Docket No. 10-112.[507]

195. Commenters express a wide variety of views on appropriate performance requirements for the millimeter wave bands and the Upper Microwave Flexible Use Service. Some commenters argue against any type of concrete performance requirements, either because secondary markets would be sufficient to achieve productive use of the spectrum,[508] or because the characteristics of services to be offered in these bands are not yet known with enough certainty,[509] or because the propagation characteristics of these bands lend themselves to site-based licensing rather than geographic area licensing.[510] Commenters who support performance requirements in some form were split between those who support "reasonable" or "flexible" performance requirements without specifics,[511] and those who support "rigorous" performance requirements.[512] Commenters also discuss more specific suggestions for performance requirements, which we discuss in more detail below.

b. Performance Metrics and Milestones

196. *Background*. Under the Act, we have an obligation to adopt rules that prevent the warehousing of spectrum, and we have an interest in doing so.[513] It is our goal to create a regulatory scheme that promotes the rapid and widespread deployment of wireless broadband, to consumers' benefit. One way to both fulfill our statutory obligation and promote widespread deployment is to institute

[502] 47 CFR § 101.1413.

[503] *Wireless Backhaul Second Report and Order*, 27 FCC Rcd at 9772, para. 101.

[504] *Wireless Backhaul Second Report and Order*, 27 FCC Rcd at 9772, para. 101.

[505] *Wireless Backhaul Second Report and Order*, 27 FCC Rcd at 9772, para. 101.

[506] *Amendment of Part 101 of the Commission's Rules to Facilitate the Use of Microwave for Wireless Backhaul and Other Uses and to Provide Additional Flexibility to Broadcast Auxiliary Service and Operational Fixed Microwave Licensees*, Report and Order, Further Notice of Proposed Rulemaking and Memorandum Opinion and Order, 26 FCC Rcd 11614, 11661, para. 114 (2011).

[507] *Wireless Backhaul Second Report and Order*, 27 FCC Rcd at 9773, para. 102.

[508] Mobile Future Comments at 15-16.

[509] AT&T Comments at 22-23, O3b Reply at 14.

[510] O3b Reply at 14-16.

[511] Facebook Comments at 6-7, CCA Reply at 3, Mobile Future Reply at 9, Samsung Reply at 11-12, Straight Path Reply at 22-23.

[512] SES Americom Reply at 2.

[513] 47 U.S.C. § 309(j)(4)(B).

enforceable buildout or coverage requirements. The Commission commonly measures performance on the basis of population covered by a licensee in a license area.[514] This approach can be readily adopted to wide-area coverage based fixed systems (point-to-multipoint systems). For licensees providing fixed, point-to-point links, the Commission has generally evaluated buildout using a different metric – it compares the number of links in operation to the population of the license area.[515] The Commission has also evaluated buildout, including in rural areas, by the percentage of land area served by a licensee.[516]

197. In the *NPRM*, we proposed to establish a unified metric by which all types of services could be evaluated, and sought comment on what form that should take.[517] Specifically, we proposed that each deployment, mobile or fixed, be assigned a "service contour," and that the residential population inside each service contour be aggregated to determine the total population coverage of the deployment.[518] We also proposed that population coverage be measured on a census tract basis; if a reliable signal level was present at the centroid of a census tract, that census tract's population would be deemed "covered" by the service.[519] Separately, we suggested that the appropriate coverage level milestone for renewal would be 40 percent of the total population of the license area.[520] In addition, the Commission sought comment on having a separate performance requirement for fixed services.[521]

198. FiberTower supports the idea of a uniform metric,[522] but many commenters oppose it on the grounds that the various possible services would be too different from each other.[523] The only commenter to address the appropriate level of population coverage was XO, who suggests a threshold of 20 percent of the population rather than 40 percent.[524]

199. Many commenters object to any population-based buildout requirement, on the grounds that services in the millimeter wave bands are too different from traditional services in lower-frequency

[514] *See*, *e.g.*, 47 CFR §§ 27.14(q)(2) ("An AWS-4 licensee shall provide terrestrial signal coverage and offer terrestrial service within seven (7) years from the date of the license to at least seventy (70) percent of the population in each of its license areas. . ."); (r)(1), (2) (AWS-3 bands).

[515] *See*, *e.g.*, 47 CFR §§ 27.14 (o)(1)(i) (For BRS and EBS, constructing six permanent links per one million people constitutes substantial service), (p)(2) (for 2.3 GHz WCS, "For point-to-point fixed systems, except those deployed in the Gulf of Mexico license area, a licensee must construct and operate a minimum of 15 point-to-point links per million persons (one link per 67,000 persons) in a license area by March 13, 2017, and 30 point-to-point links per million persons (one link per 33,500 persons) in a licensed area by September 13, 2019.")

[516] For example, in establishing a rural safe harbor, the Commission has suggested that serving at least seventy-five percent of the geographic area of a certain percentage of rural counties in a service area could be another means of meeting a buildout requirement. *See*, *e.g.*, *Facilitating the Provision of Spectrum-Based Services to Rural Areas and providing Opportunities for Rural Telephone Companies to Provide Spectrum-Based Services*, Report and Order and Further Notice of Proposed Rule Making, 19 FCC Rcd 19078, 19123, para. 79 (2004); 47 CFR § 27.14(o)(1)(iii)(A).

[517] *NPRM*, 30 FCC Rcd at 11938-39, paras. 204-05.

[518] *NPRM*, 30 FCC Rcd at 11939, para. 206.

[519] *NPRM*, 30 FCC Rcd at 11939, para. 207.

[520] *NPRM*, 30 FCC Rcd at 11940, para. 213.

[521] *NPRM*, 30 FCC Rcd at 11940, para. 210.

[522] FiberTower Comments at 9-10.

[523] Intel Comments at 23-25, Joint LMDS/Broadband One Reply at 4, TIA Comments at 26-28.

[524] XO Reply at 9-11.

bands, and the specifics of these services are not yet fully known.[525] Along those lines, some commenters object generally to the use of "traditional models" of performance requirements.[526] Some commenters suggest that the Commission instead adopt a "substantial service" requirement similar to that currently used for Part 101 Fixed Services, in order to allow licensees maximum flexibility to follow technology and industry standards as they develop;[527] however, FWCC opposes a substantial service standard, on the grounds that this method has not been successful in the past, and may even have deterred construction and deployment.[528] A number of commenters suggest a usage-based system where performance would be measured by number of devices connected, number of sessions initiated, or volume of traffic carried.[529]

200. A few commenters have more specific proposals. AT&T argues that if we must implement performance requirements, we should credit such activities as leasing spectrum or submitting a description of planned deployments.[530] Intel proposes a "performance requirement framework" consisting of several categories, with a different performance requirement for each category; licensees could choose the category that best fit the service they chose to offer.[531] CTIA suggests a substantial service standard, with safe harbors for a certain number of links per population, number of mobile connections per population, or number of mobile connections in proportion to the geographic size of the license area.[532]

201. With regard to satellite operations, we proposed in the *NPRM* that in the absence of a unified performance metric, a satellite operator who purchases a license to be used in association with an earth station would be required to demonstrate that the earth station is in operation and providing service.[533] EchoStar argues against a unified performance metric that includes satellite operators because it believes that adding another performance requirement for satellite operators would be redundant, as Part 25 already contains build-out requirements.[534]

202. We also sought comment on how to ensure productive use of this spectrum beyond the initial license term.[535] We asked whether licensees should continue to be subject to performance requirements, and perhaps stricter ones, to qualify for subsequent renewals.[536] T-Mobile and FWCC support the idea of requiring licensees to pay the price originally paid at auction for the license again at each renewal, as a substitute for performance requirements,[537] but no commenters directly address this issue.

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[525] 5G Americas Comments at 9-11, AT&T Comments at 22-23, FWCC Comments at 5-7, Intel Comments at 23-25, Nokia Comments at 19-20, SES Americom Comments at 15, T-Mobile Comments at 18-19, Qualcomm Reply at 6-7.

[526] Cisco Comments at 13-14, CTIA Comments as 23-26. *See* Qualcomm Comments at 14, XO Comments at 21-22, O3b Reply at 14-16.

[527] CCA Reply at 11-12, CTIA Comments at 23-26, Verizon Comments at 18-20.

[528] FWCC Reply at 6.

[529] 5G Americas Comments at 10-11, Nokia Comments at 20, TIA Comments at 27-28.

[530] AT&T Reply at 17 n.55, 21.

[531] Intel Comments at 23-25. *See also* Southern Co. Reply at 2-5.

[532] CTIA May 24, *Ex Parte* Letter at 1-2.

[533] *NPRM*, 30 FCC Rcd at 11943, para. 224.

[534] EchoStar Comments at 39-40, EchoStar Reply at 13-14.

[535] *NPRM*, 30 FCC Rcd at 11941, para. 218.

[536] *NPRM*, 30 FCC Rcd at 11941, para. 218.

[537] FWCC Comments at 7-8, T-Mobile Comments at 19.

203. *Discussion*. We decline to adopt a unified performance metric at this time. Based on the criticisms and alternative suggestions in the record, we conclude that such an approach would not provide the flexibility necessary to support innovative uses of the spectrum, as it would favor one deployment approach over another.[538] A unified approach might also deter investment and deployment in these bands.[539] We also decline to adopt a "substantial service" standard of performance for the Upper Microwave Flexible Use Service. We determine that such a standard, with no firm minimum requirements, would not adequately safeguard effective use of spectrum in these bands. We also decline to adopt a usage-based metric for performance requirements because it is not clear that there is a workable method of measuring or enforcing such a requirement. Instead, we adopt a series of metrics, tailored for each type of service a licensee might choose to offer. Licensees may fulfill their performance requirements by showing that they meet their choice of any one of the below standards, or a combination of several. This framework is intended to provide enough certainty to licensees to encourage investment and deployment in these bands as soon as possible, while retaining enough flexibility to accommodate both traditional services and new or innovative services or deployment patterns. Its increased level of firmness over a substantial service metric is also consistent with our recent approach in other services.[540]

204. We note that this list of metrics is not intended to be exhaustive. We recognize that the metrics we adopt today do not cover all possible types of service that licensees may seek to offer in these bands, and that new, innovative services may be developed with different characteristics that we cannot foresee at this time. We therefore seek further comment in the *FNPRM* on additional metrics that should be applied to these innovative services.[541]

205. We adopt these performance requirements today only in relation to the end of the initial license terms in these bands. Because we believe we are taking action with significant lead time before the full development of the technology, we believe an interim benchmark might be difficult to meet and may result in a substantial number of waiver and extension requests. While we do not adopt any ongoing or subsequent performance requirements at this time, we strongly encourage licensees to deploy networks and services in a timely manner consistent with the development of the technology for these bands. We emphasize, however, that the Renewal and Service Continuity proceeding (WT Docket No. 10-112), which addresses this issue, remains open, and that licensees may be subject to any requirements adopted as part of that proceeding at some later date.[542]

206. *Mobile and point-to-multipoint*. For mobile and point-to-multipoint services in the 28 GHz, 37 GHz (geographic area licenses only), and 39 GHz bands, we adopt a modified version of our proposal in the *NPRM*. In order to meet the standards for license renewal, a licensee providing mobile service must provide coverage to 40 percent of the population of the license area and must be using the facilities to provide service. This is a lower portion of the population than is the standard for lower frequency bands[543] because this level of coverage strikes the appropriate balance between ensuring

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[538] *See*, *e.g.*, EchoStar Comments at 35-37; Cisco Comments at 13-14; Mobile Future Comments at 15-16, Nokia Comments at 20; TIA Comments at 25-28.

[539] *See* TIA Comments at 27-28.

[540] *See Service Rules for Advanced Wireless Services H Block – Implementing Section 6401 of the Middle Class Tax Relief and Job Creation Act of 2012 Related to the 1915-1920 MHz and 1995-2000 MHz Bands*, 28 FCC Rcd 9483, 9558-60, paras. 195-200 (2013) (*H-Block Service Rules Report and Order*); *Amendment of the3 Commission's Rules with Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780, and 2155-2180 MHz Bands*, Report and Order, 29 FCC Fcd 4610, 4659-60, paras. 135-37 (2014) (*AWS-4 Report and Order*).

[541] *See* Section V.C.1 (Additional Metrics), *infra*.

[542] *Wireless Backhaul Second Report and Order*, 27 FCC Rcd at 9773, para. 102.

[543] *See*, *e.g.*, 47 CFR §§ 27.14(q)(2) (70 percent population coverage final buildout requirement for AWS-4), (r)(2) (75 percent population coverage final buildout requirement for AWS-4), (s)(2) (75 percent population coverage final buildout requirement for AWS-3).

sufficient use of the spectrum and allowing licensees flexibility to deploy an emerging technology which may be more suitable for smaller coverage areas. We view the current safe harbor of 20 percent population coverage as inappropriate going forward because the new technologies being developed will dramatically increase the opportunities to use these bands. Since we are not requiring service demonstrations until the end of the license term, we believe licensees will have more than adequate time to meet this benchmark. Similarly, we do not believe CTIA's suggestions of 10 "connections" per 10,000 population, or 50 connections per county, will result in robust build out in these bands.[544] Under CTIA's proposed definition of a "connection," these 10 connections could represent as little as one subscriber accessing the network 10 times in one month.[545] This is a particularly low benchmark for mobile operations, which is one of the primary target use cases for this new service. We do not believe this standard represents a sufficient level of service to justify renewal.

207. We decline to adopt the measurement method we proposed in the *NPRM* and conclude that requiring a specific methodology is unnecessary.[546] Instead, we will provide licensees with flexibility in terms of how they make their service showings, but Commission staff will continue to review showings to ensure that they accurately reflect coverage.

208. *Fixed*. We do not adopt our proposed method of "keyhole contours" for assigning fixed links a population equivalent.[547] Instead, we adopt a more traditional method of demonstrating fixed service: the number of links per population in the license area. Specifically, we adopt a requirement that geographic area licensees providing Fixed Service in the 28 GHz, 39 GHz, or 37 GHz bands must construct and operate at least four links in license areas with less than 268,000 population, and at least one link per 67,000 population in license areas with greater population. This standard is similar to the standard we established for fixed point-to-point services in the 2.3 GHz band.[548] While links in mmW bands will presumably be shorter because of the propagation characteristics, the higher frequencies will allow more reuse of spectrum in a given area. These links must be part of a network that is actually providing service, whether to unaffiliated customers or private, internal uses, and all links must be present and operational at the end of the license term. As with the mobile performance milestone, for bands licensed by areas larger than counties the number of links and the size of the population will be calculated over the entire license area, not county by county.

209. *Satellite*. We adopt our proposal from the *NPRM*.[549] A licensee who purchases a 28 GHz UMFUS license may fulfill build-out requirements for the license by deploying an earth station in the license area that is operational and providing service. We note that a licensee may not fulfill this requirement by leasing a portion of its license area to a satellite operator that builds and operates an earth station within the leased area. In 37 and 39 GHz, because we adopt significantly larger geographic license areas than counties, constructing and operating an earth station will fulfill the performance requirement only for the county in which it is constructed, and not for the entire license area. Satellite operators who develop earth stations under the satellite sharing mechanisms we adopt today for the 28 GHz and 39 GHz bands will continue to be subject to the applicable Part 25 build-out requirements.[550]

210. *Combination*. Licensees whose deployments contain a mix of services, for example mobile service combined with fixed backhaul may meet the relevant fixed or mobile/point-to-multipoint

[544] CTIA May 24 *Ex Parte* Letter at 4.

[545] CTIA May 24 *Ex Parte* Letter at 4.

[546] *NPRM*, 30 FCC Rcd at 11939, para. 207.

[547] *NPRM*, 30 FCC Rcd at 11940, para. 213.

[548] *See* 47 CFR § 27.14(p)(2).

[549] *NPRM*, 30 FCC Rcd at 11943, para. 224.

[550] *See* 47 CFR § 25.133(a)(1).

standard separately. We decline to establish a specific formula for evaluating such buildouts on a combined basis. Instead, we will evaluate such showings on a case-by-case basis, as we have done for LMDS.[551]

c. Failure to Meet Buildout Requirements

211. *Background.* In the *NPRM*, we proposed that if a licensee fails to meet the applicable buildout requirements, its authorization for each county in which it fails to meet the requirement would terminate automatically without Commission action.[552] We also proposed to evaluate whether licensees had met their build-out requirements on a county-by-county basis, as part of a proposal to license both the 28 GHz and 39 GHz bands on a county basis.[553]

212. No commenters discuss the remedy for failing to meet applicable performance requirements. EchoStar proposes that incumbent LMDS licensees continue to have their buildout requirements assessed on the basis of their current license areas, rather than county-by-county, "in recognition of [their] reasonable expectations."[554]

213. *Discussion*. We adopt a modified version of our proposal, tailored to the different license area sizes we adopt for each band. For all bands, we adopt our proposal to terminate licenses (or portions of licenses, as appropriate) automatically if a licensee fails to meet the applicable performance requirements,[555] which is widely applied in many wireless services.[556] The band-specific approaches to license renewal and termination are explained in more detail below. In the accompanying *FNPRM*, we seek to further develop the record on use-or-share obligations.

214. *28 GHz*. As discussed above, the 28 GHz band will be licensed by county because partitioning licenses in these bands into license areas smaller than counties would be administratively burdensome without providing any off-setting benefits to licensees or service providers.[557] Accordingly, if a licensee in the 28 GHz band fails to meet the applicable performance requirements at the end of its license term, the license for that county will terminate immediately in its entirety. As we are reissuing the licenses in these band by county rather than by BTA,[558] we decline to implement EchoStar's proposal to continue to evaluate incumbent licensees' performance on a BTA-wide basis.[559]

215. *37 and 39 GHz*. As discussed above, the 39 GHz band, as well as the 37.6-38.6 GHz band, will be licensed by PEAs, rather than counties.[560] In order to balance the need to ensure productive use of spectrum with the need to encourage investment and deployment, we adopt a modified approach to performance requirements in this band.

216. A licensee who meets the applicable performance requirement for the entire PEA, taken as a whole, will be eligible to renew the entire license. A licensee who does not meet the requirements for the entire license area will have two options: (1) automatic termination of the entire license, or (2) partition the license at the county level, and return a portion of the license to the Commission such that

[551] *See*, *e.g.*, *Nextlink Wireless, LLC*, Memorandum Opinion and Order, 24 FCC Rcd 8585 (WTB BD 2009).

[552] *NPRM*, 30 FCC Rcd at 11940-41 para. 214.

[553] *NPRM*, 30 FCC Rcd at 11937 paras. 199-200.

[554] EchoStar Comments at 38-39.

[555] *See NPRM*, 30 FCC Rcd 11940-941, para. 214.

[556] *See* 47 CFR § 1.955(a)(2).

[557] *See supra* Section IV.A.2 (Licensing the 28 GHz Band).

[558] *See supra* Section IV.A.2 (Licensing the 28 GHz Band).

[559] *See* EchoStar Comments at 38-39.

[560] *See supra* Section IV.B.2 (Licensing the 39 GHz Band); Section IV.C.3 (37 GHz Band, License Size).

the applicable performance requirements are met for the remaining non-forfeited area. For example, a licensee of a PEA containing five counties of 100,000 people each, who deployed mobile service covering 60 percent of the population in each of two counties, and made no deployments in the other three counties, would be covering only 24% of the total population of the license area. This would not be enough to meet performance requirements across the entire license. However, the licensee could forfeit the portion of the license covering the three un-deployed counties, and retain and renew the portion of the license covering the remaining two counties. Similarly, a licensee of the same hypothetical PEA who deployed mobile service covering 80 percent of one county, and 30 percent of another, could retain and renew the portion of the license for those two counties because the resulting two-county license area would have coverage of 55 percent of its population, which exceeds the 40 percent requirement.

d. Treatment of Incumbents

217. *Background*. Current licensees in the LMDS and 39 GHz bands are subject to different performance requirements than those we adopt today for future licensees in these bands.[561] In the *NPRM*, we proposed to apply the existing performance requirements to incumbent LMDS and 39 GHz licensees at the end of their current license terms, so long as the license term expires prior to March 1, 2021.[562] We also sought comment on allowing current licensees to meet their performance requirements under the current rules at some earlier date, for example 2018, in order to then allow licensees to begin transitioning their networks to other uses as soon as possible.[563]

218. Qualcomm and Straight Path support our proposal to allow licensees to meet their current performance requirements before the end of their current license terms.[564] XO supports giving incumbents the option to fulfill their current substantial service requirements, rather than the new requirements, at the end of their current terms. [565]

219. *Discussion*. We decline to adopt our proposal from the *NPRM*.[566] For license terms concluding before 2020, licensees may be unable as a practical matter to meet the new, more rigorous requirements we adopt for these bands at the end of their current license terms because of the nascent state of technology. Moreover, providing for additional time will provide more effective opportunities for licensees to use the spectrum in ways that maximize the flexibility now afforded by our new rules. For example, the transition toward providing innovative mobile services is likely to require complex business decisions and changes in plans. In short, it is our intent to encourage deployment of new and innovative services – particularly mobile service – as efficiently and effectively as possible.

220. Thus, we slightly modify and extend the deadline for meeting the performance requirements pertaining to licensees' current licenses for licenses expiring after the adoption date of the rules in this proceeding.[567] Specifically, current licensees in the 28 GHz and 39 GHz bands who, under the current rules, face a deadline for demonstrating substantial service after the adoption date of this *Report and Order* will not be required to demonstrate substantial service at renewal. Instead, those licensees will be required to fulfill the performance requirements we adopt today for their respective licenses by June 1, 2024. This approach will allow current licensees to focus on growing and

[561] *See* 47 CFR § 101.17.

[562] *NPRM* 30 FCC Rcd at 11942, para. 219.

[563] *NPRM* 30 FCC Rcd at 11942, para. 219.

[564] Straight Path Comments at 38, Qualcomm Reply at 7.

[565] XO Comments at 28-29.

[566] *NPRM* 30 FCC Rcd at 11942, para. 219.

[567] This rule change "relieves a restriction" otherwise applicable to licensees whose licenses expire between the adoption date and the effective date of our new rules. 5 U.S.C. § 553(d)(1).

transitioning their networks in line with new and developing industry standards, which will support earlier and more robust deployment of next-generation services in these bands.

e. Alternatives to Performance Requirements

221. *Background.* In the *NPRM*, the Commission sought comment on two alternatives to adopting performance requirements. First, we sought comment on a consecutive license concept under which applicants would bid for a license in a given county in a single, one-time auction, and the winning bidder in that auction would be required to pay the auction price, adjusted for inflation, before the start of each five-year license term. If the winning bidder made this payment before a five-year license term, a new license would be issued to the licensee for that five-year term. We reasoned that, "[s]uch an approach would be one way to incentivize construction of network facilities and spectrum use, given that a licensee would be unlikely to pay the auction price in successive license terms unless it could come up with a viable long-term plan for using the spectrum."[568] We also sought comment on separating interference and exclusion rights using an "option" concept to accomplish the goals of performance requirements. We noted that in the 3.5 GHz proceeding, we recently sought comment on a proposal to define "use" of priority access licenses in such a way as to separate the right to operate without interference from the right to exclude other users.[569] Under that proposal, the priority access licensee would have the right, but not the obligation, to exclude other users by making an additional "option" payment.[570]

222. T-Mobile and FWCC support the idea of implementing a "warehousing fee" approach under which licensees would pay the auction price again at every renewal rather than fulfilling performance requirements,[571] while Verizon explicitly opposes this option.[572] We received no comments on the "option payment" concept.

223. *Discussion*. We decline to adopt either of these alternatives for these bands. The Communications Act contemplates that the Commission will take measures "to prevent stockpiling or warehousing of spectrum by licensees."[573] As noted above, we believe the foregoing performance requirements are feasible in these bands, and the best method to prevent warehousing in this context. O3b argues that such "consecutive license terms with recurring payments" would simply change the financial calculation underpinning warehousing: while the initial bid would be smaller and discounted less, the lower price of entry could encourage warehousing by reducing the amount initially needed to hold on to the spectrum.[574] In the absence of any discussion of the "option payment" concept, we will not adopt the proposal at this time.

8. Permanent Discontinuance of Operations

224. *Background.* Under Section 1.955(a)(3) of the Commission's rules, an authorization will automatically terminate, without specific Commission action, if service is "permanently discontinued."[575] In the *NPRM*, we proposed that for Upper Microwave Flexible Use Service licensees that identify their

[568] *NPRM*, 30 FCC Rcd at 11942, para. 221.

[569] *NPRM*, 30 FCC Rcd at 11942, para. 222.

[570] *NPRM*, 30 FCC Rcd at 11942, para. 222.

[571] FWCC Comments at 7-8, T-Mobile Comments at 18-19.

[572] Verizon Comments at 21-22.

[573] 47 U.S.C. § 309(j)(4)(B).

[574] O3b Comment at 27. However, this argument ignores the fact that under this proposal, the recurring payment forces a licensee to make an annual decision about its need for the spectrum based upon a more rational and current determination of revenue relative to cost.

[575] 47 CFR § 1.955(a)(3).

regulatory status as common carrier or non-common carrier, "permanently discontinued" should be defined as a period of 180 consecutive days during which the licensee does not provide service to at least one subscriber that is not affiliated with, controlled by, or related to, the provider in the service area of its license (or smaller service area in the case of a partitioned license).[576]

225. We proposed a different approach for licensees that use their licenses for private, internal communications. For these services, we propose to define "permanent discontinuance" as a period of 180 consecutive days during which the licensee does not operate any facilities under the license.[577] We proposed that licensees not be subject to this requirement until one year after their initial license period ends, to allow them adequate time to construct their networks.[578]

226. We also proposed that when 28 GHz, 37 GHz, or 39 GHz licensees permanently discontinue service, the licensee must notify the Commission of the discontinuance within 10 days, by filing FCC Form 601 and requesting license cancellation.[579] We further proposed that an authorization automatically terminates without specific Commission action if service is permanently discontinued, even if a licensee fails to file the required form.[580] No commenters discuss the permanent discontinuance of service proposals.

227. *Discussion*. We adopt our proposals from the *NPRM* related to permanent discontinuance of operations.[581] Specifically, we adopt the two separate proposed definitions of "permanent discontinuance," for common carrier and non-common carrier service, and for private communications services. We also adopt our proposal to wait to implement this requirement until one year after the initial license period ends. This approach is consistent with the definitions the Commission has adopted for other spectrum bands that are licensed for mobile use, including the H Block, AWS-3, and AWS-4 bands.[582]

228. We also adopt our proposal that a licensee who permanently discontinues service must notify the Commission within 10 days, and our proposal that such licenses terminate automatically even if a licensee fails to appropriately notify the Commission. This approach to permanent discontinuance is consistent with Section 1.955(a)(3) of the Commission's rules.[583] The permanent discontinuance rule is intended to provide operational flexibility while ensuring that spectrum does not lie idle for extended periods, and the rules we adopt today support those goals.

9. Secondary Markets Policies

a. Partitioning and Disaggregation

229. *Background.* The Commission's Part 101 rules generally allow for geographic partitioning and spectrum disaggregation in the LMDS and 39 GHz service.[584] Geographic partitioning refers to the assignment of geographic portions of a license to another licensee along geopolitical or other boundaries. Spectrum disaggregation refers to the assignment of discrete amounts of spectrum under the

[576] *NPRM*, 30 FCC Rcd at 11943, para. 225.

[577] *NPRM*, 30 FCC Rcd at 11943, para. 226.

[578] *NPRM*, 30 FCC Rcd at 11943, para. 226.

[579] *NPRM*, 30 FCC Rcd at 11943, para. 227.

[580] *NPRM*, 30 FCC Rcd at 11943, para. 227.

[581] *NPRM*, 30 FCC Rcd at 11943, paras. 225-26.

[582] *See* 47 CFR § 27.17.

[583] 47 CFR § 1.955(a)(3).

[584] *See* 47 CFR § 101.56.

license to another entity. Disaggregation allows for multiple transmitters in the same geographic area operated by different companies on adjacent frequencies in the same band.

230. In 1997, the Commission determined that all LMDS licensees would generally be permitted to disaggregate and partition their licensees.[585] The Commission later adopted specific procedural, administrative, and operational rules to govern the disaggregation and partitioning of LMDS licenses.[586] Similarly, in the same year, the Commission concluded that partitioning and disaggregation would be permitted in the 39 GHz band and adopted partitioning and disaggregation rules in these band as well.[587] The rules require the spectrum to be disaggregated by FDD pair in the 39 GHz band.[588]

231. In the *NPRM*, we proposed to continue to allow partitioning and disaggregation in the 28 and 39 GHz bands, and to permit 37 GHz licensees to partition and disaggregate their licenses as well.[589] We also proposed to require all parties to a partitioning or disaggregation agreement to independently fulfill the applicable performance and renewal requirements,[590] which is consistent with the current requirements.[591]

232. Commenters overwhelmingly support allowing secondary market transactions in general, and partitioning and disaggregation in particular.[592] Intel supports expanding disaggregation in the 39 GHz band by also permitting pair-splitting.[593] No commenters oppose allowing secondary market transactions generally, or partitioning or disaggregation specifically. No commenters discuss performance requirements for parties to a partition or disaggregation.

233. *Discussion*. We adopt our proposal in the *NPRM* to allow partitioning and disaggregation of licenses in the 28, 37, and 39 GHz bands.[594] As the Commission noted when first establishing partitioning and disaggregation rules, allowing such flexibility could facilitate the efficient use of spectrum by enabling licensees to make offerings directly responsive to market demands for particular types of services, increasing competition by allowing new entrants to enter markets, and expediting provision of services that might not otherwise be provided in the near term.[595] This policy would leave the decision of determining the correct size of licenses to the licensees and the marketplace. Allowing this flexibility is consistent with the record, and with the flexible approach to licensing these bands that

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[585] *Second LMDS Report and Order*, 12 FCC Rcd at 12608, paras. 144-45.

[586] *See Rule Making to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 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*, Fourth Report and Order, 13 FCC Rcd 11655 (1998) (*LMDS Fourth Report and Order*). *See also* 47 CFR § 101.1111.

[587] *39 GHz Report and Order*, 12 FCC Rcd at 18635-36, paras. 71-74; 47 CFR § 101.56.

[588] 47 CFR § 101.56(a)(1).

[589] *NPRM*, 30 FCC Rcd at 11944-45, para. 233.

[590] *NPRM*, 30 FCC Rcd at 11945, para. 234.

[591] *See* 47 CFR § 101.56; 47 CFR § 101.1111.

[592] AT&T Reply at 11, Cisco Comments at 11, CTA Comments at 14-15, Ericsson Comments at 6, FiberTower Comments at 8-9, HTSC Comments at 4-5, Intel at 25-26, Mobile Future Comments at 16, TIA Comments at 30-31, Verizon Comments at 13-14, XO Comments at 23.

[593] Intel Comments at 26.

[594] *NPRM*, 30 FCC Rcd at 11944-45, paras. 233-34.

[595] *Geographic Partitioning and Spectrum Disaggregation by Commercial Mobile Radio Service Licensees*, Report and Order and Further Notice of Proposed Rulemaking, 11 FCC Rcd 21831, 21833, para. 1 (1996). We discuss spectrum aggregation policies with regard to secondary market transactions in Section IV.F.6 (Mobile Spectrum Holdings) *supra*.

we adopt above in this *Report and Order*.[596] Because the band plan we adopt for the 39 GHz band does not use paired spectrum blocks, the current rule that licenses in that band must be disaggregated in pairs will no longer apply.[597]

234. We also adopt our proposal to require all parties to a partitioning or disaggregation agreement to independently fulfill applicable performance and renewal requirements. According to the performance requirements framework we adopt above, [598] individual licensees may choose which metric they fulfill (e.g., fixed, mobile, or satellite), but each licensee must make a showing that independently satisfies the requirements. This requirement will facilitate efficient spectrum use, while enabling service providers to configure geographic area licenses and spectrum blocks to meet their operational needs.

b. Spectrum Leasing

235. *Background.* In 2003, in order to promote more efficient use of terrestrial wireless spectrum through secondary market transactions and in order to eliminate regulatory uncertainty, the Commission adopted the *Secondary Markets First Report and Order*, which contained a comprehensive set of policies and rules to govern spectrum leasing arrangements between terrestrial licensees and spectrum lessees.[599] These policies and rules enabled terrestrially-based Wireless Radio Service licensees holding "exclusive use" spectrum rights to lease some or all of the spectrum usage rights associated with their licenses to third party spectrum lessees.[600] Those third party lessees were then permitted to provide wireless services consistent with the underlying license authorization.[601]

236. This 2003 Order excluded a number of wireless radio services from the spectrum leasing rules and policies, including Part 101 services.[602] A year later, the Commission extended the spectrum leasing policies to a number of additional wireless services, including Part 101 services.[603] At that time, the Commission also built upon the spectrum leasing framework by establishing immediate approval procedures for certain categories of terrestrial spectrum leasing arrangements.[604]

237. In the *NPRM*, we proposed to apply these spectrum leasing policies to the new Part 30 radio service governing Upper Microwave Flexible Use Services, including all 28 GHz, 37 GHz, and 39

[596] *See supra* Section IV.F.1 (Creation of New Rule Service and Part).

[597] *See supra* Section IV.B.2 (Licensing the 39 GHz Band).

[598] *See supra* Section IV.F.7.b (Performance Metrics and Milestones).

[599] *Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets*, Report and Order and Further Notice of Proposed Rulemaking, 18 FCC Rcd 20604 (2003) (*Secondary Markets First Report and Order*), Erratum, 18 FCC Rcd 24817 (2003).

[600] *Secondary Markets First Report and Order*, 18 FCC Rcd at 20609-13, 20648-49, paras. 8-9, 12-13, 91-92. Wireless Radio Services do not include satellite services. 47 CFR § 1.907. Under these secondary market policies and rules, the service rules and policies applicable to the licensee under its license authorization – including all technical, interference, and operational rules – apply to the spectrum lessee as well. *Secondary Markets First Report and Order*, 18 FCC Rcd at 20648-49 paras. 91-92; *see* 47 CFR §§ 1.9020(c)-(d), 1.9030(c)-(d), 1.9035(c)-(d). The rules and procedures for spectrum leasing arrangements are set forth in Part 1, Subpart X. 47 CFR §§ 1.9001 *et seq*.

[601] *Secondary Markets First Report and Order*, 18 FCC Rcd at 20648-49, paras. 91-92.

[602] *Id.*

[603] *Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets*, Second Report and Order, Order on Reconsideration, and Second Further Notice of Proposed Rulemaking, 19 FCC Rcd 17503 (2004) (*Secondary Markets Second Report and Order*).

[604] *Id.*

GHz terrestrial licenses.[605] We proposed to apply these policies in the same manner that they apply to Part 101 services.[606]

238. As noted above,[607] many commenters support allowing secondary market transactions generally and spectrum leasing specifically.[608] Commenters cite the additional flexibility afforded by leasing spectrum,[609] and the market certainty granted by using established rules.[610] Several commenters also mention that spectrum leasing allows a broader range of entities to access licensed spectrum and provides additional competition in the marketplace.[611] No commenters oppose allowing spectrum leasing arrangements.

239. *Discussion.* We adopt our proposal to allow spectrum leasing in the 28 and 39 GHz bands, as well as the portion of the 37 GHz band licensed on a geographic area basis.[612] Allowing spectrum leasing in these bands will promote more efficient, innovative, and dynamic use of the spectrum, expand the scope of available wireless services and devices, enhance economic opportunities for accessing spectrum, and promote competition among providers. In addition, spectrum leasing policies in a particular band generally follow the same approach as the partitioning and disaggregation policies for that band.[613] Thus, our adoption of spectrum leasing rules for the 28 GHz, 39 GHz, and 37 GHz bands is consistent with our decision above to allow partitioning and disaggregation in these bands as well.[614]

10. Other Operating Requirements

240. *Background.* In the *NPRM*, we noted that licensees in the Upper Microwave Flexible Use Service may also be required to comply with rules contained in other parts of the Commission's rules, depending on the particular services they provide.[615] Examples of these rules include the filing procedures for the Universal Licensing System, as set forth in Part 1,[616] and the provisions of Part 20 governing Commercial Mobile Radio Service (CMRS), to the extent a licensee provides such a service.[617]

241. We proposed in the *NPRM* to require UMFUS licensees to comply with these service-specific rules, as well as other rule parts that pertain generally to wireless communications services.[618] We also sought comment on any provisions in existing service-specific rules that might require specific

[605] *NPRM*, 30 FCC Rcd at 11946, para. 238.

[606] *NPRM*, 30 FCC Rcd at 11946, para. 238. *See, e.g.*, 47 CFR § 1.9005(j).

[607] *Supra* Section IV.F.9.a, Partitioning and Disaggregation.

[608] AT&T Reply at 11, Cisco Comments at 11, CTA Comments at 15, Ericsson Comments at 6, FiberTower Comments at 8-9, HTSC Comments at 4, Intel Comments at 25-26, Mobile Future Comments at 16, NCTA Comments at 17-18, TIA Comments at 13, XO Comments at 23.

[609] Cisco Comments at 11, XO Reply at 13-14.

[610] XO Reply at 13-14.

[611] Mobile Future Reply at 10, XO Comments at 23.

[612] *NPRM*, 30 FCC Rcd at 11946, para. 238.

[613] *Service Rules for Advanced Wireless Services in the 2000-2020/2180-2200 MHz Band*s, Report and Order and Order of Proposed Modification, 27 FCC Rcd 16102, 16198 para. 258 (WTB 2012) (*AWS-4 Service Rules Report and Order*).

[614] *See supra* Section IV.F.9.a (Partitioning and Disaggregation).

[615] *NPRM*, 30 FCC Rcd at 11946, para. 240.

[616] *See* 47 CFR §§ 1.911-1.959.

[617] 47 CFR §§ 20.1-20.22.

[618] *NPRM*, 30 FCC Rcd at 11946-47, paras. 241-42.

recognition or adjustment to comport with the supervening application of the new Part 30, as well as any provisions that might be necessary in Part 30 to fully describe the scope of covered services and technologies.[619]

242. No commenters suggest any reason why UMFUS licensees should not also be subject to those rule parts that apply to wireless communications services generally. In addition, no commenters identify any existing provisions that might require adjustment, or suggest any specific non-technical rule provisions that should be included in Part 30.[620]

243. *Discussion*. We adopt our proposal in the *NPRM* to require UMFUS licensees to comply with other rule parts that pertain generally to wireless communications services, and with any applicable service-specific rules.[621] This approach will maintain general consistency among various wireless communications services. Consistent with our proposal, we will add UMFUS to the definitions of Wireless Radio Service and Wireless Telecommunications Service in Section 1.907 of the Commission's rules. We refrain from modifying other existing rules in other rule parts at this time, as no commenter has identified any incompatibilities or inconsistencies between the Upper Microwave Flexible Use Service and the existing service-specific or generally applicable rules. To consolidate the technical rules for all of the types of flexible uses that might be deployed by UMFUS licensees under a single rule part, and to maintain consistency between the rules that we adopt and the current technical requirements that existing LMDS and 39 GHz licensees are subject to, we will move the existing Part 101 technical rules for traditional point-to-point and point-to-multipoint operations into Part 30.

11. Competitive Bidding Procedures

244. *Background.* We explained in the *NPRM* that it would be in the public interest and consistent with our statutory mandate[622] to adopt a licensing scheme that allows the filing of mutually exclusive applications for licenses in the 28, 37, and 39 GHz bands which, if accepted, would be resolved through competitive bidding.[623] The comments on this issue generally support this proposal and the Commission's proposed use of its competitive bidding rules to auction UMFUS licenses.[624] Thus, as detailed below, we adopt our proposal to use the Part 1 competitive bidding rules to auction licenses in the bands that compose the UMFUS.

a. Applicability of Part 1 Competitive Bidding Rules

245. We proposed in the *NPRM* to conduct any spectrum auction of UMFUS licenses in conformity with the general competitive bidding procedures set forth in Part 1 Subpart Q of the Commission's rules.[625] No commenters proposed any alternative or objected. Given our experience in successfully conducting auctions using these procedures, we will adopt our proposed approach. We will employ the Part 1 rules governing competitive bidding design, designated entity preferences, unjust enrichment, application and payment procedures, reporting requirements and the prohibition on certain communications between auction applicants – including those updates made in the *Competitive Bidding*

[619] *NPRM*, 30 FCC Rcd at 11946, para. 241.

[620] In the Technical Rules section, *infra*, we will discuss incorporating certain technical rules currently in Part 101 into Part 30.

[621] *NPRM*, 30 FCC Rcd at 11946-47, paras. 241-42.

[622] *See* 47 U.S.C. § 309(j)(1), (2).

[623] *NPRM*, 30 FCC Rcd at 11947, para. 243-45.

[624] AT&T Reply at 11, Mobile Future Comments at 16, Qualcomm Comments at 6, 10, 12, Mobile Future Reply at 5.

[625] *See NPRM*, 30 FCC Rcd at 11947, para. 246.

Update Report and Order.[626] We note however, that the Commission could modify these procedures at a later time.

246. In discussing the competitive bidding rules, one commenter urges that if the Commission adopts county-level licenses, it would be critical to permit 'package bidding' so that operators could assemble larger footprints by bidding on multiple counties at one time.[627] In response, two commenters argue that the Commission should not permit any form of package bidding because such bidding procedures may make it more difficult for small bidders to acquire specific licenses that are included in larger packages.[628] Issues involving such bidding procedures are more appropriately addressed in a pre-auction proceeding that will seek public input on the competitive bidding procedures to be used for a particular auction of UMFUS licenses. Accordingly, we defer consideration of such matters to such proceeding(s) where interested parties are likely to have a more informed context for such input.[629]

b. Small Business Provisions for Geographic Area Licenses

247. In authorizing the Commission to use competitive bidding, Congress mandated that the Commission "ensure that small businesses, rural telephone companies, and businesses owned by members of minority groups and women are given the opportunity to participate in the provision of spectrum-based services."[630] One of the principal means by which the Commission fulfills this mandate is through the award of bidding credits to small businesses. In the *Competitive Bidding Second Memorandum Opinion and Order*, the Commission stated that it would define eligibility requirements for small businesses on a service-specific basis, taking into account the capital requirements and other characteristics of each particular service in establishing the appropriate threshold.[631] Further, in the *Part 1 Third Report and Order* and the more recent *Competitive Bidding Update Report and Order,* the Commission, while standardizing many auction rules, determined that it would continue a service-by-service approach to defining small businesses.[632] We recently updated our standardized schedule of small business definitions to reflect the capital challenges small businesses face in the current wireless industry, and in the *NPRM* we sought comment on whether to apply those updated definitions for auctions of spectrum in the UMFUS bands.[633]

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[626] *See* 47 C.F.R. §§ 1.2101-1.2114; *see also Updating Part 1 Competitive Bidding Rules*, *et al.*, Report and Order; Order on Reconsideration of the First Report and Order; Third Order on Reconsideration of the Second Report and Order; Third Report and Order, 30 FCC Rcd 7493 (2015) (modified by *Erratum*, 30 FCC Rcd 8518 (WTB 2015)) (*Competitive Bidding Update Report and Order*).

[627] Verizon Comments at 12-13.

[628] EchoStar Comments at 40-41; U.S. Cellular Comments at 10-12.

[629] A pre-auction proceeding conducted pursuant to the provisions of Section 309(j)(3)(E)(i) of the Communications Act typically addresses multiple issues governing the conduct of an auction such as bidding procedures, minimum opening bids and or reserve prices, cap levels on bidding credits and payment procedures. *See* 47 U.S.C. § 309(j)(3)(E)(i).

[630] 47 U.S.C. § 309(j)(4)(D). In addition, Section 309(j)(3)(B) of the Act provides that, in establishing eligibility criteria and bidding methodologies, the Commission shall seek to promote a number of objectives, including "economic opportunity and competition . . . by avoiding excessive concentration of licenses and by disseminating licenses among a wide variety of applicants, including small businesses, rural telephone companies, and businesses owned by members of minority groups and women." *Id.* § 309(j)(3)(B).

[631] *Implementation of Section 309(j) of the Communications Act—Competitive Bidding*, Second Memorandum Opinion and Order, 9 FCC Rcd 7245, 7269, para. 145 (1994); 47 CFR § 1.2110(c)(1).

[632] *Competitive Bidding Update Report and Order*, 30 FCC Rcd at 7521, para. 65; *Part 1 Third Report and Order*, 13 FCC Rcd at 388, para. 18; 47 CFR § 1.2110(c)(1).

[633] *See NPRM*, 30 FCC Rcd at 11948-49, para. 248-49. Under the new standardized schedule, businesses with average annual gross revenues for the preceding three years not exceeding $4 million would be eligible for a 35

(continued….)

248. Based on the Commission's prior experience with the use of bidding credits in spectrum auctions, we believe that the using bidding credits is an effective tool to achieve the statutory objective of promoting participation of designated entities in the provision of spectrum-based service.

249. In adopting competitive bidding rules for the 39 GHz band, the Commission included provisions for designated entities to promote opportunities for small businesses, rural telephone companies, and businesses owned by members of minority groups and women to participate in the provision of spectrum-based services.[634] Specifically, the Commission adopted bidding credits for applicants qualifying as small businesses. For auction of licenses in the 39 GHz band, the Commission adopted two small business definitions.[635] These two small business definitions were later adopted as the highest two of three thresholds in the Commission's standardized schedule of bidding credits.[636] In the *NPRM*, we proposed to adopt for the UMFUS the two small business definitions with higher gross revenues thresholds reflecting the recently adopted updates to the Part 1 schedule of small business definitions in the *Competitive Bidding Update Report and Order*.[637] We adopt our proposal to apply the two small business definitions with higher gross revenues thresholds to auctions of UMFUS licenses in the 28, 37, and 39 GHz bands and any other spectrum bands that we may subsequently designate for inclusion in the UMFUS. Accordingly, an entity with average annual gross revenues for the preceding three years not exceeding $55 million will qualify as a "small business," while an entity with average annual gross revenues for the preceding three years not exceeding $20 million will qualify as a "very small business." While the capital requirements of the services to be deployed in these bands is not yet known, we believe that using these gross revenue thresholds will enhance the ability of small businesses to acquire and retain capital and thereby complete meaningfully at auction. We also believe that these thresholds are not overly inclusive, and prevent designated entity benefits from flowing to entities for which such credits are not necessary. We believe that the various spectrum bands included in the UMFUS – spectrum that will be utilized under the same or similar technical rules – will be deployed for the same types of service, and therefore the two small business definitions with higher gross revenues thresholds should apply to all of the bands in the UMFUS.

250. We also adopt our proposal to provide qualifying "small businesses" with a bidding credit of 15 percent and qualifying "very small businesses" with a bidding credit of 25 percent, consistent with the standardized schedule in Part 1 of our rules.[638] This proposal was modeled on the small business size standards and associated bidding credits that the Commission adopted for a range of other services,

(Continued from previous page)
percent bidding credit, businesses with average annual gross revenues for the preceding three years not exceeding $20 million would be eligible for a 25 percent bidding credit, and businesses with average annual gross revenues for the preceding three years not exceeding $55 million would be eligible for a 15 percent bidding credit. *Competitive Bidding Update Report and Order*, 30 FCC Rcd at 7524, para. 74. We also adopted a monetary cap on the total amount of bidding credits that an eligible small business or rural service provider may be awarded in any particular auction. Specifically, the amount of the bidding credit cap for a small business in any particular auction will not be less than $25 million and the bidding credit cap for the total amount of bidding credits that a rural service provider may be awarded will not be less than $10 million. *See id*. at 7541, para. 114.

[634] *See 39 GHz Report and Order,* 12 FCC Rcd at 18662-63, para. 150 (1997) (defining a qualifying small business as one with no more than $40 million in average annual gross revenues for the preceding three years and a very small businesses as one with no more than $15 million in average annual gross revenues for the preceding three years); *see also* 47 U.S.C. § 309(j)(4)(D).

[635] *See id.*; 47 CFR §§ 101.1208, 101.1209.

[636] *See Amendment of Part 1 of the Commission's Rules – Competitive Bidding Proceeding*, Third Report and Order and Second Further Notice of Proposed Rulemaking, 13 FCC Rcd 374, 403-04 para. 47 (1997).

[637] *See NPRM*, 30 FCC Rcd at 11948-49, paras. 248-49 (*citing Competitive Bidding Update Report and Order*, 30 FCC Rcd at 7524, para. 74).

[638] *See NPRM*, 30 FCC Rcd at 11949, para. 249. *See also* 47 C.F.R. § 1.2110(f)(2)(i)(B), (C).

including Advanced Wireless Services in the AWS-1 band.[639] We believe that this two-tiered approach has been successful in the past, and will once again utilize it. We use the existing 39 GHz service rules as a starting point, but adjust the bidding credit levels to be consistent with the schedule in Part 1 of our rules.[640] We believe that use of the small business definitions and associated bidding credits set forth in the Part 1 bidding credit schedule will provide consistency and predictability for small businesses. No commenter provides any alternative or reason why our bidding credit thresholds or small business definitions would not work in this service. Accordingly we adopt our proposals regarding small business definitions and bidding credits.

c. Rural Service Provider Provisions for Geographic Area Licenses

251. The rural service provider bidding credit awards a 15 percent bidding credit to those servicing predominantly rural areas and that have fewer than 250,000 combined wireless, wireline, broadband and cable subscribers.[641] In the *NPRM*, we stated that in the absence of comments to the contrary, we would leave open the option for future bidding applicants to apply for rural service provider bidding credits in lieu of a small business bidding credits.[642] We now decide that we will apply the rural service provider bidding credit to auctioning the 28 GHz, 37 GHz and 39 GHz bands. Although we have not received comments about this issue, we believe that a targeted bidding credit will better enable rural service providers to compete for spectrum licenses at auction and in doing so, will increase the availability of 5G service in rural areas.

d. Small Business and Rural Service Provider Bidding Credit Caps

252. In the *Competitive Bidding Update Report and Order*, we adopted a process for establishing a reasonable monetary limit or cap on the amount of bidding credits that an eligible small business or rural service provider may be awarded in any particular auction.[643] We established the parameters to implement a bidding credit cap for future auctions on an auction-by-auction basis.[644] Consistent with the Commission's longstanding approach, after adoption of all of the necessary service rules for the Upper Microwave Flexible Use Service, the Commission will initiate a public notice process to solicit public input on certain details of auction design and the auction procedures for the initial auction of UMFUS licenses. As part of that process, we will solicit public input on the appropriate amount of the bidding credit cap and subsequently establish the cap that will apply for that auction, based on an evaluation of the expected capital requirements presented by the particular spectrum being auctioned and the inventory of licenses to be auctioned.[645]

e. Tribal Lands Bidding Credit

253. The tribal lands bidding credit program awards a discount to a winning bidder for serving qualifying tribal land that have a wireline telephone subscription rate equal to or less than 85 percent of the population.[646] We believe that tribal entities involved in the telecommunications industry face unique

[639] *NPRM*, 30 FCC Rcd at 11949, para. 249 n.424. *See*, *e.g.,* Service Rules for Advanced Wireless Services in the 1.7 GHz and 2.1 GHz Bands, WT Docket No. 02-353, *Report and Order*, 18 FCC Rcd 25162, 25220, para. 149 (2003); *Service Rules for Advanced Wireless Services in the 2000-2020/2180-2200 MHz Bands, et al.*, WT Docket No. 12-70, *et al.*, 27 FCC Rcd 16102, 16185, para. 217 (adopting the AWS-1 size standards and associated bidding credits for small businesses for any AWS-4 licenses awarded through competitive bidding).

[640] *See* 47 CFR § 1.2110(f)(2).

[641] *Competitive Bidding Update Report and Order*, 30 FCC Rcd at 7530, para. 88.

[642] *See NPRM*, 30 FCC Rcd at 11950, para. 253.

[643] *Competitive Bidding Update Report and Order*, 30 FCC Rcd at 7539-44, paras. 110-21.

[644] *Id.*

[645] *See Competitive Bidding Update Report and Order*, 30 FCC Rcd at 7541, para. 114.

[646] 47 CFR § 1.2110(f)(3).

challenges in participating in spectrum auctions and that the tribal lands bidding credit will promote further deployment and use of spectrum over tribal lands. No commenters oppose the tribal land bidding credit nor suggest that the tribal lands bidding credit is unnecessary. Accordingly, a winning bidder for a market will be eligible to receive a credit for serving qualifying Tribal lands within that market, provided it complies with the applicable competitive bidding rules.[647]

f. Bidding Process Options

254. Finally, we also sought comment in the *NPRM* on whether we should revise any of our bidding process and payment rules to ameliorate the administrative difficulties the Commission could potentially face in enforcing the construction requirements in the 3,143 counties nationwide.[648] One alternative we discussed was to allow prospective millimeter wave licensees to bid, in a single auction, on licenses that have consecutive terms of license rights in a given geographic area – i.e., licensees could bid at auction for the right to obtain a license in a given county not just for a single license term, but for each subsequent five-year license term; and the winning bidder would pay an auction-determined fee, in lieu of other performance requirements before the start of each term.[649] Once a winning bidder made this payment, a new license would issue for the next consecutive license term.[650] Some commenters support adopting such payments in lieu of performance requirements.[651] However several commenters criticize the approach as incentivizing spectrum warehousing.[652] For example, O3b notes that consecutive license terms with recurring payments would simply change the financial calculation underpinning warehousing: while the initial bid would be smaller and discounted less, the lower price of entry could encourage warehousing by reducing the amount initially needed to hold on to the spectrum.[653] We decline to adopt recurring payments as an alternative to performance requirements in this order and note it is unlikely we would adopt such payments given our review of the record and further consideration of the factors affecting these bands. In the *NPRM*, we speculated that these payments could incentivize deployment of network facilities and discourage spectrum warehousing because a licensee would be unlikely to pay the auction price for successive terms for spectrum it did not intend to use.[654] However, we believe there is a strong likelihood that bidders would still warehouse spectrum and leave it fallow if the cost of the recurring payment to the spectrum holder was outweighed by the benefit derived from foreclosing other operators' access to the spectrum. This would counter our goal of accelerating deployment in these bands. Accordingly we decline to adopt this proposal.

12. Security

255. The FCC's approach to cybersecurity proceeds from the view that communications providers are generally in the best position to evaluate and address risks to their network operations. This approach recognizes the importance of private sector leadership and innovation in cybersecurity, and it

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[647] 47 CFR § 1.2110(f)(3).

[648] *See NPRM*, 30 FCC Rcd at 11950, para. 255.

[649] *See id.*at 11950, para. 255.

[650] *See id.*at 11950, para. 255.

[651] FWCC Comments at 7-8. ("This approach at least will encourage any construction that promises eventual revenues, without unduly penalizing construction that fails to meet minimum requirements within a set time. It also enables bidders, and then licensees, to make short-term, and hence better informed financial decisions, which in turn may help moderate the wild swings in the returns of some past auctions.") T-Mobile initially called for these payments in lieu of performance, naming them a "warehousing fee." T-Mobile Comments at 19. T-Mobile has since argued the Commission should not adopt any performance requirements at this time. T-Mobile Reply at 16.

[652] *See* Verizon Comments at 21-22, O3b Comment at 27.

[653] O3b Comments at 27.

[654] *See id.* at 11942, para. 221, 11951, para. 256.

reduces the need for ongoing regulatory involvement in private sector security practices. It will prove successful, though, only if the private sector aggressively addresses evolving threats through security-by-design, even where short-term market incentives may not be sufficient to drive long-term security investments before harm is realized.

256. Emerging security standards for new flexible uses of the mmW bands (and "5G" more broadly) are developing in parallel, but not necessarily at the same pace, with the emerging networks, devices, and equipment.[655] While CTIA has observed that significant, multi-stakeholder, multi-disciplinary, and "multi-layered" efforts are ongoing, domestically and globally, "to assure that [5G] network and [mmW] device security is preserved to the maximum extent feasible,"[656] we must acknowledge that to date many wireless communications systems have not been successful at implementing security-by-design. We recognize that, in the race to market, vital security protections too often fall by the wayside.

257. We today take narrowly tailored steps to help promote an environment that encourages the early and ongoing consideration of security issues by all private sector participants, including infrastructure and device firms, established communications firms, and new entrants to communications markets. New mmW-based networks will enable valuable new services, and accelerating the deployment of those services is a national priority. Those benefits, however, will be undermined if security risks are not managed by licensees. Accordingly, we are moving expeditiously both to meet the need for new mmW spectrum for next generation services and to help ensure that security for these services is built in from the beginning, not left as an afterthought. In this approach, we concur with stakeholders who identify that there is an opportunity to take action now – before the technology is mature or the services deployed – to encourage, from the outset, the development of necessary cybersecurity protections alongside the development of emerging services and technologies.[657]

258. In the *NPRM*, we recognized the significance of security to 5G networks and the future devices enabled by and connecting to them. Because of the implications related to both sets of issues, we sought comment on how to secure mmW band devices, networks, and their communications, and specifically on "how to ensure that effective security features are built into key design principles for all mmW band communications devices and networks."[658] We expressed a belief in the value of "security-by-design" that is motivated by our expectations that these networks may provide capabilities for a wide variety of new devices and applications, including, among others, traditional mobile communications capabilities, IoT and other applications as well as devices critical to public safety and related services that provide essential protections to the nation[659] We indicated that security by design means ensuring that the goals that drive the development of networks and devices include achieving an objective state of security.[660] In that context, we explained that the security constructs of confidentiality, integrity, and availability help us gain insight into security generally,[661] and that security-by-design can help ensure that

[655] *See* AT&T Comments at 3; 4G Americas Comments, Attach. at 2-3; Qualcomm, Inc. Reply at 9; Letter from Thomas K. Sawanobori, CTO, and John A. Marinho, Vice President of Technology & Cybersecurity, CTIA, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 14-177, *et. al*, at 2-3 and 5, *quoting* TIA Comments at 36 (filed May 23, 2016) (CTIA *Ex Parte*).

[656] CTIA *Ex Parte* at 2.

[657] FiberTower Spectrum Holdings, LLC Comments at 2, 7; Huawei Comments at 4, 23; 4G Americas Comments at 17-18.

[658] *NPRM*, 30 FCC Rcd at 11952-53, paras. 260-61.

[659] *NPRM*, 30 FCC Rcd at 11952-53, paras. 260-261.

[660] *NPRM*, 30 FCC Rcd at 11952-53, paras. 260-261.

[661] *See NPRM*, 30 FCC Rcd at 11952, para. 261.

the next generation of wireless networks meets these critical components of a secure network. Several commenters expressed their support for this approach.[662]

259. We continue to believe in the significant benefits of security by design, including the benefits that we would expect to flow from using the confidentiality, integrity, and availability construct[663] for assessing, planning and incorporating security elements into networks and devices as early as possible in their developmental stages. Indeed, the record demonstrates that security elements are appropriate and important for service providers and equipment developers to consider now, during the development process, as well as part of an ongoing discussion as networks and devices are deployed and operated.

260. For example, one commenter notes that the "network-based hop-to-hop security approach used today to secure the path between communications users will not be sufficient for differentiated end-to-end security for certain 5G services."[664] Systems are in need of a "secure architecture, stringent identity management and data protection, more rigorous authentication methods, and an array of system-level protections to defend against distributed denial of service . . . attacks and other intrusions."[665] Accordingly, the commenter believes that security features that are incorporated into 5G systems by design would provide a significant advantage over any "built on top of" system design.[666] Since the service and network architecture of 5G is going through dramatic remodeling, the commenter maintains it will "improve the feature and competitive strength for 5G if security protection is included at an early stage."[667]

261. The view that security should be a fundamental component in the design of any new network architecture and protocols is also shared by 5G Americas, which underscores the heightened sense that security is expected to take on as new technology and services are deployed.[668] For example, 5G Americas states that 5G systems are expected to provide important applications such as "smart grids, telemedicine, industrial control, public safety and automotive, [which] have security requirements to defend against intrusion and to ensure uninterrupted operations."[669] Other commenters offer additional examples illustrating why it is appropriate and important to build security elements into considerations that go into developing networks and devices. For instance, AT&T notes a variety of developments that will have security implications: "machine to machine communications will contemplate energy optimization, reduced signaling, and massive connectivity. With these advancements, IoT [Internet of Things] will become a reality. 5G systems will be capable of supporting a range of machine-to-machine services, from connected cars to smart cities to telemedicine and beyond."[670] Highly secure 5G systems will be expected even in times of stress. As FiberTower notes, "reliance on 5G will only increase in the

[662] *See* Nokia Reply, Attach. at 1; Letter from Joseph M. Sandri, FiberTower, to Marlene H. Dortch, FCC, GN Docket No. 14-177, at 1 (filed Mar. 28, 2016) (FiberTower *Ex Parte*); Huawei Comments at 23-24; Letter from Patricia Paoletta, Counsel for 5G Americas, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 14-177, at 1 (filed Apr. 8, 2016) (5G Americas *Ex Parte*).

[663] These concepts guided our discussion of security in the *NRPM*. *NPRM*, 30 FCC Rcd. at 11952-54, paras. 261-64.

[664] Huawei Comments at 24.

[665] Huawei Comments at 24.

[666] Huawei Comments at 24.

[667] FiberTower Comments at 2, Huawei Comments at 23 (quoting Huawei, 5G Security: Forward Thinking at 11 (2015)).

[668] 5G Americas Comments at 17.

[669] 5G Americas Comments at 17.

[670] AT&T Comments at 8.

event of a man-made or naturally occurring outage in a critical service."[671] To support these needs, we believe 5G services will need to be highly secure prior to deployment, and we think it reasonable that the Commission be apprised of security plans in place prior to 5G services becoming operational.

262. Based on our analysis of the record, the Commission can best facilitate adoption of security-by-design approaches by promoting an open dialogue about security practices that would be consistent with a discussion at a standards organization. Therefore, we are asking to receive from licensees – before they begin operations – general statements, at a level consistent with the open forum standards body discussions, of their plans for safeguarding their networks and devices from security breaches. Requiring licensees to submit that information at that juncture creates an incentive for them to engage in the development of security measures at an earlier stage. The specific information that we receive will also facilitate the Commission's ability to help in identifying security risks, including areas where more attention to security may be needed, and in disseminating information about successful practices for addressing the risks. Moreover, this approach avoids the drawbacks of imposing prescriptive security mandates – e.g., downsides such as the likelihood that one size will not fit all, the lack of agility in responding to changing circumstances and technologies, and the rigidity that such mandates tend to introduce into systems at the outset – thereby preserving for operators, equipment developers, and other interested parties significant flexibilities for addressing security concerns.

263. As described in detail below, the provision that we are adopting today promotes "security-by-design" approaches within the mmW network and product development environment, in ways that should (i) minimally impact (but appropriately enhance the prospects for security "assurance") ongoing design and development with respect to this nascent technology, (ii) facilitate integration of network and product development with the timeline for standards development, and (iii) encourage early participation in and monitoring of such standards development. This provision – a requirement that each licensee discuss at a high level how confidentiality, integrity, and availability[672]principles are reflected in its network security design planning in a Statement submitted to the Commission prior to commencing operations – should also help inform our collective understanding and strategies for addressing security issues in the next generation of communications networks. More specifically, we are requiring licensees to file a Statement with the Commission within three years after grant of the license, but no later than six months prior to deployment.[673] This time period accords with the Commission's security-by-design goals while leaving flexibility for licensees depending on when they are able to deploy service. The Statement must be signed by a senior executive within the licensee's organization with personal knowledge of the organization's security plans and practices, within the licensee's organization, and must include, at a minimum, the following elements:

- A high-level, general description of the licensee's security approach designed to safeguard the planned network's confidentiality, integrity, and availability with respect to communications from: a device to the licensee's network; one element of the licensee's network to another

[671] FiberTower Reply at 8. *See also* Nokia Reply, Attach. at 1 ("[c]onsidering all this, it is obvious that in 5G networks security must be 'built in.' When designing 5G networks, architectural considerations must be accompanied with respect to security considerations, and such security considerations are expected to influence architectural decisions.").

[672] *Confidentiality* refers to the protection of data from unauthorized access and disclosure, both while at rest and in transit. *See, e.g.*, ATIS, ATIS Telecom Glossary, http://www.atis.org/glossary/definition.aspx?id=6609. *Integrity* refers to the protection against the unauthorized modification or destruction of information. *See, e.g.*, ATIS, ATIS Telecom Glossary, http://www.atis.org/glossary/definition.aspx?id=4584. *Availability* refers to the accessibility and usability of a network upon demand. *See, e.g.*, ATIS, ATIS Telecom Glossary, http://www.atis.org/glossary/definition.aspx?id=5637. For a discussion of all three constructs of confidentiality, integrity and availability, *see also NPRM*, 30 FCC Rcd at 11952 paras. 261-64.

[673] To the extent that there are material changes to the information presented in the Statement, licensees must file updates to notify the Commission.

element on the licensee's network; the licensee's network to another network; and device to device (with respect to telephone voice and messaging services).

- A high-level, general description of the licensee's anticipated approach to assessing and mitigating cyber risk induced by the presence of multiple participants in the band. This should include the high level approach taken toward ensuring consumer network confidentiality, integrity, and availability security principles, which are to be protected in each of the following use cases: communications between a wireless device and the licensee's network; communications within and between each licensee's network; communications between mobile devices that are under end-to-end control of the licensee; and communications between mobile devices that are not under the end-to-end control of the licensee.
- A high-level description of cybersecurity standards and practices to be employed, whether industry-recognized or related to some other identifiable approach;
- A description of the extent to which the licensee participates in standards bodies or industry-led organizations pursuing the development or maintenance of emerging security standards and/or best practices;
- The high-level identification of any other approaches to security, unique to the services and devices the licensee intends to offer and deploy; and
- Plans to incorporate relevant outputs from Information Sharing and Analysis Organizations (ISAOs)[674] as elements of the licensee's security architecture. Plans should include comment on machine-to-machine threat information sharing, and any use of anticipated standards for ISAO-based information sharing.

264. The intent of the disclosures is to facilitate multi-stakeholder peer review and earlier development of devices and a commercially viable market for the service. The Commission recognizes that the Statements concern the cybersecurity of our nation's critical communications infrastructure and, accordingly, the content of the Statements should be at a high-level and not include information that, if publicly disclosed, would create a significant risk to the security of this infrastructure or related systems and networks. The Commission also recognizes that an entity's cybersecurity posture can be a competitive differentiator[675] and that unauthorized disclosures of Statements containing more detailed information could result in competitive harm to the licensee. Here again, we conclude that the Statements should not provide information at a level of granularity that its public disclosure would jeopardize the competitive position of the licensee. For example, we expect that these disclosures will contain information that could be disclosed at a standards meeting where stakeholders gather to share ideas and information for the purpose of advancing the state of the art. If, however, licensees intend to submit information that warrant confidential treatment, they may seek confidential treatment pursuant to the Commission's rules.[676] Furthermore, the information required to be submitted under this rule as it relates

[674] An ISAO is a group created to gather, analyze, and disseminate cyber threat information. ISAOs provide a flexible approach to self-organized information sharing activities amongst communities of interest such as small businesses across sectors. *See* U.S. Dept. of Homeland Security, *ISAO FAQ*, https://www.dhs.gov/isao-faq (last visited June 15, 2016).

[675] *See, e.g.*, Ponemon Institute (sponsored by Raytheon), 2015 Global Megatrends in Cybersecurity at 2 (Feb. 2015), http://www.raytheon.com/news/rtnwcm/groups/gallery/documents/content/rtn_233811.pdf (last visited Feb. 4, 2016) (Identifying as a top trend for 2015 that "[c]ybersecurity will become a competitive advantage and C-level priority.").

[676] We note that they have the right under Title 1 of our rules to request confidential treatment. Accordingly, pursuant to Section 0.459(a)(4), licensees filing Statements will be required to file a justification for confidential treatment. The Commission will work with licensees that file such statements to work toward a Statement that can be shared publicly.

to security plans and practices will not be used for the purpose of enforcing compliance with the Communications Act or any of the Commission's rules, other than the requirement of filing such Statements.[677]

265. The Commission finds that appropriate cybersecurity safeguards are a fundamental part of the development and deployment of mmW systems and services contemplated by this *Report and Order*. The reporting requirement we adopt today will not only help ensure that industry focuses the necessary degree of attention throughout these development and deployment processes on the most effective ways to include these safeguards at the earlier possible points, but it will also keep us informed of the ongoing progress in this area so we can provide timely, measured and effective responses to address any emerging problems before they become intractable.[678] It will also be important to consider how best to ensure that the types of cyber safeguards that we encourage today for the mmW bands will be incorporated more broadly into future so called 5G networks and services. Consequently, we direct the Office of Engineering and Technology, the Public Safety and Homeland Security Bureau, and Wireless Telecommunications Bureau to, by not later than October 31, 2016, issue in a separate docket a *Notice of Inquiry* (*NOI*) exploring the security implications and solutions in future 5G networks, beyond the actions we take in this *Report and Order*. We believe this *NOI* is an opportunity to look holistically at the potential security implications in future 5G networks offering different types of services to different types of users (e.g., wireless broadband, low-data-rate IoT applications, high-data-rate IoT applications). It will also provide a collaborative vehicle for exploring 5G security-related threats, solutions, and best practices in order to address the implications more effectively. The *NOI* is not intended to duplicate or replace ongoing or future 5G security architecture and 5G design work by standards bodies, industry or academic groups, but instead to facilitate common appreciation across the 5G ecosystem for the evolving security standards. The *NOI* will also provide an opportunity for stakeholders to identify new 5G issues as new IoT functions are developed in 5G, and as national security, public safety, critical infrastructure industries, and consumers begin to understand the implications and potential opportunities of 5G.

G. Technical Rules

1. Flexible Duplexing Rules

266. *Background.* In the *NPRM*, we sought comment on our proposal to adopt flexible duplexing rules in the 27.5-28.35 GHz band, 37-38.6 GHz band, and 38.6-40 GHz band to allow TDD, FDD, or other duplexing schemes that might develop in the context of mobile mmW.[679] We also

[677] We also note that licensees making this statement are bound by the Commission's rules to make truthful and accurate statements. *See* 47 C.F.R. § 1.17. We do not intend to restrict the Commission's discretion in enforcing the Act and its rules based upon information gathered through independent investigations. In the event that the Commission determines that the public interest requires it to engage in future rulemaking in this area, its action will be informed by and may make use of information compiled from Statements consistent with appropriate treatment of any confidential information. *See, e.g.*, *Examination of Current Policy Concerning the Treatment of Confidential Information Submitted to the Commission*, Report and Order, 13 FCC Rcd 24816, 24823 & n.39, 24853 (1998).

[678] The reporting requirement that we adopt today is similar in purpose to certain other reporting requirements that we have established to help inform the Commission about ongoing progress in other areas, such as television "white spaces" (*Unlicensed Operation in the TV Broadcast Bands; Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, 25 FCC Rcd 18661, 18700-03, paras. 94-100 (2010)), and multilingual Emergency Alert System alerting (*Emergency Alert System; Petition of Independent Spanish Broadcasters Association, the Office of Communication of the United Church of Christ, Inc., and the Minority Media and Telecommunications Council for Immediate Relief; Petition of Randy Gehman for Rulemaking*, 31 FCC Rcd 2414, 2424-29 ¶¶ 19-31 (2016)).

[679] *NPRM*, 30 FCC Rcd at 11955, para. 269.

proposed to retain the existing channel plan for the 39 GHz band while recognizing that the existing channel plan favors an FDD duplexing scheme.[680]

267. Many commenters believe that TDD will be the predominant duplexing scheme used in mobile mmW systems and note the specific advantages of TDD.[681] For example, Nokia states that the advantages of TDD include the ability to use less complex radios, to use dynamic TDD, and to obtain more accurate channel state information for transmit beamforming with lower overhead.[682] CTIA states that antenna arrays and beamforming, which will be required to take full advantage of the mmW bands, are better suited to TDD.[683] Huawei notes that TDD offers the inherent reciprocal channel estimation process, which improves the system's ability to dynamically adapt to channel conditions.[684] Qualcomm and Straight Path note that TDD does not require a duplexer.[685] Samsung, Straight Path, Skyriver, and XO also note that the services these bands are expected to support will likely be asymmetric and that TDD is a more suitable technology to accommodate such services.[686]

268. However, commenters also overwhelmingly support our proposal to adopt rules that are flexible and allow for TDD as well as FDD and other duplexing schemes.[687] Cisco supports the Commission's proposal to allow TDD and FDD deployment in the mmW bands, and requests that the Commission facilitate using either technology by making the spectrum available in unpaired blocks.[688] Nokia states that while TDD is a good candidate for 5G mmW systems, the Commission should not mandate TDD for mmW systems, but instead should leave the door open to FDD and other new types of duplexing that may be available in the future.[689] Intel states that private parties should be permitted to decide on the most appropriate duplexing scheme at any point in the future, without the delays associated with a future regulatory proceeding to broaden or change the duplexing scope.[690]

269. *Discussion.* Consistent with our proposal in the *NPRM*, we will adopt flexible duplexing rules for the 27.5-28.35 GHz, 37-38.6 GHz, and 38.6-40 GHz bands.[691] While the comments indicate that TDD is the duplexing scheme licensees are most likely to deploy in the bands, we see no reason to prevent them from using other technologies. Therefore, the rules we adopt will allow any type of duplexing to be deployed, subject to other technical rules to manage interference. We also adopt changes to the 39 GHz channel plan, as discussed in more detail in Section IV.B.5 (39 GHz Band (38.6-40 GHz)), which will accommodate more flexible duplexing schemes.

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[680] *NPRM*, 30 FCC Rcd at 11955, para. 270.

[681] Cisco Comments at 9, CTIA Comments at 28, Huawei Comments at 25-27, Nokia Comments at 25-26, Qualcomm Comments at 15-16, Samsung Comments at 17, Skyriver Comments at 16-17, Straight Path Comments at 23-24, T-Mobile comments at 19, TIA Comments at 31.

[682] Nokia Comments at 25.

[683] CTIA Comments at 28.

[684] Huawei Comments at 25-27.

[685] Qualcomm Comments at 15, Straight Path Comments at 23, 24

[686] *See* Samsung Comments at 17, Straight Path Comments at 24, Skyriver Comments at 17, XO Comments at 24-25.

[687] Cisco Comments at 9-10, CTIA Comments at 28, FiberTower Comments at 6, Intel Comments at 20, Nokia Comments at 25-26, Samsung Comments at 17, Skyriver Comments at 16-17, Straight Path Comments at 40, TIA Comments at 31, T-Mobile Comments at 19, Verizon Comments at 17, XO Comments at 24-25.

[688] Cisco Comments at 9-10.

[689] Nokia Comments at 26

[690] Intel Comments at 20.

[691] *NPRM*, 30 FCC Rcd at 11955, para. 269.

2. Transmission Power Limits and Antenna Height

a. Base Stations

270. *Background*. In the *NPRM* we proposed to adopt 1640 watts (or 62dBm) EIRP as the maximum transmission power limit for base stations operating in the 28, 39, and 37 GHz bands.[692] We also proposed to adopt 100 megahertz as the scaling factor so that base station transmission power is limited to 1640 watts EIRP, when transmitting with up to and including 100 megahertz of emission bandwidth and 1640 watts EIRP per 100 megahertz when transmitting with more than 100 megahertz of emission bandwidth. This proposed rule would allow additional transmission power for systems employing more than 100 megahertz emission bandwidth, and it would support the maximum transmission power limits suggested by commenters. We also proposed to permit licensees to double their transmission power limits in rural counties where the population density is 100 or fewer persons per square mile, based on the most recently available population statistics from the Bureau of the Census.[693] Additionally, we sought comment on whether a higher transmission power limit should be considered for in-band applications where the same equipment is used for mobile service and backhaul service.[694] Finally, we sought comment on whether we should adopt a height limit for base station antennas.[695]

271. Most commenters believe that we should adopt a higher power limit than the 62 dBm EIRP proposed in the *NPRM*, but initially disagreed on the specific limit we should adopt.[696] Qualcomm, Samsung, Straight Path, and Verizon state that power limits in the 68-75 dBm range are appropriate[697] while Ericsson, Nokia, TIA, XO argue that power limits in the 82-85 dBm range are necessary.[698] More recently, Verizon, Samsung, Qualcomm, Intel, Nokia, and Ericsson (the "Consensus Filers") have reached a consensus that 75 dBm EIRP is a reasonable transmission power limit.[699] According to the Consensus Filers, the proposed 62 dBm limit will result in a lower power spectral density than is achievable in other mobile bands and therefore the base station range will be much smaller. The lower range and shorter propagation distances at these frequencies will substantially constrain 5G deployment. The Consensus Filers, while acknowledging that many parties have advocated for higher limits, state that the consensus of the group is that 75 dBm is a reasonable compromise.

272. The commenters provide many reasons why higher power limits will be advantageous for 5G systems. Qualcomm notes that additional power would increase link reliability, particularly in dense urban areas and in higher-band spectrum during weather events.[700] Verizon states that the *NPRM* considers neither the increased propagation losses nor beamsteering and antenna gain effects, and suggests that given the high frequencies and very short RF wavelengths in these bands, companies can utilize high gain antennas and planar antenna arrays in proportionally smaller volumes making a higher

[692] *NPRM*, 30 FCC Rcd at 11955, para. 274.

[693] *NPRM*, 30 FCC Rcd at 11955, para. 275.

[694] In the *NPRM*, some commenters suggested that in-band backhaul might be feasible in the mmW bands by dedicating a portion of array antennas of a 5G system for backhaul use or allocating a portion of the timeslots of a TDD 5G system for backhaul use. *NPRM*, 30 FCC Rcd at 11955, para. 276

[695] *NPRM*, 30 FCC Rcd at 11956, para. 277.

[696] CTIA and FiberTower supported allowing higher transmit powers but did not specify a limit. CTIA Comments at 29-30, FiberTower Comments at 11.

[697] Qualcomm Comments at 16, Samsung Comments at 18, Verizon Comments at 16, Straight Path Reply at 26-27.

[698] Ericsson Comments at 13, Nokia Comments at 26, TIA Comments at 33, XO Comments at 26, XO Reply at 15-16.

[699] Verizon, Samsung, Qualcomm, Intel, Nokia, and Ericsson April21, *Ex Parte* Letter.

[700] Qualcomm Comments at 16. Qualcomm suggests increasing the maximum transmit power level for base stations by 10-12 dB to account for increased propagation losses in these bands. *Id.*

base station EIRP of up to 75 dBm more appropriate.[701] Samsung points out that the proposed power limits are significantly less than what has been traditionally allowed in the millimeter wave bands.[702] Ericsson suggests setting the EIRP to 82 dBm/100MHz or 85 dBm/100 MHz in rural areas, to equalize the bands above 24 GHz with the PCS and similar bands.[703] XO argues that higher power limits in the 28 GHz and 39 GHz bands will enable larger base station footprints and account for the larger number of antennas and higher bandwidths.[704] Straight Path believes that a 72 dBm/100 MHz (75 dBm/100 MHz in rural areas) EIRP limit should be adequate even for macro cell deployment of mmW technologies with a cell radius expanding to a few kilometers[705]

273. Several commenters present analysis and simulation results that support allowing higher transmitted powers. Straight Path provides several link budget analyses showing promising results for intra-site distances between 500 – 5000 meters with an EIRP limit of 72 dBm/100 MHz.[706] Nokia provides system level simulation results showing the impact on user equipment (UE) throughput performance at 39 GHz from increasing the base stations transmit power from 62 dBm/100 MHz EIRP to 85 dBm EIRP. Nokia's simulations show that for indoor UEs, the deployment was path loss limited due to the high penetration losses at 39 GHz and, as a result, increasing the transmit power levels can significantly improve system performance.[707] Nokia's simulations also show that outdoor systems are also path loss limited and can benefit from increasing the transmit power level of base stations to 85 dBm EIRP.[708] Intel provides an analysis that shows power levels of 75 dBm are realistically implementable and meet throughput and range expectations.[709] Intel provides an example of how conducted power to each antenna element directly impacts implementation complexity and cannot be easily increased beyond certain levels, e.g., 10 dBm, without paying a considerable penalty on implementation complexity.[710] As a result, Intel claims that the main driver for increasing the EIRP becomes increasing the number of elements in the antenna array, recognizing that the antenna array size is limited by the physical dimensions of the form factors.[711]

274. However, not all commenters favor allowing a higher power limit in the band. AT&T and T-Mobile both generally support the EIRP limits proposed in the *NPRM* and AT&T states that industry and the Commission should continue to study the benefits of allowing higher powers.[712] Boeing believes that the 75 dBm limit proposed by many commenters is inconsistent with the documented operational range of contemplated 5G applications and would impair the ability of satellites systems and UMFUS to share the 37.5-40.0 GHz band.[713] SES Americom expresses concern that aggregate

[701] Verizon Comments at 16.

[702] Samsung Comments at 18. Samsung believes that the power limits proposed for the millimeter wave bands are too restrictive for fixed base stations and supports power limits up to 75 dBm. *Id.*

[703] Ericsson Comments at 12-13. TIA suggests identical limits for similar reasons. TIA Comments at 32.

[704] XO Comments at 26, XO Reply at 15-16.

[705] Straight Path Reply at 26.

[706] *See* Straight Path Reply at Appendix Tables 1, 2, and 3.

[707] Nokia Comments at 26-27, Appendix A at 7.

[708] Nokia Reply at 7, Appendix at 4.

[709] Intel Reply Appendix A at 22-28.

[710] Intel Reply at 19.

[711] Intel Reply at 19.

[712] T-Mobile Comments at 19, AT&T Reply at 17-18. AT&T notes that higher powers may make co-existence with satellite incumbents more difficult.

[713] Boeing May 9, *Ex Parte* Letter at 2.

transmissions from terrestrial stations will cause interference to satellites in the 28 GHz band and argues that we should carefully consider the maximum power of base and mobile stations because it is a critical element in this interference scenario.[714] Avanti does not believe it is possible to establish an EIRP limit on terrestrial base and mobile stations that would protect satellite receivers in the Ka-band from interference.[715]

275. No commenters directly address whether base station equipment that support both mobile services and backhaul requires higher power limits. However, comments from Straight Path and XO suggest the need for higher in-band back haul limits while also supporting the same higher limits for base/mobile operations.[716] Commenters recognize the need for traditional point-to-point and point-to-multi-point fixed services that operate at higher power levels under the current Part 101 rules.[717]

276. *Discussion.* We believe that an increase in the maximum base station power from what the *NPRM* proposed is necessary for two reasons. First, the 62 dBm/100 MHz EIRP power limit proposed in the *NPRM* will limit UMFUS base stations to a much lower power density than is permitted for other mobile services. For example, PCS and AWS base stations are permitted to transmit at 62 dBm/MHz EIRP, which would permit a total EIRP of 82 dBm for a 100 MHz signal.[718] We see no reason why UMFUS should be limited to a lower power density than PCS and AWS. Second, the propagation properties in the mmW band make higher powers necessary. Signal attenuation with distance is higher in the mmW bands than at lower frequencies and signals are more severely attenuated due to obstacles such as foliage and walls. As the simulations submitted by commenters illustrate, higher signal powers are necessary to permit relatively modest base station coverage areas and to increase data throughput. Unnecessarily limiting the base station power in the mmW bands by applying the existing Part 27 base station limit could unduly inhibit future technologies and applications.

277. We will adopt a base station power limit of 75 dBm/100 MHz EIRP as the base station power limit for the 28 GHz, the 37 GHz and 39 GHz bands.[719] For channel bandwidths less than 100 megahertz the permitted EIRP will be reduced below 75 dBm proportionally and linearly based on the bandwidth relative to 100 megahertz.[720] Because the technology for providing mobile services in these bands is still being developed, the appropriate transmitted power requirements for this equipment cannot be definitively known at this time. This 75 dBm/100 MHz limit represents a consensus that has been endorsed by the commenters who have expressed an intention to manufacture UMFUS equipment. Therefore, we are confident that this power level will provide the equipment manufacturers and future licensees with the flexibility needed to deploy service in these bands. Because of the early stage of development of UMFUS technology, we will monitor how this technology develops and revisit the base station power limit in the future if it becomes necessary.

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[714] SES Americom Reply at 5. As discussed in Section IV.G.2.d (Terrestrial Aggregate Interference Concerns to FSS Satellite Receivers in 28 GHz), numerous commenters have expressed concern about aggregate interference to satellite receivers in the 28 GHz band.

[715] Avanti Comments at 6.

[716] XO Comments at 26, Straight Path Reply at 26-27, XO Reply at 15-16.

[717] FiberTower Comments at 5-6, Nokia Comments at 26, Qualcomm Comments at 16. The *NPRM* proposed to maintain the existing 85 dBm EIRP limit for fixed point-to-point and point-to-multipoint systems. *NPRM*, 30 FCC Rcd at 11955, para. 271.

[718] Base stations for PCS, 700 MHz, and AWS are limited to 1640 watts/MHz EIRP with an emission bandwidth greater than 1 MHz. WCS base stations are limited to 2000 watts EIRP. *See* 47 CFR §§ 24.232(h)(1), 27.50.

[719] This maximum power limit is defined as the average power of the sum of all antenna elements for fixed and base stations operating in connection with mobile systems. See Appendix A, § 30.202(a).

[720] For example, a 50 MHz channel would be permitted to transmit with half the power—i.e., 72 dBm.

278. We are not persuaded by those commenters who do not favor increasing the base stations power limit above the level proposed in the *NPRM*.[721] Boeing's claim that the 75 dBm limit is inconsistent with the operational range of 5G applications is contradicted by the simulation results that show the benefits of increasing the maximum power beyond 62 dBm and the consensus among equipment manufacturers that 75 dBm is a reasonable power limit for UMFUS base stations. Furthermore, our rules for the 37.5-40.0 GHz band, about which Boeing expresses sharing concerns, limit the FSS to gateway-type earth station operations and prohibit the ubiquitous deployment of satellite earth stations designed to serve individual consumers.[722] We do not believe that the higher power limit we are adopting will significantly affect the limited gateway FSS operations permitted in the band because we are providing a means for gateway earth stations in the band to obtain protection from terrestrial transmissions.[723] As for SES Americom's and Avanti's concerns, we explain in Section IV.G.2.d. (Terrestrial Aggregate Interference Concerns to FSS Satellite Receivers in 28 GHz), that we do not believe we need to take specific action with respect to aggregate interference to satellite receivers in the 28 GHz band at this time. We therefore will not unduly restrict the development of UMFUS by limiting the base station transmit power.

279. We will not adopt a different power limit for equipment that is used to provide both mobile services and backhaul. As the *NPRM* noted, several commenters to the *Notice of Inquiry* suggested that it might be feasible to deploy such 5G equipment.[724] We note that those commenters did not address this subject in response to the *NPRM* and no other commenters specifically request higher power limits for such equipment. We believe that by adopting a higher power limit for base stations than proposed in the *NPRM*, we are also providing adequate power to ensure successful deployment for combined access/backhaul equipment. In addition, we will not limit base station antenna height at this time because no commenters address the issue. Instead, we shall seek further comment on this topic in the *FNPRM*.[725]

280. Compliance with the transmit power limit shall be ascertained with over the air measurement of EIRP of the device under test (DUT). As Qualcomm has stated, mmW devices are being designed with an array of multiple antennas employing dynamic beamforming and that these designs make verification of transmitter power, EIRP, and antenna gain challenging.[726] In this early stage of mmW development, compliance testing will be challenging because of lack of test equipment and/or facilities that can accurately measure over the air EIRP of the DUT and the need to account for the introduction of antenna arrays and beamforming. Even so, OET has issued a number of Knowledge Database (KDB) publications that delineate measurement procedures for testing of antenna arrays.[727]

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[721] T-Mobile and AT&T, who support adopting the 62 dBm/100 MHz limit, did not provide any reason why this limit was appropriate.

[722] 47 CFR § 25.202(a)(1), *V-Band Second Report and Order,* 18 FCC Rcd at 25442, para. 33.

[723] *See supra* Section IV.B.4 (Non-Federal Satellite-Terrestrial Sharing – Licensing of Gateway Earth Stations).

[724] *NPRM*, 30 FCC Rcd at 11957, para. 276.

[725] *See* Section V.G.1 (Antenna Height).

[726] *See* Qualcomm Reply at 9.

[727] *See* Federal Communications Commission, Office of Engineering and Technology, Laboratory Division, *Emissions Testing of Transmitters with Multiple Outputs in the Same Band* (October 31, 2013) and *MIMO with Cross-Polarized Antenna* (October 25, 2011) (https://apps.fcc.gov/kdb/GetAttachment.html?id=B0ZQiTBTVsn3P3wZ2WdqhQ%3D%3D and https://apps.fcc.gov/kdb/GetAttachment.html?id=i%2BFRza%2B2Hh0pf9nHJHJGHw%3D%3D). We note that OET has developed a substantial body of additional guidance that is available via public notices, frequently asked questions (FAQ's), and specific process guidance that is compiled in our online Knowledge Database (KDB). Equipment authorization topics that relate to new services and devices authorized by the Commission are often addressed in the KDB. This includes, for example, simple answers to questions, guidance on how to file for

(continued….)

Moreover, OET will address the further development of mmW measurement procedures with input from industry stakeholders and other interested parties and issue further KDB guidance.

b. Mobile Stations

281. *Background.* For mobile transmitters in the 28, 39, and 37 GHz bands, the *NPRM* tentatively proposed to adopt the same maximum peak EIRP limit of 43 dBm (20 watts) that is permitted in the 57-64 GHz band under the current Part 15 rules.[728] The *NPRM* proposed this maximum power limit for mobile transmitters while recognizing that handheld and other portable user equipment operating in close proximity to users will likely have to operate at lower power in order to comply with the Commission's rules that limit exposure to radiofrequency radiation.[729] The *NPRM* envisioned that the combined effect of those rules, with a maximum peak EIRP limit of 43 dBm, would ensure compliance with the exposure limits while allowing industry flexibility to develop higher-powered transmitters for situations where an appropriate separation distance is maintained.

282. There is strong support among commenters for the 43 dBm maximum mobile EIRP power limit.[730] Intel, Nokia and Straight Path provide in depth analyses that indicate significant benefits are achievable with a mobile station power level of 43 dBm. Intel's analysis indicates that a UE power level of 43 dBm is realistically implementable and meets throughput and range expectations.[731] Straight Path provided several link budget analyses to support the 43 dBm mobile power limit[732] and pointed out that this power limit is consistent with power limits for the Cellular Radiotelephone Service, Broadband PCS, WCS, AWS, the 700 MHz band, Wi-Fi, and the 60 GHz band.[733] Two commenters suggest the Commission adopt a higher mobile EIRP power limit to account for future technological developments and also apply to transportable and customer premise equipment devices.[734]

283. *Discussion.* As proposed in the *NPRM*, we will adopt a 43 dBm EIRP maximum mobile power limit in the 27.5-28.35 GHz, 37-38.6 GHz, and 38.6-40 GHz bands.[735] The simulations and analyses by commenters indicate that this power level will be sufficient to provide the expected range and data rates. In addition, the power level is consistent with our rules for Part 15 devices in the 57-64 GHz band that have been in place since 1995. We are also encouraged by the strong support for this power limit, especially from commenters who indicate that they will manufacture equipment for these bands.

284. We note that UMFUS devices will be expected to comply with our rules regarding radiofrequency radiation exposure in addition to complying with the 43 dBm EIRP limit we are

(Continued from previous page)
authorization of new types of devices, and guidance on how to conduct rule compliance testing. The staff guidance provided in the KDB is intended to assist the public in following Commission requirements. The guidance is not binding on the Commission and will not preclude the Commission from making a different decision in any matter that comes to its attention for resolution.

[728] *NPRM*, 30 FCC Rcd at 11955, para. 279.

[729] 47 CFR §§ 2.1091, 2.1093.

[730] Nokia Comments at 27-28, Qualcomm Comments at 16, Straight Path Comments at 41-42, TIA Comments at 32, Verizon Comments at 16-17, Intel Reply at 19.

[731] Intel Reply at 19, Appendix A at 22-28.

[732] Straight Path Comments at Appendix A1-A3, Straight Path Reply at Appendix A Tables 1, 2, and 3. Straight Path notes a considerable amount of antenna gain can be achieved in mobile or portable devices (around 10 dB) and that the maximum EIRP of 43 dBm means the average output power of these devices will be less than 33 dBm (or 2 watts) even if they operate at the peak EIRP all the time. Straight Path Comments at 41.

[733] Straight Path Comments at 41-42.

[734] CTA Comments at 15-16, XO Comments at 27.

[735] Unlike the EIRP limit for base stations, this EIRP limit is not scaled depending on the signal bandwidth.

adopting.[736] These radiofrequency radiation exposure rules specify more stringent exposure limits for devices that are designed to be used within 20 centimeters of the user's body. We recognize that such devices may have to limit their transmit power below the 43 dBm limit to meet exposure limits.

c. Transportable Stations

285. *Background*. In response to the *NPRM,* a number of commenters requested that we establish an equipment class with a maximum power limit higher than the 43 dBm EIRP we are adopting for mobile stations.[737] Commenters refer to these devices in varying ways such as customer premises equipment,[738] local hubs,[739] transportable (not mobile),[740] CPE for wireless broadband,[741] and user equipment built into vehicles.[742] Most commenters supporting this idea advocate maximum power limits between the 43 dBm mobile limit and the 62 dBm base station limit proposed in the *NPRM*.[743] Intel, Nokia, and Straight Path provide analyses that indicate significant benefits for equipment that operates at higher power levels than mobile station equipment. For instance, Intel claims their analysis suggests that an EIRP power level of 55 dBm would be adequate for this class of user devices.[744] Nokia provides simulation results showing the impact on throughput from increasing the UE transmit power from the 43 dBm EIRP to 53 dBm EIRP for 39 GHz UEs.[745] Nokia's simulations show that indoor deployments are path loss limited due to the high penetration losses at 39 GHz and that increasing the transmit power levels can significantly improve system performance.[746] Straight Path provides link budget analyses showing that an EIRP limit of 53 dBm significantly improves the uplink throughput and suggests that these devices should be generally safe because the free space loss within 1.25 meters will reduce the power density to less than 1 mW/cm^2 even along the direction of the peak EIRP.[747] As an additional precaution, Straight Path recommends that these units be placed outdoors to minimize RF exposure.[748] Verizon, Samsung, Qualcomm, Intel, Nokia, and Ericsson state that because some stakeholders envision developing and deploying semi-stationary, movable 5G devices, the Commission should establish an intermediate power limit of 55 dBm EIRP for such devices.[749]

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[736] 47 CFR §§ 1.1307(b), 2.1091, 2.1093.

[737] Nokia Comments at 27-28, Qualcomm Comments at 16, Samsung Comments at 19, TIA Comments at 32, Verizon Comments at 16-17, XO Comments at 27, AT&T Reply at 18-19, Ericsson Reply at 10, Intel Reply at 20, Straight Path Reply at 27-28, ; Verizon, Samsung, Qualcomm, Intel, Nokia, and Ericsson April 21, *Ex Parte* Letter at 1.

[738] Verizon Comments at 17, Nokia Comments at 27, Samsung Comments at 19, TIA Comments at 32, AT&T Reply at 19.

[739] Qualcomm Comments at 16.

[740] Samsung Comments at 19, TIA Comments at 32.

[741] AT&T Reply at 19.

[742] AT&T Reply at 19.

[743] Qualcomm Comments at 16, Samsung Comments at 19, TIA Comments at 32, XO Comments at 27, Nokia Comments at 27-28, AT&T Reply at 18-19, Ericsson Reply at 10, Intel Reply at 19-20, Straight Path Reply at 41-42, Verizon, Samsung, Qualcomm, Intel, Nokia, and Ericsson April 21, *Ex Parte* Letter.

[744] Intel Reply at 20, Appendix A.

[745] Nokia Comments at 27, Appendix A.

[746] Nokia Comments at 27, Appendix A.

[747] Straight Path Reply at 27-28, Appendix A.

[748] Straight Path Reply at 28.

[749] Verizon, Samsung, Qualcomm, Intel, Nokia, and Ericsson April 21, *Ex Parte* Letter.

286. *Discussion.* We agree with the majority of commenters that there is a need for an additional class of transportable stations requiring a maximum allowable power limit higher than the 43 dBm adopted for mobile user equipment stations. Higher power for such devices will increase range, enable higher data rates and provide for better coverage throughout buildings, which will allow consumers flexibility in installation locations to provide service where needed. These devices could be used to provide residential broadband service, which as the simulation results provided by Nokia illustrate will benefit from a higher transmit power than we are allowing for mobile stations. We adopt a 55 dBm EIRP maximum power limit for this for this class of equipment, which we shall refer to as transportable stations. This 55 dBm limit represents a consensus that has been endorsed by commenters who have expressed an intention to manufacture UMFUS equipment. We note that in adopting this higher power limit for transportable stations that such devices will be expected to comply with our rules regarding radiofrequency exposure.[750]

287. No commenter has proposed a definition of transportable devices for purposes of our rules. However, the terminology that most commenters have used suggests that such devices will be stationary while operating. Therefore, we shall define a transportable device as transmitting equipment that is not intended to be used while in motion, but rather at stationary locations. We believe this definition is appropriate because it will exclude portable devices that are meant to be carried by people while operating such as mobile phones or smart phones from transmitting at the higher power level. One commenter has suggested that these transportable devices could be built into vehicles, which implies that they should be permitted to operate while in motion. We have chosen not to expand our definition to include devices in moving vehicles because such devices in general will not need to transmit signals that penetrate walls and therefore will not require more power than mobile devices.

d. Terrestrial Aggregate Interference Concerns to FSS Satellite Receivers in 28 GHz

288. *Background.* EchoStar, Inmarsat, Intelsat, O3b Limited, OneWeb, SES Americom, Inc., and ViaSat Inc. (collectively, the "Satellite Operators") have jointly requested that the Commission adopt restrictions on the aggregate skyward emissions from UMFUS devices. According to the Satellite Operators, even if there is only a low level of base station deployment, the aggregate level of interference from UMFUS will result in severe degradation of satellite service. The Satellite Operators suggest that the Commission either limit skyward aggregate emissions from UMFUS to 16.5 dBm/MHz/1000km^2 or require that UMFUS devices employ techniques to reduce skyward emissions such as power control, antenna downtilt, restricting off-axis EIRP, or suppressing sidelobes of antenna patterns.[751] The suggested emission limit is based on an analysis of the level of UMFUS skyward emission that will result in an interference to noise ratio of -12.2 dB for the most sensitive of six different satellites. According to the Satellite Operators, as few as 79 UMFUS base stations transmitting at 75 dBm could cause interference to the satellite receivers.[752]

289. Several individual satellite operators have also presented analyses of the potential for interference to their satellite receivers from UMFUS transmissions. SES provides an analysis using the characteristics of its SES-15 satellite, which is scheduled to launch in the second quarter of 2017.[753] SES's analysis specifies the protection criteria for other co-primary services based on ITU-R Rec S.1432-1 as -12.2 dB.[754] This analysis assumes that the UMFUS base station antennas have a 20dB

[750] 47 CFR §§ 1.1307(b), 2.1091, 2.1093.

[751] EchoStar, Inmarsat, O3b, OneWeb, SES, ViaSat June 13, Ex Parte Letter at 5; EchoStar, Inmarsat, O3b, OneWeb, SES Americom, ViaSat May 10, *Ex Parte* Letter at 6.

[752] The number of base stations that would cause interference depends on the assumed base station environment (rural, suburban, or urban), transmitted power, and elevation angle of the satellite.

[753] *See* SES Americom May 5, *Ex Parte* Letter.

[754] SES Americom May 5, *Ex Parte* Letter at 2.

discrimination toward the satellite, that all base stations are in line of sight of SES-15 (no clutter loss), and that all base stations operate at maximum transmit power levels (either 62 dBm or 75 dBm).[755] SES also presents the number of base stations or mobile stations that can be located in several cities within one spot beam of SES-15 without causing interference.[756] For example, SES claims that only 117 base stations transmitting at 62 dBm could be located in New York City.[757]

290. O3b's analysis claims that satellite protection criteria will be exceeded when a relatively small number of UMFUS mobile stations are located within a satellite beam.[758] O3b's analysis does not appear to take into account clutter loss and uses an interference margin of -12.2 dB.[759] ViaSat also provides a technical analysis which details the protection levels needed for a number of spacecraft, including those licensed to ViaSat.[760] In its analysis, ViaSat also uses an equivalent interference criterion of -12.2 dB I/N.[761] ViaSat evaluates the impact from UMFUS mobile stations transmitting at either 23 dBm/100 MHz or 43 dBm/100 MHz EIRP. These simulations did not include the aggregating effect of transmissions from 5G base stations.[762] ViaSat's analysis shows that the interference protection criterion is exceeded even with an UE density of one UE per km^2 at either power level.

291. AT&T, Nokia, Samsung, T-Mobile, and Verizon (collectively, the "Joint Filers") provide simulation results from Nokia. These simulations show that the number of 5G mmW base station sectors that could simultaneously transmit within a spot beam of a satellite receiver without causing interference ranged from 700 to over a million depending on the interference criteria, receiver noise temperature, ratio of line of sight to non-line of sight base stations, and characteristics of the satellite (elevation angle, orbital distance, antenna gain).[763] The simulations showed that the number of mobile stations could vary from 2800 to almost half a billion depending on the assumed parameters.[764] The Joint Filers claim that the simulation results are most sensitive to the path loss and interference criteria. Ericsson has submitted simulation results showing that depending on the technical parameters of the satellite receivers, between 127,000 and 4,394,000 base stations may transmit within a satellite spot beam without causing interference.[765]

292. The Joint Filers point out that both the O3b and ViaSat analyses use satellite protection I/N ratios of -12.2 dB for purposes of their calculations, instead of using actual signal-to-interference-plus-noise ratios for the deployed systems.[766] The Joint Filers note that the -12.2 dB criteria is presumably derived from Recommendation ITU-R S.1432, which was developed by ITU-R Working Party 4A in 2000. Recommendation S.1432 specifies a 6% delta T/T interference allowance (equivalent to a -12.2 dB interference–to-noise ratio) for co-primary services, which is also the coordination trigger between satellite networks in Article 5 of the Radio Regulations.[767] The Joint Filers claim that there is a

[755] *See* SES Americom May 5, *Ex Parte* Letter at 2.

[756] *See* SES Americom May 5, *Ex Parte* Letter at 3.

[757] *See* SES Americom May 5, *Ex Parte* Letter at 3.

[758] O3b March 24, *Ex Parte* Letter at 3.

[759] O3b March 24, *Ex Parte* Letter at 2 n.3 (citing ITU-R S.1432-1 for co-primary interference sources).

[760] *See* ViaSat April 21, *Ex Parte* Letter at 2, Attach. 1.

[761] ViaSat April 21, *Ex Parte* Letter Attach. 1 at 1.

[762] ViaSat April 21, *Ex Parte* Letter Attach. 1 at 2.

[763] *See* AT&T, Nokia, Samsung, T-Mobile, Verizon May 13, *Ex Parte* Letter at 16.

[764] AT&T, Nokia, Samsung, T-Mobile, Verizon May 13, *Ex Parte* Letter at 24-27.

[765] *See* Ericsson, June 15, *Ex Parte* Letter at 8, Table 3.

[766] *See* AT&T, Nokia, Samsung, T-Mobile, Verizon May 6, *Ex Parte* Letter at 2.

[767] AT&T, Nokia, Samsung, T-Mobile, Verizon May 6, *Ex Parte* Letter at 2.

general recognition in the satellite community that this interference level was developed when satellite networks were considered to be power limited, whereas today satellite networks tend to be interference limited and, as such, this protection level is very conservative.[768] Nokia's simulations use FSS protection criteria (i.e., $I_{5G}/N_{thermal}$) of -12.2 dB, -6 dB and 0 dB, with noise temperatures of 650K and 1000K.

293. Nokia's simulations use SIA-provided parameters defined for different types of earth stations, designated Class 1, 2, and 3, to create a cumulative distribution function ("CDF") of relative 5G BS-into-FSS space station antenna gain to provide an alternative to a worst case scenario analysis.[769] The Joint Filers suggest that the SIA-provided parameters used in the simulations are very conservative in a number of respects.[770] The Joint Filers indicate that the satellite noise and receive beam gain figures are based on the most sensitive projections about future, planned satellite network deployments, not necessarily satellite networks that currently exist.[771] The Joint Filers question whether the SIA parameters are realistic in an environment where a mere 3 dB difference in the receiver sensitivity and FSS antenna gain can change the aggregate interference results by a factor of 2. The Joint Filers provide an example where the SIA-supplied parameters for Class 3 earth stations used a satellite orbital distance of approximately 1,000 km, even though the closest deployed system has an orbital distance of 8,062 km. The Joint Filers suggest that incorporating the actual deployed system orbital distance would increase, by a factor of 63, the number of simultaneously active BS sectors within the spot beam for Class 3 systems.[772]

294. *Discussion.* The analyses provided by commenters leads us to conclude that specific technical limits on UMFUS stations are not necessary at this time to address aggregate interference. As discussed in more detail below, the information in the record shows a wide disparity between assumptions and illustrates that much work must be done to accurately model mmW systems and the effects that these systems might have on co-channel satellite receivers. As a result, we do not want to unduly restrict the development and growth of UMFUS unless we have adequate evidence that actual harm will occur. We do not believe the record demonstrates that there is a risk of interference to satellites from aggregate interference caused by UMFUS stations. Consequently, we will not adopt a limit on aggregate skyward interference from 28 GHz band UMFUS stations or require that UMFUS stations employ specific techniques to reduce skyward emissions. We observe that features such as antenna downtilt, suppression of sidelobes and adaptive power control will occur naturally because they are inherent characteristics of anticipated 5G technologies.

295. The analyses provided by the satellite operators are based on very conservative assumptions and provide for a worst case scenario regarding aggregate interference from future terrestrial networks. For example, the satellite analyses appear to assume terrestrial devices will continuously operate at maximum power levels and do not account for the fact that many UMFUS deployments will occur indoors. Most of the satellite analyses assume all terrestrial devices will be line of sight to the satellites with the exception of the analysis submitted jointly by the Satellite Operators, which assumes only a 9.6 dB attenuation for a 90% non-line of sight scenario.[773] These analyses also assume a -12.2 dB interference criteria, which the Joint Filers point out has been under past review in language reflected in a Conference Preparatory Meeting report to WRC-15.[774] The Joint Filers also note that some system parameters provided by SIA, such as satellite noise and receive beam gain, are based on the most

[768] AT&T, Nokia, Samsung, T-Mobile, Verizon May 6, *Ex Parte* Letter at 2.

[769] AT&T, Nokia, Samsung, T-Mobile, Verizon May 6, *Ex Parte* Letter at 4.

[770] AT&T, Nokia, Samsung, T-Mobile, Verizon May 6, *Ex Parte* Letter at 5.

[771] AT&T, Nokia, Samsung, T-Mobile, Verizon May 6, *Ex Parte* Letter at 5.

[772] AT&T, Nokia, Samsung, T-Mobile, Verizon May 6, *Ex Parte* Letter at 5.

[773] EchoStar, Inmarsat, O3b, OneWeb, SES Americom, and ViaSat, May 10, *Ex Parte* Letter at 13.

[774] *See* AT&T, Nokia, Samsung, T-Mobile, and Verizon, May 6, *Ex Parte* Letter at 2.

sensitive projections about future, planned satellite network deployments, not necessarily satellite networks that currently exist.

296. While the Joint Filer's simulation results are not based on as conservative assumptions as the satellite operators, they vividly illustrate how the assumptions made can lead to vastly different conclusions. Assumptions such as the antenna pattern of the UMFUS devices, how many of the devices are line of sight to the satellites, the characteristics of the satellites, and the satellite interference criteria clearly can make an enormous difference in the number of devices that may transmit without interference occurring. Given that mmW technology is just being developed and the deployment scenarios of these devices are uncertain, many of these assumptions are speculative at this point and any conclusions that can be drawn from analyses or simulations at this point are necessarily tentative. We also observe that no information has been submitted into the record as to how terrestrial licensees would demonstrate compliance with a limit on aggregate energy at each satellite or each point in the sky. While we conclude that the various studies submitted by the parties do not support establishment of an aggregate interference limit or adoption of specific technical requirements to reduce skyward emissions, they do indicate the need for additional study on the effect of aggregate interference on satellite receivers.[775] We expect that the parties will continue to study this issue and inform the Commission of the outcome. We will revisit this issue if additional information comes to our attention suggesting that regulatory requirements are necessary.

3. Out-Of-Band Emission Limits

a. Use of Conductive Emission Limits

297. *Background.* In the *NPRM*, the Commission proposed a radiated out-of-band emissions (OOBE) limit that required licensees to attenuate their unwanted radiated emission power below the transmission power (P)[776] by a factor of at least $43 + 10\log_{10}(P)$ per MHz for any emissions on frequencies outside the licensee's authorized spectrum.[777] Two important concerns behind this proposal were the OOBE measurement challenges in the millimeter wave (mmW) band, and the nature of OOBE propagation. With respect to the former, the Commission concluded that defining the emission limit as radiated[778] is more practical than alternative methods.[779] Also, having defined the emission limit as radiated, the nature of OOBE propagation was implicitly assumed to be non-directional.

298. In response to the *NPRM*, a number of commenters state their general support for the OOBE limit. Samsung states that it supports the Commission proposal for out-of-band emission limits at this time, but it is continuing to study the availability of technical components required to comply with

[775] We encourage satellite operators and proponents of mmW technology to work together to study this issue and, if necessary, develop techniques to mitigate the likelihood of aggregate interference to satellite receivers. We do not believe that aggregate interference from UMFUS transmitters will ever reach a level that harms the operations of the 28 GHz satellite systems. However, any increase in the noise level due to aggregate interference that may occur will develop over a period of years as UMFUS systems are deployed. Satellite operators can monitor the noise level at the satellite receivers and inform the Commission before the satellite receiver performance is impacted.

[776] P is the conductive power in watts. *See also* 47 CFR § 2.1 n.2.

[777] *See NPRM*, 30 FCC Rcd at 11960, 11988.

[778] *See NPRM*, 30 FCC Rcd at 11960 n.488 (Most mobile services in licensed bands define the emission limit as conducted, where the measurement for determining compliance is done directly at the antenna port. Measuring the emission as radiated requires that the measurement be made at some point away from the antenna, where the measurement is made on the signal created by the radiated elements and transmitted over the air.).

[779] *See NPRM*, 30 FCC Rcd at 11960 para. 284 (5G mobile stations in mmW bands are also expected to have tens of radiating elements with multiple power amplifiers. With lack of RF ports, the emission measurement needs to be made as radiated, and the antenna gain must be characterized and subtracted from the radiated measurement if the emission limit is to be defined as conducted.).

these limits and may file supplemental information in the future once that review is completed.[780] Intel expresses concern about specifying the -13 dBm/MHz[781] level in the first 50 MHz outside the channel edge.[782] Straight Path believes the OOBE limit is achievable with a combination of digital filtering and waveform shaping, guard bands, and RF filtering.[783]

299. Most commenters, however, express concerns that implementing an OOBE limit using Effective Isotropic Radiated Power (EIRP) may be too restrictive. They argue that because the OOBE limit is expressed as radiated, a significantly higher attenuation is required for advanced systems with high gain antennas as compared to systems where the OOBE limit metric is conductive. Ericsson states that emission requirements expressed as EIRP with the same emission level as conducted emission requirements pose a significantly and unnecessarily stricter requirement on 5G antenna arrays.[784]. Sprint argues that there is no compelling need to apply such tight OOBE limits in a band that has to date had only limited use and the anticipated new mobile and fixed uses of these bands can be designed to accommodate a less restrictive OOBE approach.[785] Qualcomm states that the Commission should not implement the proposed $43 + 10\log_{10}(P)$ attenuation level using the EIRP metric.[786]

300. Some of the commenters opposing EIRP as a metric for OOBE suggest using Total Radiated Power[787] (TRP) instead.[788] Ericsson states that TRP is 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.[789] Qualcomm states that the Commission should consider using alternate measurement procedures, such as TRP, to assess compliance with emissions limits.[790] In its *ex parte*, Qualcomm proposes a second alternative, a detailed emission mask based on decibel-relative (dBr) EIRP

[780] *See* Samsung Comments at 19.

[781] The attenuation factor of $43 + 10\log_{10}(P)$) per MHz with respect to the transmit power P (in watts) is equivalent to -13 dBm/MHz ($[P_{dBm} - [43 + P_{dBm} - 30]_{dB}] = -13\ dBm$).

[782] *See* Intel Reply at 20.

[783] *See* Straight Path Comments at 43.

[784] *See* Ericsson Comments at 14 ("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.").

[785] *See* Sprint Reply at 8.

[786] *See* Qualcomm Reply at 8.

[787] *See* Straight Path August 5, 2015 *Ex Parte* Letter at 2 (The following shows the relationship between the Total Radiated Power ("TRP"), i.e., the total transmit power, and the Effective Isotropic Radiated Power ("EIRP")

$$TRP = \frac{1}{4\pi}\int_{\phi=0}^{2\pi}\int_{\theta=0}^{\pi} EIRP(\theta,\phi)\,sin\theta d\theta d\phi$$

Where θ is the angle in elevation and ϕ is the angle in azimuth. In other words, if we integrate the EIRP along a sphere that encloses the transmitter, we will arrive at the Total Radiated Power.). TRP can also be expressed as ratio of EIRP to Directivity of antenna, $TRP = \frac{EIRP}{D}$. *See* W.L. Stutzman and Gary A. Thiele, "Antenna Theory and Design", 2013, at 582.

[788] *See* Ericsson Comments at 14-15, TIA Comments at 33, Qualcomm Reply at 8-9.

[789] *See* Ericsson Comments at 14.

[790] *See* Qualcomm Reply at 8.

measurement at certain percentage frequency offset.[791] Some commenters suggest including a conductive OOBE metric as well as TRP metric.[792] Ericsson states at this stage of development of 5G systems, it is too early to exclude the conducted requirements and thus, urges "the FCC to allow for conducted requirements where the multiple transmitter output directive should be made applicable."[793] Straight Path states that the Commission should define the OOBE limit relative to the average EIRP across the entire authorized bandwidth along the spatial direction with the strongest average EIRP.[794]

301. *Discussion.* One of the implications of requiring an EIRP metric for the OOBE limit is that a transmitter has to meet the limit along the maximum EIRP direction. This makes meeting the radiative OOBE limit particularly challenging, as recognized by the commenters. In the mmW band, transmitters require higher gain antennas to compensate for significantly higher propagation losses[795] and consequently the antennas will, in general, have much smaller beamwidth, as compared to other lower band mobile systems. As a result, OOBE of mmW transmitters have highly directive characteristics, concentrating the transmission power along a narrow beam[796] in the direction of maximum EIRP. Furthermore, because the beam is narrow and because a transmitter needs to track the relative movement of its intended receiver in order to maintain the communication link, the OOBE of the mmW transmitter should be spatially averaged over the path of the receiver to reflect the spatially transient nature of the transmitter OOBE. In this regard, Qualcomm states that, "based on its simulations to date, the average interference from a mobile and a base-station/small cell with a steerable/selectable array is very different and variable when compared to a fixed link. With mobile operations, the interference impact differs from fixed links due to the dynamic nature of the array, for it points in different directions as mobile users move and are served."[797] We believe these features of the mmW spectrum make the OOBE limit in the maximum EIRP direction less significant and a spatially averaged OOBE limit more appropriate. One way to spatially average OOBE of a transmitter is to determine its out of band total radiated power (TRP) or by extension its out of band conductive power.[798] To set forth a more suitable OOBE metric that reflects the aforementioned features of mmW band, we should express the OOBE limit as an equivalent

[791] *See* Qualcomm May 9, *Ex Parte* Letter at 2, Note ("dBr is the relative difference as measured in equal bandwidth for both the transmission signal and the off-channel frequency. The mean transmit power should be used for the dBr reference transmission signal power.").

[792] *See* TIA Comments at 33.

[793] Ericsson Comments at 15.

[794] Straight Path Comments at 43.

[795] For a given aperture size, relative increase in free space propagation path loss is exactly canceled by higher antenna gain. *See* Wonil Roh, Samsung Electronics Corp. DMC R&D Center, Communications Research Team, *Performances and Feasibility of mmWave Beamforming Prototype for 5G Cellular Communications*, (2013) at 11-12 (http://faculty.poly.edu/~tsr/Publications/samsung.pdf).

[796] *See* Ericsson May 25, *Ex Parte* at 1-2 ("For millimeter wave bands, beam forming is made possible with massive array antennas. With small wavelengths, element separation is greatly reduced to the order of millimeters and it is therefore possible that radios may be built with as many as 512 elements (e.g., 16x16, cross-polarized), each with an integrated Power Amplifier ("PA") within a small total footprint. The combination of these PAs and antenna elements can by themselves achieve transmission power levels above the Commission's proposed 62 dBm/100 MHz level. If these antenna elements can be driven by Gallium Nitride ("GaN") PAs, even more gains in power levels can be achieved as long as the thermal effects can be managed").

[797] Qualcomm Reply Comments at 9.

[798] TRP of a transmitter is closely related to its' conductive power. In fact, TRP is product of antenna radiation efficiency,e_r, and conductive power P ($TRP = e_r P$) and depending on antenna efficiency TRP can be virtually the same as the conductive power P. *See* W.L. Stutzman and Gary A. Thiele, *Antenna Theory and Design*, 2013, equations 13-40 and 2-155.

conductive limit. An equivalent conductive limit is consistent with the OOBE rule for other mobile systems.

302. Compliance with a conductive OOBE limit in the mobile mmW systems will be the same as other mobile systems where access to the antenna RF port(s) is available. Where access to the RF port(s) is not available, a somewhat more complicated process is necessary. For each frequency (or band), an emission measurement of the device under test (DUT) must be performed along the direction of the maximum EIRP. The EIRP measurement value is then adjusted for the antenna gain along the same direction as the measured EIRP and at the same frequency (or band) to obtain a conductive OOBE power of the device. This process needs to be performed for both polarization and, the respective conductive OOBE power summed, to obtain the total conductive OOBE power of the device. To obtain the antenna gain, licenses should use a validated antenna pattern computation, manufacturer supplied antenna pattern, or any other approach acceptable to the Commission as may be described in OET's KDB publications.[799] We recognize that under certain circumstances the DUT antenna may interact with its supporting structure sufficiently enough that the interaction may require consideration through simulation or by an additional measurement step. One way to identify such circumstances may be through the antenna pattern validation step. Other means of identifying and considering such circumstances may be described in OET's KDB publications.

303. With respect to TRP,[800] TRP measurement requires EIRP measurement of the device under test around spherical surface of the device for both polarizations, and as a result it can be time consuming and difficult.[801] A reverberation chamber is deemed to be one of the most practical means of TRP measurement.[802] However, as noted by Straight Path, TRP measurement in a reverberation chamber requires conducted power measurement of power amplifiers. Straight Path further argues that given that in many cases 5G transceiver power amplifiers[803] and antennas may be integrated on a single printed circuit board, it is unclear how conducted measurement can be achieved for transceivers.[804] Moreover, even if access to RF ports were to be made available, a conductive measurement would be far easier and economical to perform than TRP, as no over the air measurement would be required for conductive measurement. However, given that a number of commenters have requested TRP as a metric for OOBE,

[799] *See* https://www.fcc.gov/kdb.

[800] *See* Ericsson May 25, *Ex Parte* Letter at 1 ("TRP 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 per transceiver in the antenna array would need to be kept $10 \cdot \log10(n)$ dB lower (where n is the number of transceivers) than the required unwanted emission level which is also fully in line with FCC's MIMO/Multiple transmitter requirements. However, Ericsson would also support the option of using "conducted equivalent" measurements, which is similar to TRP as both metrics correspond to same unwanted emission requirement.").

[801] *See* Tadahiro Watanabe et al., *Total Radiated Power Measurement above 1 GHz with Partially-Spherical Scanning of a Probe*, 2009 Proceedings of the Institute of Electronics, Information and Communication Engineers at 179 (http://www.ieice.org/proceedings/EMC09/pdf/21R3-3.pdf).

[802] *See* Tadahiro Watanabe et al., *Total Radiated Power Measurement above 1 GHz with Partially-Spherical Scanning of a Probe*, 2009 Proceedings of the Institute of Electronics, Information and Communication Engineers at 179 (http://www.ieice.org/proceedings/EMC09/pdf/21R3-3.pdf).

[803] *See* Ericsson *Ex Parte* Letter at 2 ("The power capability of power amplifiers for integrated circuit technology is improving over time and in particular GaN integrated circuit PA technologies are evolving rapidly and deliver power levels an order of magnitude higher compared to conventional technologies such as CMOS as shown in the figure below. Thus, a transition to GaN PA technology together with efficiency improvement schemes would pave the way for higher achievable EIRP for millimeter wave systems. In addition to possible EIRP increases due to improvement in PA integrated circuit technology power capability such as GaN, increasing the number of sub-arrays (transceiver and corresponding radiating elements) could also result in increased EIRP.").

[804] *See* Straight Path Reply Comments at 29.

and given that TRP is a spatial averaging method, we will allow TRP as the alternate metric for compliance. As there are no TRP measurement procedures currently defined, new measurement procedures will be developed through the FCC Laboratory's KDB process.

304. As mentioned above, in the *NPRM* the Commission proposed a radiated OOBE limit that requires licensees to attenuate their unwanted radiated emission power below the transmission power (P) by a factor of at least $43 + 10\log_{10}(P)$ per MHz (or an absolute power of -13 dBm/MHz) for any emissions on frequencies outside the licensee's authorized spectrum. This radiated OOBE limit is consistent with the conductive OOBE limit that the Commission has generally required for other mobile systems.[805] In addition, a number of commenters state that using TRP as a metric the proposed OOBE attenuation factor or absolute power of -13dBm/MHz would be feasible.[806] For these reasons we are setting the OOBE limit for both conductive metric and TRP metric to -13 dBm/MHz. This may be used as a basis for developing further requirements that relate to transmitter performance by industry standard organizations. This limit applies to base stations, transportable, and mobile stations.[807]

305. With respect to dBr radiated emission mask, the mask is significantly more relaxed than the -13 dBm/MHz absolute limit that a number of commenters support.[808] In addition, we find that the equivalent conductive limit (or alternatively TRP) is the appropriate metric for OOBE in this band.[809] For these reasons, we decline to adopt the dBr radiated emission mask that Qualcomm proposes.

b. Licensed Block Edge Region

306. *Background*. In the *NPRM*, the Commission proposed a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter in the first megahertz bands immediately outside and adjacent to the licensee's frequency block.

307. In response, a number of commenters suggest that the bandwidth-dependent unwanted emission limit in the first megahertz penalizes the use of broader bandwidths.[810] Ericsson urges the Commission to reconsider this requirement because it unnecessarily and unreasonably discriminates against broadband systems and recommends that the Commission instead adopt bandwidth-independent unwanted emission requirements.[811] Intel argues that a level of -11 dBm/MHz in the first 20 megahertz outside the channel edge would be a reasonable approach that balances performance and cost given the current status of the filter technology and that energy efficiency is an important objective of 5G systems. Nokia and Sprint recommend an emission limit of -13 dBm/100 kHz for the first one megahertz bands immediately adjacent to the licensee's frequency block, while TIA recommends an emission limit of -13 dBm/30 kHz for the first one megahertz bands.[812] Sprint tabulates the impact of a one percent measurement requirement and identifies a 20 dB penalty for using a 500 megahertz channel over a 5 megahertz channel.[813] Qualcomm believes that the FCC should define out-of-band emissions limits up to ± 250% of the channel bandwidth, similar to what mobile systems use today, and that a stepped limit be implemented where one limit runs from ± 50% to 150% and a second limit runs from ± 150% to 250% of

[805] *See NPRM*, 30 FCC Rcd at 11959, also *See* 47 CFR §§ 24.238, 27 (h)(1).

[806] *See* Ericsson Comments at 15 TIA Comments at 33.

[807] *See NPRM*, 30 FCC Rcd at 11959.

[808] *See* Ericsson Comments at 13-15, Intel Reply at 20, Nokia Comments at 28, Samsung Comments at 19.

[809] In its Reply, Qualcomm supported the TRP metric, but it has since changed its position to the dBr emission mask. *See* Qualcomm Reply at 8-9, Qualcomm May 9, *Ex Parte* Letter at 2.

[810] *See* TIA Comments at 32-33, Sprint Reply at 8-9.

[811] *See* Ericsson Comments at 15-16.

[812] *See* Nokia Comments at 28, Sprint Reply at 8-9, TIA Comments at 32-33.

[813] *See* Sprint Reply at 9.

the channel bandwidth.[814] Samsung recommends a bandwidth-dependent channel edge emission, starting with an emission level of -13 dBm/100kHz in the first 10 percent of the channel bandwidth, an emission level of -8 dBm/MHz between the 10 to 25 percent of the channel bandwidth, and an emission level of -13 dBm/MHz beyond the 25 percent of the channel bandwidth.[815]

308. *Discussion.* We agree with Ericsson, and some of the other commenters that a bandwidth-dependent unwanted emission requirement at the first megahertz adjacent to the licensed block discriminates against broadband systems. However, a bandwidth-independent unwanted emission requirement at the channel edge may not be sufficient for very large bandwidth channels, or may not be spectrally efficient for narrowband channels. As it is difficult at this nascent stage of mmW development to anticipate the future channel configuration of this technology, we are relaxing the emission requirement at the channel edge dependent on channel bandwidth, so as to provide for the greatest latitude for channel configuration. For the first 10 percent of the channel bandwidth from the edge of the licensed block, we require an emission level of -5 dBm/MHz. Beyond the first 10 percent of the channel bandwidth, we require an emission level of -13 dBm/MHz. These requirements exceed Intel's request over the first 10 percent of the channel bandwidth immediately outside and adjacent to the licensee's frequency block. The permissible out of band power under these emission limits are higher than Nokia and Sprint recommendations over the first 10 percent of the channel bandwidth, but lower than Samsung's recommendations. Overall, we believe these requirements balance the various comments on record.

4. Interference Protection and Coordination

a. Coordination and Field Strength Limits at Market Borders

309. As noted in the *NPRM*, the Commission's rules for mobile services typically define field strength limits at the market boundaries in order to prevent interference between licensees in adjacent markets. In the *NPRM*, we sought comment on the appropriate interference protection criteria at the market boundaries.[816] Specifically, we asked for comment on: (1) using a field strength limit of 47 dBuV/m, (2) Straight Path's proposed PFD limit of -86 dBm/m^2/MHz, and (3) any alternative more interference protection limits that commenters believe would be more appropriate.[817] We also sought comment on whether the same criteria was appropriate for both base/mobile and traditional fixed point-to-point backhaul.

(i) Base/Mobile Operations

310. *Background.* XO Communications and Skyriver support establishing field strength limits for mobile operations. XO Communications believes that the Commission should require UMFUS licensees to comply with field strength limits at the edge of their geographic service areas, but does not recommend a specific field strength limit at this time given the nascent state of 5G technology.[818] Skyriver supports applying the proposed 47 dbV/m limit for mobile operations.[819] Conversely, a number of commenters express concern with specifying a field strength limit to prevent interference at market borders. For instance Sprint suggests that a field strength approach may not be the best metric because it ignores the frequency component and measurement bandwidth that are important factors in determining the potential for interference.[820] Sprint notes in its comments that the existing level for PCS was

[814] *See* Qualcomm Reply at 9.

[815] *See* Samsung May 9, *Ex Parte* Letter at 4.

[816] *NPRM*, 30 FCC Rcd at 11955, para. 290.

[817] *NPRM*, 30 FCC Rcd at 11955, para. 290.

[818] See XO Comments at 28.

[819] Skyriver Comments at 14.

[820] Sprint Reply at 5-6.

established by ensuring that just enough power was permitted for the operator to provide service at its border while reasonably protecting the service area beyond that border and that if a 47 dBuV/m field strength border limit were to be used at 28 GHz, 37 GHz, and 39 GHz, the border power values become quite different due to the extremely high frequency component.[821] Sprint also notes in its comments that with the wide variety of transmitters, devices and use cases that are likely to be deployed in the mmW bands, it is essential that the Commission adopt interference protection rules that are flexible enough to permit highly differing uses in the band while at the same time minimizing the potential for harmful interference between users in adjacent bands or at the edges of geographic areas.[822] Therefore, Sprint recommends that an absolute value should be considered in the protection rule.[823] Nokia states that it is important for the Commission to clarify what reference bandwidth is to be used for the field strength at any location on the geographical border of a licensee's service area.[824] Nokia believes that coexistence between licensees could be managed by coordination and technology without the Commission regulating field strength limits at market borders in these bands.[825] Straight Path proposes a limit of −86 dBm/m^2/MHz.[826] Intel proposes a limit of −90.3 dBm/m^2/MHz.[827] AT&T, Nokia, Samsung, T-Mobile, and Verizon in a joint filing indicate that interference from existing transmit FSS earth stations into 5G networks can be controlled by limiting the PFD at 10 meters above ground level to -77.6 dBm/m^2/MHz at a distance of 200 meters. [828]

311. *Discussion*. We agree with the majority of commenters that some criteria is necessary at market boundaries to manage interference and coordination between adjacent area licensees. We also believe that given the wide channel bandwidths and diversity of potential applications that might be deployed in these bands, any criteria that we adopt should include a scaling factor for the bandwidth. Therefore, we will adopt a PFD limit/MHz that base operations must meet at the licensee's market boundary, absent a mutual agreement between adjacent market licensees to exceed that value.

312. We continue to believe that the 47dBuV/m field strength value that we proposed in the *NPRM* is an appropriate basis on which to set a PFD limit for the mmW bands. This is the same limit that has been successfully used in the PCS, AWS, and BRS bands. However, we note that a field strength of 47dBuV/m results in a very conservative absolute power limit because field strength does not take into consideration the bandwidth and frequency components. [829] Therefore, we believe it is appropriate to convert a 47dBuV/m field strength to a PFD limit in terms of dBm/m^2/MHz for the mmW bands. Looking again at the AWS, PCS, and BRS bands, we note that the equivalent PFD based on a 47dBuV/m field strength is within the range of -76 to -81 dBm/m^2/MHz depending on what bandwidth is assumed.[830]

[821] Sprint Reply at 6.

[822] Sprint Reply at 4.

[823] Sprint Reply Comments at 5-7.

[824] Nokia Reply Comments at 4-5.

[825] *See* Nokia Comments at 29.

[826] *See* Straight Path Aug. 5, *Ex Parte* Letter at 8-9.

[827] *See* Intel June 22, *Ex Parte* Letter Attach. at 25, Table 5, 26.

[828] *See* AT&T, Nokia, Samsung, T-Mobile, and Verizon May 6, *Ex Parte* at 1.

[829] For example, at a given distance, a 47dBuV/m field strength is equivalent to a received power level in the 28 GHz band of −119 dBm/100 MHz or −139 dBm/MHz at 28 GHz, whereas the same field strength results in a received power level of -96 dBm/5 MHz or −103dBm/MHz at PCS frequencies, where P_r(dBm/MHz) = 47-20Log(f_{MHz})-77.2+10Log(1/BW).

[830] 47dBuV/m is equivalent to −76dBm/m^2/MHz for PCS assuming a 5 MHz channel; −81dBm/m^2/MHz for PCS assuming a 15 MHz channel; −79 dBm/m^2/MHz for AWS assuming a 10 MHz channel; and −76 dBm/m^2/MHz for BRS assuming a 5.5 MHz channel, where PFD(dBm/m^2/MHz) = 47-115.8+10log(1/BW).

We observe that these values bound the -77.6 dBm/m^2/MHz PFD limit proposed by the joint filers. We also recognize that these values are higher than the −86 dBm/m^2/MHz PFD proposed by Straight Path and the -90.3 dBm/m^2/MHz PFD proposed by Intel. However, we note that Straight Path assumed an interference criteria of -10 dB I/N.[831] In recent rulemakings the Commission has assumed an interference criteria of 0 dB I/N.[832] Adjusting Straight Path's proposed limit to provide a 0dB I/N as opposed to a -10dB I/N yields a market boundary limit of -76 dBm/m^2/MHz. We also note that Intel's proposed PFD was based on worst case assumptions about the receive antenna gain, citing that the base station would have a gain of 29.1 dB in the direction of the interfering source.[833] We believe that this assumption is overly conservative. For example, the joint filers stated that a lower antenna gain is typically computed in the simulation towards the earth station since the receive beam is pointed in the direction of the transmitting UE, and it is statistically unlikely to coincide with the direction towards the earth station.[834] Thus, on balance, we believe that adopting a −77.6 dBm/m^2/MHz PFD limit as suggested by the joint filers, will protect terrestrial facilities in adjacent market areas from interference in a variety of different terrestrial to terrestrial use cases as well as the earth station to terrestrial scenario.[835] Therefore, we will adopt a market border PFD limit of −77.6 dBm/m^2/MHz measured at 1.5 meters above ground.[836] We emphasize that this level is intended to be a coordination trigger and that adjacent licensees are free to coordinate mutually agreed upon limits that exceed this value along their common market boundaries.[837] We will also reserve the right to revisit the market border PFD limit in the future if it becomes necessary as technology and services develop in these bands.

(ii) Fixed Point-to-Point Operations

313. *Background.* Several commenters address the criteria for coordinating fixed point-to-point operations near market boundaries. Skyriver states that adopting a field strength limit of 47 dBuV/m would severely impact fixed service providers because it would require a dramatic reduction in transmit power.[838] Skyriver suggests that the Commission retain a 16 kilometer coordination zone at the market boundaries for fixed point-to-point operations. Sprint recommends that the Commission require an operator proposing to initiate new fixed operations to coordinate those operations with adjacent block operators in order to avoid adjacent channel OOBE interference or brute force receiver overload.[839] Under Sprint's recommendation, coordination would be required when a new fixed transmitter is located within 3 km and within +/- 10 degrees of the receive azimuth of an existing fixed receiver, or is located within 1 km of an existing fixed receiver, but outside the +/- 10 degree receive antenna main lobe.[840]

[831] *See* Straight Path Aug. 5, *Ex Parte* Letter at 8-9.

[832] *See In the Matter of Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37, and Amendment of Part 74 of the Commission's Rules for Low Power Auxiliary Stations in the Repurposed 600 MHz Band and 600 MHz Duplex Gap*, Report and Order, 30 FCC Rcd 9551, 9609, para. 143, (2015) (a 3 dB rise in the noise floor as the appropriate interference criterion).

[833] *See* Intel June 21, *Ex Parte* Letter Attach. at 25, Table 5.

[834] *See* AT&T, Nokia, Samsung, T-Mobile, and Verizon May 6, *Ex Parte* Letter at 4 n.8.

[835] See ViaSat Comments at Exhibit 1 (ViaSat assumed a 47 dBuV/m field strength, adjusted for a 5.5 MHz bandwidth to arrive at a protection level of -106.1669 dBW/m^2/MHz (-76 dBm/ m^2/MHz), which results in required separation distances of approximately 161 meters between an FSS earth station and a terrestrial base/mobile.

[836] The 1.5 meter measurement height is consistent with our Part 27 rules.

[837] These provisions are consistent with existing Part 24 and Part 27 rules. *See* 47 CFR § 24.236 and 47 CFR § 27.55.

[838] Skyriver Comments at 13. Skyriver provides several examples that illustrate its point. Skyriver Comments at 14.

[839] Sprint Reply at 5.

[840] Sprint Reply at 5.

Sprint's suggestion is predicated on the assumption that the Commission's ULS system contains the latitudes, longitudes, and frequencies of licensed point-to-point paths, and those operating under lease, at 28 GHz and 39 GHz.[841]

314. *Discussion*. We agree with Skyriver that a field strength limit would not be appropriate for fixed point-to-point operations because it would require large power reductions by fixed service providers. As discussed above in Section IV.F.10. (Other Operating Requirements), we will retain the existing Part 101 technical rules for traditional fixed point-to-point links. As such, we believe that it is also appropriate to retain the existing requirement that fixed point-to-point operations within 16 kilometers (in the 38.6-40 GHz band) or 20 kilometers (in the 27.5-28.35 GHz band) of a licensee's market boundary must coordinate with co-channel licensees in adjacent market areas.[842] With respect to Sprint's suggestion that we impose a coordination requirement for adjacent channel licensees; in light of the OOBE limits that we are adopting,[843] we do not believe that any additional coordination requirement is necessary for adjacent channel operation.[844] We seek comment on further refining these coordination requirements in the *FNPRM*.[845]

b. Canadian and Mexican Borders

315. *Background.* In the *NPRM*, we proposed to adopt a rule for the 27.5-28.35 GHz, 37-38.6 GHz, and 38.6-40 GHz bands similar to Section 101.147(r)(13), 101.509(d), or 27.57 of our rules which provide that fixed and mobile operations are subject to existing and future international agreements with Mexico and Canada.[846] We noted that there are existing arrangements for fixed operations in the 27.5 – 28.35 GHz[847] and 38.6 – 40.0 GHz bands[848] between the United States and Canada.[849] We also noted that mmW operations must not cause harmful interference across any of our international borders. No parties filed comments with respect to this proposal.

316. *Discussion.* Consistent with our rules for other services, we adopt a rule that the 27.5-28.35 GHz, 37-38.6 GHz, and 38.6-40 GHz bands are subject to existing and future agreements with Mexico and Canada.

5. Operability

317. *Background*. The Commission historically has sought to promote the development of interoperable equipment, allowing smaller providers to benefit from the scale generated by equipment capable of operating across an entire band or adjacent bands.[850] Beginning with the licensing of cellular

[841] Sprint Reply at 5.

[842] We seek comment in the *FNPRM* on reducing these coordination distances. *See* Section V.B.1 (Coordination Mechanism for the Lower Band Segment).

[843] *See* Section IV.G.3 (Out-Of-Band Emission Limits).

[844] We also note that Sprint's assumption that ULS contains current station information is not entirely correct. While ULS does contain some information on leased links there is no requirement for licensees to report all fixed point-to-point links operating under their geographic licenses. Therefore the ULS database is an incomplete record of the existing point-to-point links.

[845] *See* Section V.G.3 (Coordination Criteria at Market Borders).

[846] *NPRM*, 30 FCC Rcd at 11955, para. 293.

[847] *See* https://transition.fcc.gov/ib/sand/agree/files/can-nb/lmdsagre.pdf.

[848] *See* https://transition.fcc.gov/ib/sand/agree/files/can-nb/24-38fin.pdf.

[849] *NPRM*, 30 FCC Rcd at 11955, para. 293

[850] We use the term 'operability' here to refer to a requirement that equipment must be capable of operating across the entire band. As noted below, the term is different from "interoperability," which we use here to refer to equipment capable of operating across multiple interfaces.

spectrum, the Commission maintained that consumer equipment should be capable of operating over the entire range of cellular spectrum as a means to "insure full coverage in all markets and compatibility on a nationwide basis."[851] Since that time, the Commission has addressed the issue of interoperability in several bands,[852] including in the Lower 700 MHz band (where it implemented an industry solution to LTE interoperability),[853] the AWS-3 band (where it mandated interoperability for some operators),[854] and the H Block band (where it stressed the importance of interoperability).[855]

318. In the *NPRM*, we proposed to require that mobile equipment operating within each mmW band be operable across the entirety of each band in which it operates, with each air interface it uses in that band or bands.[856] We also sought comment on whether it would be possible to achieve interoperability between different technologies.[857]

319. The record was mixed concerning an operability requirement. A number of commenters oppose any interoperability requirement.[858] Similarly, some commenters argue that the Commission should allow private industry standards and market forces to determine whether and to what extent to adopt interoperability standards for the millimeter wave bands.[859] Other commenters, however, support an interoperability requirement.[860] CCA and US Cellular emphasize that operability supports competition among carriers,[861] and that operability does not necessarily develop as an industry standard absent a regulatory requirement.[862] No commenters addressed the question of whether there would be unique challenges to implementing interoperability in the millimeter wave bands.

320. There was some confusion among commenters as to what type of operability we proposed to require. Some commenters interpret our proposal as requiring that all devices be capable of using all possible air interfaces, in addition to all frequencies in the band.[863] These commenters strenuously opposed this interpretation as technically infeasible.[864] To clarify, it was not our intent in the *NPRM* proposal to suggest that all devices be compatible with all air interfaces (though we did separately

[851] *Inquiry Into the Use of the Bands 825-845 MHz and 870-890 MHz for Cellular Communications Systems; and Amendment of Parts 2 and 22 of the Commission's Rules Relative to Cellular Communications Systems*, Report and Order, 86 FCC 2d 469, 482 (1981). The Commission adopted band-wide interoperability requirements for cellular service. *Id*.

[852] *Establishment of Rules and Policies for the Digital Audio Radio Service in the 2310-2360 MHz Frequency Band*, Report and Order [and] Memorandum Opinion and Order and Further Notice of Proposed Rulemaking, 27 FCC Rcd 5754 paras. 103, 106 (1997); *Amendment of the Commission's Rules to Establish New Personal Communications Services*, Memorandum Opinion and Order, 9 FCC Rcd 4957, 5021-22 paras. 163-64 (1994).

[853] *See Promoting Interoperability in the 700 MHz Commercial Spectrum*, Report and Order and Order of Proposed Modification, 28 FCC Rcd 15122 (2013).

[854] *See AWS-3 Report and Order*, 29 FCC Rcd at 4698-99, paras. 229-30.

[855] *H Block Report and Order,* 28 FCC Rcd at 9498, para. 32.

[856] *NPRM*, 30 FCC Rcd at 11964, para. 296.

[857] *NPRM*, 30 FCC Rcd at 11964, para. 296.

[858] AT&T Reply at 9-10, Ericsson Comments at 17, Verizon Comments at 17-18.

[859] CTA Comments at 15-16, CTIA Comments at 30-31, Huawei Comments at 27-28, T-Mobile Comments at 20.

[860] CCA Reply at 3, 12-13, Nokia Comments at 29-30, Straight Path Reply at 28-29, US Cellular Reply at 3-4.

[861] CCA Reply at 12-13, US Cellular Reply at 12.

[862] US Cellular Reply at 16-17.

[863] CTIA Comments at 30-31, Ericsson Comments at 17, Huawei Comments at 27-28, Qualcomm Comments at 17-18, Samsung Reply at 12, Verizon Comments at 17-18.

[864] Qualcomm Comments at 17-18, Samsung Comments at 19-20

seek comment on whether some degree of cross-technology interoperability would be possible).[865] Rather, the *NPRM* proposed that to the extent a device uses a particular air interface in a particular millimeter wave band or a block or blocks within the band, that device should be capable of accessing the entirety of that band with that air interface.[866]

321. *Discussion*. We adopt our proposal to require operability across each millimeter wave band for mobile and transportable equipment.[867] We continue believe that interoperability delivers important benefits to consumers. While there is significant opposition in the record to an interoperability requirement, no commenter offered specific reasons why the type of operability proposed in the *NPRM* would be either technically infeasible or harmful as a policy matter in these bands. In addition, much of the opposition in the record appears to be based on an interpretation of an interoperability requirement that we did not propose. We therefore conclude that the benefit to consumers outweighs the burden to manufacturers in this regard.

322. Specifically, we require that any mobile or transportable device designed to operate within the 28 GHz band (27.5 GHz – 28.35 GHz) be capable of operating at all frequencies within the 28 GHz band, on each air interface it uses to operate in the 28 GHz band, and similarly that a device operating in the 37 or 39 GHz bands be capable of operating at all frequencies within those bands (37 GHz – 40 GHz). For example, a device that uses an LTE air interface to operate in a lower frequency band, and a future 5G air interface to operate in the 28 GHz band, would be compliant with this requirement if it could operate on frequencies from 27.5 GHz to 28.35 GHz using the 5G air interface.

323. For the purposes of this requirement, for the 37 GHz and 39 GHz bands, a device operating in either band must be capable of operating across the entirety of *both* bands, from 37 GHz to 40 GHz (including the 37-37.6 MHz lower block). This requirement will increase the market for equipment in these bands, and allow both smaller and larger service providers to benefit from economies of scale and increased equipment availability. Mandating operability will also facilitate shared use of the 37 GHz band by ensuring that a wide variety of equipment is available by both Federal agencies and non-Federal SALs.

324. We emphasize that we are not mandating compatibility of each device with all possible air interfaces to be used in these bands, as some commenters interpreted.[868] Rather, we are mandating that *with each air interface* used by a particular device in a millimeter wave band, that device must be capable of operating across the entire band. We do not adopt any requirement that a device must be capable of utilizing any particular standard, technology, or air interface. Additionally, while we do not require operability of base or fixed equipment, it is our expectation that licensees will work in good faith through the standards setting process to develop standards, as technically feasible, that support the operation of base and fixed equipment across each band.

6. Technical Rules for Part 15 Operation within the 64-71 GHz Band

325. As indicated above,[869] we are adopting requirements for unlicensed operations in the 64-71 GHz band that are based on the technical standards used for the 57-64 GHz band under Section

[865] *NPRM*, 30 FCC Rcd at 11964, para. 296.

[866] As US Cellular noted, this meaning was further clarified by the text of our proposed rules, which read in relevant part, "The basic interoperability requirement in paragraph (a) of this section does not require a licensee to use any particular industry standard." US Cellular Comments at 15-16, *NPRM*, 30 FCC Rcd at 11990 (Appendix A).

[867] *NPRM*, 30 FCC Rcd at 11964, para. 296.

[868] CTIA Comments at 30-31, Ericsson Comments at 17, Huawei Comments at 27-28, Qualcomm Comments at 17-18, Samsung Reply at 12, Verizon Comments at 17-18.

[869] *See supra* Section IV.D (64-71 GHz Band).

15.255 of our rules.[870] Part 15 of the Commission's regulations permits the operation of radio frequency (RF) devices without an individual license from the Commission or the need for frequency coordination.[871] The technical standards contained in Part 15 are designed to ensure that there is a low probability that such devices will cause harmful interference to other users of the radio spectrum.[872] Except for operating on-board aircraft or satellites, and in mobile field disturbance sensor applications, any type of unlicensed operation is permitted within the 57-64 GHz band under Section 15.255 of our rules.[873]

326. *Suitability of the Existing Rules in Section 15.255 to the 64-71 GHz Band*. In the *NPRM*, the Commission proposed to apply the existing rules in Section 15.255 to the 64-71 GHz band with some adjustments, and sought comments on certain aspects of the rules to further the growth and development of devices without increasing the potential for harmful interference to authorized users in the bands.[874] Proponents of unlicensed operations unanimously support the proposal to extend the technical rules in Section 15.255 to cover the entire 57-71 GHz band. Google argues that harmonized rules for the frequencies between 57 and 71 GHz will allow economies of scale and other efficiencies, thereby facilitating rapid and widespread deployment of unlicensed devices;[875] the Wi-Fi Alliance confirms that extending Part 15 rules to the 64-71 GHz band would greatly enhance the capacity of next-generation WiGig technologies."[876] We find that the existing technical rules in the 57-64 GHz band can successfully apply to the proposed 64-71 GHz adjacent band, with certain adjustments, as we examine the pertinent rules in detail below.

a. Operation On-board Aircraft

327. *Background*. Section 15.255(a)(1) prohibits operation of equipment used on aircraft in the 57-64 GHz band. This requirement was adopted in 1995 pursuant to the request of CORF to protect radio astronomy (RAS) operations.[877] In the *NPRM*, the Commission did not propose to allow 60 GHz operations on-board aircraft, but stated it believes that the prohibition on operation on-board aircraft of 60 GHz devices may be revisited at the present time. To compile a comprehensive record on this issue, the Commission sought technical studies and interference analyses demonstrating whether transmissions in the 57-71 GHz band should be permitted on aircraft over the entire band, or potentially limited to a narrower portion of the band to minimize impact to the radio astronomy observations.[878] The Commission further noted that there is an ongoing industry collaboration with NTIA and other Federal

[870] 47 CFR § 15.255.

[871] 47 CFR §§ 15.1 *et seq*.

[872] The primary operating conditions under Part 15 are that the operator of a Part 15 device must accept whatever interference is received and must correct whatever harmful interference is caused. Should harmful interference occur, the operator is required to immediately correct the interference problem, even if correction of the problem requires ceasing operation of the Part 15 equipment causing interference. *See* 47 CFR § 15.5.

[873] A field disturbance sensor is defined as "a device that establishes a radio frequency field in its vicinity and detects changes in that field resulting from the movement of persons or objects within its range." 47 CFR § 15.3(l). Examples of unlicensed field disturbance sensors include radars operating under 47 CFR §§ 15.252 or 15.256; and perimeter protection systems operating under 47 CFR §§ 15.209(g) or 15.229.

[874] *NPRM*, 30 FCC Rcd at 11965, para. 303.

[875] Google Comments at 7.

[876] Wi-Fi Alliance Comments at 5.

[877] *See Above 40 GHz First Report and Order and Second FNPRM*, 11 FCC Rcd at 4496-97, para. 35. The Commission also stated that "if future filings indicate a need for use of these devices on aircraft and demonstrate how such devices can be designed to avoid potential interference to radio astronomy operations, then we may ultimately allow such use." *Id.*

[878] *NPRM*, 30 FCC Rcd at 11966, para. 304.

agencies to study the compatibility of operation of new chipsets and their operation on-board in-flight aircraft.[879] In addition, the Commission observed that new tri-band chipsets compliant with IEEE Standard 802.11ad[880] and intended for use in WiGig products such as laptops and other mobile electronic devices used by travelers on airplanes may operate in the 2.4 GHz, 5 GHz and 60 GHz bands, and that the present prohibition in the rules would require mobile devices to affirmatively disable Wi-Fi operation at 60 GHz (but not in the 2.4 GHz or 5 GHz frequency ranges) while operating on-board a plane, possibly creating difficulty in enforcing compliance.[881]

328. Many commenters endorse using 60 GHz transmitters on-board aircraft.[882] These parties state that according to certain European CEPT ECC[883] and ITU reports,[884] modern aircraft can be expected to provide 5 to 35 dB of fuselage attenuation, and that *shielded* aircraft windows could provide attenuation levels of up to 25 dB.[885] Boeing states that the optimal location of WiGig access points on aircraft is within the ceiling, pointing straight down toward passenger laptops (and directly away from Earth Exploration Satellite Service (EESS) satellites above); it contends that due to this reason, only much weaker side lobe transmissions (reduced by 10 dB or more) from WiGig access points would be directed near the windows.[886] The Wi-Fi Alliance submits a link budget analysis in which it found no interference to EESS with interference margins of 29 dBm for 1000 planes and 59 dBm for one plane; and no interference to radio astronomy with margins ranging from 3 dBm to 27 dBm, depending on the frequency and integration.[887] Zodiac Inflight Innovations (ZII), a wireless inflight entertainment products provider, submits calculations and analysis of a ZII-developed aircraft cabin radio local area network (RLAN), operating in the 60 GHz spectrum and using link budgets based on the recommendations in ITU-R RA.769-2 which specifies the minimum required protection level for radio astronomy stations.[888]

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[879] *NPRM*, 30 FCC Rcd at 11966, para. 306.

[880] 802.11ad is an amendment to the existing IEEE 802.11 standard, which is at the core of billions of Wi-Fi products available worldwide. *See also,* n.314 *supra*.

[881] *See* Wi-Fi Alliance, *Wi-Fi Certified WiGig,* http://www.wi-fi.org/discover-wi-fi/wigig-certified. WiGig products that bear the Wi-Fi Alliance Certification mark operate in the 60 GHz frequency band. Popular use cases for WiGig® include cable replacement for input/output and display extensions, wireless docking between devices like laptops and tablets, instant synchronization and backup, and simultaneous streaming of multiple, ultra-high definition video signals.

[882] *See, e.g.*, Boeing Comments at 15, CTA Comments at 8,IEEE 802 Comments at 5, Intel Comments at 19, Microsoft Comments at 13, ViaSat Comments at 22, Wi-Fi Alliance Comments at 6.

[883] *Co-existence study considering UWB applications inside aircraft and existing radio services in the frequency bands from 3.1 GHz to 4.8 GHz and from 6.0 GHz to 8.5 GHz*, European Conference of Postal and Telecommunications Administrations (CEPT) Electronic Communications Committee (ECC) ECC Report 175 (March 2012).

[884] International Telecommunication Union Radiocommunication Sector, *Technical characteristics and spectrum requirements of Wireless Avionics Intra-Communications systems to support their safe operation*, Report M.2283-0 (November 2013) (for frequencies below 18 GHz) (ITU-R Report M.2283) (http://www.itu.int/pub/R-REP-M.2283); International Telecommunication Union Radiocommunication Sector, *Compatibility analysis between wireless avionic intra-communication systems and systems in the existing services in the frequency band 4 200-4 400 MHz*, Report M.2319-0 (November 2014) (for frequencies below 4.4 GHz) (http://www.itu.int/pub/R-REP-M.2283-2013).

[885] Boeing Reply at 22-23, Wi-Fi Alliance Reply at 8. Note that the 25 dB attenuation figure is for *shielded* windows (which most airplanes do not provide), as indicated in ITU-R Report M.2283-0, Appendix A, Table A-3.3.

[886] Boeing Reply at 23.

[887] Wi-Fi Alliance Reply at 8, Attach. at 16.

[888] International Telecommunication Union Radiocommunication Sector, *Recommendation RA.769-2: Protection criteria used for radio astronomical measurements,* (May 2003).

Contrary to the Wi-Fi Alliance findings, ZII found that some combinations of transmit power levels, antenna radiation patterns and beam steering algorithms used on commercial radio components can result in RLAN systems that do not meet the protection recommendations of ITU-R RA.769-2 for RAS in all conditions, specifically in frequencies above approximately 63 GHz.[889] ZII therefore only supports the use of RLAN systems in the 57-64 GHz band on-board aircraft and hopes that its continuing studies will have results to support operation in the 64-71 GHz band in the future.[890]

329. On the other hand, the National Radio Astronomy Observatory (NRAO), the IEEE Geoscience and Remote Sensing Society Technical Committee on Frequency Allocations in Remote Sensing (IEEE FARS), and CORF oppose the use of 60 GHz transmitters on-board aircraft. NRAO states that current discussions on possible aeronautical use of the 60 GHz band between Boeing and NRAO, the National Science Foundation (NSF) and NASA Jet Propulsion Laboratory (JPL) representatives from the radio astronomy and remote sensing passive services have suffered from a lack of clarity about the implementation of airborne 60 GHz WiGig systems and basic quantities such as the power levels and distribution of signals inside the plane, and the expected leakage from the fuselage and windows.[891] The IEEE FARS believes that the usage of WiGig devices operating in the 60 GHz band on-board aircraft requires further peer-review study to protect passive services in the band before lifting the prohibition on operations on-board aircraft in Section 15.255;[892] it states that based on its calculations of a worst-case scenario, as few as 20-30 WiGig users on-board aircraft could potentially exceed the interference threshold level for passive sensors prescribed by the ITU by 13-15 dB.[893] It recommends that the Commission either require RF shielding of aircraft windows of at least an additional 25 dB, or prohibit on-board aircraft WiGig operations altogether. CORF also recommends further study of real-world transmission scenarios on aircraft prior to authorizing unlicensed airborne use of the 57-71 GHz, particularly in the 57-59.3 GHz sub-band (where EESS has a primary allocation) because this band is vitally important for weather forecasting from satellite remote sensing instruments and cannot be moved to another frequency.[894] CORF asserts that interference in this band would substantially degrade weather forecasts and could significantly affect the U.S economy and public safety.[895] CORF is concerned that airborne applications do not have the same oxygen attenuation as terrestrial applications so that the atmospheric attenuations are different for different altitudes, which could result in more interference.[896] In addition, CORF expresses concern that because there are few direct lines of sight between centrally located access points and user terminals on aircraft, access points will attempt to use scattered and reflected signals to maximize throughput, and that walls of the aircraft near the windows are thus likely to be favored "bounce" sites, which could cause signals to escape through the aircraft windows.[897] If airborne operations are allowed, CORF requests that we prohibit the first WiGig channel at 57.24-59.4 GHz on-board aircraft because of the uncertainty of enforcing compliance of user devices on-board

[889] ZII Reply at 13-14

[890] ZII Reply at 14-15.

[891] NRAO Comments at 5.

[892] IEEE FARS Reply at 5-7.

[893] International Telecommunication Union Radiocommunication Sector, *Recommendation RS.2017-0: Performance and interference criteria for* satellite *passive remote sensing*, (August 2012) (http://www.itu.int/rec/R-REC-RS.2017-0-201208-I).

[894] CORF Comments at 14.

[895] CORF Reply at 3.

[896] CORF Comments at 12.

[897] CORF Reply at 5.

aircraft,[898] By automatically disabling it, this will also eliminate the longer-term problem of device-to-device airborne communications.[899]

330. Boeing, the Wi-Fi Alliance, and Intel filed *ex parte* letters to respond to CORF and reiterate that WiGig would not cause interference to either RAS or EESS in any of the WiGig channels.[900] Boeing argues that there is no justification for the Commission to adopt CORF's proposal to prohibit airborne use of WiGig Channel 1 (covering 57.24 GHz to 59.4 GHz) or to require RF shielding on windows, because WiGig transmissions do not use reflections but beam forming, in which multiple antennas create narrow, discrete, directional (line-of-sight) communications between in-cabin access points and user devices in passengers' hands, laps, or on tray tables.[901] Intel recommends that we permit use of WiGig technology aboard aircraft in the entire 57-71 GHz band, except for the 57-59.3 GHz EESS sub-band, thus allowing most of the WiGig channels to be used.[902] Intel further recommends that the FCC delegate authority to OET to permit WiGig technology to use the 57-59.3 GHz sub-band if and when it determines a sufficient technical showing has been made.[903]

331. *Discussion.* We are reluctant to allow 60 GHz unlicensed operations on-board aircraft in the 57-71 GHz band at the present time. As indicated above, in the *NPRM* the Commission did not propose to permit unlicensed operations on-board aircraft but sought to start the discussion to compile a comprehensive record on this subject.[904] We note that as described above, there are substantial technical disagreements between the passive services licensees and the WiGig industry regarding the attenuation provided by aircraft components (e.g., windows and fuselage) and how WiGig signals would propagate (e.g., by direct line-of-sight or reflections, etc.) and aggregate.[905] We further observe that even among the WiGig industry advocates, there is technical disagreement. For example, ZII, a wireless inflight entertainment services and products provider, opposes on-board aircraft operation of WiGig devices in the 64-71 GHz band at the present time due to its findings of potential harmful interference to passive services above 63 GHz despite its financial interest in providing these services. Conversely, the Wi-Fi Alliance's analysis found no harmful interference to EESS and RAS in the entire 57-71 GHz spectrum.[906] We also find that the studies and technical analyses submitted in the record are not persuasive for several reasons. First, the CEPT ECC and ITU reports do not address the 60 GHz band, but cover lower frequencies.[907] Second, as indicated above, the various link budget analyses from the industry (e.g., from ZII and Wi-Fi Alliance) do not show a technical consensus, at least for a portion of the proposed 57-71 GHz band, and cast doubt on the validity of certain assumptions used to derive these link budgets. Third,

[898] CORF Reply at 3.

[899] CORF Reply at 7.

[900] *See* Boeing Apr. 12, *Ex Parte* Letter at 2, Intel Apr. 25 *Ex Part* Letter, Wi-Fi Alliance Apr. 21, *Ex Parte* Letter at 2.

[901] Boeing Apr. 12, *Ex Parte* Letter at 4-5.

[902] Intel Apr. 25, *Ex Parte* Letter at 2.

[903] Intel Apr. 25, *Ex Parte* Letter at 2.

[904] *See supra* Section IV.D (64-71 GHz Band); *NPRM*, 30 FCC Rcd at 11898-900, paras. 54-59.

[905] For example, IEEE FARS found that based on its calculations of a worst-case scenario, as few as 20-30 WiGig users on-board aircraft could potentially exceed the interference threshold level for passive sensors prescribed by the ITU by 13-15 dB, whereas the Wi-Fi Alliance analysis show no harmful interference to RAS and EESS from WiGig operation on board 1000 planes. *See* IEEE FARS Reply at 5-7, Wi-Fi Alliance Reply at 8, Attach. at 16.

[906] *See* ZII Reply at 15.

[907] The CEPT ECC Report 175 covers only frequency ranges of 3.1-4.8 GHz and 6.0-8.5 GHz; the ITU-R Report M.2283-0 covers only frequencies up to 18 GHz; the ITU-R Report M.2319-0 covers only the frequency range of 4.2-4.4 GHz.

since the collaboration effort between the WiGig industry and NTIA/NSF/JPL has not yet resolved many issues, as indicated by NRAO,[908] a decision on our part at this time could prejudge the outcome of that work. Finally, we note that 60 GHz transmitters in mobile devices are only just beginning to be marketed, and the impact of their deployment in real-world scenarios will require time to be assessed adequately.[909] Further, the technology will continue to evolve to address signal propagation challenges in the mmW spectrum such that analyses of WiGig transmissions on-board aircraft could change substantially once we have wide deployments.

332. We find that further technical analyses and data are necessary before lifting the present operation restriction because the record so far did not reflect a clear perspective of the types of WiGig applications envisioned on-board aircraft, the priority/order of their planned introduction, etc., to provide an adequate assessment of their associated potential harmful interference profile as we elaborate further in the *FNPRM* to seek additional information on this topic, *infra*.[910] Specifically, we request sharing studies and data demonstrating that 60 GHz transmitters could operate on-board aircraft without causing harmful interference to passive sensor services in various types of inflight applications and on various types of aircraft.

333. Finally, we find that as long as we do not permit 60 GHz operations on-board aircraft, the airlines (who control the aircraft) would not install access points operating at 60 GHz on airplanes to provide entertainment/broadband services to WiGig user devices. Without the presence of 60 GHz access points, the potential for widespread airborne WiGig transmissions is removed. We also expect manufacturers/host integrators of WiGig transmitters that are incorporated into mobile devices, such as laptops, to provide instructions to end users regarding the prohibition of operating such transmitters on-board aircraft, in compliance with our rules as part of the equipment authorization process. Consequently, end users will be aware of this rule to avoid device-to-device transmissions.[911] Based on the above, we are extending the restriction on on-board aircraft operation in Section 15.255(a)(1) to cover the entire 57-71 GHz band.

b. Field Disturbance Sensor Operation

334. *Background*. Section 15.255(a)(2) prohibits operation of field disturbance sensors in the 57-64 GHz band; however, it makes an exception for sensors in certain fixed industrial applications (speed control, fluid level, and motion detection functions, etc.).[912] These devices are required to operate at a power level 30 dB lower than communications devices in the 57-64 GHz band, in order to avoid causing harmful interference to co-channel communications devices.[913] In the *NPRM*, the Commission

[908] NRAO comments at 5.

[909] *See* Aaron Souppouris, *Acer introduces "World's First" Laptop with 802.11ad WiFi*, Engadget Jan. 4, 2016 (http://www.engadget.com/2016/01/04/acer-travelmate-p648-802-11-ad-wifi-wigig/).

[910] *See* discussion in Section V.G.5 (Technical Issues-Part 15 Operation on-board Aircraft in the 57-71 GHz Band), at paras. 514-516, *infra*.

[911] Device-to-device transmissions typically must be performed with a line of sight and at low power levels due to battery conservation requirements in mobile devices, unlike transmissions from access points to user devices that could occur at the maximum allowable power. *See* Wi-Fi Alliance Reply at 8.

[912] *See* Amendment of Parts 2, 15, and 97 of the Commission's Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications, *Memorandum Opinion and Order and Fourth Further Notice of Proposed Rulemaking*, 12 FCC Rcd at 12214-12215, paras. 6-11 (1997).

[913] Fixed field disturbance sensors must limit emissions to less than 10 dBm peak EIRP as well as the peak transmitter conducted output power to less than −10 dBm. 47 CFR § 15.255(b)(2) & (b)(3). However, they are allowed to operate within the 61.0-61.5 GHz frequency band at the same emission levels as communications devices, as long as they limit their emissions outside of this 500 MHz band to less than 10 dBm average / 13 dBm peak EIRP in the rest of the 57-64 GHz band. This requirement was part of the spectrum etiquette developed by the Millimeter Wave Communications Working Group (MWCWG) at the behest of the Commission to facilitate

(continued….)

observed that since the rules require these fixed field disturbance sensors to operate at a much lower power than communications equipment in the band, and they have not been the subject of any case of harmful interference over the years. These devices should be able to co-exist with communications equipment in the proposed 64-71 GHz band without additional harmful interference potential. The Commission proposed to extend the requirements for these fixed field disturbance sensors in Section 15.255 into the proposed 64-71 GHz band.[914]

335. The CTA urges the Commission to completely eliminate restrictions on field disturbance sensors across the 57-71 GHz band, thereby allowing both mobile and fixed radar applications to co-exist with communication devices.[915] It states that applications using these sensors are powering new innovations in wireless technology – including gesture technology that allows users to interact with devices (such as mobile watches and smartphones) without needing to touch them. It argues that today's field disturbance sensors can operate at much lower power levels and have smaller fields of influence, greatly lessening their potential for interference.[916]

336. Google also states that its research Project Soli uses a radar at 60 GHz to allow users to interact via hand gestures with devices a short distance away without needing to touch the device itself.[917] Google states that the power limits for these very short-range mobile radar applications can be less than 10 dBm EIRP, but that longer-range applications, such as in-room activity tracking, can be supported by power limits equal to those of communication devices operating in the band. Google further argues that the interference profile of these field disturbance sensors does not exceed that of other communications devices currently authorized for use in the 57-64 GHz band.[918] No other party elaborated on the harmful interference potential of mobile radar applications in the band. No party opposed the operation of fixed field disturbance sensors at their existing power limits in the 64-71 GHz band.

337. *Discussion.* We are reluctant at this time to lift the restriction on mobile field disturbance applications in the 60 GHz spectrum. At this time, we do not have sufficient information about the operation of these mobile field disturbance sensors in this spectrum to allow general operation of all mobile field disturbance sensors. However, we find that the narrow application of mobile radars in short-range devices for interactive motion sensing, such as that described in Google's Project Soli, – where a radar is used to detect hand gestures very close to a device to control the device without touching it – could be allowed without causing harmful interference to other authorized users. As a first cautious step, we will not permit these devices to operate at the same power levels as 60 GHz communications devices in this spectrum, as Google requests,[919] but will allow these short-range devices to operate at the same low power levels as those permitted in existing *fixed* field disturbance sensors (*i.e.*, 10 dBm peak EIRP and −10 dBm peak transmitter conducted output power, approximately 30 dB below the allowable power levels of WiGig communications devices). These power levels will ensure that the mobile radars will operate at very short distances – such as using hand gestures to control a watch, a smartphone's or tablet's screen – which will minimize their harmful interference potential.[920] As we acquire more

(Continued from previous page)
co-existence of all 60 GHz devices in the 57-64 GHz band, and adopted into the rules in 1998. *See Revision of Part 15 of the Commission's Rules Regarding Operation in the 57-64 GHz Band*, Third Report and Order, 13 FCC Rcd 15074 (1998). The spectrum etiquette is available at http://www.fcc.gov/oet/dockets/et94-124/etiquette.pdf.

[914] *NPRM*, 30 FCC Rcd at 11967, para. 307.

[915] A radar is one type of field disturbance sensor.

[916] CTA Comments at 8-9.

[917] *See Google Project Soli* (https://www.google.com/atap/project-soli/).

[918] Google Comments at 9.

[919] Google Comments at 8-9.

[920] 47 C.F.R. § 15.255(b)(3).

experience with these devices, we may consider allowing them higher power levels in the future.[921] Accordingly, we are amending Section 15.255 to permit the operation of short-range devices for interactive motion sensing at 10 dBm peak EIRP and −10 dBm peak transmitter conducted output power over the entire 57-71 GHz band.

338. With respect to fixed field disturbance sensors, we find that these devices can continue to operate under the technical rules in Section 15.255, as they have successfully done over the years, and that these rules may be extended to the 64-71 GHz band without increasing the potential for harmful interference to communication devices in the band. This would result in their wider usage in wireless factory automation processes in manufacturing facilities, such as those mentioned by Boeing.[922] Accordingly, we are amending Section 15.255 to allow the operation of fixed field disturbance sensors over the entire 57-71 GHz band at the existing power limits permitted in the 57-64 GHz band (i.e., 10 dBm peak EIRP and −10 dBm peak transmitter conducted output power).

c. Emission Limits

339. *Background*. Prior to 2013, except for fixed field disturbance sensors discussed above, Section 15.255(b) limited the average power of any emission in this band to 40 dBm EIRP and the peak power to 43 dBm EIRP for transmitters located either indoors or outdoors.[923] In 2013, the Commission modified these rules to raise the emission limits for outdoor transmitters equipped with very high gain antennas (i.e., higher than 30 dBi) to an average EIRP emission limit of 82 dBm and a peak EIRP limit of 85 dBm, in each case minus 2 dB for every dB that the antenna gain is below 51 dBi.[924]

340. In the *NPRM*, the Commission observed that the two existing types of emission limits that it proposed to apply to the 64-71 GHz band will continue to benefit both the low-power networking communication links, including mobile use for data and voice communications, and the high-power high-antenna-gain fixed point-to-point backhaul links. The Commission further noted that although oxygen attenuation is most severe in the 57-64 GHz band, which is centered approximately at 60 GHz,[925] its effect becomes much less pronounced in the adjacent 64-71 GHz band. The Commission tentatively concluded that equipment operating in the proposed 64-71 GHz band at the same emission levels would effectively be able to provide longer range and higher data throughput, as these levels are not as attenuated by the oxygen phenomenon.[926]

341. Commenters generally agree with, and support the Commission's observations and tentative conclusion. All are in favor of maintaining the existing EIRP limits of outdoor transmitters with very high-gain antennas. However, some parties request an additional 10 dB for the lower power indoor and outdoor networking transmitters, which would increase the EIRP limits of these devices to 50 dBm (100W) average/53 dBm (200W) peak, from 40 dBm (10W) average/43 dBm (20W) peak.[927] For example, the Wi-Fi Alliance argues that the higher EIRP limits would support devices with more antenna array elements and power amplifiers – promoting a greater diversity of applications, including those

[921] Google indicates that in-room activity tracking can be supported at power levels as high as those permitted in WiGig devices. Google Comments at 9.

[922] Boeing Comments at 12.

[923] 47 CFR § 15.255(b)(1)(i).

[924] 47 CFR § 15.255(b)(1)(ii).

[925] Attenuation of radio waves caused by oxygen is a little more than 15 dB/km at 60 GHz, and about 3 dB/km at 70 GHz. *See* OET Bulletin 67, *Millimeter Wave Propagation: Spectrum Management Implications*, July 1997, available at https://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet70/oet70a.pdf.

[926] *Id. See also Attenuation by Atmospheric Gases*, International Telecommunication Union, *Reports of the CCIR*, 1990, Vol V, Report 719-3, at pg. 189.

[927] DSA Comments at 1, 3, IEEE 802 Comments at 4, NCTA Comments at 6-7, Wi-Fi Alliance Comments at 8.

requiring multiple-room coverage indoors.[928] NCTA states that companies will likely use the 64-71 GHz band—as they use the 57-64 GHz band today—for outdoor, high-power, directional point-to-point backhaul links, as well as short-range indoor technologies like WiGig and WirelessHD,[929] and short-range outdoor networks. NCTA believes that the Commission can best promote the complementary development of all types of unlicensed technologies and their successful coexistence by adopting sufficiently high transmission power limits for low- power devices, – by increasing the emission limits by 10 dB – to enable such devices to receive each other's transmissions clearly, even in the presence of co-channel high-power transmissions.[930] The IEEE 802 also recommends the same increase and believes that it will enhance indoor performance for a variety of consumer applications.[931]

342. *Discussion.* We decline to increase the EIRP limits for low-power networking indoor and outdoor 60 GHz transmitters by a factor of 10 as requested by commenters. We note that the existing generous average and peak EIRP limits were adopted based on the very high oxygen attenuation in the 57-64 GHz band, which would ensure that unlicensed transmitters operating in this band do not cause harmful interference to other authorized services. We further note that we proposed the same emission limits for the 64-71 GHz band, despite the fact that this band does not exhibit the same atmospheric attenuation characteristics, which would enable equipment operating in the proposed 64-71 GHz band at the same emission levels to effectively provide longer range and higher data throughput.[932] We find that keeping the same emission limits in the absence of high oxygen attenuation in the 64-71 GHz band effectively provides an increase in power. No additional increase is necessary at this time and we are amending the EIRP limits for 60 GHz transmitters in Section 15.255 to apply across the 57-71 GHz band.

d. Spurious Emissions

343. *Background*. Section 15.255(c) restricts spurious emissions to a power density limit of 90 pW/cm^2 at a distance of 3 meters for frequencies between 40 and 200 GHz,[933] and to the general limit for intentional radiators in Section 15.209 for frequencies below 40 GHz.[934] In the *NPRM*, the Commission proposed to apply the same requirements to transmitters operating in the proposed 64-71 GHz band.

344. NRAO and CORF express concern that 64-71 GHz band operations could interfere with RAS operations via harmonics.[935] NRAO notes that "radio astronomy does not observe from the ground in the spectrum band 52-68 GHz, where the upper end is somewhat approximate; therefore, radio astronomy's concerns are more likely with the harmonics above the fundamental that propagate more freely."[936] CORF states that while RAS does not have allocations at the 64-71 GHz Band, it does have

[928] Wi-Fi Alliance Comments at 8.

[929] WirelessHD, also known as UltraGig, is a proprietary standard owned by Silicon Image (originally SiBeam) for wireless transmission of high-definition video content for consumer electronics products.

[930] NCTA Comments at 6-7, NCTA Reply at 8.

[931] IEEE 802 Comments at 4-5.

[932] *See* discussion in para. 340, and n.925, *supra.*

[933] A power density of 90 pW/cm^2 is equivalent to a field strength of 18430 µV/m or 85.3 dBµV/m; and to an EIRP of -10 dBm. Power density (P_D), EIRP and field strength (E) are readily converted through the following formulae: $P_D = E^2/120(Pi) = EIRP / (4 Pi D^2)$, where D is the separation distance in meters, provided measurements are performed in the far field.

[934] 47 CFR § 15.255(c); 47 CFR § 15.209(a). The limit for emissions above 960MHz is 500 µV/m (54 dBµV/m) as measured at 3 meters, or -41.3 dBm EIRP.

[935] NRAO Comments at 5-6. CORF indicates that low-power terrestrial signals have little impact on EESS observations. CORF Comments at 12.

[936] NRAO Comments at 5, para. 16.

co-primary allocations at the first and second harmonics of this band, at 128-142 GHz and at 192-213 GHz, and that these harmonic bands are subject to protection due to allocations for RAS, as well as pursuant to footnote US342.[937] No other party objected to our proposal.

345. *Discussion.* We observe that since we first adopted Part 15 rules for unlicensed operation in the 57-64 GHz band in the 1995-2000 time frame,[938] 60 GHz unlicensed transmitters have been operating without causing harmful interference to RAS by their harmonic signals.[939] This indicates that our spurious emission limits in Section 15.255 for transmitters operating in the existing 57-64 GHz band are adequate for protecting these passive services.[940] Thus, we are only concerned with the potential effect of the harmonics of fundamental signals in the proposed 64-71 GHz band.[941] We observe at the outset that the existing spurious emission limit in Section 15.255, at 90 pW/cm^2, is extremely low as compared to the spurious limit adopted for other unlicensed transmitters operating in comparative spectrum, such as the 76-77 GHz,[942] which, at 600 pW/cm^2, is more than 6 times higher than the spurious limit in Section 15.255.

346. While acknowledging that attenuation effects due to oxygen become much less pronounced in the 64-71 GHz band as compared to the 57-64 GHz band, we still find that interference to RAS stations is unlikely for the following reasons. First, RAS receivers discriminate against off-axis signals, are generally located in rural and remote areas, and radio astronomy observatories typically have control over access to a distance of one kilometer from the telescopes to provide protection from interference caused by uncontrolled radio frequency interference (RFI) sources.[943] Second, the severe propagation losses of RF signals in the 64-71 GHz band,[944] their ability to be blocked easily by terrain and obstacles, and the typically directional emissions of transmitters at these frequencies limit any potential for interference from fundamental emissions to a short distance (e.g., 100-200 meters).[945] Third, spurious and harmonic emissions generally roll off (i.e., reduce in amplitude) the further they are in frequency from the fundamental emission; therefore, if fundamental emissions are severely attenuated, harmonics

[937] CORF Comments at 15. *See* 47 CFR § 2.106 n.US 342.

[938] We first adopted Section 15.255 for unlicensed operation in the 59-64 GHz band. *See Above 40 GHz First Report and Order and Second FNPRM,* 11 FCC Rcd at 4496, para. 33. In 2000, we added the final 2-gigahertz from 57-59 GHz to Section 15.255. *See Amendment of Part 2 of the Commission's Rules to Allocate Additional Spectrum to the Inter-Satellite, Fixed, and Mobile Services and to Permit Unlicensed Devices to Use Certain Segments in the 50.2-50.4 GHz and 51.4-71.0 GHz Bands*, Report and Order, 15 FCC Rcd. 25264 (2000).

[939] The first harmonic signals of the 57-64 GHz band fall in the 114-128 GHz band, and the second harmonic signals of this band fall in the 171-192 GHz band.

[940] The Commission previously indicated that RAS allocations in the 111.8-114.25, 114.25-116, 182-185, and 226-231 GHz bands were made prior to the addition of unlicensed operation in the 57-64 GHz band. *See Revision of Part 15 of the Commission's Rules Regarding Operation in the 57-64 GHz Band*, Report and Order, 28 FCC Rcd 12517, 12532, para. 39, n.102 (2013) (*60 GHz Report and Order*).

[941] Footnote US342 protects passive observations, *inter alia,* at the following bands that include harmonics of fundamental signals in the 64-71 GHz band: 128.33-128.59 GHz, 129.23-129.49 GHz, 130-134 GHz, 136-148.5 GHz, 195.75-196.15, 209-226, and 241-250 GHz. 47 CFR § 2.106.

[942] 47 CFR § 15.253(d).

[943] *See Amendment of Sections 15.35 and 15.253 of the Commission's Rules Regarding Operation of Radar Systems in the 76-77 GHz Band/Amendment of Section 15.253 of the Commission's Rules to Permit Fixed Use of Radar in the 76-77 GHZ Band*, Report and Order, 27 FCC Rcd at 7885, paras. 15-16 (2012).

[944] Free space path loss (FSPL) for a 64 GHz signal is 78.07 dB and for a 71 GHz signal is 78.97 dB at 3 meters from the transmitter (i.e., FSPL (in dB)= 20 log F + 20 log d – 147.55, where F is the signal frequency in Hertz and d is the distance from the transmitter in meter).

[945] *See NPRM*, 30 FCC Rcd at 11955, paras. 272 (2015) ("quoting Intel who states: "we anticipate the cell size of the resulting mmW technology to be relatively small, and lie between 100-200m in outdoor deployments.")

would be affected proportionally.[946] Based on all these factors, we find that spurious and harmonic emissions of 57-71 GHz unlicensed transmitters at the very low limit of 90 pW/cm^2 in Section 15.255 would not cause harmful interference to RAS operations.[947] Accordingly, we are amending the spurious emission rule in Section 15.255 to apply across the 57-71 GHz band.

e. Publicly-Accessible Coordination Channel

347. Section 15.255(d) sets aside a publicly-accessible coordination channel in the 57.00-57.05 GHz band, in which only spurious emissions and emissions related to coordination techniques regarding interference management between diverse, non-interoperable, transmitters are permitted.[948] The Commission observed in the *NPRM* that with recent technological advances and industry standardization, co-existence between 60 GHz devices is better resolved by voluntary standards than by a coordination channel requirement in the rules, and proposed to remove this requirement.[949] Commenters unanimously agree with the Commission's assessment and support the elimination of this requirement to free a 50-megahertz swath of spectrum for communications usage.[950] Accordingly, we are removing the requirement for a publicly-accessible coordination channel from Section 15.255.

f. Conducted Transmitter Output Power

348. *Background*. Section 15.255(e) limits the peak transmitter conducted output power of 57-64 GHz unlicensed devices to 500 mW (i.e., 27 dBm)[951] for transmitters with an emission bandwidth of at least 100 MHz, and is reduced for systems that employ narrower bandwidths.[952] In the *NPRM*, the Commission proposed to apply this conducted transmitter output power requirement to transmitters operating in the entire 57-71 GHz band.[953]

349. NCTA recommends removing the peak transmitter conducted power limit in Section 15.255 to promote a wider range of applications and use cases that require more than just in-room coverage, and to enable device manufacturers to reduce the gain, size, cost, and complexity of antennas.[954] No other party commented on NCTA's recommendation. All other parties support our proposal.

350. *Discussion.* We decline to remove this requirement. The reason for limiting the peak transmitter conducted output power while allowing very high EIRP limits (in this case, 40 dBm (10W) average / 43 dBm (20W) peak) for an unlicensed transmitter is to ensure that the transmitter antenna

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[946] *See 60 GHz Report and Order*, 28 FCC Rcd at 12532, para. 39.

[947] We note that NTIA also agrees that "at these higher frequencies, the existing Section 15.255 emission limit is adequate to protect the RAS sites performing observations in the 128-142 GHz and 192-213 GHz bands from second and third harmonic emissions generated by terrestrial unlicensed devices operating in the 64-71 GHz band." *See 2016 NTIA Letter* at 8.

[948] 47 CFR § 15.255(d).

[949] *NPRM*, 30 FCC Rcd at 11969, para. 312.

[950] *See e.g.*, Intel Comments at 19, Microsoft Comments at 19, Qualcomm Comments at 15, Vubiq Comments at 6, Wi-Fi Alliance Comments at 9.

[951] *See* 47 CFR § 15.255(e). The 500 mW limit is equivalent to 27 dBm, with P (dBm) = 10 log (P (mW)).

[952] 47 CFR § 15.255(b)(1)(i) limits the average EIRP of 60 GHz transmitters to 40 dBm and the peak EIRP to 43 dBm. In transmitters operating at the maximum peak EIRP permitted under the rules of Section 15.255(b)(1)(i), the antenna gain may not exceed 16 dBi.

[953] *NPRM*, 30 FCC Rcd at 11969, para. 313.

[954] NCTA Comments at 7; NCTA Reply at 8-9.

beamwidth[955] is kept sufficiently narrow to avoid causing harmful interference to other users in the band and to minimize the risk of RF exposure to humans.[956] Accordingly, we deny NCTA's request and amend the peak transmitter conducted output power requirement in Section 15.255 to apply across the 57-71 GHz band.

g. Frequency Stability

351. Section 15.255(f) requires that fundamental emissions be contained within the 57-64 GHz frequency band during all conditions of operation; and that equipment be able to operate over the temperature range −20 to +50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage.[957] In the *NPRM*, the Commission proposed to apply the same requirements to transmitters operating in the 64-71 GHz band.[958] No party objects to this proposal. Accordingly, we are amending Section 15.255 to apply across the 57-71 GHz band.

h. Co-location of Separately-Authorized Transmitters

352. Section 15.255(h) allows group installation of transmitters that have been tested separately for compliance with the rules and received separate equipment authorizations, as long as no transmitter in the group is equipped with external phase-locking inputs that permit beam-forming arrays to be realized. In the *NPRM*, the Commission indicated that this requirement seeks to prevent the possibility of producing a high-power coherent beam from discrete transmitters that have not been tested for compliance together. This could lead to non-compliance with the emission limits but it does not preclude the use of advanced antenna technologies with beam-forming arrays in any transmitter, as long as the emissions in any array configuration comply with the emission and RF exposure limits.[959] The Commission proposed to apply the same requirement to equipment operating in the 64-71 GHz band.[960] No party objects to this proposal. Accordingly, we are amending Section 15.255 to apply across the 57-71 GHz band.

7. Equipment Authorization

353. The Office of Engineering and Technology (OET) was delegated authority by the Commission[961] to administer the equipment authorization program for RF devices under Part 2 of its rules.[962] All RF devices subject to equipment authorization must comply with the Commission's rules

[955] "Beamwidth" refers to the angle between the half-power points (i.e., the -3 dB points) of the main lobe of an antenna, when referenced to the peak effective radiated power of the main lobe. Beamwidth is usually expressed in degrees.

[956] RF exposure levels in the near field and on the antenna surface may increase as the size of the antenna decreases, and the use of a lower gain antenna could result in a transmission system that is more likely to exceed the RF exposure guidelines. *See 60 GHz Report and Order*, 28 FCC Rcd at 12529, para. 31 (2013).

[957] 47 CFR § 15.255(f).

[958] *NPRM*, 30 FCC Rcd at 11969, para. 314.

[959] Guidance for compliance testing of millimeter-wave transmitters is found in C63.10-2013, *American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices*, Clause 9, available at https://standards.ieee.org/findstds/standard/C63.10-2013.html; and in a series of KDB Publications: KDB No. 662911 D01 *Emissions Testing of Transmitters with Multiple Outputs in the same Band*, and D02 *MIMO with Cross-polarized Antenna,* available at https://apps.fcc.gov/oetcf/kdb/forms/FTSSearchResultPage.cfm?switch=P&id=49466; KDB No. 200443, *Millimeter Wave Devices Measurement Procedures*, available at https://apps.fcc.gov/oetcf/kdb/forms/FTSSearchResultPage.cfm?id=20677&switch=P.

[960] *NPRM*, 30 FCC Rcd at 11970, para. 315.

[961] 47 CFR § 0.241(b).

[962] 47 CFR Part 2 Subpart J.

prior to importation or marketing, by being tested for compliance with the applicable technical requirements, using measurement procedures that either follow guidance issued by OET through its Knowledge DataBase (KDB) publications,[963] or have been found to be acceptable to the Commission in accordance with Section 2.947 of the rules.[964]

a. Measurement Techniques

354. In the *NPRM*, the Commission recognized that there are some unique technical challenges specific to demonstrating compliance for the purpose of equipment authorization of millimeter wave devices. The Commission sought comments on a variety of challenges involved with measurements of in-band, out-of-band and spurious emissions.[965] As discussed, *supra*,[966] a number of parties discuss the measurement challenges concerning emission limit metrics. For example, certain parties oppose using EIRP as the metric for measuring OOBE limits,[967] proposing instead a different metric using Total Radiated Power (TRP),[968] claiming consistency with recent academic research for multiple-input, multiple-output (MIMO) antenna arrays.[969] However, TRP is not presently part of the Commission's measurement procedure guidance for devices using MIMO antennas.[970] Commenters recommend that the Commission continue to provide guidance on acceptable new measurement procedures via OET's KDB publications.[971] Commenters also recognize that 5G technology is in the early stages of equipment design and development so it is difficult at this point in time to identify all of the potential compliance and measurement challenges.[972]

355. We find that the mmW technology will continue to evolve to address various technical challenges in this spectrum (with respect to propagation, interference protection, modulation techniques, transmission security, etc.), and pending new measurement equipment availability to cover the entire mmW spectrum that we are making available for the next generation of wireless services herein, mmW measurement procedures are best developed by OET with the participation of interested parties. We expect that OET will provide guidance on various acceptable measurement techniques for mmW devices through its KDB publications as products are developed.

b. RF Exposure Compliance

356. (RF) exposure compliance is an ongoing requirement for all transmitters authorized by the Commission.[973] In the *NPRM*, we proposed to similarly require compliance with our general RF

[963] *See* https://www.fcc.gov/kdb.

[964] 47 CFR § 2.947.

[965] *See NPRM*, 30 FCC Rcd at 11971-11972, paras. 318-320.

[966] *See supra* Section IV.G.3 (Out-Of-Band Emission Limits).

[967] *See e.g.*, Ericsson Comments at 14, Straight Path Comments at 43, Sprint Reply at 8.

[968] TRP can also be expressed as ratio of EIRP to Directivity of antenna, $= \frac{EIRP}{D}$. *See supra* Section IV.G.3 (Out-Of-Band Emission Limits) n.770.

[969] Ericsson Comments at 15, fn. 24, citing the research of Christopher Mollén, *et al.*, *Out-of-Band Radiation Measure for MIMO Arrays with Beamformed Transmission* (Oct. 19, 2015), available at http://arxiv.org/pdf/1510.05513.

[970] The Commission has issued KDB Publication No. 662911, *Emissions Testing of Transmitters with Multiple Outputs in the Same Band (e.g., MIMO, Smart Antenna, etc)* (v.02 r.01), available at https://apps.fcc.gov/kdb/GetAttachment.html?id=B0ZQiTBTVsn3P3wZ2WdqhQ==&desc=662911%20D01%20Multiple%20Transmitter%20Output%20v02r01&tracking_number=49466.

[971] *See, e.g.*, TIA Comments at 35, Qualcomm Reply at 9.

[972] Samsung Comments at 18; Qualcomm Reply at 9.

[973] *See* 47 CFR § 1.1310; 47 CFR §§ 1.1307(b) (for fixed), 2.1091 (for mobile), and 2.1093 (for portable).

exposure limits in Sections 1.1307(b), 2.1091 and 2.1093 of the rules for equipment operating in the Upper Microwave Flexible Use Service.[974] While we sought comment on this proposal alongside some of the other relevant technical challenges unique to compliance demonstration for devices envisaged to be operating under the Upper Microwave Flexible Use Service,[975] we acknowledged in the *NPRM* that any issues raised involving the present exposure limits themselves would be considered in the context of our separate proceeding on this particular issue.[976]

357. In the *NPRM*, we sought comment on how to address determining compliance with the RF exposure limit for portable devices (intended for use within 20 centimeters of the body of a user) operating above 6 GHz,[977] recognizing that the FCC Laboratory will likely issue guidance to address these specific technical issues.[978] Also in the *NPRM*, because we proposed a 20 watt (43 dBm) peak EIRP for mobile devices, we sought comment on whether to maintain our continued approach to allow portable devices to be authorized up to the maximum EIRP permitted by the rules as long as our RF exposure limits are met.[979] In addition, because we had proposed in the *RF Further Notice*[980] determining compliance with the maximum permissible exposure (MPE) limits above 6 GHz over an area of one square centimeter, to be consistent with one gram cube (one cubic centimeter) averaging of our specific absorption rate (SAR) limit below 6 GHz, we sought comment on whether an averaging area of one square centimeter should be applied to Upper Microwave Flexible Use Service devices.[981]

358. We received seven comments pertaining to RF exposure for the Upper Microwave Flexible Use Service. According to Qualcomm[982] all of the commenters support using the limits and test procedures set out in IEEE[983] and ICNIRP[984] standards for portable device operations in the millimeter

[974] *NPRM*, 30 FCC Rcd 11990 App. A § 30.208.

[975] *NPRM*, 30 FCC Rcd 11972-75, paras. 321-24.

[976] *See Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies; Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields*, *First Report and Order* (*RF Order*), and Further Notice of Proposed Rule Making (*RF Further Notice*), and Notice of Inquiry *(RF Inquiry)*, 28 FCC Rcd 3498 (2013).

[977] *NPRM*, 30 FCC Rcd 11972-74, paras. 322-23.

[978] *See* April 2016 TCB Workshop slides 14 to 17, available at: https://transition.fcc.gov/oet/ea/presentations/files/apr16/4.1-RF-Exposure-TCB-Slides-April-2016-KC.pdf.

[979] *NPRM*, 30 FCC Rcd 11974-11975, para. 324.

[980] See *RF Further Notice*, 28 FCC Rcd at 3539, para. 125. Applying this SAR equivalency rationale to the MPE limit for general population/uncontrolled exposure above 6 GHz, the limit would more specifically be 10 W/m^2, averaged over any 1 cm^2 (defined in the shape of a 1 cm-by-1 cm square). Note the conversion from mW/cm^2 to W/m^2 for international system (SI) units: (10,000 cm^2) / (1 m^2) * (1 W) / (1,000 mW) = 10. However, see also *RF Further Notice* at para. 126, 28 FCC Rcd 3540 (2013), where "we seek comment on whether the blanket exemption as proposed may not be adequate to prevent exposure over our limits, for example, in a situation involving multiple high-gain millimeter-wave radiators." No comments were received in response to this specific solicitation of comments. *See also RF Inquiry*, 28 FCC Rcd at 3576-78, paras. 221-24 ("As portable devices are developed for operation at higher frequencies, lack of clear definitions of spatial peak and spatially averaged power density in our limits may become more significant. We invite comment on whether we should change or clarify spatial averaging requirements and spatial maximum power density limits, at least at higher frequencies, either in our rules limiting human exposure to RF energy or in our non-mandatory materials.").

[981] *NPRM*, 30 FCC Rcd at 11975 para. 324.

[982] Qualcomm Mar. 7, *Ex Parte* Letter.

[983] Institute of Electrical and Electronics Engineers, Inc. (IEEE), IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, IEEE Std C95.1-2005, (2006).

[984] International Commission on Non-Ionizing Radiation Protection (ICNIRP), *Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (Up to 300 GHz)*, 74 Health Physics 494 (1998).

wave bands. Most of the comments were relatively brief, with the exception of MMF's more detailed comments.[985]

359. MMF suggests that, based on their review of FCC, ICNIRP, and IEEE power density limits at millimeter wave frequencies, a better basis for such limits would be those from IEEE C95.1-2005 (C95.1-2005 and C95.1a-2010). However, all of these limits need to be updated because of their differences above 10 GHz. MMF also point out the discontinuity of "several dB" that has been reported in the literature when using the FCC exposure limits for localized exposure at the transition frequency of 6 GHz, where the basic restriction changes from SAR to MPE, and they state that this discontinuity would constrain network capacity and coverage. MMF agrees that it is better dealt with the in the context of the *RF Inquiry*. Finally, MMF requests greater clarity and guidance from the Commission through OET's KDB publications as to measurement and assessment methodologies that can be used to demonstrate compliance with our limits.

360. TIA, while recognizing the ongoing *RF Inquiry* and pointing out the discontinuity between the SAR and MPE limits at 6 GHz, suggests that the Commission should promptly adopt IEEE C95.1-2005 as the applicable standard in the millimeter wave bands because it reflects well-established research and would support mobile applications.[986] Even if this is not done, TIA suggests that manufacturers still require early guidance on evaluation procedures to determine compliance at these higher frequencies to support device design, and that this guidance could be provided through KDB publications. Device manufacturers Ericsson and Nokia both suggest that the Commission consider adopting the IEEE C95.1-2005 limits for the services contemplated, with Nokia suggesting that the Commission not delay while broader issues in the RF proceedings are resolved.[987] Like others, Ericsson points to the discontinuity at 6 GHz and references papers by Foster *et al* and Colombi *et al*.[988] Ericsson states that the Foster paper questions the application of the current limits at higher frequencies.

361. Component manufactures Qualcomm and Intel both support spatial averaging of power density in determining compliance with the exposure limits.[989] Qualcomm also emphasizes time averaging of power density to account for the effect of multiple element antennas when determining compliance for portable handsets above 24 GHz. Qualcomm suggests that since ICNIRP and IEEE have specified spatial averaging areas and a time window for time averaging, these standards should be used to establish testing methods and measurement procedures for millimeter wave portable devices, and that these procedures should be formalized in a KDB publication when they are stable. Finally, Straight Path, a spectrum licensee, quotes the FCC limits and states that they are in line with ICNIRP guidelines and that such guidelines are well established.[990] In addition, Straight Path supports the spatial and time averaging considerations put forward by Qualcomm and recommends that the Commission continue to

[985] *See generally* MMF Comments.

[986] TIA Comments at 34-35.

[987] Ericsson Comments at 17-19, Nokia Comments at 6, 30-31.

[988] Kenneth R. Foster et al, *Thermal Response of Tissues to Millimeter Waves: Implications for Setting Exposure Guidelines*, 99 Health Physics, 806 (2010) and Davide Colombi et al, *Implications of EMF Exposure Limits on Output Power Levels for 5G Devices above 6 GHz*, DOI 10.1109/LAWP.2015.2400331, IEEE Antennas and Wireless Propagation Letters. The paper by Colombi et al shows a comparison of IEEE, ICNIRP, and FCC limits in terms of the total maximum output power to comply at a 2 cm separation distance. Although the paper uses half-wave dipoles, which may not be sufficiently representative of antennas foreseen to be used in this service, above 30 GHz their results show a maximum of roughly 23 dBm using IEEE, 18 dBm using ICNIRP, and 15 dBm using FCC. Thus, the maximum discontinuity above 30 GHz is about 8 dB between IEEE and FCC, but varies below 30 GHz. However as the authors note, because IEEE has "not yet been adopted by any regulatory authority," comparing FCC and ICNIRP–presently being used by many countries, this maximum discontinuity above 30 GHz is about 3 dB.

[989] Qualcomm Comments at 18-20, Intel Reply at 17.

[990] Straight Path Comments at 44-45, Straight Path Reply at 29-30.

follow the ICNIRP guidelines for these factors and suggests that the Commission support any further study of exposure limits in the millimeter wave bands in its ongoing proceedings on RF exposure limits and policies. Straight Path also supports the proposals by other commenters to adopt industry standards.

362. With respect to the rules specific to Upper Microwave Flexible Use Service in Part 30 of the Commission's rules, we adopt the paragraph we proposed in the *NPRM* that requires compliance with our general RF exposure limits in Sections 1.1307(b), 2.1091 and 2.1093 of the rules.[991] The comments from industry advocate adopting alternative exposure limits, which we continue to view as beyond the scope of this proceeding, and that will be considered in a separate proceeding.[992] We are not changing our fundamental exposure limits at this time in light of the devices to be expected under the Upper Microwave Flexible Use Service rules.[993] More specifically, we are not modifying our specified SAR values as a primary exposure limit between 100 kHz and 6 GHz,[994] and we will continue to use the specified MPE power density limit as a primary exposure limit above 6 GHz.[995]

363. We recognize that there is a discontinuity at 6 GHz resulting from the fact that our rules do not specify a spatial averaging area (an area over which to average power density) or a spatial peak power density above 6 GHz that is consistent with our localized (over 1 gram) specific absorption rate (SAR) below 6 GHz.[996] At lower frequencies for sources at least 20 cm from the body, spatial averaging over the entire body has been acceptable. However, both IEEE and ICNIRP have recognized that at higher frequencies spatial averaging areas need to be smaller. Of these specifications, the smaller and more conservative area is by ICNIRP, which has specified a spatial averaging area of 20 cm^2 above 10 GHz. While we note this as an apparently reasonable requirement we are not suggesting any particular changes to our evaluation procedures at this time. We will separately consider the broader questions of the RF exposure limits and how they should be applied in our *RF Inquiry*. In the meantime, as we acknowledged in the *NPRM*, specific guidance on evaluating devices operating in this service will be issued by OET, and it is consistent with our existing discussions on spatial averaging to further clarify guidance on an area over which to average power density in our KDB publications through that process. Finally, we acknowledge the variations between standards pointed out by the MMF and encourage further

[991] *See* Appendix A *infra*.

[992] *See RF Inquiry*, 28 FCC Rcd at 3570 para. 205.

[993] *See* 47 CFR § 1.1310.

[994] *See RF Order*, 28 FCC Rcd at 3506 *et. seq*., paras. 20-27. The SAR limits are based on criteria published by the American National Standards Institute (ANSI) for localized SAR in §4.2 of "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," ANSI/IEEE Std C95.1-1992, copyright 1992 by the Institute of Electrical and Electronics Engineers, Inc., New York, New York 10017.

[995] *See* 47 CFR § 1.1310(e). The MPE limits are based on criteria published by the National Council on Radiation Protection and Measurement (NCRP) in "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," NCRP Report No. 86, §§ 17.4.1, 17.4.1.1, 17.4.2 and 17.4.3, copyright 1986 by NCRP.

[996] Our localized SAR limit for the general population is 1.6 W/kg as averaged over any one gram cube of tissue, applicable over the frequency range from 100 kHz through 6 GHz. (For occupational exposure over this same frequency range, the localized SAR limit is 8 W/kg as averaged over any one gram cube of tissue.) Similarly at these frequencies, our whole-body SAR limit for the general population is 0.08 W/kg as averaged over the whole human body. (For occupational exposure, the whole-body SAR limit is 0.4 W/kg.) *See* 47 CFR § 1.1310(c): "The SAR limits for general population/uncontrolled exposure are 0.08 W/kg, as averaged over the whole body, and a peak spatial-average SAR of 1.6 W/kg, averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube)." (*See also* 47 CFR § 1.1310(b) for occupational limits.)

efforts on the specific issue of localized millimeter wave exposure by the standards setting bodies and the broader research community.[997].

H. Other Allocation Issues

364. *Background*. The 42-42.5 GHz band (42 GHz band) is allocated to the fixed, mobile, broadcasting, and broadcasting-satellite services on a primary basis for non-Federal use.[998] Footnote US211 urges applicants for airborne or space stations assignments in the 40.5-42.5 GHz band to take all practicable steps to protect radio astronomy observations in the adjacent 42.5-43.5 GHz band from harmful interference.[999]

365. In the *V-Band Third NPRM*, the Commission proposed to delete the broadcasting service and broadcasting-satellite service (BSS) allocations from the 42 GHz band to protect the radio astronomy service (RAS) in the adjacent 42.5-43.5 GHz band.[1000] The Commission reasoned that the fixed service (FS) designation of the 42 GHz band made it potentially available for ubiquitous FS deployments that would interfere with similarly ubiquitously deployed BSS consumer receiver equipment and the general, wide BSS coverage of the band.[1001] The Commission also sought comment on whether to add a primary allocation for the non-Federal fixed-satellite service (FSS) (space-to-Earth) in the 42 GHz band.[1002] The band had already been internationally allocated for FSS downlink use and WRC-03 had adopted power flux density (PFD) limits on any potential satellite operations at 42-42.5 GHz to protect RAS in the 42.5-43.5 GHz band.[1003] The *V-Band Third NPRM* also hypothesized that FSS could operate with greater constraints on PFD and could use a limited number of spot-beams to communicate with relatively few earth stations, making the service a less ubiquitous interference threat to RAS than BSS, and enhancing possible sharing between RAS and FSS.[1004] Satellite operators supported the expansion of FSS service into 42.5-43.5 GHz, to complement the existing contiguous satellite allocation at 40-42 GHz.[1005]

366. In the *NPRM*, we declined to propose service rules for the 42 GHz band at that time due to concerns that we would be unable to adequately protect the RAS, which receives extremely weak radio waves of cosmic origin in the adjacent 42.5-43.5 GHz band,[1006] and because we found the band already

[997] MMF, *REQUEST FOR PROPOSAL, EMF Exposure Limits and Compliance Assessment for Wireless Devices Operating at Frequencies above 6 GHz,* December 2, 2014, http://emfhealth.info/docs/eng/MMF_RFP_DosimetryAbove6GHz_021214.pdf.

[998] 47 CFR § 2.106.

[999] 47 CFR § 2.106 n.US211.

[1000] *See V-Band Third NPRM*, 25 FCC Rcd at 15668-70, paras. 12-16.

[1001] *See id.* at para. 14. Although the 42 GHz band has both a domestic fixed service designation and an international high-density fixed service (HDFS) designation, currently no service rules have been adopted to authorize fixed operations in the band. 47 CFR § 2.106 n.5.547.

[1002] *See V-Band Third NPRM*, 25 FCC Rcd at 15668-70, paras. 17-19.

[1003] *See id.* at paras.17, 19.

[1004] *See id.* at para. 18. The Commission asked whether FSS should operate according to the same rules in this band as it did at 37.5-40 GHz. *See id.* at para. 19.

[1005] Boeing Reply at 19, SIA Reply at 14.

[1006] Protection of RAS stations that observe in the 42.5-43.5 GHz band is addressed in two footnotes in the Allocation Table. Footnote US342 addresses in-band interference by requiring that, in making assignments to other services to which the 42.77-42.87 GHz, 43.07-43.17 GHz, and 43.37-43.47 GHz band segments are allocated, all practicable steps be taken to protect the RAS from harmful interference. Footnote US342 also notes that emissions from spaceborne or airborne stations can be particularly serious sources of interference to the RAS. Footnote US211 addresses adjacent-band interference by urging applicants for airborne or space station assignments in the 40.5-42.5 GHz band to take all practicable steps to protect radio astronomy observations in the adjacent bands (e.g., 42.5-43.5 GHz) from harmful interference. 47 CFR § 2.106 nn.US211, US342.

encumbered by pending proposals to place both FS and non-Federal FSS in the band.[1007] Such considerations made this band less desirable vis-à-vis the 28 or 39 GHz bands. We nevertheless asked commenters to analyze its relative merit for FS, FSS, or mobile use, as well as the different mechanisms that these various services could use to share the 42 GHz band, and how such uses would be impacted by the need to protect RAS in the 42.5-43.5 GHz band.[1008] While satellite interests have opposed use of the band for terrestrial service and have argued for FSS use instead, T-Mobile supports its use for mobile.[1009] CORF describes the adjacent 42.5-43.5 GHz band as being one of the most important bands for radio astronomy because it is used to observe silicon monoxide, which yields important information on stellar temperatures, density, and wind velocities.[1010] FWCC contends that the 42-43.5 GHz band is more suitable for fixed point-to-point service.[1011]

367. *Discussion.* For the reasons mentioned above and discussed in the *NPRM*, we delete the broadcasting and broadcasting-satellite service allocations from the 42 GHz band to better protect the radio astronomy observations of the 42.5-43.5 GHz band from out-of-band emissions. Further, the ubiquitous nature of the BSS and the broadcasting service would likely interfere with ubiquitous mobile deployment in similar ways to a ubiquitous fixed service deployment. As previously noted, the BSS also poses an interference risk to adjacent RAS services. Nevertheless, the BSS will still retain 1.5 gigahertz of spectrum in the 40.5-42 GHz band for its future operations.

368. We also decline to adopt our proposal to allocate the 42 GHz band for FSS downlink operations. Given our decision today to grant FSS enhanced access to the 37.5-40 GHz band, and the fact that FSS has access to the 40.5-42 GHz band, we find there is less reason to further expand FSS operations to the 42 GHz band. We believe there is value in potentially having an Upper Microwave Flexible Use Service (UMFUS) band available for exclusive terrestrial use, and we address this issue in the companion *FNPRM*.

V. FURTHER NOTICE OF PROPOSED RULEMAKING

369. This *Further Notice of Proposed Rulemaking* will have two sections. First, we propose to adopt service rules allowing flexible fixed and mobile uses in additional bands. These bands potentially offer 17.7 gigahertz of spectrum that could be available for fixed or mobile use. By examining the suitability for mobile use of such a large amount of spectrum, we take steps to ensure that additional spectrum is available to allow the next generation of wireless technologies to flourish in the mmW bands. In addition, many of these bands will require sharing solutions to unlock their potential for flexible use services – we seek comment on the potential sharing mechanisms, and continue to encourage all stakeholders to work to develop and refine effective solutions to sharing. Second, we seek further comment on refinements to the rules we adopt today. In particular, we seek comment on: (1) providing additional detail on the sharing arrangement we adopted today for the 37 GHz band; (2) performance requirements for innovative uses such as IoT and machine-to-machine communications; (3) additional issues relating to our mobile spectrum holdings policies; (4) whether antenna height limits are necessary in mmW bands; (5) whether minimum bandwidth scaling factors are necessary for transmitter power limits; (6) whether allowing higher PFD levels for FSS in the 37 and 39 GHz bands would be consistent with terrestrial use of those bands; (7) refining the coordination limits for point-to-point operations; and (8) on sharing analysis and modeling. We undertake these additional inquiries to ensure that mmW band spectrum is utilized as fully and efficiently as possible.

[1007] *NPRM*, 30 FCC Rcd at 11904, paras. 79-80.

[1008] *See NPRM*, 30 FCC Rcd at 11904, para. 80.

[1009] Global VSAT Forum Comments at 6, T-Mobile Comments at 8, Boeing Reply at 19, SIA Reply at 14.

[1010] CORF Reply at 8-9.

[1011] FWCC Comments at 3.

A. Additional Bands

1. Introduction

370. In the *NPRM*, we used four main criteria to determine which bands to propose for mobile use in the *NPRM*. First, for purposes of the *NPRM*, we focused on bands with at least 500 megahertz of contiguous spectrum. Second, to the extent practical, we proposed bands that are being considered internationally for mobile service. Third, we sought to propose bands that are compatible with existing incumbent license assignments and uses. Finally, we noted the importance of developing a flexible regulatory framework that would accommodate as wide a variety of services as possible.[1012]

371. Several commenters ask the Commission to consider other bands for mobile use.[1013] Many commenters argue that the criteria should not preclude the Commission from considering bands that do not meet all of those criteria. For example, CTIA and Nokia ask the Commission to consider bands that do not have 500 megahertz of spectrum because certain applications may be feasible for smaller bandwidths.[1014] Commenters also agree that while international harmonization is preferable, the Commission should not preclude bands from further consideration just because they are not proposed for mobile use throughout the world.[1015]

372. Several factors lead us to conclude that it is now appropriate to consider additional bands for mobile use. First, as the record has made clear, there are a wide variety of services, including fixed, mobile, and satellite, for which these bands could be used. This variety favors making multiple bands available, including bands for which we did not to propose service rules in the *NPRM*. Second, the World Radio Conference identified a large number of bands as candidate bands for IMT-2020, including several bands that we did not address in the *NPRM*. Third, it appears that the amount of global data traffic will continue to grow exponentially. Cisco estimates that global mobile data traffic will grow nearly tenfold between 2014 and 2019.[1016] Under these circumstances, we believe it is now appropriate to seek comment on proposing mobile service rules for most of the bands identified at the 2015 World Radio Conference.

373. Specifically, we propose authorizing flexible use licenses that would permit fixed and mobile services in the following bands: 24.25-24.45 GHz and 24.75-25.25 GHz, 31.8-33.4 GHz, 42-42.5 GHz, 47.2-50.2 GHz, 50.4-52.6 GHz, 71-76 GHz, and 81-86 GHz. Each of these bands was identified as a candidate band for IMT-2020.

374. At the same time, we recognize that there are challenges that must be overcome before we can authorize service in these bands, including existing allocations and/or operations in these bands. We will continue to work with existing stakeholders, wireless providers, the satellite industry, NTIA, and other interested Federal stakeholders to determine where different services can coexist and develop ways to maximize flexible use. In several bands, we believe sharing mechanisms we have adopted in this and other proceedings can allow many of these bands to be utilized for fixed and mobile use while also accommodating existing uses.

375. We discuss each of the bands in additional detail below. We generally propose to use the licensing and service rule framework we adopt today. Except for the 71-76 GHz, and 81-86 GHz bands, we propose to use geographic area licensing with PEAs as the license area size. For the 71-76 GHz and 81-86 GHz bands, we propose to use a licensing framework similar to the framework developed for the Citizens Broadband Radio Service. For any UMFUS bands for which we adopt geographic area licensing

[1012] *NPRM*, 30 FCC Rcd at 11887-88, paras. 20-23.

[1013] ITIC Comments at 6-7, Mobile Future Comments at 9, Nokia Comments at 11-13, Samsung Comments at 14-15, T-Mobile Comments at 4-9.

[1014] CTIA Comments at 10, Nokia Comments at 9.

[1015] CTIA Comments at 11, Nokia Comments at 9.

[1016] Cisco Comments at 3.

and accept mutually exclusive initial applications, we have decided to conduct any spectrum auction of licenses in conformity with the general competitive bidding procedures set forth in Part 1 Subpart Q of the Commission's rules, including rules governing designated entity preferences.[1017] We seek comment here on whether to apply the same small business definitions and associated bidding credits we have adopted for auctions of UMFUS licenses to auctions of licenses in the additional bands discussed below, as well as any other spectrum bands that we may subsequently decide to include in the UMFUS. Our proposal is based on our anticipation that the same types of services would be deployed in these additional bands as are contemplated to be deployed in the bands that we have already designated for the UMFUS. We ask commenters to provide specific data on the costs and benefits associated with the licensing mechanisms we have proposed.

376. In the *Report & Order* portion of this item, we are making 3.85 GHz of mmW spectrum available for licensed mobile use, as well as adding seven gigahertz of spectrum for unlicensed use, bringing the total to 14 GHz of unlicensed spectrum available in the 57-71 GHz band. In view of these relative proportions, we believe it is appropriate to make additional licensed spectrum available for flexible use. Furthermore, we continue to believe there is value in using both geographic area licensing and shared access. We seek comment on alternative licensing mechanisms for each of these bands, including unlicensed operation. To the extent we adopt geographic area licensing, we also seek comment on alternative license area sizes.

377. We also propose to generally apply the Part 30 technical rules we have adopted today to each of the bands where we ultimately adopt flexible use rules. We seek comment on any deviations from those rules or special technical rules that would be needed for any of those bands. Commenters who propose special technical rules should explain the specific need for such rules and quantify the costs and benefits associated with their proposed rules. We also encourage commenters to provide detailed technical analysis supporting any technical proposals.

378. As we explained in the *NPRM*, we believe these bands might be able to support expanded sharing, including two-way shared use between Federal and non-Federal users in these bands and sharing among different types of service platforms. We continue to believe there is an opportunity to leverage the propagation characteristics of these bands to further enhance sharing between Federal and non-Federal users. We seek comment generally on ways to further Federal and non-Federal sharing in these bands, including refinement of the concept we adopt today for the 37 GHz band.

2. 24 GHz Bands (24.25-24.45 GHz and 24.75-25.25 GHz)

379. *Background.* There are two types of fixed licenses in this band. The 24 GHz Service has a total of 176 EA or EA-like service areas.[1018] In 2004, the Commission held Auction 56, in which it made 890 24 GHz licenses available. Only seven of the 890 licenses were sold, and five of those licenses are currently active.[1019] In addition, FiberTower holds a total of 38 pre-auction Digital Electronic Messaging Service licenses in this band.

380. There are no Federal allocations in the 24.25-24.45 GHz or 24.75-25.25 GHz band segments.[1020] The 24.75-25.25 GHz band segment is non-Federal allocated for FSS (Earth-to-space), and the 25.05-25.25 GHz band segment also has a co-primary allocation for non-Federal Fixed Service. A footnote to the U.S. Table of Frequency Allocations provides that the use of the 24.75-25.25 GHz band by

[1017] *See supra* at para. 243.

[1018] *See* 47 CFR § 101.523.

[1019] *See 24 GHz Service Spectrum Auction Closes, Winning Bidders Announced*, Public Notice, 19 FCC Rcd 14738 (WTB 2004).

[1020] *See* 47 CFR § 2.106.

the FSS (Earth-to-space) is limited to feeder links for the Broadcast Satellite Service (BSS).[1021] Section 25.203(l) of the Commission's rules provides that applicants for feeder link earth station facilities operating in the 25.05-25.25 GHz band may be licensed only where no existing Fixed Service licensee has been authorized, and shall coordinate their operations with 24 GHz Fixed Service operations if the power flux density of their transmitted signal at the boundary of the Fixed Service license area is equal to or greater than −114 dBW/m^2 in any 1 MHz.[1022] The *17/24 GHz Broadcasting-Satellite Service Report and Order* determined that future Fixed Service systems locating near an authorized 17/24 GHz BSS feeder link earth station may not claim protection from interference from the feeder link earth station's transmissions, provided that those transmissions are compliant with the Commission's rules, and that future 24 GHz Fixed Service applicants would be required to take into account the transmissions from the previously authorized earth station when considering system designs, including their choices of locations for their license areas.[1023] There are four active licenses for feeder link earth stations in the 24.75-25.25 GHz band segment and one pending application, all of them held by DIRECTV.[1024]

381. There is no mobile allocation in either of the 24 GHz band segments, and no fixed allocation at 24.75-25.05 GHz.[1025] In the *24 GHz Report and Order*, the Commission found that it would be premature to allow mobile operations in the 24 GHz bands but reserved the discretion to revisit that issue if it is presented with technical information demonstrating that such operations would be technically feasible without generating interference to fixed operations and BSS feeder links in 24 GHz band segments.[1026] In the *NPRM*, the Commission declined to propose mobile service rules because there was relatively low interest in the band, there was less than 500 megahertz of spectrum available, and there was no mobile allocation.[1027] The Commission sought further comment, however, because it did not want to preclude further consideration of the band.[1028]

382. FiberTower, Global VSAT Forum, ITIC, Mobile Future, NCTA, Nokia, Samsung, and T-Mobile support mobile operations in the 24 GHz band.[1029] Commenters cite the relatively low frequency of the band,[1030] its potential global harmonization,[1031] and the existing manufacturing base[1032] as factors

[1021] *See* 47 CFR § 2.106 n.NG 167. Pursuant to 47 CFR § 25.202(g), 17/24 GHz BSS satellite telemetry, tracking, and command functions may also be authorized at the upper edge of the 25.05-25.25 GHz band.

[1022] 47 CFR § 25.203(l).

[1023] *Establishment of Policies and Service Rules for the Broadcasting-Satellite Service at the 17.3-17.7 Frequency Band and at the 17.7-17.8 GHz Frequency Band Internationally, and at the 24.75-25.25 GHz Frequency Band for Fixed-Satellite Services Providing Feeder Links to the Broadcasting-Satellite Service*, Report and Order and Further Notice of Proposed Rulemaking, 22 FCC Rcd 8842, 8895, para. 128 (2007) (*17/24 GHz Broadcasting-Satellite Service Report and Order*).

[1024] *See* DIRECTV Enterprises, LLC, call signs E070027, E130081, E140116, E150138, and E160062

[1025] *See* 47 CFR § 2.106.

[1026] *See Amendments to Parts 1, 2, 87 and 101 of the Commission's Rules to License Fixed Services at 24 GHz*, Report and Order, 15 FCC Rcd 16934, 16938, para. 7 (2000).

[1027] *NPRM*, 30 FCC Rcd at 11901, para. 65. The band segments under consideration in the *NPRM* were 24.25-24.45 GHz and 25.05-25.05 GHz, which totaled only 400 MHz. *Id.*

[1028] *NPRM*, 30 FCC Rcd at 11901, para. 66.

[1029] FiberTower Comments at 2-5, Global VSAT Comments at 4, ITIC Comments at 7, Mobile Future Comments at 9, NCTA Comments at 18-20, Nokia Comments at 11-13, Samsung Comments at 15-16, T-Mobile Comments at 6-7.

[1030] FiberTower Comments at 5.

[1031] NCTA Comments at 19-20, Nokia Comments at 11-13, Samsung Comments at 15-16, T-Mobile Comments at 6.

[1032] FiberTower Comments at 4.

supporting a mobile authorization. FiberTower and T-Mobile argue that the relatively small size of the band (2x200 MHz) should not preclude consideration for mobile use, because a 400 MHz bandwidth is sufficient to support gigabit speeds[1033] and "not all use cases require 500 megahertz of spectrum."[1034] No commenters oppose mobile use of the band.

383. *Discussion.* We propose to add a mobile allocation to the 24.25-24.45 and 24.75-25.25 GHz segments of the 24 GHz band, a fixed allocation to 24.75-25.05 GHz, and to authorize both mobile and fixed operations in those segments under the new Part 30 Upper Microwave Flexible Use Service rules. This band is already used internationally for fixed service[1035] and is included in the WRC study for future international mobile allocation. The existing manufacturing base and global harmonization of this band make it an attractive option for mobile use. We further propose to grant mobile rights to the existing fixed licensees, in order to facilitate coordination between fixed and mobile uses in the areas that are currently licensed. We propose to add these new fixed and mobile authorizations on a co-primary basis. We seek comment on that arrangement, as well as on the alternative of making mobile or fixed use secondary to FSS.

384. We recognize that there are existing satellite interests and operations in this band, and we seek comment on the best way to promote effective sharing between satellite and mobile uses. Given that the current use of the band for satellite appears to be rather limited, should we maintain the existing limits and coordination procedures on satellite operations in the 25.05-25.25 GHz band, and apply those same limits to the 24.75-25.05 GHz band? Alternatively, are there other sharing mechanisms that would better achieve coexistence? Would the sharing regime we have adopted for the 28 GHz band be appropriate in this band, or do the differences between FSS earth stations in that band and BSS feeder links here suggest a different solution?

385. We also propose to modify the existing band plan for new licenses in the 24 GHz band. Currently, the 24 GHz bands is channelized into five 40 megahertz by 40 megahertz channel pairs.[1036] As with the 39 GHz band, we see benefits to converting the 24 GHz band plan to unpaired blocks. Going forward, we propose to license the 24.25-24.45 GHz band segment as a single, unpaired block of 200 megahertz, and the 24.75-25.25 GHz band segment as two unpaired blocks of 250 megahertz each. We seek comment on this proposal, as well as the alternative of using 100 megahertz unpaired channels, or two 200 megahertz channels and one 100 megahertz channel in 24.75-25.25 GHz. We also seek comment on how to treat existing 24 GHz band licensees. Should incumbent licenses be converted to UMFUS licenses, as we have done in 28 GHz and 39 GHz? Also, is it necessary to repack existing licensees, or can they keep their existing frequency assignments because there are so few licensees?

3. 32 GHz Band (31.8-33.4 GHz)

386. *Background*. There are no current non-Federal licensees in the 32 GHz band.[1037] Internationally, the 32 GHz band is allocated for Fixed and Radionavigation services.[1038] Administrations should take practical measures "to minimize potential interference between stations in the fixed service and stations in the radionavigation service . . . taking into account the operational needs of the airborne radar systems."[1039] In the United States, the entire 32 GHz band is allocated for the Federal

[1033] FiberTower Comments at 4-5.

[1034] T-Mobile Comments at 7.

[1035] *See* FiberTower Comments at 4, n.5.

[1036] *See* 47 CFR § 101.147(r)(13).

[1037] In the *NPRM*, the Commission addressed the 31.8-33 GHz band. Because the ITU identified 31.8-33.4 GHz as a potential candidate band, we will expand our consideration to the 31.8-33.4 GHz band.

[1038] *See* 47 CFR § 2.106 n.5.547A.

[1039] *See* 47 CFR § 2.106 n.5.547A.

Radionavigation Service and the 32.3-33.4 GHz band is allocated for the non-Federal Radionavigation Service.[1040] Ground based radionavigation aids are not permitted to operate in the band except where they operate in cooperation with airborne or shipborne radionavigation devices.[1041] The 31.8-32.3 GHz portion of the band is allocated to the Space Research Service (deep space) (space-to-Earth) on a co-primary basis, but use of that band for the Space Research Service is limited to Goldstone, California.[1042] Finally, the 32.3-33 GHz band is allocated for Inter-Satellite Service (ISS).[1043]

387. We note that other U.S. footnotes place additional limitations on radionavigation and space research (deep space) (space-to-Earth) operations. Under footnote US211, applicants for airborne or space station assignments are urged to take all practicable steps to protect radio astronomy observations in the adjacent bands from harmful interference.[1044] Finally, under footnote US74, radio astronomy service in the adjacent 31.3-31.5 GHz band must be protected from unwanted emissions only to the extent that such radiation exceeds the level which would be present if the offending station were operating in compliance with the technical standards or criteria applicable to the service in which it operates.[1045]

388. In the *NPRM*, the Commission explained that there are two challenges to authorizing the 32 GHz band for 5G services.[1046] First, the 32 GHz band, unlike the other bands under consideration for 5G use, is not currently allocated for mobile use.[1047] Second, the Commission noted that the amount of usable spectrum in the 32 GHz band appears to be significantly curtailed by the need to protect the existing Federal and deep space research systems in the 32 GHz band, as well as operations in the adjacent 31.3-31.8 GHz passive band.[1048]

389. *Discussion*. We propose to add primary non-Federal fixed and mobile service allocations to the 32 GHz band. We also propose to authorize fixed and mobile operations in the 32 GHz under the Part 30 Upper Microwave Flexible Use Service rules. In the *NPRM*, the Commission noted that the 32 GHz band is not currently allocated for mobile operations, and therefore, perhaps it is not as suited to the provision of 5G services as other bands under consideration.[1049] Since the *NPRM* was adopted, however, ITU WRC-15 decided to conduct the appropriate sharing and compatibility studies for the 32 GHz band, which may lead to an allocation for mobile service in the 32 GHz band at WRC-19 and the opportunity for globally harmonized services in this band.[1050] Global harmonization, in turn, will promote global interconnection, roaming, and interoperability.[1051] In addition, there is a significant amount of contiguous

[1040] *See* 47 CFR § 2.106. *See also* 47 CFR § 87.173(b).

[1041] *See* 47 CFR § 2.106 n.US69.

[1042] *See* 47 CFR § 2.106 n.US262.

[1043] *See* 47 CFR § 2.106.

[1044] *See* 47 CFR § 2.106 n.US211.

[1045] *See* 47 CFR § 2.106 n.US74.

[1046] *NPRM*, 30 FCC Rcd at 11903, paras. 73-74.

[1047] *NPRM*, 30 FCC Rcd at 11903, paras. 73-74.

[1048] *NPRM*, 30 FCC Rcd at 11903, paras. 73-74.

[1049] *NPRM*, 30 FCC Rcd at 11903, para. 73.

[1050] *See* Avanti Comments at 8.

[1051] *See* Boeing Comments at 19-20, Samsung Comments at 15.

bandwidth available in the 32 GHz band.[1052] Finally, we note that there is significant support among the commenters to allocate the 32 GHz band for fixed and mobile 5G services.[1053]

390. However, there are still two major challenges to authorizing mobile operations in the 32 GHz band: (1) protecting radionavigation operations in the 32 GHz band; and (2) protecting radio astronomy observations in the adjacent 31.3-31.8 GHz band. We discuss those challenges and invite further comment on those issues below.

a. Federal and non-Federal Services in the 32 GHz Band

391. In the *NPRM*, the Commission sought comment on the compatibility of mobile use of the 32 GHz band with existing aeronautical and shipborne radar use of the band, future radionavigation and other Federal services, as well as deep space research in the 31.8-32.3 GHz portion of the 32 GHz band.[1054] Commenters did not address these issues directly. Instead, Echodyne, a technology startup, asks the Commission to proceed cautiously to ensure that it does not hinder the development of innovative technologies for the radionavigation bands.[1055] Echodyne states that "near term advances in radar technology soon will help fuel revolutionary changes in many sectors."[1056] For instance, Echodyne indicates that "accurate, lightweight, and low-power detect and avoid systems will be essential to widespread commercial deployment of Unmanned Aerial Systems and autonomous vehicles,"[1057] which Echodyne argues, will change the face of transportation, shipping, security, and numerous other industries.[1058] According to Echodyne, these advances rely on effective radionavigation operations that need consistent operating conditions across a geographic region, including a predictable and uniform interference environment.[1059] Echodyne indicates that it is skeptical that the 32 GHz band could be made available for mobile use.[1060]

392. We seek comment on the compatibility of fixed and mobile services with existing allocated services in the 32 GHz band. Commenters who support mobile use of this band should provide specific technical information and proposals showing how fixed and mobile uses of this band is compatible with radionavigation uses. In that regard, we ask Echodyne and other commenters to provide specific information on existing and planned non-Federal uses of radar in this band. We will continue to work with NTIA and other Federal partners to determine the protection requirements for Federal users and the opportunity to expand shared Federal use across the band.

393. We also seek comment on protecting other allocated service within the 32 GHz band. For Space Research Service operations in the Goldstone, California area, would coordination requirements be sufficient to protect those operations? In the *NPRM*, we noted that the risk of interference between terrestrial operations and ISS links in 64-71 GHz appeared to be low because of atmospheric absorption.[1061] Would the same analysis apply in the 32 GHz band?

[1052] *See* Avanti Comments at 7.

[1053] Avanti Comments at 7, ESOA Comments, at 8, Global VSAT Forum Comments at 4-5, Nokia Comments at 12, Samsung Comments at 15.

[1054] *NPRM*, 30 FCC Rcd at 11878, para. 74 (2015).

[1055] Echodyne Comments at 3.

[1056] Echodyne Comments at 3.

[1057] Echodyne Comments at 3.

[1058] Echodyne Comments at 3.

[1059] Echodyne Comments at 4.

[1060] Echodyne Comments at 4-5.

[1061] *NPRM*, 30 FCC Rcd at 11899, para. 59.

b. Radio Astronomy and EESS in the Adjacent 31.3-31.8 GHz Band

394. The 32 GHz band is adjacent to the 31.3-31.8 GHz band. In the United States, the 31.3-31.8 GHz band is allocated for Earth Exploration Satellite (passive), radio astronomy, and Space Research (passive).[1062] Under footnote US246, no station is authorized to transmit in the 31.3-31.8 GHz band.[1063] And under footnote US74, the radio astronomy operations in the 31.3-31.8 GHz band are protected from unwanted emissions only to the extent that such radiation exceeds the level which would be present if the offending station were operating in compliance with the technical standards or criteria applicable to the service in which it operates.[1064]

395. In the *NPRM*, the Commission noted that the need to protect the 31.3-31.8 GHz passive band may severely limit the availability of usable spectrum in the 31.8-33 GHz band and sought detailed technical analysis from commenters on the out-of-band emission limits required to protect operations in the 31.3-31.8 GHz band.[1065] The Commission indicated that a detailed analysis would help it determine how much of the 31.8-33 GHz band could be used for mobile operations while protecting the passive services in the 31.3-31.8 GHz band.[1066]

396. CORF submitted the most information on this topic. CORF states that although the critical science undertaken by Radio Astronomy observers cannot be performed without access to interference free bands, RAS bands can be protected regionally by limiting emissions within a certain radius of the facility.[1067] But, CORF explains, "the emissions that radio astronomers receive are extremely weak—a radio telescope receives less than 1 percent of one-billionth of one-billionth of a watt (10-20 W) from a typical cosmic object."[1068] CORF further explains that radio observatories are particularly vulnerable to interference from in-band emissions, spurious and out-of-band emissions from licensed and unlicensed users of neighboring bands, and emissions that produce harmonic signals in the RAS bands, even when those manmade signals are weak and distant.[1069] ESOA argues that any deep space research operations in the 31.3-31.8 GHz band can be protected from mobile terrestrial operations in the 32 GHz band because there are very few research facilities and they are located in very remote areas.[1070] We seek specific comment on how we should protect these operations.

397. CORF stresses the importance of the data collected from EESS and that billions of dollars have been invested in EESS satellites.[1071] CORF notes that for certain applications, satellite-based microwave remote sensing is the only practical method of obtaining atmospheric and surface data for the entire planet.[1072] Data derived from EESS have contributed substantially to the study of meteorology, atmospheric chemistry, climatology, and oceanography and is used by multiple governmental agencies.[1073] CORF indicates that incumbent users designed and developed EESS missions without the

[1062] *See* 47 CFR § 2.106.

[1063] *See* 47 CFR § 2.106 n.US246.

[1064] *See* 47 CFR § 2.106 n.US74.

[1065] *NPRM*, 30 FCC Rcd at 11903, paras. 73-74.

[1066] *NPRM*, 30 FCC Rcd at 11903, para. 74.

[1067] CORF Comments at 3-5.

[1068] CORF Comments at 3-4.

[1069] CORF Comments at 3-4.

[1070] ESOA Comments at 8.

[1071] CORF Comments at 4-5.

[1072] CORF Comments at 4-5.

[1073] CORF Comments at 4-5. The agencies include the National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation, the National Aeronautics and Space Administration (NASADoD (especially the (continued….)

expectation of transmissions in close proximity to the 31.3-31.8 GHz band.[1074] They also report that most incumbent users at 31.5 GHz operate in a direct detection (homodyne) mode.[1075] CORF recommends that the Commission adopt adequate guard bands to protect EESS operations in the 31.3-31.8 GHz "until the current satellites can be replaced with satellites with filtering suited to the new spectral environment."[1076] CORF claims that proportionally larger guard bands are needed as the frequency increases.[1077] In direct detection, CORF explains, band definition is achieved with filters that are limited by the properties of the materials used in the filter itself.[1078] Thus, for example, "for a given material, the minimum bandwidth of a filter is proportional to the central frequency, so that the width of the necessary guard bands to suppress emissions to a desired level also increases in proportion to the frequency."[1079] CORF continues, "it is impossible to reject a signal 10 MHz away from a band edge at these higher frequencies, so guard bandwidths must be scaled in frequency to accommodate this physical limitation."[1080] We seek comment on whether we should adopt a guard band to protect EESS operations in the 31.3-31.8 GHz band, and if so, how large should the guard band be? ESOA, disagrees with CORF and states that services operating in the 31.3-31.8 GHz band can be protected through "carefully crafted operating requirements."[1081] We seek comment on ESOA's statement and ask what these "carefully crafted operating requirements" might be.

398. CORF also expresses concern that "mobile devices with limited size and cost will not be able to adequately filter their out-of-band emissions to meet the stringent requirements" of the 31.3-31.8 GHz band.[1082] Avanti responds that under agenda item 1.13 for WRC-19, the ITU-R will develop technical measures, if necessary, to protect passive services from interference from 5G mobile broadband systems.[1083] We seek detailed information concerning the capability of mobile and other consumer devices to limit out-of-band emissions into the 31.3-31.8 GHz band, and seek comment on whether guard bands or other special rules will be necessary to limit emissions into the 31.3-31.8 GHz band.

c. Band Plan

399. We also seek comment on the appropriate band plan for the 32 GHz band. We propose to license the band using channels of either 200 megahertz or 400 megahertz bandwidth. Given the contemplated use cases and the nature of this band, what channel size would be best? We encourage commenters to discuss the specific advantages and disadvantages of various band plans.

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U.S. Navy), the Department of Agriculture, the U.S. Geological Survey, the Agency for International Development, the Federal Emergency Management Agency, and the U.S. Forest Service. *Id.*

[1074] CORF Comments at 5.

[1075] CORF Comments at 5.

[1076] CORF Comments at 5. The other alternative CORF mentions, but does not recommend, is time sharing of the band. *Id.*

[1077] CORF Comments at 5-6.

[1078] CORF Comments at 5-6.

[1079] CORF Comments at 5-6.

[1080] CORF Comments at 5-6.

[1081] ESOA Comments at 9.

[1082] CORF Comments at 5-6.

[1083] Avanti Comments at 8.

4. 42 GHz Band (42-42.5 GHz)

400. *Background.* The 42-42.5 GHz band (42 GHz band) is now allocated to the fixed and mobile services on a primary basis for non-Federal use.[1084] There are currently no terrestrial service rules in place for this band. On May 9, 2012, FWCC filed a petition for rulemaking seeking to establish service rules for fixed point-to-point use of the 42-43.5 GHz band under Part 101 of the Commission's rules.[1085] The adjacent 42.5-43.5 GHz band is allocated to RAS on a primary basis for Federal and non-Federal use and to the Federal fixed, fixed-satellite (Earth-to-space), and mobile except aeronautical mobile services on a primary basis.[1086] Footnote US211 urges applicants for airborne or space stations assignments in the 40.5-42.5 GHz band to take all practicable steps to protect radio astronomy observations in the 42.5-43.5 GHz band from harmful interference.[1087]

401. In the *NPRM*, we declined to propose service rules for the band at that time due to concerns that we would be unable to adequately protect the RAS in the adjacent 42.5-43.5 GHz band,[1088] and because we found the band already encumbered by pending proposals to place both FS and FSS operations in the band.[1089] Such considerations made this band less desirable vis-à-vis the 28 or 39 GHz bands. We nevertheless asked commenters to analyze its relative merit for FS or mobile use, as well as the different mechanisms that such various services could use to share the band, and how such uses would be impacted by the need to protect RAS in the 42.5-43.5 GHz band.[1090] In particular, we note that T-Mobile supports mobile service use of the 42 GHz band.[1091] CORF describes the adjacent 42.5-43.5 GHz band as being one of the most important bands for radio astronomy because it is used to observe silicon monoxide, which yields important information on stellar temperatures, density, and wind velocities.[1092] FWCC contends that the 42-43.5 GHz band is more suitable for fixed point-to-point service than mobile use.[1093]

402. While these proposals were pending, FWCC filed petitions for rulemaking seeking the establishment of a non-Federal fixed service allocation at 42.5-43.5 GHz as well as service rules for fixed point-to-point use of the 42.0-43.5 GHz band under Part 101.[1094] In its comments to this proceeding,

[1084] In the companion *Report and Order*, we are deleting the broadcasting and broadcasting-satellite service allocations from the 42 GHz band. There are currently no Federal allocations in the 42 GHz band.

[1085] Petition for Rulemaking, Fixed Wireless Communications Coalition, RM-11664 (filed May 9, 2012). FWCC originally sought the establishment of service rules for the 41-42.5 GHz band. In light of opposition from satellite licensees, FWCC revised its proposal to specify the 42-43.5 GHz band. *See* Letter from Mitchell Lazarus, Esq., counsel for the Fixed Wireless Communications Coalition to Marlene H. Dortch, Secretary, Federal Communications Coalition, RM-11664 (filed Feb. 11, 2013).

[1086] 47 CFR § 2.106.

[1087] 47 CFR § 2.106 n. US211.

[1088] The footnote corresponding to this band in the Allocation Table urges applicants for airborne assignments in the 42 GHz band to take all practicable steps to protect RAS observations in the 42.5-43.5 GHz band from harmful interference. 47 CFR § 2.106 n.US211. The footnote corresponding to the 42.5-43.5 GHz band also requires that any assignments to the stations of other services also allocated to the band take all practicable steps to protect the RAS from harmful interference. 47 CFR § 2.106 n.US342.

[1089] *NPRM*, 30 FCC Rcd at 11904, paras. 79-80.

[1090] *See NPRM*, 30 FCC Rcd at 11904, para. 80.

[1091] T-Mobile Comments at 8.

[1092] CORF Reply at 8-9.

[1093] FWCC Comments at 10.

[1094] FWCC originally sought the establishment of service rules for the 41-42.5 GHz band. *See* Petition for Rulemaking, Fixed Wireless Communications Coalition (FWCC), RM-11664 (filed May 9, 2012). In light of opposition from satellite licensees, FWCC withdrew its proposal as to the 41-42 GHz band, leaving its request for

(continued….)

FWCC reiterates its request for a fixed allocation and service rules for the 42-43.5 GHz band so it can coordinate its co-primary operations with the RAS and operate subject to interference from Federal uplink earth stations located in the band.[1095]

403. *Discussion.* We propose to authorize fixed and mobile service operations to operate in the 42 GHz band under the Part 30 Upper Microwave Flexible Use Service rules, as long as we can ensure that adjacent channel RAS services will be protected. The band potentially offers 500 megahertz for new flexible use services, has existing fixed and mobile allocations, and is being studied internationally for possible mobile use. We also propose to adopt geographic area licensing using PEAs as the geographic area. We seek comment on this proposal, as well as alternatives.

404. We deny FWCC's request that we establish service rules to enable fixed service at 42.-42.5 GHz, but keep its request pending for the 42.5-43.5 GHz band. We believe that flexible use licensing, which would allow a variety of services to be offered, would be more likely to place the spectrum in its highest and best use, as opposed to rules that would only allow point-to-point operation. Nevertheless, we do not deny FWCC's petition with respect to the 42.5-43.5 GHz band because point-to-point operation may be more likely to co-exist with co-channel RAS. We will give further consideration to the 42.5-43.5 GHz band separately.

405. We seek comment on whether it is possible to authorize fixed and mobile use in the 42 GHz band while protecting RAS observations in the adjacent 42.5-43.5 GHz band. If protection is possible, we seek comment on what protections should be established. CORF notes that frequency lines at 42.519, 42.821, 43.122, and 43.424 GHz (for observations of silicon monoxide) are among those of greatest importance to radio astronomy.[1096] CORF represents, "The detrimental levels for continuum and spectral line radio astronomy observations for single dishes are -227 dBW/m^2/Hz and -210 dBW/m^2/Hz, respectively, for the average across the full 1 GHz band and the peak level in any single 500 kHz channel. For observations using the entire Very Long Baseline Array (VLBA), the corresponding limit is -175 dBW/m^2/Hz."[1097] Do we need to establish special out-of-band emission limits into the 42.5-43.5 GHz band? Is it necessary or appropriate to establish a guard band below 42.5 GHz? We ask proponents of terrestrial use in the 42 GHz band to provide detailed studies demonstrating how such use can be compatible with RAS use in the 42.4-43.5 GHz band. We also ask CORF and other radio astronomy interests to provide additional information on the locations where observations are made in the 42.4-43.5 GHz band.

406. We also seek comment on the appropriate band plan for the 42 GHz band. Should the band be licensed as a single channel, split into two channels, or split into multiple 100 megahertz channels? We recognize that if we adopt a guard band to protect adjacent channel radio astronomy, the guard band will affect the band plan by making less spectrum available. Given the contemplated use cases and the nature of this band, what channel size would be best? We encourage commenters to discuss the specific advantages and disadvantages of various band plans.

(Continued from previous page)
service rules in the 42-42.5 GHz band. *See* FWCC Reply, RM-11664 (filed July 24, 2012); *see also* Letter from Mitchell Lazarus, Esq., counsel for the Fixed Wireless Communications Coalition to Marlene H. Dortch, Secretary, Federal Communications Coalition, RM-11664 (filed Feb. 11, 2013). In a separate supplemental petition, FWCC sought a non-Federal fixed service allocation and the establishment of fixed service rules for the 42.5-43.5 GHz band. *See* Supplemental Petition for Rulemaking, FWCC (filed Feb. 11, 2013) ("FWCC Supplemental Petition"). FWCC contended in its NPRM comments that the 42-43.5 GHz band is more suitable for fixed point-to-point service. FWCC Comments at 3.

[1095] FWCC Comments at 10 (requesting "a non-Federal fixed allocation and service rules for the 42-43.5 GHz band, co-primary with the Radio Astronomy Service at 42.5-43.5 GHz and subject to possible interference from Federal Fixed Satellite uplink earth stations.").

[1096] CORF Reply at 8-9.

[1097] CORF Reply at 9.

407. Finally, we propose to add Federal fixed and mobile allocations into this band, and additionally seek comment on establishing a framework under which Federal and non-Federal users could share the band. Given the short propagation distances, lack of incumbent licensees, and other factors, as described in the 37 GHz sharing section and the rules we are adopting today,[1098] we believe it is possible for both Federal and non-Federal users to coexist on a co-primary basis, particularly using simple methods of coordination (to enable geographic sharing). We therefore seek comment on whether to extend Federal access to this band, including how to best achieve coexistence with non-Federal uses. For instance, are there additional considerations in addition to leveraging the sharing regime adopted for the co-primary coordinated sharing in the 37 GHz band? Should we use more static sharing mechanisms? Would an SAS-based sharing approach facilitate Federal and non-Federal sharing of this band? Are there other tools we can leverage to create a robust sharing environment that allows this spectrum to meet both Federal and non-Federal needs?

5. 47 GHz Band (47.2-50.2 GHz)

408. *Background.* While there are primary non-Federal fixed and mobile allocations throughout the 47 GHz band, there are currently no service rules for terrestrial operations in this band.[1099] We note that the Commission has designated the 47.2-48.2 GHz segment of the 47 GHz band for wireless services use and the 48.2-50.2 GHz segment for FSS use.[1100] The fixed allocations in the 47.2-47.5 GHz and 47.9-48.2 GHz segments are designated for use by high altitude platform stations.[1101] Airborne mobile operations are prohibited in the 48.94-49.04 GHz segment.[1102] There is a non-Federal Fixed-Satellite (Earth-to-space) allocation throughout this band, and service rules currently exist for satellite operation under Part 25. The 47.2-49.2 GHz band is also available for BSS feeder links.[1103] In the 48.2-50.2 GHz band, there are also primary Federal allocations for fixed, mobile, and Fixed-Satellite (Earth-to-space) services. The 48.94-49.04 GHz band is also used by radio astronomy for spectral line observations, and all practicable steps must be taken to protect radio astronomy in that band from interference.[1104]

409. This band was not addressed in the *NPRM*. At WRC-15, however, this band was identified as one of the bands for which sharing and compatibility studies were directed with an eye towards identifying the band for IMT-2020. T-Mobile supports further consideration of this band.[1105]

410. *Discussion.* We propose to authorize fixed and mobile operations in the 47 GHz band under the Part 30 Upper Microwave Flexible Use Service rules. The band potentially offers 3 gigahertz of spectrum and is being studied internationally for possible mobile use.

411. At the same time, we recognize that this band is authorized for FSS use. While there are no current authorized operations, this band may be paired with the 40-42 GHz downlink band. Unlike in the 28 GHz or 39 GHz bands, where FSS can use other spectrum to operate user equipment, FSS would

[1098] *See* Section IV.C.3 (License Area Size).

[1099] *See* 47 CFR § 2.106.

[1100] *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*, First Report and Order, 13 FCC Rcd 24649, 24651 para. 2 (1999) (*V-Band First Report and Order*).

[1101] *See* 47 CFR § 2.106 n.5.552A

[1102] *See* 47 CFR § 2.106 n.US264.

[1103] *See* 47 CFR § 2.106 n.US297.

[1104] *See* 47 CFR § 2.106 nn.5.555, US342.

[1105] T-Mobile Comments at 6.

have to use some portion of the 47 GHz band to operate user equipment. Sharing between terrestrial mobile and FSS user equipment is more complicated, particularly when the FSS user equipment is transmitting.

412. With respect to individually licensed earth stations, it appears that we could adopt the sharing framework we have adopted for the 28 GHz band. Specifically, in each PEA, we propose that there can be one location where FSS earth stations can be located on a co-primary basis, subject to the conditions and limitations we have adopted in other bands. We seek comment on this proposal, as well as alternatives.

413. We seek comment on the best approach for sharing between FSS user equipment and terrestrial operations. One option would be to have geographic area licensing on a PEA basis, but also authorize database-driven sharing between terrestrial licensees and stationary FSS user equipment. In the *NPRM*, we sought comment on leveraging a Spectrum Access System (SAS) or other database coordination mechanism to facilitate sharing between terrestrial operations and FSS user equipment.[1106] Under the SAS proposal, terrestrial licensees would provide the geographic coordinates and other pertinent technical information concerning their facilities to the SAS. Satellite operators would then access the information in the SAS to determine where their user equipment could transmit without causing interference to terrestrial operations.[1107] We recognize that many terrestrial operators oppose being required to provide information on their deployments to a database,[1108] but those operators have not presented a viable alternative that would allow sharing between these services.

414. Another option would be to divide the band into a segment where FSS has priority and a segment where UMFUS operations has priority.[1109] In the segment where FSS had priority, FSS could operate its user equipment without any obligation to protect UMFUS operations. Conversely, in the segment where UMFUS licensees had priority, satellite user equipment could operate on a purely secondary basis and would be required to cease transmitting if it caused interference to fixed or mobile operations. Supporters of this option should propose a split for the band and explain how their proposed split best balances the needs of UMFUS and FSS licensees.

415. A third option would be to develop specific criteria for assigning priority between FSS and terrestrial operations. For example, we could require both FSS and UMFUS licensees to register their operations in a database, and we could assign interference protection on a first-come, first-served basis. We seek comment on a first-come, first-served approach, and we also invite commenters to propose alternative criteria for assigning priority. Commenters should provide detailed information on the costs and benefits of their proposed mechanisms for assigning priorities. We also seek comment on other alternatives for sharing between UMFUS and FSS in this band.

416. We also seek comment on sharing with co-primary Federal services in the 48.2-50.2 GHz band, as well as protection of passive services in the adjacent 50.2-50.4 GHz band. Our understanding is that there are currently no authorized Federal or non-Federal operations in the 48.2-50.2 GHz band but that there may be future Federal operations in that band. Are the rules and framework we have adopted today for sharing of the 37 GHz band applicable to the 48.2-50.2 GHz band? Could a modified first-come, first-served mechanism be used to establish priority in this band without precluding use of the band by co-primary Federal users? Should we leverage the database-driven sharing mechanism? We intend to work with NTIA and other Federal agencies to identify an appropriate framework to protect current or

[1106] *NPRM*, 30 FCC Rcd at 11923-24, paras. 150-153.

[1107] *See NPRM*, 30 FCC Rcd at 11923-24, paras. 150-153.

[1108] *See, e.g.*, T-Mobile Reply at 12.

[1109] We could maintain the current wireless services and FSS designations. When the Commission made the separate designations for the FSS and wireless services in the band, it did not place any restrictions on the use of either portion of the band by either the FSS or wireless services.

planned Federal interests in and ensure future access to this band on a co-primary shared basis. We also seek comment on protecting radio astronomy in the 48.94-49.04 GHz band. Are there any steps we need to take to protect radio astronomy over and above implementing the existing prohibition on aeronautical use in that segment? We encourage CORF and other radio astronomy interests to provide information on locations where this band is used for radio astronomy observations. With respect to the 50.2-50.4 GHz band, we note that the international allocation for the passive services "shall not impose undue constraints on the use of adjacent bands by the primary allocated services in those bands."[1110] On the other hand, at WRC-12, the WRC recognized "that long-term protection of the EESS in the [, *inter alia*, 50.2-50.4 GHz band] is vital to weather prediction and disaster management."[1111] The WRC did establish emission limits for FSS stations operating in the 49.7-50.2 GHz and 50.4-50.9 GHz bands, but did not address fixed or mobile stations operating in those bands.[1112] Given that framework, what requirements would be appropriate to protect passive services in the 50.2-50.4 GHz bands?

417. We also seek comment on the appropriate band plan for the 47 GHz band. One possibility would be to divide the band into six channels of 500 megahertz each. One advantage of that band plan is that the channels would align with 48.2 GHz, which is where the Federal allocation and current FSS designation begin and where FSS user equipment can begin to be deployed. On the other hand, 500 megahertz channels would not align with the band plan in other bands, where we are using multiples of 200 megahertz. Given the contemplated use cases and the nature of this band, what channel size would be best? We encourage commenters to discuss the specific advantages and disadvantages of various band plans.

6. 50 GHz Band (50.4-52.6 GHz)

418. *Background*. While there are primary fixed and mobile service allocations throughout this band, there are currently no service rules for this band.[1113] There are also primary Federal allocations for the fixed and mobile services in the 50 GHz band. In the 50.4-51.4 GHz segment, there are primary Federal and non-Federal allocations for the fixed-satellite (Earth-to-space) and mobile satellite (Earth-to-space) services, although the Federal allocations are limited to military systems.[1114] We note that the Commission has designated the 50.4-51.4 GHz segment for use by wireless services.[1115] For fixed stations in this band, the unwanted emissions power into the adjacent 52.6-54.25 GHz band shall not exceed – 33dBW/100 MHz (measured at the input of the antenna).[1116]

419. This band was not addressed in the *NPRM*. At WRC-15, however, this band was identified as one of the bands for which sharing and compatibility studies were directed with an eye towards identifying the band for IMT-2020. T-Mobile supports further consideration of this band.[1117]

420. *Discussion*. We propose to authorize fixed and mobile operations in the 50 GHz band under the Part 30 Upper Microwave Flexible Use Service rules. The band potentially offers 2 gigahertz of spectrum and is being studied internationally for possible mobile use. We also propose to use geographic area licensing in this band and license the band on a PEA basis. We seek comment on these proposals, as well as alternatives.

[1110] *See* 47 CFR § 2.106 n.5.340.1.

[1111] *See* 47 CFR § 2.106 n.5.338. *See also* WRC-12 Resolution 750.

[1112] *See* WRC-12 Resolution 750.

[1113] *See* 47 CFR § 2.106.

[1114] *See* 47 CFR § 2.106 n.G117.

[1115] *V-Band First Report and Order*, 13 FCC Rcd at 24651, para. 2.

[1116] *See* 47 CFR § 2.106 n.US157.

[1117] T-Mobile Comments at 6.

421. We also seek comment on the non-Federal satellite allocations in the 50.4-51.4 GHz band.[1118] Assuming that the 40-42 GHz (space-to-Earth) band is paired with the 48.2-50.2 GHz (Earth-to-space) band, we request comments on how this uplink band would be used by FSS operators. We also request comments on means of accommodating sharing between terrestrial and satellite operations.

422. We also seek comment on sharing with co-primary Federal services in the 50.4-52.6 GHz band, as well as protection of passive services in the adjacent 50.2-50.4 GHz and 52.6-54.25 GHz bands. Our understanding is that there are currently no authorized Federal or non-Federal operations in this band but that there may be future Federal operations in that band. Are the rules and framework we are adopting today for sharing of the 37 GHz band applicable to this band? Could a database-driven sharing approach facilitate sharing between Federal and non-Federal operations? Could a modified first-come, first-served mechanism be used to establish priority in this band without precluding use of the band by co-primary Federal users? We intend to work with NTIA and other Federal agencies to identify an appropriate framework to protect current or planned Federal interests and to ensure future access to this band on a co-primary shared basis. With respect to the 50.2-50.4 GHz band, as noted above, this band is vital to weather prediction and disaster management, and the international allocation for the passive services "shall not impose undue constraints on the use of adjacent bands by the primary allocated services in those bands."[1119] Given that framework, what limits on emissions into the 50.2-50.4 GHz would be appropriate? On the other hand, there is a specific limit on fixed emissions into the 52.6-54.25 GHz band. What impact will that limit have on the suitability of this band to provide terrestrial service? What limits would be necessary on mobile service to protect the 52.6-54.25 GHz band?

423. We also seek comment on the appropriate band plan for the 50 GHz band. One option is to establish ten channels of 200 megahertz each, which would be consistent with the channel plan for the 39 GHz band. Other options include four channels of 500 megahertz each or five channels of 400 megahertz each, with one extra 200 megahertz channel. Is there any value in establishing a guard band immediately below 52.6 GHz to protect the passive band above 52.6 GHz? Given the contemplated use cases and the nature of this band, what channel size would be best? We encourage commenters to discuss the specific advantages and disadvantages of the various band plans.

7. 70/80 GHz Bands (71-76 GHz and 81-86 GHz)

424. *Background.* On October 16, 2003, the Commission adopted a *Report and Order* establishing service rules to promote non-Federal development and use of the millimeter wave spectrum in the 71-76 GHz, 81-86 GHz, and 92-95 GHz bands, which are allocated to non-Federal and Federal users on a co-primary basis.[1120] Based on the determination that highly directional, "pencil-beam" signal characteristics permit systems in these bands to be engineered so that many operations can co-exist in the same vicinity without causing interference to one another, the Commission adopted a flexible and innovative regulatory framework for the bands.[1121] Specifically, the Commission created a two pronged authorization scheme for non-Federal entities for the entire 12.9 GHz of spectrum in the band. First, a licensee applies for a non-exclusive nationwide license; second, the licensee registers individual point-to-point links. Under this licensing scheme, a non-exclusive license serves as a prerequisite for registering

[1118] We note that the NATO Joint Frequency Agreement identifies the 39.5-40.5 GHz downlink band and the 50.4-51.4 GHz uplink band for future military FSS and MSS requirements. *See* NTIA letter, IB Docket No. 97-95, received May 7, 1997, at p. 4. *See also* NTIA's Federal Long-Range Spectrum Plan, September 2000, at p. 122 (available at https://www.ntia.doc.gov/files/ntia/publications/final-lrsp.pdf).

[1119] *See* 47 CFR § 2.106 n.5.340.1.

[1120] The bands are allocated to both Federal and non-Federal users on a co-primary basis, except the 94.0-94.1 GHz portion, which is allocated for Federal use on a primary basis. *See generally Allocations and Service Rules for the 71-76 GHz, 81-86 GHz, and 92-95 GHz Bands*, Report and Order, 18 FCC Rcd 23318, 23322-23331, paras. 6-26 (2003) (*70-80-90 GHz Report and Order*).

[1121] *70-80-90 GHz Report and Order*, 18 FCC Rcd at 23337-39, paras. 44-47.

individual point-to-point links. Licensees may operate a link only after the link is both registered with a third-party database and coordinated with NTIA.[1122] This flexible and streamlined regulatory framework was designed to encourage innovative uses of the millimeter wave spectrum, facilitate future development in technology and equipment, promote competition in the communications services, equipment, and related markets, and advance sharing between non-Federal and Federal systems.

425. As of June 10, 2016, there were 446 active non-exclusive nationwide licenses covering the 70 GHz, 80 GHz, and 90 GHz bands.[1123] Based upon information available from the third-party database managers that are responsible for registering links in those bands, as of June 10, 2016, there were approximately 22,600 registered fixed links[1124] in the 71-76 GHz and 81-86 GHz bands.[1125]

426. Access to these bands is based on a set of spectrum rights and sharing mechanisms between Federal and non-Federal users, and among different types of non-Federal uses (fixed and satellite). In these bands, non-Federal operations may not cause harmful interference to, nor claim protection from, Federal Fixed-Satellite Service operations located at 28 military bases.[1126] In addition, in the 80 GHz band, licensees proposing to register links located near 18 radio astronomy observatories must coordinate their proposed links with those observatories.[1127] Third-party database managers are responsible for recording each proposed non-Federal link in the third-party database link system and coordinating with NTIA's automated "green light/yellow light" mechanism to determine the potential for harmful interference to Federal operations and radio observatories.[1128]

427. The 71-74 GHz band segment has co-primary allocations for Federal and non-Federal Fixed, FSS, Mobile, and MSS (space-to-Earth) operations.[1129] The 74-76 GHz band segment has co-primary allocations for Federal and non-Federal Fixed, FSS (space-to-Earth), Mobile, and SRS operations.[1130] In addition, there are non-Federal allocations in that band segment for Broadcasting and BSS operations.[1131] The 81-86 GHz band has co-primary allocations for Federal and non-Federal Fixed, FSS (Earth-to-space), and Mobile, and within that band the 81-84 GHz band segment also has a Federal and non-Federal allocation for MSS (Earth-to-space).[1132] The 76-77 GHz band is currently used for unlicensed vehicular radars under Part 15 of the rules.[1133] The Commission has proposed to authorize

[1122] *See Wireless Telecommunications Bureau Announces Permanent Process for Registering Links in the 71-76 GHz, 81-86 GHz, and 92-95 GHz Bands*, Public Notice, 20 FCC Rcd 2261 (WTB BD 2005).

[1123] These statistics are based on a review of the Universal Licensing System on May 9, 2016.

[1124] A link in this context is defined as a communication path between one location and another in a single direction, regardless of frequency channel. In other words, multiple channels registered between the same transmit and receive location are not considered separate links. Bi-directional communications are counted as separate links.

[1125] These statistics are based on a review of the third party database managers' data on May 9, 2016. *See* www.micronetcommunications.com/LinkRegistration/ ; www.comsearch.com/applications/link7090/index.jsp ; http://mmradioforms.com/mmRadioForms/FrontPage.aspx

[1126] *See* 47 CFR § 2.106 n.US389.

[1127] *See* 47 CFR § 2.106 n.US388.

[1128] *See Wireless Telecommunications Bureau Announces Permanent Process for Registering Links in the 71-76 GHz, 81-86 GHz, and 92-95 GHz Bands*, Public Notice, 20 FCC Rcd 2261 (WTB BD 2005).

[1129] *See* 47 CFR § 2.106.

[1130] *See* 47 CFR § 2.106.

[1131] *See* 47 CFR § 2.106.

[1132] *See* 47 CFR § 2.106.

[1133] *See* 47 CFR § 15.253.

non-Federal radar applications in the 76-81 GHz band on a licensed basis under Part 95. This proposal would shift vehicular radars away from the existing Part 15 unlicensed model.[1134]

428. In the *NPRM*, the Commission stated that interest among commenters in using these bands for mobile operations appeared to be rather limited.[1135] It also noted that the coordination process between fixed and mobile operations would be considerably more complicated in these bands because there are multiple fixed licensees in a given area (as opposed to 28 GHz or 39 GHz, which are geographically licensed resulting in a limited number of potential users in any given area and band). The Commission further acknowledged that the need to protect Federal earth stations and radio astronomy locations would also require limits on mobile operations in these bands.

429. The Commission declined to offer a specific proposal to amend its rules for the 70 and 80 GHz bands in *NPRM*, stating that it was not clear how either licensed mobile or unlicensed Wi-Fi units could be coordinated to avoid interference to fixed links.[1136] However, the Commission sought comment on whether it should revisit its 2003 decision not to allow Part 15 operations in these bands,[1137] and if so, what specific bands it should consider for Part 15 operations or for licensed use.[1138] The *NPRM* further asked about the structure of a sharing mechanism between fixed and mobile systems if the Commission were to authorize mobile operations in the 70 and 80 GHz bands, and how the coordination and licensing might be administered.[1139] With respect to pending proposals to change the current Part 101 rules governing fixed operations in these bands, the Commission noted that some of those issues were already under consideration in the Wireless Backhaul proceeding, WT Docket No. 10-153.[1140]

430. In response to the *NPRM,* commenters propose diverse alternative service plans for the 70 and 80 GHz bands. Those recommendations include licensed mobile service,[1141] unlicensed access,[1142] and fixed service licensed by rule.[1143] CORF contends that it is essential that the protections presently afforded to the primary allocations for the Radio Astronomy Service (RAS) at 76.0-77.5 GHz and 78.0-94 GHz remain in place, and that we maintain geographic separation between emitters and RAS facilities sufficient to ensure that aggregate interference remains below threshold levels.[1144] CORF also recommends that the Commission enable wide guard bands to protect the primary allocation to the Earth Exploration Satellite Service (EESS) at 86-92 GHz.[1145]

431. *Discussion.* When evaluating services or uses that could be viable if we authorize their introduction into the 71-76 and 81-86 GHz bands, we must consider three basic issues. First, we need to

[1134] *See* Amendment of Parts 1, 2, 15, 90 and 95 of the Commission's Rules to Permit Radar Services in the 76-81 GHz Band, *Notice of Proposed Rulemaking and Reconsideration Order*, 30 FCC Rcd 1625, 1632-1638, paras. 24-44 (2015).

[1135] *NPRM*, 30 FCC Rcd at 11906, para. 86.

[1136] *NPRM*, 30 FCC Rcd at 11906, para. 87.

[1137] *NPRM*, 30 FCC Rcd at 11906, para. 87, *citing 70-80-90 GHz Report and Order*, 18 FCC Rcd at 23336, para. 41.

[1138] *NPRM*, 30 FCC Rcd at 11906, para. 87.

[1139] *NPRM*, 30 FCC Rcd at 11906, para. 87.

[1140] *NPRM*, 30 FCC Rcd at 11906, para. 88.

[1141] Huawei Comments at 7, 19-22, Mobile Future Comments at 9, Nokia Comments at 12-13, TIA Comments at 6 n. 14, T-Mobile Comments at 4, 8-9; Intel Reply at 15.

[1142] Dynamic Spectrum Alliance Comments at 1, 3, Microsoft Comments at 18, Wi-Fi Alliance Comments at 9-10; Microsoft Reply at 4-6, 10-11, NCTA Reply at 14, Qualcomm Reply at 8.

[1143] FWCC Comments at 8-9; Intel Reply at 15.

[1144] CORF Comments at 16-20.

[1145] CORF Comments at 16-20.

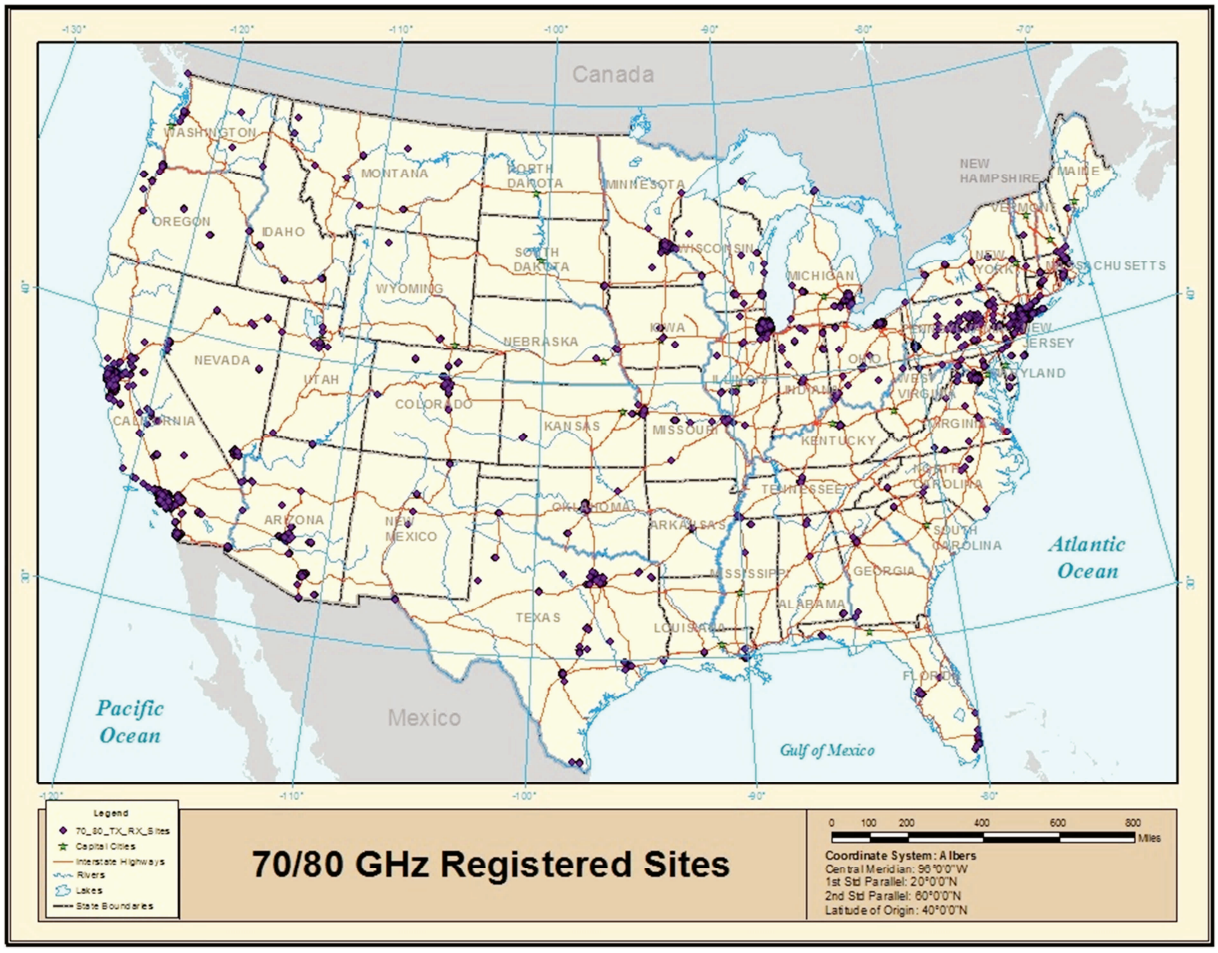
consider whether the bands offer adequate spectrum for the proposed new services or uses in bands where tens of thousands of incumbent operations are already registered. Second, we need to consider whether the new services or uses are compatible with the fundamental electromagnetic characteristics of the relevant spectrum. And third, we need to consider whether more than one service or use can coexist in the bands. We address each of these considerations and corollary concerns below.

432. As noted above, the *NPRM* posited that it might not be possible to authorize mobile services or unlicensed access in the 71-76 and 81-86 GHz bands without causing interference to incumbent point-to-point links.[1146] After further review, we find that the bands are relatively lightly used both in terms of the number of registered sites (especially on a large geographic scale) and with respect to the quantity of spectrum available. As E-Band Communications notes, "The 10 GHz of spectrum available [in the 71-76 and 81-86 GHz bands] represents by far the most ever allocated by the FCC at any one time, representing 50-times the bandwidth of the entire cellular spectrum."[1147] Moreover, the great majority of existing links in the bands are concentrated in just a few localities, as illustrated in Figure 3. As of June 10, 2016, only 16 counties had an average site density of more than one transmission or reception site per square mile, and those 16 counties contain more than 73 percent of all registered transmitters and receivers in the 71-76 and 81-86 GHz bands. Given the narrow beamwidths and limited path lengths involved, it would be reasonable to treat the remaining 3,125 counties and county-equivalents as the functional equivalent of a green field, provided that adequate measures are taken to protect the few incumbents in them.

Figure 3

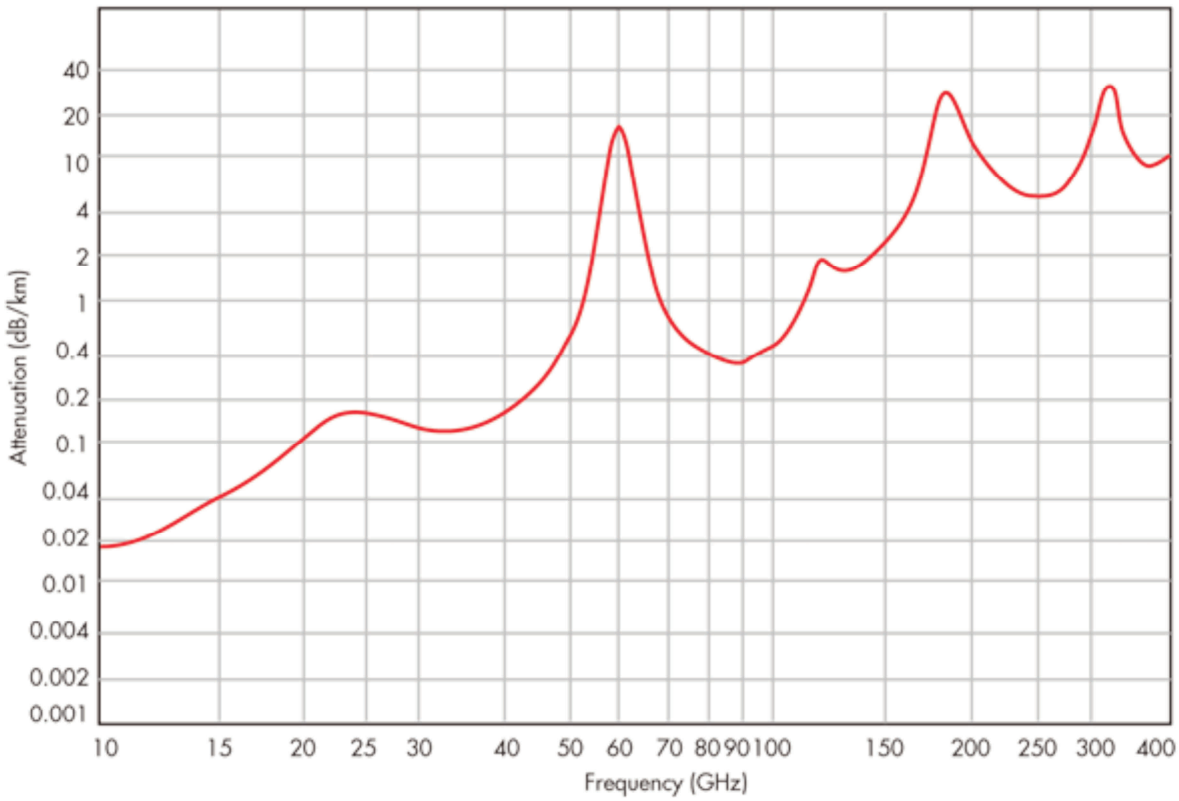
[1146] *See NPRM*, 30 FCC Rcd at 11906, para. 87.

[1147] E-Band Communications, LLC, web site (http://www.e-band.com/index.php?id=86).



433. We must also consider whether the physical characteristics of the bands are suitable for the kinds of services that might be authorized in the bands – this is particularly true for mmW bands where atmospheric and other environmental phenomena affect the utility of the band. In general, for example, atmospheric attenuation increases the higher one goes in the electromagnetic spectrum, limiting the potential length of transmission paths. However, as shown in Figure 4, the 71-76 and 81-86 GHz bands experience less attenuation than frequencies in the 50-60 GHz range.

Figure 4



Millimeter Wave Signal Attenuation Characteristics Based on Oxygen and Water Absorption (Source: Dynamic Spectrum Alliance Comments at 3, citing Penton Electronics, http://electronicdesign.com/communications/millimeter-waves-will-expand-wireless-future)

434. In addition to atmospheric attenuation, spreading loss also becomes an issue in the mmW bands. As the Friis transmission law states, path loss grows with the square of the frequency, even when radio waves are traveling through a vacuum. The caveat, however, is that Friis's law applies only to transmissions from omnidirectional antennas. As a recent technical study and analysis explains, "[T]he smaller wavelength of mmW signals also enables proportionally greater antenna gain for the same physical antenna size. Consequently, the higher frequencies of mmW signals do not in themselves result in any increased free space propagation loss, provided the antenna area remains fixed and suitable directional transmissions are used."[1148] In short, the directionality of the antennas that are feasible at shorter wavelengths may result in less path loss than theorized. Based upon this preliminary analysis, we believe the bands might be valuable for a variety of uses, including mobile as well as fixed uses.

435. In determining whether new and different services can coexist in these bands, we must also look at whether the new service use can be authorized in a manner that does not disrupt the incumbent use (or otherwise, we could decide to disrupt the incumbent use), and whether the existing use can and should continue to expand. Specific to this analysis is whether the current and potential future fixed point-to-point uses of these bands might be compatible with other types of fixed or mobile uses.

436. When evaluating the compatibility between fixed and mobile services in the 70/80 GHz band, one important consideration is the beamwidths of their transmission paths because tighter beams are less likely to cause interference. Historically, the Commission has tried to balance the desire for smaller

[1148] Sundeep Rangan, Theodore S. Rappaport, and Elza Erkip, *Millimeter-Wave Cellular Wireless Networks: Potentials and Challenges*, Proceedings of the IEEE (Vol. 102, No. 3, March 2014) at 366 (Digital Object Identifier: 10.1109/JPROC.2014.2299397) (http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6732923).

antennas against the spectrum efficiencies of narrow beamwidths in the 70/80 GHz band. Over the last decade, the Commission has continued to explore modifying the technical rules to allow larger beamwidths.[1149] Most recently, on October 13, 2015, WTB's Broadband Division opened a new docket to address two waiver requests seeking a further relaxation of antenna standards in the 71-76 and 81-86 GHz bands.[1150] As the waiver requests and comments filed in that docket attest, evidence suggests that we might further relax the allowed beamwidth to 2.2 degrees.[1151] That step, if taken, would bring the bands' technical standards into a realm that is at least potentially compatible with dynamic beamforming technology because a 2.2-degree beamwidth is also achievable by the kinds of MIMO base stations that will be supporting mmW mobile services.[1152] At least when operating with beamforming MIMO, these base stations would likely be able to coexist with conventional point-to-point Fixed Service links.[1153]

437. The introduction of fixed services under somewhat relaxed directionality requirements in addition to mmW mobile services pose a new coexistence consideration. It is likely that, when both fixed and mobile mmW services are operated by the same entity, they can sufficiently plan, coordinate, and time their use to facilitate coexistence.[1154] In looking at whether incumbent fixed services, new more dynamic fixed services, and potential mobile services (and equipment) in these bands may coexist, it is apparent that the use of a central coordinating database capable of calculating and enforcing protections among different types of users, like a Spectrum Access System, could facilitate this coexistence.

438. Initially, coordination of non-Federal links with Federal operations in the 71-76 GHz, 81-86 GHz, and 92-95 GHz (70/80/90) bands was accomplished under a traditional coordination process:

[1149] Originally, the Commission adopted a maximum EIRP of +55 decibel watt (dBW) and required a minimum antenna gain of 50 dBi with 0.6 degree half-power bandwidth. *70/80/90 GHz Report and Order*, 18 FCC Rcd at 23355, para. 96. On reconsideration, the Commission was "persuaded as a policy matter that relaxing the technical parameters to allow for lower-gain, wider beamwidth antennas best serves the public interest by promoting increased development of the nascent 70/80 GHz industry. . .," and reduced the minimum antenna gain to 43 dBi, with a requirement that the maximum authorized EIRP be reduced by 2 dB for each dB the antenna gain was less than 50 dBi. *Allocations and Service Rules for the 71-76 GHz, 81-86 GHz, and 92-95 GHz Bands*, Memorandum Opinion and Order, 20 FCC Rcd 4889, 4905, para. 34 (2005) (*70/80/90 GHz Reconsideration Order*). The Commission estimated that allowing smaller antennas would expand the potential use of the bands from 20-25 percent of business locations to 75-80 percent of business locations. *Id.*

[1150] Wireless Telecommunications Bureau Seeks Comment on Requests of Aviat Networks and CBF Networks, Inc. d/b/a Fastback Networks for Waiver of Certain Antenna Requirements in the 71-76 and 81-86 GHz Bands, Public Notice 30 FCC Rcd 10961 (WTB 2015).

[1151] *See* Wireless Telecommunications Bureau Seeks Comment on Requests of Aviat Networks and CBF Networks, Inc. d/b/a Fastback Networks for Waiver of Certain Antenna Requirements in the 71-76 and 81-86 GHz Bands, Public Notice, 30 FCC Rcd 10961 (WTB 2015). AT&T, Comsearch, the Fixed Wireless Communications Coalition, the Telecommunications Industry Association, and T-Mobile filed comments supporting a relaxation of antenna standards. Dash Networks was the sole commenter opposing the proposal.

[1152] *See, e.g.*, Robert W. Heath, Jr., and Tianyang Bai, Cockrell School of Engineering, University of Texas at Austin, *Coverage and Capacity Analysis of mmWave Cellular Systems* (June 15, 2013) at 17 (64-element MIMO base station capable of 1.6-degree beamwidth when communicating with mobile units equipped with 16 antenna elements) (http://users.ece.utexas.edu/~rheath/presentations/2013/mmWave_coverage_heath.pdf). *See also* Tianyang Bai, Ahmed Alkhateeb, and R. W. Heath, Jr., *Coverage and Capacity of Millimeter Wave Cellular Networks*, IEEE Communications Magazine (vol. 52, no. 9, 2014) at 70-77; Tianyang Bai and R. W. Heath, Jr., *Coverage and Rate Analysis for Millimeter Wave Cellular Networks*, IEEE Transactions on Wireless Communications (Vol. 14, no. 2, Feb. 2015) at 1100-1114 (http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6894455&searchWithin=%22Publication%20Title%22:communications%20magazine&searchWithin=%22Volume%22:52&searchWithin=%22Issue%22:9&searchWithin=%22Start%20Page%22:70&newsearch=true).

[1153] *See NPRM*, 30 FCC Rcd at 11962, para. 292.

that is, requested non-Federal links were recorded in the Commission's Universal Licensing System (ULS) database and coordinated with the NTIA through the Interdepartment Radio Advisory Committee (IRAC) Frequency Assignment Subcommittee.[1155] However, beginning on February 8, 2005, this interim link registration process was replaced by a permanent process in which third-party database managers are responsible for recording each proposed non-Federal link in the third-party database link system and coordinating with NTIA's automated "green light/yellow light" mechanism to determine the potential for harmful interference with Federal operations.[1156] A "green light" response indicates that the link is coordinated with the Federal Government; a "yellow light" response indicates a potential for interference to Federal Government or certain other operations.[1157] In the case of a "yellow light," the licensee must file an application for the requested link with the Commission, which in turn will submit the application to IRAC for individual coordination.[1158] This automated process is designed to streamline the administrative process for non-Federal users in the bands. The Commission noted that the classified nature of some Federal operations precludes the use of a public database containing both Federal and non-Federal links.[1159]

439. This system has been effectively used for over a decade to facilitate coexistence between commercial systems and Federal systems: the technical data needed to avoid interfering with incumbent non-Federal licensees is already available in existing registration databases, and an automated system to prevent interference with Federal systems is already in place and has been in operation for years.

440. Recently, the Commission has developed other means of facilitating spectrum sharing. In May 2016, seven parties filed applications to be certified SAS Administrators for the Citizens Broadband Radio Service.[1160] The SAS is a critical tool to enable spectrum sharing in the band. SAS will protect incumbent users based on technical criteria, authorize all devices in the band, protect a Priority Access Tier, and coordinate a General Authorized Access (GAA) Tier. By leveraging the SAS computational power, protections can be tailored to the characteristics of the systems that require protection, different uses with different characteristics can be coordinated in a similar area, and spectrum efficiency can be maximized. Based on the experience with the coordination system for the 70/80 GHz band, and the existing rules for the SAS, we propose to establish a SAS-based regulatory framework adapted to the constraints and the opportunities of the 71-76 and 81-86 GHz bands. In particular, we invite comments on the following questions and proposals:

- We propose to establish three tiers of users for the 71-76 and 81-86 GHz band, consisting of: (1) Incumbent Access users, which would receive the highest level of protection; (2) Priority Access Licensees (PALs); and (3) General Authorized Access (GAA) users. Each tier would be required to prevent interference to, and accept interference from, higher tier users.
- We seek comment on whether the rules for these bands should be included in Part 30 (Upper Microwave Flexible Use Service) or Part 96 (Citizens Broadband Radio Service).
- *Incumbent Access*: We propose to continue to protect existing Federal locations and seek comment on the ability to add future sites on the same protected basis. We seek comment on whether existing 70/80 GHz licensees and registered links should also qualify for incumbent

[1155] *70-80-90 GHz Report and Order*, 18 FCC Rcd at 23343, para. 60.

[1156] *See Wireless Telecommunications Bureau Announces Permanent Process for Registering Links in the 71-76 GHz, 81-86 GHz, and 92-95 GHz Bands*, Public Notice, 20 FCC Rcd 2261 (WTB BD 2005).

[1157] *See generally* 47 CFR § 2.106 n.US388, US389.

[1158] *See 70-80-90 GHz Report and Order*, 18 FCC Rcd at 23341-43, paras. 52, 54, 58.

[1159] *See 70-80-90 GHz Report and Order*, 18 FCC Rcd at 23340, para. 48.

[1160] Press Release, FCC, *Continuing Momentum in the 3.5 GHz Band* (May 17, 2016), https://www.fcc.gov/news-events/blog/2016/05/17/continuing-momentum-35-ghz-band.

protection. Alternatively, we seek comment on whether they should be grandfathered for some period of time, then required to transition to the new service we propose here (most notably, deploy equipment consistent with the technical rules and capable of communicating to an SAS).[1161] To the extent grandfathered links are protected, we propose to require the links to be operational and in service, and seek comment on requiring incumbent licensees to certify their construction and operational status with the Commission. We also seek comment on the appropriate means for protecting Federal incumbents, including whether we should modify the existing system or utilize a more automated system (like a sensor-based system). Finally, we seek comment on the extent to which Federal users could expand their service area and gain protected status under the incumbent tier.

- *Priority Access*: As in the Citizens Broadband Radio Service, we propose to create a Priority Access Tier in which we would make PALs available for geographic license areas. We propose to authorize PALs within census tracts, with one-year, non-renewable license terms. We believe that this approach will provide licensees with the certainty required to promote investment while maximizing efficient use of the spectrum and incentivizing a variety of innovative deployment models. We seek comment on this proposal.
- *General Authorized Access*: We propose to create a GAA tier, and seek comment on whether the tier should be licensed by rule or subject to a "licensed light" regime similar to the existing structure for the 70/80 GHz band (non-exclusive nationwide licenses with individual sites authorized). We seek comment on whether the GAA tier should have access to a set channels, (i.e., there would be some first-in-time right that would provide some level of certainty) or if we should require (or allow) the SAS to dynamically maximize the number of GAA sites in a given area. Finally, we seek comment on whether we should defer authorizing GAA users until the conclusion of initial Priority Access license terms.
- *Protection Methodology*: We invite comment on the appropriate technical methodologies for protecting licensees that are entitled to protection, including but not limited to the following alternatives:
    a. Require SAS to calculate expected aggregate interference at each incumbent or Priority Access receiver, based on their positions and the technical parameters of their equipment, together with the corresponding parameters of intruding transmitters.
    b. Establish a maximum aggregate received signal level within Priority Access license areas, which would be measured in terms of power flux density (PFD) per megahertz of bandwidth at specified heights above the ground.
    c. Implement an alternate protection scheme whereby the SAS would protect operator-defined contours around Priority Access base stations to a protection level at a specified dBm per megahertz of bandwidth anywhere within the contour.
- *Technical Rules*: We propose to establish two classes of licenses for point-to-point operations in these bands that will be subject to the technical requirements described below.
    a. Class A licenses would be authorized only for operations at a minimum specified height above ground level, would be authorized to use comparatively high power levels, and would be required to use tight-beamwidth antennas. Class B point-to-point licenses would be authorized transmit at streetlamp level, with somewhat relaxed beamwidth requirements in order to accommodate smaller antennas. We invite comment on the

[1161] *See* 47 CFR § 90.1338 (discussing grandfathering of existing 3650-3700 MHz operations during transition of band to Citizens Broadband Radio Service).

appropriate height limits, power levels, and beamwidth constraints that would be appropriate for these purposes.

b. We propose to authorize dynamic beamforming antennas to provide in-band backhaul so long as they conform to the same beamwidth requirements, height limitations, and other requirements that apply to conventional antennas used for point-to-point links.

c. We propose to authorize the same dynamic beamforming antennas to serve mobile user equipment, with further relaxation of beamwidth requirements, provided that they are situated no higher than streetlamp level and provided further that their antennas are inclined downward at a minimum specified angle when they are communicating with mobile user equipment. We invite comment on appropriate beamwidths, inclination angles, power levels, and height constraints for these purposes.

d. We propose to require that Class A license equipment be professionally installed but that non-professionals be allowed to install Class B license equipment and mobile base station equipment, provided that the installer is equipped with the necessary geo-location equipment or that the equipment itself is capable of ascertaining its location and its orientation.

e. We invite comment on technical requirements that would be appropriate for different kinds of user equipment in these bands, differentiating between point-to-point, handheld mobile equipment, and mobile equipment that will typically be situated more than 20 centimeters away from people. We propose to require that user equipment be allowed to transmit only when it is locked onto a serving base station, with the possible exception of brief pilot or sounding signals.

f. We propose to require SAS to maintain and verify information from registered base stations and Fixed Service transmitters and receiver equipment under their coordination, and we invite comment on the minimum geographic positioning accuracy that we should require, including accuracy with respect to altitude as well as latitude and longitude. We also seek comment on requiring licenses to update registration information if the location or operational status of registered base station equipment changes. We do not propose to require SAS to maintain position awareness of mobile user equipment.

g. We propose to establish OOBE limits for all equipment authorized to operate in these bands, and we invite comments on the appropriate technical parameters to apply for that purpose.

- *Indoor Use*: We invite comments on the feasibility of authorizing unlicensed, indoor-only operations, subject to Part 15 of our rules. We have decided not to adopt the *NPRM*'s proposal to authorize unlicensed indoor-only operations in the 37 GHz band, but we believe that the comparative amount of signal leakage through windows could be much lower in the 71-76 GHz and 81-86 GHz bands, and consequently would be less likely to interfere with outdoor operations.[1162] We seek further information on that issue, especially from commenters that have performed relevant tests or have access to the results of such tests. We note that Part 15 already provides technical rules for indoor-only operation in the 92-95 GHz band that are similar to the rules in the existing 57-64 GHz band,[1163] but require that these devices be AC-powered in order to

[1162] We note that in response to the *NPRM*, and as discussed *supra*, a number of parties requested the Commission to permit indoor use of the 72.5-76 GHz band by unlicensed devices. These parties also requested unlicensed operation (both indoors and outdoors) in the 64-72.5 GHz band, (instead of the narrower 64-71 GHz band as the Commission proposed in the *NPRM*,) which the Commission denied. *See supra,* Section IV.D (64-71 GHz).

[1163] 47 CFR § 15.257. We also note that thus far, there has been no unlicensed equipment authorized under these rules. *See* https://apps.fcc.gov/oetcf/eas/reports/GenericSearch.cfm?

ensure that they only operate indoors.[1164] If we allow unlicensed operation at 71-76 GHz/81-86 GHz, should similar technical rules apply? What additional restrictions should be added to ensure that this type of equipment will not interfere with authorized services, as indicated above, that are currently operating in these bands? Alternatively, would registered indoor GAA use be a better mechanism for facilitating indoor use of these bands? We seek comment on this and any other relevant issue regarding unlicensed and indoor operations within this spectrum.

- We propose to extend the same requirements and privileges to all parts of the United States, but we also invite comment on the alternative of establishing a separate regulatory framework for the 16 counties that are heavily registered with incumbent users.[1165]
- We propose to require SAS to be capable of performing the following operations:
    a. Determine the available frequencies at a given geographic location and assign them to PAL and/or GAA licensees;
    b. Determine the maximum permissible transmission power level for incumbent, PAL, and GAA licensees at a given location and communicate that information;
    c. Register and authenticate the identification information and location of incumbent, PAL and GAA licensees;
    d. Enforce Exclusion and Protection Zones, including any future changes to such Zones, to ensure compatibility between non-Federal users of spectrum in the 71-76 GHz and 81-86 GHz bands and incumbent Federal operations;
    e. Ensure that PAL and GAA licensees protect non-Federal incumbent users consistent with the rules;
    f. Protect Priority Access Licensees from impermissible interference from other users;
    g. Facilitate coordination between GAA users to promote a stable spectral environment;
    h. Ensure secure and reliable transmission of information between the SAS, ESC, and PAL and GAA licensees;
    i. Provide any ESC that we might approve with any sensing information reported by PAL and GAA licensees if available;
    j. Facilitate coordination and information exchange with other SASs and exchange information, as needed, with NTIA.

441. We also seek comment on alternative methods of authorizing additional access to these bands, including exclusive use licensing and unlicensed. As discussed, authorizing new flexible use operations in these bands is difficult given the incumbent fixed commercial and Federal operations. How would an exclusive use licensing or unlicensed access models work? How would incumbents be protected and be permitted to expand? Could the Commission auction overlay licenses that allow the auction winner to negotiate with the incumbents in the area for their rights? How could unlicensed operations sufficiently protect incumbents? Have circumstances changed since the Commission declined

[1164] 47 CFR § 15.257(a)(1) requires that "devices operating under the provisions of this section, by the nature of their design, must be capable of operation only indoors. The necessity to operate with a fixed indoor infrastructure, e.g., a transmitter that must be connected to the AC power lines, may be considered sufficient to demonstrate this."

[1165] As of June 10, 2016 the sixteen counties that have a site density of more than one transmit or receive site per square mile include Hudson, NJ; San Francisco, CA; New York, NY; Union, NJ; Essex, NJ; Bergen, NJ; Kings, NY; Middlesex, NJ; Richmond, NY; Passaic, NJ; Bronx, NY; Dupage, IL; Queens, NY; Suffolk, MA; Washington, DC; Cook, IL.

to allow unlicensed operations in these bands in 2003? We seek comment on these and other issues implicated in any alternative licensing or authorization scheme.

8. Bands Above 95 GHz

442. In the *NPRM* we noted that several parties expressed support for making additional spectrum available in the upper reaches of the spectrum, particularly above 95 GHz.[1166] We invited parties to submit proposals for use of this spectrum, including proposals for authorizing use under our Part 15 rules for unlicensed devices. Commenters generally did not respond to this request, but we recognize that the NPRM explored many spectrum issues and commenters may have chosen to focus on the specific proposals for the frequency bands below 95 GHz. Moreover, we are aware that operations above 95 GHz involve nascent technology that is being developed by small companies that may not be accustomed to participating in FCC proceedings. Nevertheless, we are committed to developing a record that will provide a basis for proposing rules that will encourage the introduction of new services and devices above 95 GHz.

443. The spectrum from 95 to 275 GHz has been allocated for a variety of different types of Federal and non-Federal radio services. In addition, the international Table of Frequency Allocations has been extended from 275 to 1,000 GHz for specific services and, in a separate proceeding, we are considering how to amend the United States table.[1167] The bands above 95 GHz have already been identified for services that typically involve the reception of extremely weak signals, such as radio astronomy, space research, and Earth Exploration Satellite. All of the bands, with some minor exceptions, are allocated on a co-primary basis for Federal and non-Federal use.

444. We recognize that signals in the frequency bands above 95 GHz will attenuate rapidly, intuitively tending to minimize the risk of harmful interference to other radio services. However, this does not by itself provide a basis for proposing to allow use of any spectrum above 95 GHz. We believe the process of facilitating technology above 95 GHz can best be advanced by identifying specific frequency bands rather than attempting to address all parts of the spectrum above 95 GHz. Accordingly, we take this opportunity to solicit information on the specific parts of the spectrum that would be most attractive from the standpoint of technology development while successfully coexisting with the types of radio communications services that operate under the existing allocations.[1168]

445. In identifying specific frequency bands, we ask commenters to provide specific analyses to justify any claims that there are no risks of harmful interference to other radio services. Which bands should be made available for licensed or unlicensed use? Is there sufficient information to identify where and on what frequencies both existing and planned radio astronomy, space research, Earth Exploration Satellite, and similar users will actually operate? What technical rules may be appropriate? For parties supporting unlicensed use, will it be necessary to control the locations of operation to prevent harmful interference to radio astronomy, space research, Earth Exploration Satellite, or other services? If so, how could the areas of permissible operations be controlled under the unlicensed rules? For bands that commenters believe should be made available on a licensed basis, should the new Part 30 rules or other

[1166] *NPRM*, 30 FCC Rcd at 11955, paras. 89-91.

[1167] *See supra* para. 2. The Commission has proposed to expand the Table of Frequency Allocations up to 3,000 GHz and not to allocate spectrum above 275 GHz to any service. *See Amendment of Parts 2, 15, 80, 90, 97 and 101 of the Commission's Rules Regarding Implementation of the Final Acts of the World Radiocommunication Conference (Geneva, 2012)*, ET Docket No. 15-99, Notice of Proposed Rulemaking, 30 FCC Rcd 4183, 4269-70. In making this proposal, the Commission stated that it is premature to establish an allocation in this frequency range and tentatively concluded that "it is necessary to avoid spectrum use restrictions and maintain flexibility in our spectrum allocation decisions to support the development of new uses in the future." *Id.*

[1168] As noted in the *NPRM*, we will consider a petition for rulemaking filed by Battelle Memorial Institute in our Wireless Backhaul proceeding, WT Docket No. 10-153. *See NPRM*, 30 FCC Rcd 11907, para. 91; Petition for Rulemaking, Battelle Memorial Institute, RM-11713 (filed Feb. 6, 2014).

service rules apply? How would we create a licensing scheme for signals that generally propagate over very short distances? Should we permit both mobile and fixed service? What technical rules should apply? We encourage parties to file comments addressing these matters.

B. Federal Sharing Issues - 37 GHz band (37-38.6 GHz)

446. *Background*. In the *Report and Order*, we adopt rules to enable Federal and non-Federal co-primary geographic sharing. The licensing approach divides the 37 GHz band into two segments, a lower band segment from 37-37.6 GHz and an upper band segment from 37.6-38.6 GHz, with differing licensing rules. By adopting this licensing scheme we have accomplished two goals. First, we developed an effective sharing paradigm between Federal and non-Federal users throughout the band that ensures both are able to use the band now and in the future. Second, by applying the same licensing and technical rules to the upper band segment and the 39 GHz band, we have created 2,400 megahertz of contiguous spectrum that will give commercial operators the flexibility to combine or pair this spectrum to suit their own needs. We find that the sharing scheme in the lower band segment will facilitate expanded access for next generation wireless services; make spectrum available for both important Federal missions and wireless broadband needs; and create an environment establishing robust Federal and non-Federal sharing on a coordinated and flexible basis that could be applied in other bands to further enhance sharing generally and specifically Federal and non-Federal sharing.

447. *Discussion.* As we indicated in the *Report and Order*, FCC staff will – in coordination with NTIA, DOD, and other Federal and non-Federal stakeholders – further define the sharing framework by more fully developing the coordination mechanisms we adopt for the lower band segment. We also seek comment on adopting methods for shared (Federal and non-Federal) access of the upper band segment, including through a use or share requirement, and how to facilitate coordination for potential future Federal access across the licensed portions. Thus we seek comment on the issues described below.

1. Coordination Mechanism for the Lower Band Segment

448. As explained above in the *Report and Order*, the lower band segment is available for coordinated coequal sharing between Federal fixed and mobile users and non-Federal fixed and mobile users. Non-Federal fixed and mobile users, which we will identify as Shared Access Licensees (SALs), will be authorized by rule. Federal and non-Federal fixed and mobile users will access the band by registering individual sites through a coordination mechanism. The *Report and Order* explained that FCC staff will work with stakeholders, both Federal and non-Federal, to help develop the details of the coordination process. Here, we seek comment on the coordination mechanism – that is, the regulatory, technical, or procedural tool necessary to actually facilitate coordinated access. Our expectation is that some of the issues raised here may be further developed through the collaborative process between the FCC, NTIA, DOD, and other Federal users set out in the *Report and Order*, as well as through comments in response to this *FNPRM*.

449. We believe that a robust coordination mechanism is essential to ensuring that both Federal and non-Federal fixed and mobile users have effective coordinated access to the lower band segment. The coordination mechanism will authorize a particular user to use a particular bandwidth of spectrum at a particular location. To do so efficiently and effectively, it must be able to obtain information about the type of equipment used, the signal contour from the coordinated location, and the bandwidth requested compared with the bandwidth available. As discussed below, it must also be capable of regularly updating the status of a coordinated location (on/off or authorized/unauthorized). Moreover, it will have to incorporate this type of information for both Federal and non-Federal fixed and mobile uses. Here, the sharing environment is relatively straight forward – there are limited incumbent uses that need to be protected, and Federal and non-Federal fixed and mobile users will have coequal

rights to the band. We also believe that the propagation characteristics of this band might help minimize the complexity of the coordination mechanism.[1169]

450. We note that historically the Commission has used manual frequency coordination managed by third party frequency coordinators. Recently however, the Commission finalized the rules for the 3.5 GHz Citizens Broadband Radio Service, which relies not on a static frequency coordination mechanism, but on a dynamic mechanism known as a Spectrum Access System (SAS) that coordinates uses among different tiers of users, rather than on an individual basis. We seek comment on the most appropriate mechanism for the lower band segment. Should we rely on static, manual frequency coordination, a dynamic SAS-type mechanism, or something in between? For instance, would the advanced capabilities of automated coordination from SAS present advantages over other types of coordination? Is a full SAS implementation, consistent with the Part 96 requirements, appropriate here?

451. We also seek comment on the protection or operation contours necessary for the coordination mechanism to reserve a quantity of spectrum at a location for a user. In the *Report and Order,* we establish technical rules for operation in the lower band segment, which are consistent with the rules adopted for the 28 GHz band, the 39 GHz band, and the upper band segment of the 37 GHz band. Based on this technical information, should we establish a maximum protection contour for coordinated sites? Alternatively, should we allow the coordinated party to request less or more protection?[1170]

452. Although non-Federal fixed and mobile users must follow the coordination requirements that we adopted in the *Report and Order* to protect the Federal sites listed in Section 30.205 of our rules,[1171] we seek comment on how to ensure coexistence between Federal and non-Federal fixed and mobile users. Ideally, Federal fixed and mobile uses would comply with the same or similar technical requirements as non-Federal fixed and mobile uses. For instance, NTIA might establish in its Manual of Regulations and Procedures for Federal Radio Frequency Management[1172] a set of technical rules for operations in this band, there could be a notation in the U.S. Table of Frequency Allocations, or we could rely on some other means. We seek comment on these and other mechanisms. Absent consistent (or known) technical rules governing Federal operations, how should the coordination mechanism account for their protection or operational area of these operations?

453. Finally, we seek comment on how best to coordinate Federal access. Is it feasible for Federal users rely on the same coordination mechanism as non-Federal? How should the coordination mechanism address information security issues particular to Federal users? We seek comment on the means of achieving information security, including ways for the information to be masked, e.g., by having Federal users coordinate through a Federal intermediary that interfaces with the non-Federal coordination mechanism, such as the existing mechanism in the 70/80/90 GHz band.

2. Channelization of the Lower Band Segment

454. As discussed in the *Report and Order*, the lower band segment consists of 600 megahertz of spectrum from 37-37.6 GHz. Although we adopt a channelization plan for the upper band segment, we did not do so for the lower band segment. Thus, we propose to guarantee users in the lower band segment a minimum channel size. Specifically, we propose to establish a 100 megahertz minimum channel size. We also propose, however, to allow users to aggregate 100 megahertz channels into larger channel sizes, up to the maximum of 600 megahertz where available (subject to use requirements as described below).

[1169] *See generally* para. 6, *supra*.

[1170] We note that in the 3.5 GHz band, the Commission established a two-pronged approach wherein licensees are able to report their own protection contour, up to a technically defined maximum.

[1171] *See supra* Section IV.E.2 (Federal Sharing Issues; 37-38.6 GHz). *See also* Appendix D, *infra.*

[1172] NTIA's Redbook, or Manual of Regulations and Procedure for Federal Radio Frequency Management, governs Federal spectrum allocation and use.

455. We also find that our proposal to adopt a minimum channel size of 100 megahertz strikes the right balance between providing enough spectrum for a diversity of wireless uses with helping to minimize the complexity of the coordination mechanism. We note that while most commenters in this proceeding generally favor channel sizes of 200 megahertz or greater, other commenters suggest that smaller channel sizes can still facilitate robust wireless broadband services.[1173] By permitting users to aggregate up to 600 megahertz channels, we find that we have enabled maximum flexibility for a variety of use cases involving a variety of channel sizes. We seek comment on these proposals. We also seek comment on alternative approaches, including whether we should adopt 100 megahertz or a larger minimum channel size. In addition, we seek comment on whether we should refrain from setting a minimum channel size and instead require the coordination mechanism to attempt to maximize the number of users in a given area.

3. Authorization Expiration/Construction Requirement for the Lower Band Segment

456. To achieve a robust and efficient sharing environment and prevent spectrum warehousing, we propose that registered non-Federal sites must be put into service within seven days of coordination and that registered and coordinated sites must reassert their registration every seven days. For example, if we rely on a database for coordination, a user could query the database for available frequencies at a location, and reserve those frequencies for seven days. Within seven days, it would need to activate a device that is capable of notifying the database that it is active on the channel. That device would then check in with the database (or receive and respond to a message from the database) at least once every seven days. If the device fails to check in within the seven day period, its authorization would lapse. We seek comment on this proposal. Are these time frames appropriate? Are there other tools to ensure the spectrum is put to use consistent with the public interest?

4. Priority Access for Federal Users of the Lower Band Segment

457. We recognize that Federal users' needs are not necessarily commensurate with non-Federal users' needs. The use cases will likely differ, the level of certainty and protection or a use related to a critical defense or national security mission may vary. We therefore seek comment on whether we should make a portion of the lower band segment available for priority access by Federal users. For instance, should we allow Federal users to claim priority access to up to 200 megahertz of the 600 megahertz lower band segment? Could the coordination mechanism statically reserve this space or dynamically make it available when requested? For instance, if the entire band is in use, could the database reconfigure the channels or clear the necessary channel size?

5. Interference Mitigation in the Lower Band Segment

458. We seek comment on any necessary enforcement mechanism in the lower band segment to help identify and rectify interference events. Because we propose to require users in the lower band segment to coordinate on a site-basis, it may be easier to identify and rectify any interference issues that may arise. We recognize, however, that there may be users and uses, both Federal and non-Federal, for which any interference may be significantly problematic. Therefore, we seek comment on any additional interference mitigation and enforcement mechanisms that might be necessary.

6. Secondary Market Policies for the Lower Band Segment

459. Finally, we seek comment on whether and how to apply secondary market rules to the lower band segment. As proposed, the band will be made available on a site-by-site basis. Partitioning and disaggregation generally do not apply in site-based licensing circumstances. Should they apply here, and if so, how? Should we apply our leasing rules? What are the benefits to secondary market rules for the lower band segment relative to other ways to gain access to the spectrum?

[1173] *See*, *e.g.*, T-Mobile Comments at 7 (supporting further consideration of 29.1-29.25 GHz band), XO Comments at 15-16 (same).

7. Use It or Share It and Federal Sharing in the Upper Band Segment

460. As described above in the *Report and Order*, the upper band segment, 37.6-38.6 GHz, is divided into five channels each 200 megahertz wide. The upper band segment will be available on a geographic basis (with protected Federal sites) via auction. The technical and service rules we adopt allow continuity between the upper band segment and the 39 GHz band, which provides 2400 megahertz of contiguous spectrum under the same licensing and technical rules. Given the types of uses that may be deployed in the 37 GHz band and the flexible build out requirements that we adopt in the *Report and Order*, there may be significant unused spectrum in in the upper band segment at any given time. To improve the spectrum efficiency and provide an opportunity for Shared Access Licensees and Federal users to expand in a manner that does not impact geographically licensed uses, we propose to permit shared access of the unused portions of the five channels in the upper band segment, under certain conditions. We also seek comment on establishing a process by which Federal users could coordinate with licensees for future expanded access in the upper band segment.

461. We note that the Commission has found spectrum sharing to be an effective tool to maximize spectrum efficiency. In the 700 MHz band, the Commission adopted a performance requirement that results in the licensee losing its unconstructed license area. In the Citizens Broadband Radio Service, Priority Access License areas that are not in use must be made available for General Authorized Access use. Moreover, in the *Report and Order*, to meet the applicable performance requirements, licensees in the 28 GHz and 39 GHz band may choose to share access to their licensed spectrum. Furthermore, we believe that the prospect of future shared access (on a coordinated and non-interference basis) to the remainder of the band may create incentives for investment and innovation in the shared channel.

462. We understand that upper band segment licensees may make reasonable business decisions to not serve particular parts of a licensed area, and that these decisions may change over time. In an environment where these unserved areas are shared, it is important to be able to both accurately identify the areas in use and enable the geographic area licensees to expand or contract their coverage as necessary. Under our proposal, the upper band segment licensee would retain the primary right to construct and provide service anywhere within its license area at any time, and any operations undertaken on a shared basis would be subject to displacement by the primary licensee. We therefore propose to require licensees to provide information about the extent of their operations at some future point in order to enable shared access.

463. We also seek comment on when we should phase in shared access. Would it be appropriate to phase in shared access at the end of the initial license term, or would it be appropriate to adopt a sharing requirement at an earlier time (e.g., 5 years from the date the upper band segment geographic area license is granted). We seek comment on the scope of the information that the incumbent licensee must provide to the coordinating mechanism. Would a map with simple protection contours be sufficient, or would additional information be necessary? We also seek comment on the appropriate mechanism for dealing with multiple requests to share the same spectrum in the same location. Should we adopt a first-come, first-served approach, require multiple parties to share unused spectrum amongst themselves, or adopt some other mechanism?

464. In the *Report and Order*, we established coordination zones around three Space Research Service sites and 14 military sites that apply across the entire 37 GHz band, including the upper band segment. As we envision non-Federal users being able to coordinate for access on within the 14 military sites, we seek comment on additional circumstances and methods under which the upper band segment can be made for expanded future Federal use, in addition to the shared access scheme described above. For example, should we establish a required coordination process under which Federal users could formally request coordinated access from a licensee? If we establish such a process, how do we properly balance the respective rights and interests of Federal users and non-Federal licensees? How would we ensure co-existence between deployed commercial systems (or planned systems) and the Federal system that is seeking coordinated access? Should we impose an obligation on UMFUS licensees to consider in

good faith such coordination requests from Federal users? What standards should we establish for consideration of such coordination requests? Are there alternative ways of ensuring that Federal users can take advantage of their co-primary fixed and mobile allocations while protecting the rights of non-Federal licensees? Are there lessons and recommendations that we can incorporate form the ongoing work within the Commerce Spectrum Management Advisory Committee?[1174] We seek comment on all issues relating to Federal access to the upper band segment.

C. Performance Requirements

1. Additional Metrics

465. In the above *Report and Order*, we adopt a list of performance metrics for measuring sufficient use of a license to qualify for renewal.[1175] We acknowledge that this list is not exhaustive, and in particular, does not contain metrics designed to accommodate new and innovative services that may develop in the millimeter wave bands. We therefore seek comment on additional performance metrics that will better accommodate these new services while fulfilling our statutory obligation to encourage productive use of spectrum and avoid warehousing and speculation.

466. In particular, we seek comment on an appropriate metric to evaluate the deployment and performance of an "Internet of Things" type service, which is designed primarily to facilitate machine-to-machine communication. Such services may or may not be deployed in areas of substantial residential population, and may or may not be designed to serve unaffiliated customers. Examples of this type of service would include the Supervisory Control and Data Acquisition (SCADA) systems described by Southern Co.[1176] Because of the unique characteristics of these machine-to-machine services, we propose to develop a distinct metric by which to measure the deployment of such services, rather than attempting to modify a population coverage approach for this purpose. We seek comment on this proposal, including specific suggestions for what aspects of such services should be measured, how they should be measured, and what specific levels would constitute an acceptable level of service.

467. Several commenters suggested that we measure performance for all services in the millimeter wave bands on the basis of actual use of the service, including number of devices connected, volume of data transmitted, or number of sessions initiated on the network.[1177] We seek further comment on these metrics, including specific numbers for the levels of devices, sessions, and data volume that commenters believe would be appropriate milestones. Would one of these metrics be the most appropriate way to measure deployment of an Internet of Things or machine-to-machine type service? We also seek comment on whether and how it would be practical to implement this type of usage-based requirement. How could the Commission verify information provided by licensees? Should all kinds of devices, sessions, and/or data be counted equally? How should such a requirement be structured to ensure that it both measures and encourages meaningful service, rather than gamesmanship?

468. As some commenters note, licensees in these bands may seek to provide service to areas with high daytime or transient populations but low or no residential populations, such as corporate campuses, interstate highways, or event venues.[1178] We seek comment on how to define such locations for the purposes of evaluating service coverage. We also seek comment on the appropriate framework for

[1174] *See* Commerce Spectrum Management Advisory Committee, Subcommittee on Federal Access to Non-Federal Bands, "Subcommittee Update: Federal Access to Non-Federal Bands," (June 8, 2016), *available at* https://www.ntia.doc.gov/files/ntia/publications/csmac_subcommittee_federal_access_to_non_federal_bands_-_6-8-16_update.pdf.

[1175] *See supra* Section IV.F.7 (Performance Requirements).

[1176] Southern Co. Reply at 3.

[1177] 5G Americas Comments at 9-11, TIA Comments at 25-28.

[1178] XO Comments at 21-22.

incorporating coverage of such locations into an overall performance metric. Would a venue per population metric be appropriate, similar to the current treatment for fixed links? Should the applicable milestone be based on the daytime or transient population served by such venues or traffic corridors? How should such population be measured?

469. We also seek comment on any other types of service being contemplated by potential providers, as well as metrics that would be appropriate to measure performance or build-out of those services.

470. Finally, in the *Report and Order* we explain that licensees may demonstrate combinations of fixed and mobile deployments in order to meet their performance requirement, and that we intend to review the showings on a case-by-case basis.[1179] Here, we seek comment on whether to establish clear benchmarks or even guidance for the amount of buildout that might be adequate in these combined showings. For instance, should we establish a scale with levels showing acceptable combinations of mobile and fixed deployment, where either mobile or fixed is increased relative to the other? Or should we establish variations depending on the population density of a given license area, the land mass of the area, or some other factor? We seek comment on any other means to provide flexibility and clarity in how we may measure combined showings, or whether we should continue to review the showings on a case-by-case basis as contemplated in the *Report and Order*.

2. Sharing Mechanisms

471. *Background*. In the *NPRM*, we proposed a "use-or-share" rule that would supplement performance requirements to ensure that spectrum is put to efficient and productive use.[1180] Mechanisms for sharing unused spectrum are currently present in other bands licensed by the Commission, including a "keep what you use" regime in the 700 MHz band,[1181] and a three-tier shared access system in the 3.5 GHz band that makes geographically licensed spectrum available opportunistically.[1182] These and other mechanisms can be effective tools to allow licensees to construct networks consistent with their deployment plans and business models, and also make spectrum that a licensee has chosen not to use available for other users.

472. Some commenters support a more intensive sharing regime, including OTI and Public Knowledge, Facebook, Microsoft, and Federated Wireless.[1183] These commenters argue that adopting a SAS-driven sharing approach similar to that in 3.5 GHz would allow otherwise fallow spectrum to be productively used, and support that development of innovative uses of spectrum in these bands.[1184] Many commenters, however, generally oppose any use or share regime.[1185] These commenters provide very little concrete detail in their discussion of the proposal, and generally do not address our specific questions relating to how we might implement this kind of sharing regime. Other than objecting to the

[1179] *See supra* Section IV.F.7 (Performance Requirements).

[1180] *NPRM*, 30 FCC Rcd at 11941, para. 215.

[1181] 47 CFR § 27.14(h). WCS licensees with REAG authorizations in Block C and Block C2 must meet construction requirements for each EA within the REAG. Authorization terminates automatically at the end of the license term for any EA in which the licensee has not met the construction requirements.

[1182] 47 CFR §§ 96.15 – 96.38.

[1183] Facebook Comments at 6-7, Federated Wireless Comments at 20-21, Microsoft Reply at 12-13, OTI and Public Knowledge Comments at 5.

[1184] Federated Wireless Comments at 20-21, Microsoft Reply at 12-13, NCTA Comments at 10-11, OTI and Public Knowledge Comments at 20-21.

[1185] AT&T Comments at 20-21, CTIA Comments at 26-27, HTSC Comments at 5, Intel Comments at 20-23, Mobile Future Comments at 16, NCTA Comments at 10-11, Nokia Comments at 20, Qualcomm Comments at 14, TIA Comments at 26 n.56, Verizon Comments at 20-21.

burden of providing deployment information to a database or SAS, commenters also do not address what the specific costs of a use-or-share system might be.[1186] Opposition was primarily in the form of general objections to increased uncertainty,[1187] lower flexibility,[1188] and increased potential for interference.[1189] Some commenters also argue that a use-or-share system is premature given the state of both the technology in these bands and technologies that would support sharing.[1190]

473. In the *NPRM*, the Commission posited that the relatively short propagation characteristics of the bands above 24 GHz enable significant spectrum reuse, which makes these bands good candidates for sharing.[1191] In addition, the record suggests one use case for UMFUS spectrum is targeted, geographically-limited coverage, instead of traditional cellular-like deployment.[1192] To the extent that this type of small-cell bandwidth augmentation or geographically limited (in terms of area covered) use cases proliferate, additional methods beyond traditional performance requirements, like shared access of unused spectrum, may help ensure that we meet our statutory obligation to prevent the warehousing of spectrum.[1193]

474. *Discussion.* Given the relatively limited record on the substantive issues regarding mechanisms for sharing unused portions of UMFUS licenses, we seek further comment on the possibility of implementing a use-or-share regime in the UMFUS bands. We continue to believe that a use-or-share regime may have the potential to enhance the efficiency and productivity of spectrum, if properly implemented. In particular, given the propagation characteristics, and high potential for re-use, of the mmW spectrum, we seek comment on whether such a regime could maximize the efficient use of these spectrum bands. We further seek comment on the costs and benefits of adopting mechanisms for sharing unused UMFUS spectrum, as well as on the incentives that particular sharing regimes will create. In addition, we seek comment on the appropriateness of requiring UMFUS licensees to share unused portions of their license in addition to, or in lieu of, meeting specific construction requirements, particularly in geographically licensed bands such as 28 GHz and 39 GHz.

475. In crafting an effective mechanism to share unused spectrum, there are two governing considerations: first, ensuring the licensee has exclusive use of the areas in which it is using the spectrum; and second, creating an efficient mechanism that both makes unused spectrum available and protects the licensee from interference. There are a variety of potential options for enhanced sharing mechanisms that address these considerations. We seek comment generally on the following opportunistic sharing mechanisms: a fully dynamic sharing solution, facilitated by a SAS or other third-party database; a modified shared access system that would be less dynamic but simpler; an unlicensed shared access approach, similar to white spaces, and other alternatives.

476. We seek comment on variations of a use it or share it mechanism. A potential drawback of a keep what you use mechanism is that the Commission must reclaim, and later re-auction, the unused portions of the band, which takes time and minimizes a licensee's ability to decide later to deploy in an area (which is also a feature of the approach because it incentivizes maximum initial deployment). Use or share mechanisms permit a licensee to retain control of its license area, but require the licensee to share with other entrants in portions of the license area in which it is not operating. A use or share mechanism

[1186] XO Comments at 29-32.

[1187] AT&T Comments at 20-21, HTSC Comments at 5, Qualcomm Comments at 14, Nokia Reply at 4.

[1188] Mobile Future Comments at 16.

[1189] AT&T Comments at 20-21, XO Comments at 29-32.

[1190] AT&T Comments at 20-21, CCA Reply at 10-12, CTIA Comments at 26-27, Intel Comments at 20-23.

[1191] *NPRM*, 30 FCC Rcd at 11941, para. 215.

[1192] CTIA May 24, *Ex Parte* Letter at 2-3.

[1193] 47 U.S.C. § 309(j)(4)(B).

may be less administratively burdensome than keep what you use, and may also allow a greater number of users to access the shared spectrum. There are a number of possible variations of use or share, all of which share characteristics of basic frequency coordination.

477. One option would be to automate shared access to enable dynamic opportunistic sharing. In a dynamic sharing solution, licensees would have some initial period of time to build out their networks. After this period, information about the extent of licensees' deployment would be made available, and other entities would be free to deploy outside of the area used by the licensee's operations on a coordinated basis, subject to further expansion by the licensee. We seek comment on whether an automated dynamic use or share mechanism would be appropriate in the mmW bands. Generally, these shared users would need to operate similar technologies subject to the same technical rules as the licensee to maximize spectrum efficiency and economies of scale with respect to equipment. We seek comment on whether the propagation characteristics of these bands might facilitate shared access with slightly different technical rules. With respect to the sharing mechanism, what types of information, and what level of detail, would be required to facilitate dynamic sharing? Should opportunistic users be authorized on a license-by-rule basis, or by some other method? Should opportunistic users be afforded some level of interference protection from each other, and if so what should that level be?

478. Another option is to rely on more traditional frequency coordination, typically used in point-to-point microwave, shared millimeter wave bands, and other services today. Under a simple frequency coordination process, the licensee's operations would be protected around a contour, and new sites would be individually coordinated into the license area. While a database could further automate this process, it may not be necessary given the relatively simple sharing regime. We seek comment on whether a sharing mechanism based on traditional frequency coordination would be appropriate for the mmW bands.

479. Yet another option is to established pre-defined geographic areas that will be available for shared access, depending on a licensee's construction. For instance, if a licensee meets its performance requirement, we could find that any county (or other unit of geographic area) in which it has any operation is unavailable for sharing. For example, a licensee of a PEA might deploy heavily in some counties but not others; the heavily-deployed counties would then be deemed "in use," while the counties with no deployment would be available for opportunistic use in undeployed areas. We seek comment on the appropriateness of this mechanism as a whole, and on the specific details. What level of subdivision would best accommodate both licensee certainty and sharing opportunity? Should we stop at the county level, or should we further subdivide into census tracts or census blocks? What level of deployment in each subdivision should qualify that area for "used" status? How should we enable sharing – through a database, individual coordination, or some other method?

480. Finally, we also seek comment on implementing unlicensed shared access, similar to TV white spaces, in the unused portions of the UMFUS bands. In this case, opportunistic users would operate on an unlicensed basis at lower power in any area where the licensee was not actually deployed. We seek comment on whether and how to implement such a system in the millimeter wave bands. Would this system require a third-party database, similar to the dynamic sharing solution described above? How should we draw the contours around licensee deployments? Should we use a fixed radius, or an interference contour at a certain level, or some other metric? Would this method be preferable to a dynamic sharing solution where the opportunistic users and the licensee followed the same technical rules? Are there technical benefits to this approach? Will there be sufficient scale to drive more special-purpose equipment development?

481. To the extent that we implement any variation of a use it or share it mechanism in the mmW bands, certain key aspects of that mechanism must be defined. Most importantly, we seek comment on how to define a licensee's "use" of its licensed spectrum. Should "use" be defined geographically, either by the service area of a network or by a defined radius or contour around deployed equipment? In the Citizens Broadband Radio Service, the Commission recently adopted an engineering metric to determine the extent to which Priority Access Licenses are in use. Licensees can define the area

of use subject to an objective maximum.[1194] Should we follow this model? Should "use" be defined differently for different types of deployments, for example mobile vs. fixed links? Additionally, we seek comment on how best to allow the licensee room to expand beyond its area of actual deployment (or its "used" spectrum, however ultimately defined). For example, should we define a contour for an additional protected area? If so, on what basis and how often should we do so? Should we set some level at which a subdivision of a license area would be declared "used" in its entirety, and off-limits to opportunistic use? If so, what subdivisions and what level of deployment would be appropriate (e.g., 40% of the geographic area of a census tract)? Finally, we seek comment on the appropriate level of protection for licensees at the boundaries between "used" and "unused" areas. Should the level of cross-border interference protection be the same as that between two licensees, or would some other limit, either higher or lower, be more appropriate?

482. In addition to the inquiries above, we seek comment on any other mechanisms of opportunistic sharing that could enhance spectrum efficiency in the UMFUS bands, as well as any other aspects of such a system that would be required to ensure it could be reliably and effectively implemented. We especially seek comment from any entity interested in using spectrum on an opportunistic basis in these bands. What technologies or business cases would lend themselves to this type of spectrum access? Which sharing mechanism, described above or otherwise, would best accommodate that use?

D. Mobile Spectrum Holdings Policies

483. As discussed above, today we adopt an *ex ante* spectrum aggregation limit of 1250 megahertz that will apply to licensees acquiring spectrum in the 28 GHz, 37 GHz, and 39 GHz bands through competitive bidding.[1195] By helping to ensure that multiple providers have access to the spectrum we make available today, the spectrum aggregation policies we adopt support our overarching goals of facilitating competition, innovation, and the efficient use of the spectrum. We seek comment below on additional mobile spectrum holdings issues related to how to implement the spectrum aggregation limit; the appropriate holding period; and whether a spectrum aggregation limit would be appropriate as additional "frontier" spectrum bands become available.

1. Implementation of a Spectrum Aggregation Limit at Auction

484. *Accounting for Existing Holdings and Geographic License Area in Determining Eligibility to Bid*. As noted above, of the 986 designated license areas in the 28 GHz band, 412 areas have active licenses, which cover about 75 percent of the U.S. population,[1196] while the 37 GHz band is not yet licensed, and in the 39 GHz band, current licensed areas cover about 49 percent of the U.S. population.[1197] Further, in terms of geographic licensed areas, the 28 GHz band will be licensed on a county basis across the U.S., while the 37 GHz and 39 GHz bands will be licensed by PEA.[1198]

485. For purposes of assessing eligibility to bid across the three spectrum bands, as noted above, any given entity cannot hold more than 1250 megahertz of this spectrum in total. Taking into

[1194] Amendment to the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, *Order on Reconsideration and Second Report and Order*, GN Docket 12-354, FCC 16-66, at para. 174 (rel. May 2, 2016).

[1195] We also adopt a spectrum threshold of 1250 megahertz for proposed secondary market transactions, and note that while this 1250 megahertz threshold would help identify those markets that provide particular reason for further competitive analysis, our consideration of potential competitive harms would not be limited solely to those markets. *See supra* Section IV.F (Licensing, Operating, and Regulatory Issues).

[1196] *See supra* Section IV.A (28 GHz Band (27.5-28.35 GHz)).

[1197] *See supra* Section IV.B (39 GHz Band (38.6-40 GHz)).

[1198] *See supra* Sections IV.A (28 GHz Band (27.5-28.35 GHz)); IV.B (39 GHz Band (38.6-40 GHz)).

account existing incumbents' holdings in the 28 GHz band and the 39 GHz band, as well as different geographical license areas, we put forward and seek comment on two alternative methodologies for assessing bidding eligibility. We ask for comment on which methodology is more appropriate, and why. We also ask that interested parties comment on the likely costs and benefits associated with each methodology. Are there additional methodologies beyond the two alternatives set out below that would be more appropriate to adopt? If so, we invite interested parties to present their alternatives. Which methodological approach should we use and how best would we implement?

486. The first methodology that we invite comment on is the "maximum county-to-PEA" option. Under this option, if any incumbent licensee in the 28 GHz band, for example, holds such spectrum, its spectrum holdings at the county level would be counted at the PEA level when determining eligibility to bid on 37 GHz and 39 GHz spectrum. For instance, if an incumbent licensee currently holds two licenses, or 850 megahertz of spectrum, in the 28 GHz band in any county within a PEA, then that licensee's 28 GHz spectrum holdings would be counted as 850 megahertz for the PEA as a whole.[1199] In addition, that same licensee's 39 GHz holdings, if any, would be added on to its 28 GHz holdings of 850 megahertz. That licensee would then be able to acquire a maximum of an additional 400 megahertz of spectrum across the 37 GHz and 39 GHz bands if it so chose (this maximum of 400 megahertz assumes it has no current holdings in the 39 GHz band). Similar calculations would apply in the 39 GHz band. For instance, for those licensees that currently hold more than 400 megahertz of spectrum in the 39 GHz band in any county in a given PEA, such entities would be unable to bid on both licenses in the 28 GHz band but potentially could still bid for one license in the 28 GHz band, as well as on 37 GHz spectrum and additional 39 GHz spectrum. To determine bidding eligibility across the three bands for those entities who do not currently hold licenses in the 28 GHz or 39 GHz band, we would similarly count maximum spectrum holdings in counties at the PEA level. The "maximum county-to-PEA" option is a simple way to calculate spectrum holdings in which the licensing areas of each band have varied geographies, and we seek comment on this first methodology for determining eligibility to bid.

487. The second methodology that we invite comment on is the "population-weighted-average" option. This option involves calculating an entity's current spectrum holdings on a county-by-county basis within a PEA in the 28 GHz and 39 GHz bands, and then constructing a population weighted average for that PEA as a whole. For incumbent licensees in the 28 GHz and 39 GHz bands, we would sum the product of county spectrum holdings and county population within the PEA (using U.S. Census 2010 population data), and then divide that sum by the total population of the PEA. This would provide us with the population-weighted amount of 28 GHz and 39 GHz spectrum held by that incumbent in that PEA. The entity would then be able to bid on 28 GHz spectrum (by county, and any winning bid would be weighted by the county population divided by the PEA population), and 37 GHz and 39 GHz spectrum (by PEA or partial PEA), up to the population-weighted limit of 1250 megahertz. To determine eligibility to bid for those entities who do not currently hold licenses in the 28 GHz or 39 GHz bands, we would also calculate prospective holdings based on a population-weighted average within the PEA. Overall, any entity would not be able to bid on certain spectrum if, across the three bands, it would hold 1250 megahertz or more on a population-weighted basis. We seek comment on this second methodology for determining eligibility to bid.

2. Holding Period

488. In addition to the decisions made today, we seek comment on our proposal to adopt a holding period that would preclude certain proposed secondary market transactions for licensees that acquire certain amounts of 28 GHz, 37 GHz, and/or 39 GHz spectrum at auction. In the *Mobile Spectrum Holdings Report and Order,* the Commission established a six-year holding period, which represented the interim buildout period for 600 MHz licensees, restricting certain proposed secondary market transactions

[1199] We note that with respect to those PEAs in the 28 GHz band in which the incumbent already has certain county-wide holdings, incumbents would still be able to bid on any remaining counties in the PEA.

for 600 MHz band licensees.[1200] The Commission determined that establishing a holding period best balanced its goals of preserving the integrity of the market-based spectrum reserve it had established while still permitting some flexibility in secondary market transactions.[1201]

489. We propose to adopt a holding period for licensees acquiring spectrum in the 28 GHz, 37 GHz, and/or 39 GHz bands. In particular, we seek comment on our proposal to adopt a holding period that would restrict certain proposed secondary market transactions for mmW licensees necessary to support the spectrum aggregation policies we adopt today as well as our objective of ensuring that multiple providers will be able to access mmW spectrum as it becomes available.

490. We propose a period of three years, given the nascent nature of the frontier spectrum in the 28 GHz, 37 GHz, and 39 GHz bands and the likely rapid development of multiple use cases for this spectrum. While we could establish a holding period tied to the length of the license term or build out period for licensees in these bands, a shorter three-year holding period that is half of the buildout period we establish for incumbent licensees in the 28 GHz and 39 GHz bands may best serve the public interest by allowing flexibility while still preventing entities from undermining our *ex ante* spectrum aggregation policies. We seek comment on our proposal. To the extent commenters support a longer holding period, we seek comment on how a longer holding period would better help the Commission achieve its objectives for the use of this spectrum. If a longer holding period is warranted, how long should it be? For example, should the length of the holding period be based on the 10 year license term and performance benchmarks for new licensees that we adopt today or would a different holding period be appropriate? We ask commenters to address how the Commission can best balance its general policy of promoting flexibility in secondary market transactions with our goals of encouraging competition and facilitating the deployment of new services and innovation to the benefit of consumers.

3. Spectrum Aggregation Limits For Additional Spectrum Bands

491. As discussed above, we determined that grouping spectrum in the 28 GHz, 37 GHz, and 39 GHz bands together for purposes of applying these mobile spectrum holdings policies is appropriate in view of the similar technical characteristics and potential uses of spectrum in these bands.[1202] We seek comment on the proposal to apply spectrum aggregation policies generally in the bands we propose making available in this Further Notice. The objective of the spectrum aggregation polices we adopt today is to promote competitive conditions and help ensure that multiple providers have the ability to acquire mmW spectrum as it becomes available, while avoiding the excessive concentration of licenses. Further, to the extent these bands to be made available have similar technical characteristics and potential uses as the 28 GHz, 37 GHz, and 39 GHz bands, we propose to use the approximately one-third threshold of the total amount of spectrum as our starting point but recognize that the Commission's understanding of the appropriate approach for these bands is developing and that other thresholds may be appropriate. Is the approximately one-third threshold appropriate or are there alternative thresholds that the Commission should consider? What are the likely benefits and costs of our proposed threshold? We ask interested parties to provide us with any alternative approaches to the appropriate spectrum aggregation policies for these bands as they become available.

E. 37.5-40 GHz Band Satellite Issues

1. Satellite Power Flux Density Limits

492. *Background.* In the *V-Band Second Report and Order,* the Commission determined that Fixed Service use of the 37.5-40 GHz band would be primarily for high density FS operations[1203] while

[1200] *Mobile Spectrum Holdings Report and Order*, 29 FCC Rcd at 6212-13, paras. 196-200.

[1201] *Id.* at 6212, para. 197.

[1202] *See supra* Section IV.F (Licensing, Operating, and Regulatory Issues).

[1203] *See V-band Second Report and Order*, 18 FCC Rcd at 25438, para. 23.

Fixed-Satellite Service use of that band would be for gateway earth stations.[1204] The Commission defined high density FS as follows:

493. High density systems and usages in the fixed service are generally characterized by applications requiring the ability to: (1) operate on a point-to-point or point-to-multipoint basis, or a combination of both; (2) flexibly achieve, over short periods of time, a concentration of links on the same channel(s) within an area; (3) increase frequency reuse; and (4) decrease terminal size and cost of equipment. The term "high density fixed service" does not refer to a particular application or band in the fixed service, but does describe the phenomena of maximized deployment densities, spectrum reuse and spectral efficiencies realized by concentrated deployments. Often these deployment density, spectrum reuse and spectral efficiency factors become more pronounced in the higher bands.[1205]

494. To accommodate FS in the 37.5-40.0 GHz band and FSS in the 40.0-42.0 GHz band, the Commission adopted what it called a "soft segmentation" approach by implementing power flux density (PFD) limits on FSS at a level 12 dB lower in the 37.5-40.0 GHz band than in the 40.0-42.0 GHz band.[1206] The Commission stated that it was making higher power levels available for satellite operations in the 40.0-42.0 GHz band in order to motivate high density FSS (HDFSS) to use that band rather than the 37.5-40.0 GHz band, and that it was setting satellite PFD limits at a lower level in the 37.5-40.0 GHz band in order to protect ubiquitously deployed high density FS stations from interference from satellite signals.[1207] The Commission proposed to allow satellites to raise the power levels of their spot beams during rain storms,[1208] but the agency has not yet adopted a rulemaking order to implement that proposal.[1209]

495. The *NPRM* in this proceeding sought to refresh the record by inviting comments on the terms and conditions under which satellite operators should be allowed to increase their PFDs in the 37.5-40 GHz band to overcome rain-fade conditions, as the Commission proposed earlier in the *V-Band Third FNPRM*.[1210] The Commission invited commenters to propose means by which satellite operators might be able to discern the conditions under which terrestrial operations would be shielded by the same rain storms that are affecting satellite earth stations and, thus, would not necessarily experience interference if a satellite operator were to raise its PFD.[1211] It also sought to identify means by which satellite operators could discern when the affected terrestrial operators would not be shielded from increased satellite PFD and would experience elevated levels of interference, asking if satellite operators might be able to use weather radar data to determine when satellite PFD adjustments are needed and when terrestrial systems would also be affected by rain fade. The Commission also asked if commercially available equipment

[1204] *See V-band Second Report and Order*, 18 FCC Rcd at 25442, para. 33.

[1205] *In the Matter of Amendment of Part 2 of the Commission's Rules to Allocate Additional Spectrum to the Inter-Satellite, Fixed, and Mobile Services and to Permit Unlicensed Devices to Use Certain Segments in the 50.2-50.4 GHz and 51.4-71.0 GHz Bands*, Report and Order, 15 FCC Rcd 25264 at _, para. 24, n. 46 (2000).

[1206] *See V-Band Third FNPRM,* 25 FCC Rcd at 15675, para. 31*, citing V-Band Second Report and Order,* 18 FCC Rcd at 25438, para. 23, and 47 CFR § 25.208(q)-(t) (PFD limits for FSS).

[1207] *See V-Band Third FNPRM,* 25 FCC Rcd at 15675, para. 31.

[1208] *See V-Band Third FNPRM,* 25 FCC Rcd at 15674-15683, paras. 30-55.

[1209] 47 CFR §§ 25.208(q)(2) and (r)(2) provide language that would allow satellite operators to raise PFD levels during rain conditions, but both subsections are followed by notes stating, "The conditions under which satellites may exceed the power flux-density limits for normal free space propagation . . . to compensate for the effects of rain fading are under study and have therefore not yet been defined. Such conditions and the extent to which these limits can be exceeded will be the subject of a further rulemaking by the Commission on the satellite service rules."

[1210] *NPRM*, 30 FCC Rcd at 11927, para. 165, *citing V-Band Third FNPRM,* 25 FCC Rcd at 15674-15683, paras. 30-55.

[1211] *NPRM*, 30 FCC Rcd at 11927, para. 165.

could enable terrestrial operators to determine when they are experiencing elevated levels of interference from satellite signals, and to differentiate that source of interference from the rain-fade conditions that might be causing nearby satellite earth stations to request increased PFD from the satellite. The *NPRM* further requested comment on the feasibility of establishing automatic, real-time linkages between satellite and terrestrial operators so that their equipment can coordinate their strategies to overcome interference from natural causes and from each other.[1212]

496. FiberTower, Straight Path, and T-Mobile oppose any increase in satellite PFD levels; Nokia says that the interference impact should be carefully assessed before the Commission adopts any changes.[1213] Straight Path provides the most detailed critique, noting that mobile units' beamforming antennas will typically be angled upward at a slight angle to receive signals from mobile base stations, and that mobile units will have only a limited ability to suppress interference from satellite signals.[1214] Straight Path estimates that allowing three satellites to operate at the higher PFD level would result in a coverage area reduction between 15 and 80 percent, depending on the terrestrial use.[1215] Satellite interests generally favor increasing satellite PFD limits in the 37.5-40 GHz band.[1216] Boeing argues that satellite systems can be configured to produce 'no significant impact' on terrestrial systems even if the satellites operate at the higher PFD level.[1217]

497. *Discussion.* We do not believe the current record is sufficient for us to conclude that authorizing satellites to operate at the higher PFD of -105 dBW/m^2/MHz would be consistent with terrestrial use of the 37.5-40 GHz band. In theory, the same rain storm that impairs satellite reception might be able to shield earth stations if the satellite raises its power level; the problem is that rain will rarely be uniformly present throughout a spot beam's footprint, leaving at least some terrestrial stations unshielded or inadequately shielded by rain and, hence, vulnerable to any increase in the spot beam's PFD level. Unlike with respect to the 28 GHz band, the issue of satellite-terrestrial coexistence in the 39 GHz band has received relatively little attention.

498. At the same time, we recognize that Boeing has submitted a study which shows that coexistence is possible, even at the higher PFD level. Boeing's presentation suggests that terrestrial mobile units might be able to suppress interfering signals from satellites if the satellite signals arrive at sufficiently high angles of elevation.[1218] On the other hand, Boeing assumes a maximum distance of 200 meters between mobile units and base stations.[1219] We believe the record would benefit from further development on this issue.

499. Accordingly, we seek further comment on whether there are any circumstances under which allowing FSS satellites in the 37.5-40 GHz band to operate at a higher PFD level than permitted under the existing rules would be consistent with terrestrial use of the 37.5-40 GHz band. If a higher PFD limit would be appropriate, what limit should we adopt? Commenters should provide detailed technical studies that explicitly list the assumptions they made concerning both terrestrial and satellite operations. Studies should study both fixed and mobile terrestrial operations. If a commenter believes a study submitted by another commenter is not valid, it should list the specific assumptions or analysis that it

[1212] *NPRM*, 30 FCC Rcd at 11927, para. 165.

[1213] Fiber Tower Comments at 7, Nokia Comments at 25, Straight Path Comments at 33-35, and T-Mobile Comments at 18; FiberTower Reply at 6 and Straight Path Reply at 21.

[1214] *See* Straight Path Comments at 34.

[1215] Straight Path Comments at 35, Appendix B.

[1216] *See, e.g.*, ViaSat Comments at ii, 10, 20; SIA Reply at 13.

[1217] Boeing May 9, *Ex Parte* Letter, Attach. at 5. *See also* Boeing June 17, *Ex Parte* Letter.

[1218] *See* Boeing May 9, *Ex Parte* Letter. *See also* Boeing June 17, *Ex Parte* Letter.

[1219] Boeing May 9, *Ex Parte* Letter, Attach. at 5. *See also* Boeing June 17, *Ex Parte* Letter.

believes are not valid and provide its own assumptions or analysis. Ultimately, we believe the burden is on FSS interests to show that the higher PFD level is consistent with terrestrial use. Terrestrial interests do have an obligation to provide sufficient information concerning the nature of their systems to allow other parties to analyze the interference impact of a higher PFD level.

2. Authorizing Satellite User Equipment

500. *Background.* Currently, satellite earth station facilities in the 37.5-40 GHz band may not be ubiquitously deployed and may not be used to serve individual consumers.[1220] ViaSat proposes allowing satellite user equipment in this band on a secondary basis.[1221] It argues that allowing user equipment would have no impact on terrestrial operations because earth stations receive in this band and because the user equipment would have to accept interference from terrestrial operations.[1222] Boeing suggests that satellite receivers offer high isolation and may be able to share with terrestrial mobile and base stations, although it admits that further study and consultation with the wireless industry is required.[1223] Straight Path, on the other hand, claims that prohibiting satellite user equipment "is an essential part of the regulatory structure to preserve the 37.5–40 GHz band for terrestrial services."[1224]

501. *Discussion*. We seek comment on the possibility of repealing the prohibition on satellite user equipment in the 37.5-40 GHz band. Initially, we ask satellite interests to provide further information concerning the need and demand for user equipment in that band. We note that FSS user equipment can receive in the 40-42 GHz band, which is not licensed for terrestrial operations. Are there uses for which access to the 40-42 GHz band is insufficient? We ask FSS providers to provide specific examples and data demonstrating the need for user equipment in the 37.5-40 GHz band.

502. Assuming a need exists, we seek comment on the appropriate manner of authorizing satellite user equipment. We agree with ViaSat's observation that because user equipment in this band would be receiving, it would not cause interference to terrestrial operations. One option would be to adopt ViaSat's proposal to allow FSS user equipment purely on a secondary basis at their own risk. If we adopted that proposal, we emphasize that the equipment would truly be on a secondary basis and that FSS user equipment would have no expectation of interference protection. A variation on that option, based on the analysis Boeing has done, would be to require terrestrial operators to provide information on their deployments to FSS providers through a database, which the FSS providers could then use to determine where user equipment could operate without interference. We ask other parties to comment on Boeing's technical analysis. To the extent Boeing relies on erroneous data concerning the nature of technical operations, we ask terrestrial operators and equipment manufacturers to provide a specific analysis in response, with an explanation for the specific parameters used in their analysis. We also seek comment on whether the benefit to FSS operators of enhancing the ability to operate user equipment in the band outweighs the burden to UMFUS licensees of providing information on their deployments. We ask both FSS operators and terrestrial operators to provide specific data on the relative costs and benefits.

F. Digital Station Identification

503. Currently, AM/FM/TV broadcasters are required to announce their call signs, as are land mobile station operators. Adopting a similar requirement for millimeter wave band operations could make it easier to identify and monitor signals, which in turn could make it easier to find sources of interference to these systems. Accordingly, we seek comment on requiring a digital identification (digital ID) for the millimeter wave band systems under consideration in this proceeding. Specifically, should

[1220] 47 CFR § 25.202(a)(1) n.3.

[1221] ViaSat Comments at 21.

[1222] ViaSat Comments at 21.

[1223] *See* Boeing June 6, *Ex Parte* Letter, Attach. at 19 -20.

[1224] Straight Path Comments at 31.

operators be required to transmit an ID that is readily observable and decipherable by the Commission and/or other users that could be used to identify the operator/licensee of an unknown and/or interference source?

504. If so, we seek comment on the details of such a digital ID requirement. For example, should the ID requirement apply to all millimeter wave band services, or be limited to licensed services, non-licensed services, or fixed operations? Alternatively, should it apply to all transmissions above a certain power limit or antenna height, or be limited to transmissions with some other technical parameter? If so, what should those technical parameters be? If there is an ID requirement for unlicensed equipment, what should the content of the ID be? Should unlicensed equipment authorization holder or equipment user be required to register in a nationwide database that would allow either the FCC and/or anyone to search an ID for operator contact information? Should the ID be continuously broadcast, similar to consumer Wi-Fi routers, only when the transmitter is operational, or only at regular intervals? Finally, should there be a labeling (or software screen display) requirement for the equipment itself that identifies the owner/operator? If so, should the requirement apply to all millimeter wave band equipment, or only to fixed or mobile equipment, only to outdoor equipment, or only to some other subset of millimeter wave band equipment?

G. Technical Issues

1. Antenna Height

505. *Background*. In the *NPRM*, we sought comment on antenna height limits. One of the questions asked in the *NPRM* was "Should lower transmission power limits be applied to unusually high antennas?" This question received little comment on the record. However, we believe that further consideration of antenna height and power limits may be warranted as an additional measure to mitigate interference between licensees and promote sharing among services. Straight Path believes that the 1,000 foot height limit will be sufficient to mitigate the risk of harmful interference from high-elevation transmitters in the mmW bands[1225]. T-Mobile also generally supports the Commission's proposal to follow its PCS and AWS rules for base station power limits and antenna heights. The current Part 27 rules require the reduction of the transmit power limit as the height is increased (above 305 meters).[1226]

506. *Discussion*. We seek further comment on whether antenna height limits are appropriate and, if so, what thresholds and corresponding reductions in power should apply at higher antenna heights. Considering what future wireless networks are envisioned to be, are the antenna height thresholds and corresponding power reductions in the existing Part 24 (PCS)[1227] or Part 27[1228] rules appropriate for future mmW mobile base stations? Based on what has been presented on the record, mobile mmW base stations in this band may be more likely deployed at street lamp post height, and will not be deployed at the heights of traditional mobile base station deployments. In that context is the 305 meter threshold currently in Part 27 valid or would lower thresholds be appropriate? Is there an alternative maximum height that should be considered? Conversely, given the existing PFD limits that we have adopted to control interference at market boundaries and at the edge of an earth station contour, are additional antenna height restrictions and corresponding power reductions even necessary? We tentatively propose to adopt antenna height and power limits similar to those in our Part 27 rules. However, we seek comment on whether power limits based on antenna height are necessary and/or whether any modifications should be made to either the height thresholds or the power limits at specific heights that we have proposed. We also seek comment on whether there would there be any benefit in requiring antenna downtilt for antennas above a certain height?

[1225] Straight Path Comments at 43.

[1226] *See* 47 CFR § 27.50(b).

[1227] *See* 47 CFR § 24.232(a)(4)

[1228] *See* 47 CFR § 27.50(e)(4)

2. Minimum Bandwidth for Given BS/MS/Transportable Transmit Power Levels

507. *Background*. In the rule we adopt for the base station power limits we scale the maximum power over a 100 MHz band width. Part 27 mobile devices do not have band width scaling factor requirements such as the base stations whose power levels are typically measured over channels band widths ranging from 5 megahertz to 10 megahertz. In the context of future wireless networks such as those envisioned for 5G, it seems reasonable to consider an overarching 5G umbrella network that resides over multiple disparate subnetworks, some of which might operate with bandwidths scaled much smaller than the 100 MHz band width factor for which the maximum power adopted in the *Report and Order* for base stations is to be applied across. Additionally a band width scaling factor for mobiles stations and transportable stations was not contemplated in the *NPRM*.

508. *Discussion*. For applications and technologies that operate under the umbrella of the next generation of wireless networks, is it worth considering a sub-set of networks that might operate with band widths less than 100 megahertz and how the maximum power limits adopted should be evaluated? What minimum band width should be established for base stations, transportable station, and mobile station classes of equipment? Is there value in establishing these bandwidth scaling limits for mobile and transportable classes such as we did for base stations? If so what should the minimum band width scaling factors be for these classes of equipment based on the power levels we adopt in the *Report and Order*? What is the minimum bandwidth that should be established for these two classes of equipment in relation to the adopted transmit power limits? Should the establishment of these limits be comparable to the rules that currently exist for part 27 frequency bands?

3. Coordination Criteria at Market Borders for Fixed Point-to-Point Operations

509. *Background.* In the *Report and Order*, we recognize that the unique characteristics of traditional fixed point-to-point deployments warrant different market border limits and coordination requirements than base/mobile operations and in-band backhaul using the same equipment. We adopt a PFD at the border for base/mobile operations and in-band backhaul, but retain the existing Part 101 coordination requirements for traditional fixed point-to-point deployments. Under the existing rules, fixed point-to-point operations within 16 kilometers (in the 38.6-40 GHz band) or 20 kilometers (in the 27.5-28.35 GHz band) of a licensee's market boundary must coordinate with co-channel licensees in adjacent market areas. We also adopt rules that modified the size of the market areas for 28 GHz and 39 GHz band. Specifically, we adopt counties as the license market area for the 28 GHz band and PEAs as the market area for the 39 GHz band.

510. *Discussion*. In the context of the newly adopted rules, in particular with smaller licensed areas, we recognize that the existing coordination distances of 16 km for 39 GHz and 20 km for 28GHz result in coordination zones that encompass a large part of many license areas. In fact, in the context of 28 GHz county based licenses, the entire market area is subject to the coordination requirement in many cases. In adopting market border limits and coordination requirements our goal is to ensure that there is a mechanism in place to mitigate interference between adjacent area licensees without creating an unnecessary burden on licensees. While we recognize that under our rules adjacent area licensees are able to negotiate and agree to mutual terms and criteria that deviate from the market border and coordination limits imposed in our rules, we also believe that the changes that we adopt to market sizes warrants re-examination of the market boundary coordination requirements that were originally developed in the context of larger market sizes. Therefore, we now seek to create a record with an eye toward reducing the coordination burden on licensees. We note that in its comments in response to the *NPRM*, Sprint recommends that the Commission require an operator proposing to initiate new fixed operations to coordinate those operations with the adjacent block operator when a new fixed transmitter would be located within 3 km and within +/- 10 degrees of the receive azimuth of an existing fixed receiver, or a new fixed transmitter would be within 1 km of an existing fixed receiver, but outside the +/- 10 degree receive antenna main lobe, in order to avoid adjacent channel OOBE interference or brute force

receiver overload.[1229] While Sprint's comments were in relation to adjacent channel interference a similar approach might be appropriate for co-channel coordination. We seek comment first on whether the existing coordination distances for traditional fixed point-to-point operations are still appropriate given smaller market area sizes. We also seek comment on whether the coordination distance should incorporate other technical criteria into factoring the distance. For example, should the coordination distances be dependent on the orientation of the fixed point-to-point antenna relative to the market boundary? Should the coordination distance be reduced in cases where a directional antenna is pointed away from the market boundary? Should the coordination distance be dependent on other technical factors such as the EIRP of the transmitting station, gain of the antenna, or other factors? We request comment on these issues. We request that commenters support any proposal with technical analysis.

4. Sharing Analysis and Modeling

511. *Background.* In the *NPRM* the Commission solicited comment on issues pertaining to spectrum sharing analysis and modeling.[1230] In particular we asked for comment on a sharing analysis framework for fixed, mobile, and satellite systems as well as between active and passive services in the millimeter bands. We specifically requested technical information on transmitter, receiver, and antenna characteristics, operational assumptions including antenna orientation and practical use cases. We also requested information on appropriate propagation models that would assist in evaluating the interference potential for each sharing use case, including aggregate effects, as applicable. We received limited comments on this topic[1231] therefore we are soliciting further comment in this *FNPRM*.

512. *Discussion*. The wireless industry, standards groups, government organizations, and academia are currently engaged in developing propagation models for millimeter wave bands. The National Institute of Standards and Technology (NIST) and the European Commission's 5G partnership with industry have active study groups looking at millimeter wave propagation modeling.[1232] Academia have published papers describing several models such as the Close In (CI) and alpha-beta-gamma (ABG) free space reference distance models.[1233] We seek comment on whether these or other models are appropriate propagation models to apply when analyzing inter-service interference between terrestrial-based transmitters and receivers of different services. There are several factors that are common to the interference effects in both directions to and from 5G stations, including antenna beam forming, the location and height of antennas, and the propagation distance and environment between other systems and the 5G stations. Lower gain 5G antennas that are mostly indoors in cluttered environments and at lower heights will reduce the degree of RF coupling in both directions, and therefore reduce the propagation path loss required to meet interference threshold limits. Which millimeter wave propagation models are most appropriate for sharing analyses where the interfering emitters may be assembled from a group of indoor and outdoor emitters? When applying transmitter or receiver isolation factors such as antenna directionality, should a degree of statistical probability be associated with the factor versus the assumption of worse case interference? We ask parties to submit propagation analysis and path loss models of 5G deployment in both indoor and outdoor environments for use in determining interference impact and potential mitigation.

[1229] *See* Sprint Reply at 5.

[1230] *See generally NPRM*, 30 FCC Rcd at 11970.

[1231] *See* Vubiq Comments at 6-7.

[1232] *See* 5GPPP: The 5G Infrastructure Public Private Partnership, https://5g-ppp.eu/mmmagic/, National Institute of Science and Technology, *5G Millimeter Wave Channel Alliance*, http://www.nist.gov/ctl/wireless-networks/5gmillimeterwavechannelmodel.cfm.

[1233] *See, e.g.*, Shu Sun et. al., *Propagation Path Loss Models for 5G Urban Micro- and Macro-Cellular Scenarios*, in 2016 IEEE 83rd Vehicular Technology Conference (May 2016) (https://arxiv.org/pdf/1511.07311.pdf).

513. If the terrestrial receiver or transmitter is fixed at a specific location then a terrain-based propagation loss model can be employed; what terrain based propagation models are most appropriate for millimeter wave analyses? When the terrestrial receiver is not at a known location, what are the most appropriate millimeter wave models to apply? How much isolation could one typically assume due to antenna beam forming techniques? What other interference mechanism, such as clutter, should be considered when modeling inter-service interference in millimeter wave bands? Generally, we seek further comment on millimeter wave propagation models appropriate for spectrum sharing studies between fixed, mobile and satellite systems, as well as active and passive services.

5. Part 15 Operation On-board Aircraft in the 57-71 GHz Band

514. *Background.* In the *NPRM*, the Commission did not propose to allow 60 GHz operation on-board aircraft, but stated it believed that the prohibition on operation on-board aircraft of 60 GHz devices may be revisited. To compile a comprehensive record on this issue, the Commission sought technical studies and interference analyses demonstrating whether transmissions in the 57-71 GHz band should be permitted on aircraft over the entire band, or potentially limited to a narrower portion of the band to minimize impact to the radio astronomy observations.[1234] In the *Report and Order* portion of this item, we determined that the record thus far did not reflect a clear perspective of the types of unlicensed applications envisioned on-board aircraft that would provide an adequate assessment of their harmful interference potential to passive sensor services.[1235]

515. *Discussion*. We are seeking further technical analyses and sharing studies, specifically with respect to the various types of unlicensed applications envisioned on-board aircraft, the priority/order of their planned introduction, as well as their associated potential harmful interference profile with respect to passive sensor services. For example, is the intent to provide only for applications that are used by the aircraft itself to reduce weight by replacing cabling and wiring with radio for applications, such as for connecting inflight entertainment systems, seatback display consoles, or connecting with sensors used to monitor the health of the aircraft structure and its critical systems in wireless avionics intra-communication (WAIC)? [1236] Or is the intent to provide for the direct streaming of movies/news/internet service from ceiling-mounted access points to portable electronic devices carried aboard the aircraft by passengers in nearby seats? Are there additional inflight applications that commenters further envision?

516. What harmful interference profile could be expected from each of these various types of on-board aircraft provisions of 60 GHz transmitters? How much difference would the type of aircraft body make in providing additional protection to passive sensor services from operation of these transmitters? Should we propose, as a first cautious step, to allow WiGig transmissions on-board aircraft only for certain applications, such as inflight entertainment provision beaming from seatback display to user-provided devices, because such transmissions would be at a very short distance (1-2 feet, or 30 to 60 cm), in a direct line-of-sight between each seatback display and user-provided device, with little risk of escaping through cabin windows?[1237] If we were to prohibit the first WiGig channel (57.24-59.4 GHz) as

[1234] *NPRM*, 30 FCC Rcd at 11966, para. 304.

[1235] *See* discussion in Section V.G.5 (Technical Rules for Part 15 Operation in the 57-71 GHz Band) at para. 332, *supra*.

[1236] WAIC systems provide radio communication between two or more stations on a single aircraft and constitute exclusive closed on-board networks required for the operation of an aircraft. Examples of WAIC applications that could benefit from the high-data rate provided by 60 GHz transmitters are flight deck and cabin crew communications, still-frame and video imagery, high-data rate engine sensors, or avionics data bus communications throughout the aircraft. High-data rates WAIC applications could also encompass external structural sensors or external cameras mounted on the outside of the aircraft structure to monitor the taxi, take-off, landing, cruise, etc. phases of aircraft operation. WAIC systems do not provide air-to-ground, air-to-satellite or air-to-air communications. *See Technical characteristics and spectrum requirements of Wireless Avionics Intra-Communications systems to support their safe operation*, ITU-R Report M.2283-0 (November 2013), at 6.

[1237] Note that not all existing aircraft provide seatback displays at each seat or row of seats.

CORF suggested to protect EESS,[1238] would this limitation ameliorate in any way the need to protect RAS, as WiGig devices will be using the rest of the spectrum from 59.4 GHz to 71 GHz? How would RAS and EESS be protected from potential WAIC applications using external structural sensors or cameras mounted on the outside of the aircraft structure to monitor the performance of the aircraft during various phases of aircraft operation (taxi, take-off, landing, cruise, etc.)?[1239] Commenters should provide detailed technical analyses, with possible real-world transmission scenarios on aircraft, including expected signal leakage in this particular frequency band through *unshielded* cabin windows for the various types of inflight applications (*e.g.*, entertainment provisions, WAIC provisions, etc.) in different aircraft body structures if the fuselage type and cabin window placements make a difference in signal shielding, etc., and any other additional harmful interference considerations involving use of 60 GHz transmitters on-board aircraft.[1240]

VI. PROCEDURAL MATTERS

A. *Ex Parte* Rules – Permit-But-Disclose

517. Pursuant to Section 1.1200(a) of the Commission's rules,[1241] this *FNPRM* shall be treated as a "permit-but-disclose" proceeding in accordance with the Commission's *ex parte* rules.[1242] Persons making *ex parte* presentations must file a copy of any written presentation or a memorandum summarizing any oral presentation within two business days after the presentation (unless a different deadline applicable to the Sunshine period applies). Persons making oral *ex parte* presentations are reminded that memoranda summarizing the presentation must (1) list all persons attending or otherwise participating in the meeting at which the *ex parte* presentation was made, and (2) summarize all data presented and arguments made during the presentation. If the presentation consisted in whole or in part of the presentation of data or arguments already reflected in the presenter's written comments, memoranda or other filings in the proceeding, the presenter may provide citations to such data or arguments in his or her prior comments, memoranda, or other filings (specifying the relevant page and/or paragraph numbers where such data or arguments can be found) in lieu of summarizing them in the memorandum. Documents shown or given to Commission staff during *ex parte* meetings are deemed to be written *ex parte* presentations and must be filed consistent with rule 1.1206(b). In proceedings governed by rule 1.49(f) or for which the Commission has made available a method of electronic filing, written *ex parte* presentations and memoranda summarizing oral *ex parte* presentations, and all attachments thereto, must be filed through the electronic comment filing system available for that proceeding, and must be filed in their native format (e.g., .doc, .xml, .ppt, searchable .pdf). Participants in this proceeding should familiarize themselves with the Commission's *ex parte* rules.

B. Comment Period and Procedures

518. Pursuant to Sections 1.415 and 1.419 of the Commission's rules, 47 CFR §§ 1.415, 1.419, interested parties may file comments and reply comments on or before the dates indicated on the first page of this document. Comments may be filed using the Commission's Electronic Comment Filing System (ECFS). *See Electronic Filing of Documents in Rulemaking Proceedings*, 63 FR 24121 (1998).

[1238] CORF Reply at 7.

[1239] *See Technical characteristics and spectrum requirements of Wireless Avionics Intra-Communications systems to support their safe operation*, ITU-R Report M.2283-0 (November 2013), at 15-16.

[1240] Note that cabin window placements are very different in a wide-body aircraft than in a small single/quad-passenger aircraft. WAIC systems would also greatly benefit a small passenger aircraft by reducing its weight due to cabling and wiring, and providing enhanced flexibility and safety.

[1241] 47 CFR § 1.1200(a).

[1242] 47 CFR §§ 1.1200 *et seq.*

- Electronic Filers: Comments may be filed electronically using the Internet by accessing the ECFS: http://fjallfoss.fcc.gov/ecfs2/.

- Paper Filers: Parties who choose to file by paper must file an original and one copy of each filing. If more than one docket or rulemaking number appears in the caption of this proceeding, filers must submit two additional copies for each additional docket or rulemaking number.

  Filings can be sent by hand or messenger delivery, by commercial overnight courier, or by first-class or overnight U.S. Postal Service mail. All filings must be addressed to the Commission's Secretary, Office of the Secretary, Federal Communications Commission.

  - All hand-delivered or messenger-delivered paper filings for the Commission's Secretary must be delivered to FCC Headquarters at 445 12th St., SW, Room TW-A325, Washington, DC 20554. The filing hours are 8:00 a.m. to 7:00 p.m. All hand deliveries must be held together with rubber bands or fasteners. Any envelopes and boxes must be disposed of before entering the building.

  - Commercial overnight mail (other than U.S. Postal Service Express Mail and Priority Mail) must be sent to 9300 East Hampton Drive, Capitol Heights, MD 20743.

  - U.S. Postal Service first-class, Express, and Priority mail must be addressed to 445 12th Street, SW, Washington DC 20554.

519. People with Disabilities: To request materials in accessible formats for people with disabilities (braille, large print, electronic files, audio format), send an e-mail to fcc504@fcc.gov or call the Consumer & Governmental Affairs Bureau at 202-418-0530 (voice), 202-418-0432 (tty).

C. Regulatory Flexibility Analysis

520. As required by the Regulatory Flexibility Act of 1980 (RFA),[1243] the Commission has prepared a Final Regulatory Flexibility Analysis (FRFA) of the possible significant economic impact on small entities of the policies and rules adopted in the *Report and Order*. The analysis is found in Appendix E.

521. In addition, we have prepared an Initial Regulatory Flexibility Analysis (IRFA) regarding the significant economic impact on small entities of the policies and rules adopted in the *Further Notice of Proposed Rulemaking*, which is found in Appendix G. We request written public comment on the IRFA. Comments must be filed in accordance with the same deadlines as comments filed in response to the *FNRPM* and must have a separate and distinct heading designating them as responses to the IRFA.

D. Paperwork Reduction Analysis

522. This document contains new and proposed information collection requirements. The Commission, as part of its continuing effort to reduce paperwork burdens, invites the general public and the Office of Management and Budget to comment on the information collection requirements contained in this document, as required by the Paperwork Reduction Act of 1995, Public Law 104-13. In addition, pursuant to the Small Business Paperwork Relief Act of 2002, Public Law 107-198, *see* 44 U.S.C. 3506(c)(4), we seek specific comment on how we might further reduce the information collection burden for small business concerns with fewer than 25 employees.

[1243] *See* 5 U.S.C. § 603.

E. Further Information

523. For further information, contact John Schauble of the Wireless Telecommunications Bureau, Broadband Division, at 202-418-0797 or John.Schauble@fcc.gov, Michael Ha of the Office of Engineering and Technology, Policy and Rules Division, at 202-418-2099 or Michael.Ha@fcc.gov, or Jose Albuquerque of the International Bureau, Satellite Division, at 202-418-2288 or Jose.Albuquerque@fcc.gov.

VII. ORDERING CLAUSES

524. IT IS ORDERED, pursuant to the authority found in Sections 1, 2, 3, 4, 5, 7, 10, 201, 225, 227, 301, 302, 302a, 303, 304, 307, 309, 310, 316, 319, 332, and 336 of the Communications Act of 1934, 47 U.S.C. §§ 151, 152, 153, 154, 155, 157, 160, 201, 225, 227, 301, 302, 302a, 303, 304, 307, 309, 310, 316, 319, 332, 336, Section 706 of the Telecommunications Act of 1996, as amended, 47 U.S.C. § 1302, and Section 1.411 of the Commission's Rules, 47 CFR § 1.411, that this *Report and Order and Further Notice of Proposed Rulemaking* IS HEREBY ADOPTED

525. IT IS FURTHER ORDERED that the Commission's rules ARE HEREBY AMENDED as set forth in Appendix A.

526. IT IS FURTHER ORDERED that the rules adopted herein WILL BECOME EFFECTIVE 30 days after the date of publication in the *Federal Register*, except for those rules and requirements which contain new or modified information collection requirements that require approval by the Office of Management and Budget under the Paperwork Reduction Act and WILL BECOME EFFECTIVE after the Commission publishes a notice in the *Federal Register* announcing such approval and the relevant effective date.

527. IT IS FURTHER ORDERED that the Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, SHALL SEND a copy of this *Report and Order and Further Notice of Proposed Rulemaking,* including the Final and Initial Regulatory Flexibility Analysis, to the Chief Counsel for Advocacy of the Small Business Administration.

528. IT IS FURTHER ORDERED that the petition for rulemaking filed by the Fixed Wireless Communications Coalition (RM-11664) IS DENIED with respect to the 42-42.5 GHz band.

529. IT IS FURTHER ORDERED that the Commission SHALL SEND a copy of this Report and Order to Congress and the Government Accountability Office pursuant to the Congressional Review Act, *see* 5 U.S.C. § 801(a)(1)(A).

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

APPENDIX A

Final Rules

For the reasons discussed in the preamble, the Federal Communications Commission amends 47 CFR parts 1, 2, 15, 25, and 101 and adds a new part 30 as follows:

PART 1 – PRACTICE AND PROCEDURE

1. The authority citation for part 1 is revised to read as follows:

Authority: 47 U.S.C. 151, 154(i), 154(j), 155, 157, 160, 201, 225, 227, 303, 309, 332, 1403, 1404, 1451, 1452, and 1455.

2. Section 1.907 is amended by revising the definitions for "Wireless Radio Services" and "Wireless Telecommunications Services" to read as follows:

§ 1.907 Definitions.

* * * * *

Wireless Radio Services. All radio services authorized in parts 13, 20, 22, 24, 26, 27, 30, 74, 80, 87, 90, 95, 96, 97 and 101 of this chapter, whether commercial or private in nature.

Wireless Telecommunications Services. Wireless Radio Services, whether fixed or mobile, that meet the definition of "telecommunications service" as defined by 47 U.S.C. 153, as amended, and are therefore subject to regulation on a common carrier basis. Wireless Telecommunications Services include all radio services authorized by parts 20, 22, 24, 26, 27, and 30 of this chapter. In addition, Wireless Telecommunications Services include Public Coast Stations authorized by part 80 of this chapter, Commercial Mobile Radio Services authorized by part 90 of this chapter, common carrier fixed microwave services, Local Television Transmission Service (LTTS), Local Multipoint Distribution Service (LMDS), and Digital Electronic Message Service (DEMS), authorized by part 101 of this chapter, and Citizens Broadband Radio Services authorized by part 96 of this chapter.

3. Section 1.1307 is amended by adding an entry for "Upper Microwave Flexible Use Service (part 30)" above the entry for "Radio Broadcast Services (part 73)" in Table 1 in paragraph (b)(1) and revising paragraph (b)(2)(i) to read as follows:

§ 1.1307 Actions that may have a significant environmental effect, for which Environmental Assessments (EAs) must be prepared.

* * * * *

(b) * * *

(1) * * *

Table 1—Transmitters, Facilities and Operations Subject to Routine Environmental Evaluation

Service (title 47 CFR rule part)	Evaluation required if:
* * * * *	* * * * *
Upper Microwave Flexible Use Service (part 30)	Non-building-mounted antennas: height above ground level to lowest point of antenna <10 m and power >1640 W EIRP.
	Antennas are mounted on buildings.
* * * * *	* * * * *

(2)(i) Mobile and portable transmitting devices that operate in the Commercial Mobile Radio Services pursuant to part 20 of this chapter; the Cellular Radiotelephone Service pursuant to part 22 of this chapter; the Personal Communications Services (PCS) pursuant to part 24 of this chapter; the Satellite Communications Services pursuant to part 25 of this chapter; the Miscellaneous Wireless Communications Services pursuant to part 27 of this chapter; the Upper Microwave Flexible Use Service pursuant to part 30 of this chapter; the Maritime Services (ship earth stations only) pursuant to part 80 of this chapter; the Specialized Mobile Radio Service, the 4.9 GHz Band Service, or the 3650 MHz Wireless Broadband Service pursuant to part 90 of this chapter; the Wireless Medical Telemetry Service (WMTS), or the Medical Device Radiocommunication Service (MedRadio) pursuant to part 95 of this chapter; or the Citizens Broadband Radio Service pursuant to part 96 of this chapter are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use, as specified in §§ 2.1091 and 2.1093 of this chapter.

* * * * *

4. Section 1.9001 is amended by revising paragraph (a) to read as follows:

§ 1.9001 Purpose and scope.

(a) The purpose of part 1, subpart X is to implement policies and rules pertaining to spectrum leasing arrangements between licensees in the services identified in this subpart and spectrum lessees. This subpart also implements policies for private commons arrangements. These policies and rules also implicate other Commission rule parts, including parts 1, 2, 20, 22, 24, 25, 27, 30, 80, 90, 95, and 101 of

title 47, chapter I of the Code of Federal Regulations.

* * * * *

5. Section 1.9005 is amended by revising paragraphs (hh) through (kk) and adding paragraph (ll) to read as follows:

§ 1.9005 Included services.

* * * * *

(hh) The Multipoint Video Distribution and Data Service (part 101 of this chapter);

(ii) The 700 MHz Guard Bands Service (part 27 of this chapter);

(jj) The ATC of a Mobile Satellite Service (part 25 of this chapter);

(kk) The 600 MHz band (part 27 of this chapter); and

(ll) The Upper Microwave Flexible Use Service (part 30 of this chapter).

PART 2 – FREQUENCY ALLOCATIONS AND RADIO TREATY MATTERS;

GENERAL RULES AND REGULATIONS

6. The authority citation for part 2 continues to read as follows:

Authority: 47 U.S.C. 154, 302a, 303, and 336, unless otherwise noted.

7. Section 2.106, the Table of Frequency Allocations, is amended as follows:

a. Pages 55, 57, 58, and 61 are revised.

b. In the list of United States (US) Footnotes, footnote US151 is added.

c. In the list of Non-Federal Government (NG) Footnotes, footnote NG63 is added.

§ 2.106 Table of Frequency Allocations.

The revisions and additions read as follows:

* * * * *

International Table			United States Table		FCC Rule Part(s)
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table	
27-27.5 FIXED INTER-SATELLITE 5.536 MOBILE	27-27.5 FIXED FIXED-SATELLITE (Earth-to-space) INTER-SATELLITE 5.536 5.537 MOBILE		27-27.5 FIXED INTER-SATELLITE 5.536 MOBILE	27-27.5 Inter-satellite 5.536	RF Devices (15)
27.5-28.5 FIXED 5.537A FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.539 MOBILE 5.538 5.540			27.5-30	27.5-29.5 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE	RF Devices (15) Satellite Communications (25) Upper Microwave Flexible Use (30) Fixed Microwave (101)
28.5-29.1 FIXED FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.523A 5.539 MOBILE Earth exploration-satellite (Earth-to-space) 5.541 5.540					
29.1-29.5 FIXED FIXED-SATELLITE (Earth-to-space) 5.516B 5.523C 5.523E 5.535A 5.539 5.541A MOBILE Earth exploration-satellite (Earth-to-space) 5.541 5.540					
29.5-29.9 FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.539 Earth exploration-satellite (Earth-to-space) 5.541 Mobile-satellite (Earth-to-space) 5.540 5.542	29.5-29.9 FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.539 MOBILE-SATELLITE (Earth-to-space) Earth exploration-satellite (Earth-to-space) 5.541 5.525 5.526 5.527 5.529 5.540 5.542	29.5-29.9 FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.539 Earth exploration-satellite (Earth-to-space) 5.541 Mobile-satellite (Earth-to-space) 5.540 5.542		29.5-30 FIXED-SATELLITE (Earth-to-space) MOBILE-SATELLITE (Earth-to-space) 5.525 5.526 5.527 5.529 5.543	Satellite Communications (25)
29.9-30 FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.539 MOBILE-SATELLITE (Earth-to-space) Earth exploration-satellite (Earth-to-space) 5.541 5.543 5.525 5.526 5.527 5.538 5.540 5.542					
30-31 FIXED-SATELLITE (Earth-to-space) 5.338A MOBILE-SATELLITE (Earth-to-space) Standard frequency and time signal-satellite (space-to-Earth) 5.542			30-31 FIXED-SATELLITE (Earth-to-space) MOBILE-SATELLITE (Earth-to-space) Standard frequency and time signal-satellite (space-to-Earth) G117	30-31 Standard frequency and time signal-satellite (space-to-Earth)	

International Table			United States Table		FCC Rule Part(s)
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table	
34.7-35.2 RADIOLOCATION Space research 5.550 5.549			34.7-35.5 RADIOLOCATION US360 G117	34.7-35.5 Radiolocation US360	Private Land Mobile (90)
35.2-35.5 METEOROLOGICAL AIDS RADIOLOCATION 5.549					
35.5-36 METEOROLOGICAL AIDS EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION SPACE RESEARCH (active) 5.549 5.549A			35.5-36 EARTH EXPLORATION-SATELLITE (active) RADIOLOCATION SPACE RESEARCH (active) US360 G117	35.5-36 Earth exploration-satellite (active) Radiolocation Space research (active) US360	
36-37 EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE SPACE RESEARCH (passive) 5.149 5.550A			36-37 EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE SPACE RESEARCH (passive) US342 US550A		
37-37.5 FIXED MOBILE except aeronautical mobile SPACE RESEARCH (space-to-Earth) 5.547			37-38 FIXED MOBILE SPACE RESEARCH (space-to-Earth)	37-37.5 FIXED MOBILE US151	Upper Microwave Flexible Use (30)
37.5-38 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE except aeronautical mobile SPACE RESEARCH (space-to-Earth) Earth exploration-satellite (space-to-Earth) 5.547				37.5-38 FIXED FIXED-SATELLITE (space-to-Earth) NG63 MOBILE US151	Satellite Communications (25) Upper Microwave Flexible Use (30)
38-39.5 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE Earth exploration-satellite (space-to-Earth) 5.547			38-38.6 FIXED MOBILE 38.6-39.5	38-39.5 FIXED FIXED-SATELLITE (space-to-Earth) NG63 MOBILE NG175	
39.5-40 FIXED FIXED-SATELLITE (space-to-Earth) 5.516B MOBILE MOBILE-SATELLITE (space-to-Earth) Earth exploration-satellite (space-to-Earth) 5.547			39.5-40 FIXED-SATELLITE (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) US382 G117	39.5-40 FIXED FIXED-SATELLITE (space-to-Earth) NG63 MOBILE NG175 US382	

40-40.5 EARTH EXPLORATION-SATELLITE (Earth-to-space) FIXED FIXED-SATELLITE (space-to-Earth) 5.516B MOBILE MOBILE-SATELLITE (space-to-Earth) SPACE RESEARCH (Earth-to-space) Earth exploration-satellite (space-to-Earth)			40-40.5 EARTH EXPLORATION-SATELLITE (Earth-to-space) FIXED-SATELLITE (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) SPACE RESEARCH (Earth-to-space) Earth exploration-satellite (space-to-Earth) G117	40-40.5 FIXED-SATELLITE (space-to-Earth) MOBILE-SATELLITE (space-to-Earth)	Satellite Communications (25)
40.5-41 FIXED FIXED-SATELLITE (space-to-Earth) BROADCASTING BROADCASTING-SATELLITE Mobile 5.547	40.5-41 FIXED FIXED-SATELLITE (space-to-Earth) 5.516B BROADCASTING BROADCASTING-SATELLITE Mobile Mobile-satellite (space-to-Earth) 5.547	40.5-41 FIXED FIXED-SATELLITE (space-to-Earth) BROADCASTING BROADCASTING-SATELLITE Mobile 5.547	40.5-41 FIXED-SATELLITE (space-to-Earth) Mobile-satellite (space-to-Earth) US211 G117	40.5-41 FIXED-SATELLITE (space-to-Earth) BROADCASTING BROADCASTING-SATELLITE Fixed Mobile Mobile-satellite (space-to-Earth) US211	
41-42.5 FIXED FIXED-SATELLITE (space-to-Earth) 5.516B BROADCASTING BROADCASTING-SATELLITE Mobile 5.547 5.551F 5.551H 5.551I			41-42.5 US211	41-42 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE BROADCASTING BROADCASTING-SATELLITE US211 42-42.5 FIXED MOBILE US211	
42.5-43.5 FIXED FIXED-SATELLITE (Earth-to-space) 5.552 MOBILE except aeronautical mobile RADIO ASTRONOMY 5.149 5.547			42.5-43.5 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE except aeronautical mobile RADIO ASTRONOMY US342	42.5-43.5 RADIO ASTRONOMY US342	
43.5-47 MOBILE 5.553 MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE 5.554			43.5-45.5 FIXED-SATELLITE (Earth-to-space) MOBILE-SATELLITE (Earth-to-space) G117	43.5-45.5	
			45.5-46.9 MOBILE MOBILE-SATELLITE (Earth-to-space) RADIONAVIGATION-SATELLITE 5.554		RF Devices (15)

International Table			United States Table		FCC Rule Part(s)
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table	
59-59.3 EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE 5.556A MOBILE 5.558 RADIOLOCATION 5.559 SPACE RESEARCH (passive)			59-59.3 EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE 5.556A MOBILE 5.558 RADIOLOCATION 5.559 SPACE RESEARCH (passive) US353	59-59.3 EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE 5.558 RADIOLOCATION 5.559 SPACE RESEARCH (passive) US353	RF Devices (15)
59.3-64 FIXED INTER-SATELLITE MOBILE 5.558 RADIOLOCATION 5.559 5.138			59.3-64 FIXED INTER-SATELLITE MOBILE 5.558 RADIOLOCATION 5.559 5.138 US353	59.3-64 FIXED MOBILE 5.558 RADIOLOCATION 5.559 5.138 US353	RF Devices (15) ISM Equipment (18)
64-65 FIXED INTER-SATELLITE MOBILE except aeronautical mobile 5.547 5.556			64-65 FIXED INTER-SATELLITE MOBILE except aeronautical mobile	64-65 FIXED MOBILE except aeronautical mobile	RF Devices (15)
65-66 EARTH EXPLORATION-SATELLITE FIXED INTER-SATELLITE MOBILE except aeronautical mobile SPACE RESEARCH 5.547			65-66 EARTH EXPLORATION-SATELLITE FIXED MOBILE except aeronautical mobile SPACE RESEARCH	65-66 EARTH EXPLORATION-SATELLITE FIXED INTER-SATELLITE MOBILE except aeronautical mobile SPACE RESEARCH	RF Devices (15) Satellite Communications (25)
66-71 INTER-SATELLITE MOBILE 5.553 5.558 MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE 5.554			66-71 MOBILE 5.553 5.558 MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE 5.554	66-71 INTER-SATELLITE MOBILE 5.553 5.558 MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE 5.554	
71-74 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE MOBILE-SATELLITE (space-to-Earth)			71-74 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE MOBILE-SATELLITE (space-to-Earth) US389		Fixed Microwave (101)
74-76 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE BROADCASTING BROADCASTING-SATELLITE Space research (space-to-Earth) 5.561			74-76 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE Space research (space-to-Earth) US389	74-76 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE BROADCASTING BROADCASTING-SATELLITE Space research (space-to-Earth) US389	RF Devices (15) Fixed Microwave (101)

UNITED STATES (US) FOOTNOTES

* * * * *

US151 In the band 37-38 GHz, stations in the fixed and mobile services shall not cause harmful interference to Federal earth stations in the space research service (space-to-Earth) at the following sites: Goldstone, CA; Socorro, NM; and White Sands, NM. Applications for non-Federal use of this band shall be coordinated with NTIA in accordance with 47 CFR 30.205. * * * * *

NON-FEDERAL GOVERNMENT (NG) FOOTNOTES

* * * * *

NG63 In the band 37.5-40 GHz, earth station operations in the fixed-satellite service (space-to-Earth) shall not claim protection from stations in the fixed and mobile services, except where individually licensed earth stations are authorized pursuant to 47 CFR 25.136.

* * * * *

8. Section 2.1091 is amended by revising paragraph (c)(1) introductory text to read as follows:

§ 2.1091 Radiofrequency radiation exposure evaluation: mobile devices.

* * * * *

(c) * * *

(1) Mobile devices that operate in the Commercial Mobile Radio Services pursuant to part 20 of this chapter; the Cellular Radiotelephone Service pursuant to part 22 of this chapter; the Personal Communications Services pursuant to part 24 of this chapter; the Satellite Communications Services pursuant to part 25 of this chapter; the Miscellaneous Wireless Communications Services pursuant to part 27 of this chapter; the Upper Microwave Flexible Use Service pursuant to part 30 of this chapter; the Maritime Services (ship earth station devices only) pursuant to part 80 of this chapter; the Specialized Mobile Radio Service, and the 3650 MHz Wireless Broadband Service pursuant to part 90 of this chapter; and the Citizens Broadband Radio Service pursuant to part 96 of this chapter are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use if:

* * * * *

9. Section 2.1093 is amended by revising paragraph (c)(1) to read as follows:

§ 2.1093 Radiofrequency radiation exposure evaluation: portable devices.

* * * * *

(c) * * *

(1) Portable devices that operate in the Cellular Radiotelephone Service pursuant to part 22 of this chapter; the Personal Communications Service (PCS) pursuant to part 24 of this chapter; the Satellite Communications Services pursuant to part 25 of this chapter; the Miscellaneous Wireless Communications Services pursuant to part 27 of this chapter; the Upper Microwave Flexible Use Service pursuant to part 30 of this chapter; the Maritime Services (ship earth station devices only) pursuant to part 80 of this chapter; the Specialized Mobile Radio Service, the 4.9 GHz Band Service, and the 3650 MHz Wireless Broadband Service pursuant to part 90 of this chapter; the Wireless Medical Telemetry Service (WMTS) and the Medical Device Radiocommunication Service (MedRadio), pursuant to subparts H and I of part 95 of this chapter, respectively, unlicensed personal communication service, unlicensed NII devices and millimeter wave devices authorized under §§ 15.253(f), 15.255(g), 15.257(g), 15.319(i), and 15.407(f) of this chapter; and the Citizens Broadband Radio Service pursuant to part 96 of this chapter are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use.

* * * * *

PART 15 – RADIO FREQUENCY DEVICES

10. The authority citation for part 15 continues to read as follows:

Authority: 47 U.S.C. 154, 302a, 303, 304, 307, 336, 544a, and 549.

11. Section 15.255 is amended by revising the section heading, paragraph (a)(2), the introductory text to paragraph (b), paragraphs (b)(1), (b)(1)(i), (b)(1)(ii), (b)(2), (b)(3), (b)(4), and (c)(1); removing paragraph (d); redesignating paragraphs (e) through (h) as paragraphs (d) through (g); revising newly redesignated paragraph (d)(2); and adding new paragraph (h) to read as follows:

§ 15.255 Operation within the band 57-71 GHz.

(a) * * *

(1) * * *

(2) Field disturbance sensors, including vehicle radar systems, unless the field disturbance sensors are employed for fixed operation, or used as short-range devices for interactive motion sensing. For the purposes of this section, the reference to fixed operation includes field disturbance sensors installed in

fixed equipment, even if the sensor itself moves within the equipment.

(b) Within the 57-71 GHz band, emission levels shall not exceed the following equivalent isotropically radiated power (EIRP):

(1) Products other than fixed field disturbance sensors and short-range devices for interactive motion sensing shall comply with one of the following emission limits, as measured during the transmit interval:

(i) The average power of any emission shall not exceed 40 dBm and the peak power of any emission shall not exceed 43 dBm; OR

(ii) For fixed point-to-point transmitters located outdoors, the average power of any emission shall not exceed 82 dBm, and shall be reduced by 2 dB for every dB that the antenna gain is less than 51 dBi. The peak power of any emission shall not exceed 85 dBm, and shall be reduced by 2 dB for every dB that the antenna gain is less than 51 dBi.

(A) The provisions in this paragraph for reducing transmit power based on antenna gain shall not require that the power levels be reduced below the limits specified in paragraph (b)(1)(i) of this section.

(B) The provisions of § 15.204(c)(2) and (4) that permit the use of different antennas of the same type and of equal or less directional gain do not apply to intentional radiator systems operating under this provision. In lieu thereof, intentional radiator systems shall be certified using the specific antenna(s) with which the system will be marketed and operated. Compliance testing shall be performed using the highest gain and the lowest gain antennas for which certification is sought and with the intentional radiator operated at its maximum available output power level. The responsible party, as defined in § 2.909 of this chapter, shall supply a list of acceptable antennas with the application for certification.

(2) For fixed field disturbance sensors that occupy 500 MHz or less of bandwidth and that are contained wholly within the frequency band 61.0-61.5 GHz, the average power of any emission, measured during the transmit interval, shall not exceed 40 dBm, and the peak power of any emission shall not exceed 43 dBm. In addition, the average power of any emission outside of the 61.0-61.5 GHz band, measured during the transmit interval, but still within the 57-71 GHz band, shall not exceed 10 dBm, and the peak power of any emission shall not exceed 13 dBm.

(3) For fixed field disturbance sensors other than those operating under the provisions of paragraph (b)(2)

of this section, and short-range devices for interactive motion sensing, the peak transmitter conducted output power shall not exceed −10 dBm and the peak EIRP level shall not exceed 10 dBm.

(4) The peak power shall be measured with an RF detector that has a detection bandwidth that encompasses the 57-71 GHz band and has a video bandwidth of at least 10 MHz. The average emission levels shall be measured over the actual time period during which transmission occurs.

(c) * * *

(1) The power density of any emissions outside the 57-71 GHz band shall consist solely of spurious emissions.

* * * * *

(d) * * *

(2) Peak transmitter conducted output power shall be measured with an RF detector that has a detection bandwidth that encompasses the 57-71 GHz band and that has a video bandwidth of at least 10 MHz.

* * * * *

(h) Measurement procedures that have been found to be acceptable to the Commission in accordance with § 2.947 of this chapter may be used to demonstrate compliance.

PART 25 – SATELLITE COMMUNICATIONS

12. The authority citation for part 25 continues to read as follows:

Authority: Interprets or applies Sections 4, 301, 302, 303, 307, 309, 319, 332, 705, and 721 of the Communications Act, as amended, 47 U.S.C. 154, 301, 302, 303, 307, 309, 319, 332, 605, and 721, unless otherwise noted.

13. Add § 25.136 to read as follows:

§ 25.136 Earth Stations in the 27.5-28.35 GHz and 37.5-40 GHz bands.

(a) FSS is secondary to the Upper Microwave Flexible Use Service in the 27.5-28.35 GHz band. Notwithstanding that secondary status, an earth station in the 27.5-28.35 GHz band that meets one of the criteria listed below may operate consistent with the terms of its authorization without providing any additional interference protection to stations in the Upper Microwave Flexible Use Service:

(1) The FSS licensee also holds the relevant Upper Microwave Flexible Use Service license(s) for the

area in which the earth station generates a power flux density (PFD), at 10 meters above ground level, of greater than or equal to -77.6 dBm/m^2/MHz;

(2) The FSS earth station was authorized prior to July 14, 2016; or

(3) The application for the FSS earth station was filed prior to July 14, 2016 and has been subsequently granted; or

(4) The applicant demonstrates compliance with all of the following criteria in its application:

(i) There are no more than two other authorized earth stations operating in the 27.5-28.35 GHz band within the county where the proposed earth station is located that meet the criteria contained in either paragraphs (a)(1), (2), (3), or (4) of this section. For purposes of this requirement, multiple earth stations that are collocated with or at a location contiguous to each other shall be considered as one earth station;

(ii) The area in which the earth station generates a power flux density (PFD), at 10 meters above ground level, of greater than or equal to -77.6 dBm/m^2/MHz, together with the similar area of any other earth station authorized pursuant to section (a) of this rule, does not cover, in the aggregate, more than 0.1 percent of the population of the county within which the earth station is located;

(iii) The area in which the earth station generates a power flux density (PFD), at 10 meters above ground level, of greater than or equal to -77.6 dBm/m^2/MHz does not contain any major event venue, arterial street, interstate or U.S. highway, urban mass transit route, passenger railroad, or cruise ship port; and

(iv) The applicant has successfully completed frequency coordination with the UMFUS licensees within the area in which the earth station generates a power flux density (PFD), at 10 meters above ground level, of greater than or equal to -77.6 dBm/m^2/MHz with respect to existing facilities constructed and in operation by the UMFUS licensee. In coordinating with UMFUS licensees, the applicant shall use the applicable processes contained in § 101.103(d) of this part.

(b) Applications for earth stations in the 37.5-40 GHz band shall provide an exhibit describing the zone within which the earth station will require protection from transmissions of Upper Microwave Flexible Use Service licensees. For purposes of this rule, the protection zone shall consist of the area where UMFUS licensees may not locate facilities without the consent of the earth station licensee. The earth station applicant shall demonstrate in its application, using reasonable engineering methods, that the

requested protection zone is necessary in order to protect its proposed earth station.

(c) The protection zone (as defined in paragraph (b) of this section) shall comply with the following criteria. The applicant shall demonstrate compliance with all of the following criteria in its application:

(1) There are no more than two other authorized earth stations operating in the 37.5-40 GHz band within the Partial Economic Area within which the proposed earth station is located that meet the criteria contained in paragraph (c) of this section. For purposes of this requirement, multiple earth stations that are collocated with or at a location contiguous to each other shall be considered as one earth station;

(2) The protection zone, together with the protection zone of other earth stations in the same Partial Economic Area authorized pursuant to this section, does not cover, in the aggregate, more than 0.1 percent of the population of the Partial Economic Area within which the earth station is located;

(3) The protection zone does not contain any major event venue, arterial street, interstate or U.S. highway, urban mass transit route, passenger railroad, or cruise ship port; and

(4) The applicant has successfully completed frequency coordination with the UMFUS licensees within the protection zone with respect to existing facilities constructed and in operation by the UMFUS licensee. In coordinating with UMFUS licensees, the applicant shall use the applicable processes contained in § 101.103(d) of this part.

(d) If an earth station applicant or licensee in the 27.5-28.35 GHz or 37. 5-40 GHz bands enters into an agreement with an UMFUS licensee, their operations shall be governed by that agreement, except to the extent that the agreement is inconsistent with the Commission's rules or the Communications Act.

14. Section 25.202 is amended by revising footnotes 1 and 7 to the table in paragraph (a)(1) to read as follows:

§ 25.202 Frequencies, frequency tolerance, and emission limits.

(a) * * *

(1) * * *

[1] Use of this band by the Fixed-Satellite Service is limited to individually licensed earth stations. Satellite earth station facilities in this band may not be ubiquitously deployed and may not be used to serve individual consumers.

* * *

[7]The Fixed-Satellite Service is secondary to the Upper Microwave Flexible Use Service authorized pursuant to 47 CFR part 30, except for FSS operations associated with earth stations authorized pursuant to 47 CFR § 25.136.

* * * * *

15. Part 30 is added to read as follows:

PART 30 – UPPER MICROWAVE FLEXIBLE USE SERVICE

Subpart A – General

Sec.

Subpart B – Applications and Licenses

Subpart C – Technical Standards

Subpart D – Competitive Bidding Procedures

Subpart E - Special Provisions for Fixed Point-to-Point, Fixed Point-to-Multipoint Hub Stations, and Fixed Point-to-Multipoint User Stations

Authority: 47 U.S.C. 151, 152, 153, 154, 301, 303, 304, 307, 309, 310, 316, 332, 1302.

§ 30.1 Creation of upper microwave flexible use service, scope and authority.

As of **[effective date of final rule],** Local Multipoint Distribution Service licenses for the 27.5-28.35 GHz band, and licenses issued in the 38.6-40 GHz band under the rules in part 101 of this chapter shall be reassigned to the Upper Microwave Flexible Use Service. Local Multipoint Distribution Service licenses in bands other than 27.5-28.35 GHz shall remain in that service and shall be governed by the part 101 of this chapter applicable to that service.

§ 30.2 Definitions.

The following definitions apply to this part:

Authorized bandwidth. The maximum width of the band of frequencies permitted to be used by a station. This is normally considered to be the necessary or occupied bandwidth, whichever is greater. (See § 2.202 of this chapter).

Authorized frequency. The frequency, or frequency range, assigned to a station by the Commission and specified in the instrument of authorization.

Fixed satellite earth station. An earth station intended to be used at a specified fixed point.

Local Area Operations. Operations confined to physical facility boundaries, such as a factory.

Point-to-Multipoint Hub Station. A fixed point-to-multipoint radio station that provides one-way or two-way communication with fixed Point-to-Multipoint Service User Stations.

Point-to-Multipoint User Station. A fixed radio station located at users' premises, lying within the coverage area of a Point-to-Multipoint Hub station, using a directional antenna to receive one-way communications from or providing two-way communications with a fixed Point-to-Multipoint Hub Station.

Point-to-Multipoint Service. A fixed point-to-multipoint radio service consisting of point-to-multipoint hub stations that communicate with fixed point-to-multipoint user stations.

Point-to-point station. A station that transmits a highly directional signal from a fixed transmitter location to a fixed receive location.

Portable device. Transmitters designed to be used within 20 centimeters of the body of the user.

Prior coordination. A bilateral process conducted prior to filing applications which includes the distribution of the technical parameters of a proposed radio system to potentially affected parties for their evaluation and timely response.

Secondary operations. Radio communications which may not cause interference to operations authorized on a primary basis and which are not protected from interference from these primary operations

Transportable Station. Transmitting equipment that is not intended to be used while in motion, but rather at stationary locations.

Universal Licensing System. The Universal Licensing System (ULS) is the consolidated database, application filing system, and processing system for all Wireless Radio Services. ULS supports electronic

filing of all applications and related documents by applicants and licensees in the Wireless Radio Services, and provides public access to licensing information.

§ 30.3 Eligibility.

Any entity who meets the technical, financial, character, and citizenship qualifications that the Commission may require in accordance with such Act, other than those precluded by Section 310 of the Communications Act of 1934, as amended, 47 U.S.C. 310, is eligible to hold a license under this part.

§ 30.4 Frequencies.

The following frequencies are available for assignment in the Upper Microwave Flexible Use Service:

(a) 27.5 GHz – 28.35 GHz band - 27.5-27.925 GHz and 27.925-28.35 GHz.

(b) 38.6-40 GHz band:

(1) New channel plan:

Channel Number	Frequency band limits (MHz)
1	38,600-38,800
2	38,800-39,000
3	39,000-39,200
4	39,200-39,400
5	39,400-39,600
6	39,600-39,800
7	39,800-40,000

(2) Pending transition to the new channel plan, existing 39 GHz licensees licensed under part 101 of this chapter may continue operating on the following channel plan:

Channel Group A		Channel Group B	
Channel No.	Frequency band limits (MHz)	Channel No.	Frequency band limits (MHz)
1-A	38,600-38,650	1-B	39,300-39,350
2-A	38,650-38,700	2-B	39,350-39,400
3-A	38,700-38,750	3-B	39,400-39,450
4-A	38,750-38,800	4-B	39,450-39,500
5-A	38,800-38,850	5-B	39,500-39,550
6-A	38,850-38,900	6-B	39,550-39,600
7-A	38,900-38,950	7-B	39,600-39,650
8-A	38,950-39,000	8-B	39,650-39,700
9-A	39,000-39,050	9-B	39,700-39,750
10-A	39,050-39,100	10-B	39,750-39,800
11-A	39,100-39,150	11-B	39,800-39,850
12-A	39,150-39,200	12-B	39,850-39,900

13-A	39,200-39,250	13-B	39,900-39,950
14-A	39,250-39,300	14-B	39,950-40,000

(c) 37-38.6 GHz band: 37,600-37,800 MHz; 37,800-38,000 MHz; 38,000-38,200 MHz; 38,200-38,400 MHz, and 38,400-38,600 MHz. The 37,000-37,600 MHz band segment shall be available on a site-specific, coordinated shared basis with eligible Federal entities.

§ 30.5 Service areas.

(a) Except as noted in paragraphs (b) and (c) of this section, and except for the shared 37-37.6 GHz band, the service areas for the Upper Microwave Flexible Use Service are Partial Economic Areas.

(b) For the 27.5-28.35 GHz band, the service areas shall be counties.

(c) Common Carrier Fixed Point-to-Point Microwave Stations licensed in the 38.6-40 GHz bands licensed with Rectangular Service Areas shall maintain their Rectangular Service Area as defined in their authorization. The frequencies associated with Rectangular Service Area authorizations that have expired, cancelled, or otherwise been recovered by the Commission will automatically revert to the applicable county licensee.

(d) In the 37.5-40 GHz band, Upper Microwave Flexible Use Service licensees shall not place facilities within the protection zone of Fixed-Satellite Service earth stations authorized pursuant to § 25.136 of part 25 of this chapter, absent consent from the Fixed-Satellite Service earth station licensee.

§ 30.6 Permissible communications.

(a) A licensee in the frequency bands specified in § 30.4 may provide any services for which its frequency bands are allocated, as set forth in the non-Federal Government column of the Table of Frequency Allocations in § 2.106 of this chapter (column 5).

(b) Fixed-Satellite Service shall be provided in a manner consistent with part 25 of this chapter.

§ 30.7 37-37.6 GHz Band – Shared Coordinated Service.

(a) The 37-37.6 GHz band will be available for site-based registrations on a coordinated basis with co-equal eligible Federal

entities.

(b) Any non-Federal entity meeting the eligibility requirements of § 30.3 of this part may operate

equipment that complies with the technical rules of this part pursuant to a Shared Access License.

(c) Licensees in the 37-37.6 GHz band must register their individual base stations and access points prior to placing them in operation.

§ 30.8 5G Provider Cybersecurity Statement Requirements.

(a) Statement. Each Upper Microwave Flexible Use Service licensee is required to submit to the Commission a Statement describing its network security plans and related information, which shall be signed by a senior executive within the licensee's organization with personal knowledge of the security plans and practices within the licensee's organization. The Statement must contain, at a minimum, the following elements:

(1) Security Approach. A high-level, general description of the licensee's approach designed to safeguard the planned network's confidentiality, integrity, and availability, with respect to communications from:

(i) A device to the licensee's network;

(ii) One element of the licensee's network to another element on the licensee's network;

(iii) The licensee's network to another network; and

(iv) Device to device (with respect to telephone voice and messaging services).

(2) Cybersecurity Coordination. A high-level, general description of the licensee's anticipated approach to assessing and mitigating cyber risk induced by the presence of multiple participants in the band. This should include the high level approach taken toward ensuring consumer network confidentiality, integrity, and availability security principles, are to be protected in each of the following use cases: communications between a wireless device and the licensee's network; communications within and between each licensee's network; communications between mobile devices that are under end-to-end control of the licensee; and communications between mobile devices that are not under the end-to-end control of the licensee;

(3) Cybersecurity Standards and Best Practices. A high-level description of relevant cybersecurity standards and practices to be employed, whether industry-recognized or related to some other identifiable approach;

(4) Participation with Standards Bodies, Industry-Led Organizations. A description of the extent to which the licensee participates with standards bodies or industry-led organizations pursuing the development or maintenance of emerging security standards and/or best practices;

(5) Other Security Approaches. The high-level identification of any other approaches to security, unique to the services and devices the licensee intends to offer and deploy; and

(6) Plans with Information Sharing and Analysis Organizations. Plans to incorporate relevant outputs from Information Sharing and Analysis Organizations (ISAOs) as elements of the licensee's security architecture. Plans should include comment on machine-to-machine threat information sharing, and any use of anticipated standards for ISAO-based information sharing.

(b) Timing. Each Upper Microwave Flexible Use Service licensee shall submit this *Statement* to the Commission within three years after grant of the license, but no later than six months prior to deployment.

(c) Definitions. The following definitions apply to this section:

Confidentiality: the protection of data from unauthorized access and disclosure, both while at rest and in transit.

Integrity: the protection against the unauthorized modification or destruction of information.

Availability: the accessibility and usability of a network upon demand.

Subpart B – Applications and Licenses

§ 30.101 Initial authorizations.

Except with respect to in the 37-37.6 GHz band, an applicant must file a single application for an initial authorization for all markets won and frequency blocks desired. Initial authorizations shall be granted in accordance with § 30.4. Applications for individual sites are not required and will not be accepted, except where required for environmental assessments, in accordance with §§ 1.1301 through 1.1319 of this chapter.

§ 30.103 Transition of existing local multipoint distribution service and 39 GHz licenses.

Local Multipoint Distribution Service licenses in the 27.5 – 28.35 GHz band issued on a Basic Trading Area basis shall be disaggregated into county-based licenses and 39 GHz licenses issued on an Economic Area basis shall be disaggregated into Partial Economic Area-based licenses on **[effective date of final**

rule]. For each county in the Basic Trading Area or Partial Economic Area in the Economic Area which is part of the original license, the licensee shall receive a separate license. If there is a co-channel Rectangular Service Area licensee within the service area of a 39 GHz Economic Area licensee, the disaggregated license shall not authorize operation with the service area of the Rectangular Service Area license.

§ 30.104 License term.

Initial authorizations will have a term not to exceed ten years from the date of initial issuance or renewal.

§ 30.105 Construction requirements.

(a) Upper Microwave Flexible Use Service licensees must make a buildout showing as part of their renewal applications. Licensees relying on mobile or point-to-multipoint service to demonstrate that they are providing reliable signal coverage and service to at least 40 percent of the population within the service area of the licensee, and that they are using facilities to provide service in that area either to customers or for internal use. Licensees relying on point-to-point service must demonstrate that they have four links operating and providing service, either to customers or for internal use. If the population within the license area is equal to or less than 268,000. If the population within the license area is greater than 268,000, a licensee relying on point-to-point service must demonstrate it has at least one link in operation and providing service for each 67,000 population within the license area.

(b) Showings that rely on a combination of multiple types of service will be evaluated on a case-by-case basis.

(c) If a licensee in this service is also a Fixed-Satellite Service licensee and uses the spectrum covered under its UMFUS license in connection with a satellite earth station, it can demonstrate compliance with the requirements of this section by demonstrating that the earth station in question is in service, operational, and using the spectrum associated with the license. This provision can only be used to demonstrate compliance for the county in which the earth station is located.

(d) Failure to meet this requirement will result in automatic cancellation of the license. In bands licensed on a Partial Economic Area basis, licensees will have the option of partitioning a license on a county basis in order to reduce the population within the license area to a level where the licensee's buildout would

meet one of the applicable performance metrics.

(e) Existing 28 GHz and 39 GHz licensees shall be required to make a showing pursuant to this rule by June 1, 2024.

§ 30.106 Geographic partitioning and spectrum disaggregation.

(a) Parties seeking approval for partitioning and disaggregation shall request from the Commission an authorization for partial assignment of a license pursuant to § 1.948 of this chapter. Upper Microwave Flexible Use Service licensees may apply to partition their licensed geographic service area or disaggregate their licensed spectrum at any time following the grant of their licenses.

(b) Technical standards—(1) Partitioning. In the case of partitioning, applicants and licensees must file FCC Form 603 pursuant to § 1.948 of this chapter and list the partitioned service area on a schedule to the application. The geographic coordinates must be specified in degrees, minutes, and seconds to the nearest second of latitude and longitude and must be based upon the 1983 North American Datum (NAD83).

(2) Spectrum may be disaggregated in any amount.

(3) The Commission will consider requests for partial assignment of licenses that propose combinations of partitioning and disaggregation.

(4) For purposes of partitioning and disaggregation, part 30 systems must be designed so as not to exceed the signal level specified for the particular spectrum block in § 30.204 at the licensee's service area boundary, unless the affected adjacent service area licensees have agreed to a different signal level.

(c) License term. The license term for a partitioned license area and for disaggregated spectrum shall be the remainder of the original licensee's license term as provided for in § 30.104.

(d)(1) Parties to partitioning agreements must satisfy the construction requirements set forth in § 30.105 by the partitioner and partitionee each certifying that it will independently meet the construction requirement for its respective partitioned license area. If the partitioner or partitionee fails to meet the construction requirement for its respective partitioned license area, then the relevant partitioned license will automatically cancel.

(2) Parties to disaggregation agreements must satisfy the construction requirements set forth in § 30.105 by the disaggregator and disaggregatee each certifying that it will independently meet the construction

requirement for its respective disaggregated license area. If the disaggregator or disaggregatee fails to meet the construction requirement for its respective disaggregated license area, then the relevant disaggregated license will automatically cancel.

§ 30.107 Discontinuance of service.

(a) An Upper Microwave Flexible Use License authorization will automatically terminate, without specific Commission action, if the licensee permanently discontinues service after the initial license term.

(b) For licensees with common carrier regulatory status, permanent discontinuance of service is defined as 180 consecutive days during which a licensee does not provide service to at least one subscriber that is not affiliated with, controlled by, or related to the licensee in the individual license area. For licensees with non-common carrier status, permanent discontinuance of service is defined as 180 consecutive days during which a licensee does not operate.

(c) A licensee that permanently discontinues service as defined in this section must notify the Commission of the discontinuance within 10 days by filing FCC Form 601 or 605 requesting license cancellation. An authorization will automatically terminate, without specific Commission action, if service is permanently discontinued as defined in this section, even if a licensee fails to file the required form requesting license cancellation.

Subpart C – Technical Standards

§ 30.201 Equipment authorization.

(a) Except as provided under paragraph (c) of this section, each transmitter utilized for operation under this part must be of a type that has been authorized by the Commission under its certification procedure.

(b) Any manufacturer of radio transmitting equipment to be used in these services may request equipment authorization following the procedures set forth in subpart J of part 2 of this chapter. Equipment authorization for an individual transmitter may be requested by an applicant for a station authorization by following the procedures set forth in part 2 of this chapter.

(c) Unless specified otherwise, transmitters for use under the provisions of subpart E of this part for fixed point-to-point microwave and point-to-multipoint services must be a type that has been verified for compliance.

§ 30.202 Power limits.

(a) For fixed and base stations operating in connection with mobile systems, the average power of the sum of all antenna elements is limited to an equivalent isotopically radiated power (EIRP) density of +75dBm/100 MHz. For channel bandwidths less than 100 megahertz the EIRP must be reduced proportionally and linearly based on the bandwidth relative to 100 megahertz.

(b) For mobile stations, the average power of the sum of all antenna elements is limited to a maximum EIRP of +43 dBm.

(c) For transportable stations, as defined in § 30.2, the average power of the sum of all antenna elements is limited to a maximum EIRP of +55 dBm.

(d) For fixed point-to-point and point-to-multipoint limits see § 30.405.

§ 30.203 Emission limits.

(a) The conductive power or the total radiated power of any emission outside a licensee's frequency block shall be -13 dBm/MHz or lower. However, in the bands immediately outside and adjacent to the licensee's frequency block, having a bandwidth equal to 10 percent of the channel bandwidth, the conductive power or the total radiated power of any emission shall be -5 dBm/MHz or lower.

(b)(1) Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater.

(2) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the licensee's frequency block edges as the design permits.

(3) The measurements of emission power can be expressed in peak or average values.

(c) For fixed point-to-point and point-to-multipoint limits see § 30.404.

§ 30.204 Field strength limits.

(a) Base/Mobile Operations: The predicted or measured Power Flux Density (PFD) from any Base Station operating in the 27.5-28.35 GHz band, 37-38.6 GHz band, and 38.6-40 GHz bands at any location on the geographical border of a licensee's service area shall not exceed -76dBm/m^2/MHz (measured at 1.5 meters above ground) unless the adjacent affected service area licensee(s) agree(s) to a different PFD.

(b) Fixed Point-to-point Operations:

(1) Prior to operating a fixed point-to-point transmitting facility in the 27,500-28,350 MHz band where the facilities are located within 20 kilometers of the boundary of the licensees authorized market area, the licensee must complete frequency coordination in accordance with the procedures specified in § 101.103 (d)(2) of this chapter with respect to neighboring licensees that may be affected by its operations.

(2) Prior to operating a fixed point-to-point transmitting facility in the 37,000 – 40,000 MHz band where the facilities are located within 16 kilometers of the boundary of the licensees authorized market area, the licensee must complete frequency coordination in accordance with the procedures specified in § 101.103 (d)(2) of this chapter with respect to neighboring licensees that may be affected by its operations.

§ 30.205 Federal coordination requirements.

(a) Licensees in the 37-38 GHz band located within the zones defined by the coordinates in the tables below must coordinate their operations with Federal Space Research Service (space to Earth) users of the band via the National Telecommunications and Information Administration (NTIA). All licensees operating within the zone defined by the 60 dBm/100 MHz EIRP coordinates in the tables below must coordinate all operations. Licensees operating within the area between the zones defined by the 60 dBm and 75 dBm/100 MHz EIRP coordinates in the tables below must coordinate all operations if their base station EIRP is greater than 60 dBm/100 MHz or if their antenna height exceeds 100 meters above ground level. Licensees operating outside the zones defined by the 75 dBm/100 MHz EIRP coordinates in the tables below are not required to coordinate their operations with NTIA.

Table 1: Goldstone, California Coordination Zone

60 dBm/100 MHz EIRP		75 dBm/100 MHz EIRP	
Latitude/Longitude (decimal degrees)	**Latitude/Longitude (decimal degrees)**	**Latitude/Longitude (decimal degrees)**	**Latitude/Longitude (decimal degrees)**
34.69217/-115.6491	34.19524/-117.47963	34.69217/-115.6491	34.19524/-117.47963
35.25746/-115.32041	34.24586/-117.36210	35.25746/-115.32041	34.24586/-117.36210
36.21257/-117.06567	35.04648/-117.03781	36.11221/-116.63632	34.21748/-117.12812
36.55967/-117.63691	35.04788/-117.00949	36.54731/-117.48242	34.20370/-116.97024
36.66297/-118.31017	34.22940/-117.22327	36.73049/-118.33683	34.12196/-116.93109
36.06074/-118.38528	34.20370/-116.97024	36.39126/-118.47307	34.09498/-116.75473
35.47015/-118.39008	34.12196/-116.93109	36.36891/-118.47134	34.13603/-116.64002
35.40865/-118.34353	34.09498/-116.75473	35.47015/-118.39008	34.69217/-115.6591
35.35986/-117.24709	34.19642/-116.72901	35.40865/-118.34353	34.69217/-115.6491

35.29539/-117.21102	34.64906/-116.62741	35.32048/-117.26386	
34.67607/-118.55412	34.44404/-116.31486	34.63725/-118.96736	
34.61532/-118.36919	34.52736/-116.27845	34.55789/-118.36204	
34.91551/-117.70371	34.76685/-116.27930	34.51108/-118.15329	
34.81257/-117.65400	34.69217/-115.6591	34.39220/-118.28852	
34.37411/-118.18385	34.69217/-115.6491	34.38546/-118.27460	
34.33405/-117.94189		34.37524/-118.24191	
34.27249/-117.65445		34.37039/-118.22557	

Table 2:Socorro, New Mexico Coordination Zone

60 dBm/100 MHz EIRP		75 dBm/100 MHz EIRP
Latitude/Longitude (decimal degrees)	**Latitude/Longitude (decimal degrees)**	**Latitude/Longitude (decimal degrees)**
34.83816/-107.66828	33.44401/-108.67876	33.10651/-108.19320
34.80070/-107.68759	33.57963/-107.79895	33.11780/-107.99980
34.56506/-107.70233	33.84552/-107.60207	33.13558/-107.85611
34.40826/-107.71489	33.85964/-107.51915	33.80383/-107.16520
34.31013/-107.88349	33.86479/-107.17223	33.94554/-107.15516
34.24067/-107.96059	33.94779/-107.15038	33.95665/-107.15480
34.10278/-108.23166	34.11122/-107.18132	34.08156/-107.18137
34.07442/-108.30646	34.15203/-107.39035	34.10646/-107.18938
34.01447/-108.31694	34.29643/-107.51071	35.24269/-107.67969
33.86740/-108.48706	34.83816/-107.66828	34.06647/-108.70438
33.81660/-108.51052		33.35946/-108.68902
33.67909/-108.58750		33.29430/-108.65004
33.50223/-108.65470		33.10651/-108.19320

Table 3: White Sands, New Mexico Coordination Zone

60 dBm/100 MHz EIRP		75 dBm/100 MHz EIRP	
Latitude/Longitude (decimal degrees)	**Latitude/Longitude (decimal degrees)**	**Latitude/Longitude (decimal degrees)**	**Latitude/Longitude (decimal degrees)**
33.98689/-107.15967	31.78455/-106.54058	31.7494/-106.49132	32.88382/-108.16588
33.91573/-107.46301	32.24710/-106.56114	32.24524/-106.56507	32.76255/-108.05679
33.73122/-107.73585	32.67731/-106.53681	32.67731/-106.53681	32.56863/-108.43999
33.37098/-107.84333	32.89856/-106.56882	32.89856/-106.56882	32.48991/-108.50032
33.25424/-107.86409	33.24323/-106.70094	33.04880/-106.62309	32.39142/-108.48959
33.19808/-107.89673	33.98689/-107.15967	33.21824/-106.68992	31.63664/-108.40480
33.02128/-107.87226		33.24347/-106.70165	31.63466/-108.20921
32.47747/-107.77963		34.00708/-107.08652	31.78374/-108.20798
32.31543/-108.16101		34.04967/-107.17524	31.78322/-106.52825
31.79429/-107.88616		33.83491/-107.85971	31.7494/-106.49132

(b) Licensees in the 37-38.6 GHz band located within the zones defined by the coordinates in the table

below must coordinate their operations with the Department of Defense via the National Telecommunications and Information Administration (NTIA).

Table - Coordination Areas for Federal Terrestrial Systems

Location	Agency	Coordination Area (Decimal Degrees)
China Lake, CA	Navy	30 kilometer radius centered on latitude 35.59527 and longitude -117.22583 30 kilometer radius centered on latitude 35.52222 and longitude -117.30333 30 kilometer radius centered on latitude 35.76222 and longitude -117.60055 30 kilometer radius centered on latitude 35.69111 and longitude -117.66916
San Diego, CA	Navy	30 kilometer radius centered on latitude 32.68333 and longitude -117.23333
Nanakuli, HI	Navy	30 kilometer radius centered on latitude 21.38333 and longitude -158.13333
Fishers Island, NY	Navy	30 kilometer radius centered on latitude 41.25 and longitude -72.01666
Saint Croix, VI	Navy	30 kilometer radius centered on latitude 17.74722 and longitude -64.88
Fort Irwin, CA	Army	30 kilometer radius centered on latitude 35.26666 and longitude -116.68333
Fort Carson, CO	Army	30 kilometer radius centered on latitude 38.71666 and longitude -104.65
Fort Hood, TX	Army	30 kilometer radius centered on latitude 31.11666 and longitude -97.76666
Fort Bliss, TX	Army	30 kilometer radius centered on latitude 31.8075 and longitude -106.42166
Yuma Proving Ground, AZ	Army	30 kilometer radius centered on latitude 32.48333 and longitude -114.33333
Fort Huachuca, AZ	Army	30 kilometer radius centered on latitude 31.55 and longitude -110.35
White Sands Missile Range, NM	Army	30 kilometer radius centered on latitude 33.35 and longitude -106.3
Moody Air Force Base, GA	Air Force	30 kilometer radius centered on latitude 30.96694 and longitude -83.185
Hurlburt Air Force Base, FL	Air Force	30 kilometer radius centered on latitude 30.42388 and longitude -86.70694

§ 30.206 International coordination.

Operations in the 27.5-28.35 GHz, 37-38.6, and 38.6-40 GHz bands are subject to existing and future international agreements with Canada and Mexico.

§ 30.207 RF safety.

Licensees and manufacturers are subject to the radio frequency radiation exposure requirements specified

in §§ 1.1307(b), 1.1310, 2.1091, and 2.1093 of this chapter, as appropriate. Applications for equipment authorization of mobile or portable devices operating under this section must contain a statement confirming compliance with these requirements. Technical information showing the basis for this statement must be submitted to the Commission upon request.

§ 30.208 Operability.

Mobile and transportable stations that operate on any portion of frequencies within the 27.5-28.35 GHz or the 37-40 GHz bands must be capable of operating on all frequencies within those particular bands.

§ 30.209 Duplexing.

Stations authorized under this rule part may employ frequency division duplexing, time division duplexing, or any other duplexing scheme, provided that they comply with the other technical and operational requirements specified in this part.

Subpart D – Competitive Bidding Procedures

§ 30.301 Upper microwave flexible use service subject to competitive bidding.

Mutually exclusive initial applications for Upper Microwave Flexible User Service licenses are subject to competitive bidding. The general competitive bidding procedures set forth in part 1, subpart Q of this chapter will apply unless otherwise provided in this subpart.

§ 30.302 Designated entities and bidding credits.

(a) Eligibility for small business provisions. (1) A small business is an entity that, together with its affiliates, its controlling interests and the affiliates of its controlling interests, have average gross revenues that are not more than $55 million for the preceding three (3) years.

(2) A very small business is an entity that, together with its affiliates, its controlling interests and the affiliates of its controlling interests, has average gross revenues that are not more than $20 million for the preceding three (3) years.

(b) Bidding credits. A winning bidder that qualifies as a small business, as defined in this section, or a consortium of small businesses may use a bidding credit of 15 percent, as specified in § 1.2110(f)(2)(i)(C) of this chapter. A winning bidder that qualifies as a very small business, as defined in this section, or a consortium of very small businesses may use a bidding credit of 25 percent, as specified in §

1.2110(f)(2)(i)(B) of this chapter.

(c) A rural service provider, as defined in § 1.2110(f)(4) of this chapter, who has not claimed a small business bidding credit may use a bidding credit of 15 percent bidding credit, as specified in § 1.2110(f)(4)(i) of this chapter.

Subpart E - Special Provisions for Fixed Point-to-Point, Fixed Point-to-Multipoint Hub Stations, and Fixed Point-to-Multipoint User Stations

§ 30.401 Permissible service.

Stations authorized under this subpart may deploy stations used solely as fixed point-to-point stations, fixed point-to-multipoint hub stations, or fixed point-to-multipoint user stations, as defined in § 30.2 of this part, subject to the technical and operational requirements specified in this subpart.

§ 30.402 Frequency tolerance.

The carrier frequency of each transmitter authorized under this sub-part must be maintained within the following percentage of the reference frequency (unless otherwise specified in the instrument of station authorization the reference frequency will be deemed to be the assigned frequency):

Frequency (MHz)	Frequency tolerance (percent)
27,500 to 28,350	0.001
38,600 to 40,000	0.03

§ 30.403 Bandwidth.

(a) Stations under this sub-part will be authorized any type of emission, method of modulation, and transmission characteristic, consistent with efficient use of the spectrum and good engineering practice.

(b) The maximum bandwidth authorized per frequency to stations under this sub-part is set out in the table that follows.

Frequency band (MHz)	Maximum authorized bandwidth
27,500 to 28,350	850 MHz
38,600 to 40,000	200 MHz[1]

[1]For channel block assignments in the 38,600-40,000 MHz bands when adjacent channels are aggregated, equipment is permitted to operate over the full channel block aggregation without restriction.

§ 30.404 Emission limits.

(a) The mean power of emissions must be attenuated below the mean output power of the transmitter in accordance with the following schedule:

(1) When using transmissions other than those employing digital modulation techniques:

(i) On any frequency removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: At least 25 decibels;

(ii) On any frequency removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: At least 35 decibels;

(iii) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least $43 + 10 \text{ Log}_{10}$ (mean output power in watts) decibels, or 80 decibels, whichever is the lesser attenuation.

(2) When using transmissions employing digital modulation techniques in situations not covered in this section:

(i) In any 1 MHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 250 percent of the authorized bandwidth: As specified by the following equation but in no event less than 11 decibels:

$A = 11 + 0.4(P-50) + 10 \text{ Log}_{10} B$. (Attenuation greater than 56 decibels or to an absolute power of less than −13 dBm/1MHz is not required.)

(ii) In any 1 MHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least $43 + 10 \text{ Log}_{10}$ (the mean output power in watts) decibels, or 80 decibels, whichever is the lesser attenuation. The authorized bandwidth includes the nominal radio frequency bandwidth of an individual transmitter/modulator in block-assigned bands. Equipment licensed prior to April 1, 2005 shall only be required to meet this standard in any 4 kHz band.

(iii) The emission mask in paragraph (a)(2)(i) of this section applies only to the band edge of each block of spectrum, but not to subchannels established by licensees. The value of P in the equation is the percentage removed from the carrier frequency and assumes that the carrier frequency is the center of the

actual bandwidth used. The emission mask can be satisfied by locating a carrier of the subchannel sufficiently far from the channel edges so that the emission levels of the mask are satisfied. The emission mask shall use a value B (bandwidth) of 40 MHz, for all cases even in the case where a narrower subchannel is used (for instance the actual bandwidth is 10 MHz) and the mean output power used in the calculation is the sum of the output power of a fully populated channel. For block assigned channels, the out-of-band emission limits apply only outside the assigned band of operation and not within the band.

(b) [Reserved]

§ 30.405 Transmitter power limitations.

On any authorized frequency, the average power delivered to an antenna in this service must be the minimum amount of power necessary to carry out the communications desired. Application of this principle includes, but is not to be limited to, requiring a licensee who replaces one or more of its antennas with larger antennas to reduce its antenna input power by an amount appropriate to compensate for the increased primary lobe gain of the replacement antenna(s). In no event shall the average equivalent isotropically radiated power (EIRP), as referenced to an isotropic radiator, exceed the following:

Maximum allowable EIRP	
Frequency band (MHz)	**Fixed (dBW)**
27,500-28,350[1]	+ 55
38,600-40,000	+ 55

[1]For Point-to-multipoint user stations authorized in these bands, the EIRP shall not exceed 55 dBw or 42 dBw/MHz.

§ 30.406 Directional antennas.

(a) Unless otherwise authorized upon specific request by the applicant, each station authorized under the rules of this sub-part must employ a directional antenna adjusted with the center of the major lobe of radiation in the horizontal plane directed toward the receiving station with which it communicates: provided, however, where a station communicates with more than one point, a multi- or omni-directional antenna may be authorized if necessary.

(b) Fixed stations (other than temporary fixed stations) must employ transmitting and receiving antennas (excluding second receiving antennas for operations such as space diversity) meeting the appropriate

performance Standard A indicated below, except that in areas not subject to frequency congestion, antennas meeting performance Standard B may be used. For frequencies with a Standard B1 and a Standard B2, in order to comply with Standard B an antenna must fully meet either Standard B1 or Standard B2. Licensees shall comply with the antenna standards table shown in this paragraph in the following manner:

(1) With either the maximum beamwidth to 3 dB points requirement or with the minimum antenna gain requirement; and

(2) With the minimum radiation suppression to angle requirement.

Frequency (MHz)	Category	Maximum beamwidth to 3 dB points[1] (included angle in degrees)	Minimum antenna gain (dbi)	Minimum radiation suppression to angle in degrees from centerline of main beam in decibels						
				5° to10°	10° to 15°	15° to 20°	20° to 30°	30° to 100°	100° to 140°	140° to 180°
38,600 to 40,000[2]	A	n/a	38	25	29	33	36	42	55	55
	B	n/a	38	20	24	28	32	35	36	36

[1]If a licensee chooses to show compliance using maximum beamwidth to 3 dB points, the beamwidth limit shall apply in both the azimuth and the elevation planes.

[2]Stations authorized to operate in the 38,600-40,000 MHz band may use antennas other than those meeting the Category A standard. However, the Commission may require the use of higher performance antennas where interference problems can be resolved by the use of such antennas.

§30.407 Antenna polarization.

In the 27,500-28,350 MHz band, system operators are permitted to use any polarization within its service area, but only vertical and/or horizontal polarization for antennas located within 20 kilometers of the outermost edge of their service area.

PART 101 – FIXED MICROWAVE SERVICES

16. The authority citation for part 101 continues to read as follows:

Authority: 47 U.S.C. 154, 303.

§101.17 [Removed and Reserved]

17. Remove and reserve § 101.17.

§101.56 [Removed and Reserved]

18. Remove and reserve § 101.56.

19. Section 101.63 is amended by revising paragraph (a) to read as follows:

§ 101.63 Period of construction; certification of completion of construction.

(a) Each Station, except in Multichannel Video Distribution and Data Service, Local Multipoint Distribution Service, and the 24 GHz Service, authorized under this part must be in operation within 18 months from the initial date of grant.

* * * * *

§ 101.101 [Amended]

20. Section 101.101, the table, is amended by removing the entries "27,500-28,350" and "38,600-40,000."

21. Section 101.103 is amended by revising paragraph (g)(1) and by removing paragraph (i) as follows:

§101.103 Frequency coordination procedures.

* * * * *

(g) * * *

(1) When the transmitting facilities in a Basic Trading Area (BTA) are to be operated in the bands 29,100-29,250 MHz and 31,000-31,300 MHz and the facilities are located within 20 kilometers of the boundaries of a BTA, each licensee must complete the frequency coordination process of paragraph (d)(2) of this section with respect to neighboring BTA licensees that may be affected by its operations prior to initiating service. In addition, all licensed transmitting facilities operating in the bands 31,000-31,075 MHz and 31,225-31,300 MHz and located within 20 kilometers of neighboring facilities must complete the frequency coordination process of paragraph (d)(2) of this section with respect to such authorized operations before initiating service.

* * * * *

§101.107 [Amended]

22. Section 101.107 is amended by removing the entry "27,500 to 28,350" from the table following paragraph (a).

23. Section 101.109 is amended by removing the entries "27,500 to 28,350" and "38,600 to 40,000" in the table following paragraph (c) and revising footnote 7 to the table.

The revision reads as follows:

§101.109 Bandwidth.

* * * * *

(c) * * *

[7] For channel block assignments in the 24,250-25,250 MHz band, the authorized bandwidth is equivalent to an unpaired channel block assignment or to either half of a symmetrical paired channel block assignment. When adjacent channels are aggregated, equipment is permitted to operate over the full channel block aggregation without restriction.

* * * * *

§ 101.113 [Amended]

24. Section 101.113 is amended by removing the entries "27,500-28,350" and "38,600 to 40,000" in the table following paragraph (a).

§ 101.115 [Amended]

25. Section 101.115 is amended by removing the entry "38,600 to 40,000" in the table following paragraph (b)(2) and redesignating footnote 15 as footnote 14.

26. Section 101.147 is amended by revising paragraphs (a) and (t) and removing and reserving paragraph (v).

The revisions read as follows:

§ 101.147 Frequency assignments.

(a) Frequencies in the following bands are available for assignment for fixed microwave services.

928.0-929.0 MHz (28)

932.0-932.5 MHz (27)

932.5-935 MHz (17)

941.0-941.5 MHz (27)

941.5-944 MHz (17) (18)

952.0-960.0 MHz (28)

1,850-1,990 MHz (20) (22)

2,110-2,130 MHz) (1) (3) (7) (20) (23)

2,130-2,150 MHz (20) (22)

2,160-2,180 MHz (1) (2) (20) (23)

2,180-2,200 MHz (20) (22)

2,450-2,500 MHz (12)

2,650-2,690 MHz

3,700-4,200 MHz (8) (14) (25)

5,925-6,425 MHz (6) (14) (25)

6,425-6,525 MHz (24)

6,525-6.875 MHz (14) (33)

6,875-7,125 MHz (10), (34)

10,550-10,680 MHz (19)

10,700-11,700 MHz (8) (9) (19) (25)

11,700-12,200 MHz (24)

12,200-12,700 MHz (31)

12,700-13,200 (22), (34)

13,200-13,250 MHz (4) (24) (25)

14,200-14,400 MHz (24)

17,700-18,820 MHz (5) (10) (15)

17,700-18,300 MHz (10) (15)

18,820-18,920 MHz (22)

18,300-18,580 MHz (5) (10) (15)

18,580-19,300 MHz (22) (30)

18,920-19,160 MHz (5 (10) (15)

19,160-19,260 MHz (22)

19,260-19,700 MHz (5) (10) (15)

19,300-19,700 MHz (5) (10) (15)

21,200-22,000 MHz (4) (11) (12) (13) (24) (25) (26)

22,000-23,600 MHz (4) (11) (12) (24) (25) (26)

24,250-25,250 MHz

29,100-29,250 MHz (5), (16)

31,000-31,300 MHz (16)

42,000-42,500 MHz

71,000-76,000 MHz (5) (17)

81,000-86,000 MHz (5) (17)

92,000-94,000 MHz (17)

94,100-95,000 MHz (17)

* * * * *

(t) 29,100-29,250; 31,000-31,300 MHz. These frequencies are available for LMDS systems. Each assignment will be made on a BTA service area basis, and the assigned spectrum may be subdivided as desired by the licensee.

* * * * *

§ 101.149 [Removed and Reserved]

27. Remove and reserve § 101.149.

28. Section 101.1005 is amended by revising paragraphs (a) and (b) to read as follows:

§ 101.1005 Frequencies available.

(a) The following frequencies are available for assignment to LMDS in two license blocks:

Block A of 300 MHz

29,100-29,250 MHz

31,075-31,225 MHz

Block B of 150 MHz

31,000-31,075 MHz

31,225-31,300 MHz

(b) In Block A licenses, the frequencies are authorized as follows:

(1) 29,100-29,250 MHz is shared on a co-primary basis with feeder links for non-geostationary orbit Mobile Satellite Service (NGSO/MSS) systems in the band and is limited to LMDS hub-to-subscriber transmissions, as provided in §§ 25.257 and 101.103(h) of this chapter.

(2) 31,075-31,225 MHz is authorized on a primary protected basis and is shared with private microwave

point-to-point systems licensed prior to March 11, 1997, as provided in § 101.103(b).

* * * * *

Subpart N — [Removed and Reserved]

Remove and reserve subpart N, consisting of §§101.1201 through 101.1209

APPENDIX B

Population Densities of Cities with Long-Haul Internet Nodes

Sources:
U.S. Census Bureau[1]
Demographia, http://www.demographia.com/db-uscity98.htm.
University of Wisconsin at Madison, Internet Atlas Project (www.internetatlas.org)[2]

Location of Long-Haul Internet Node	Population Density per Square Mile	Notes
Pine, Arizona	61.7	Unweighted population density per sq mi
Manchester, California	75.0	Unweighted population density per sq mi
Nassau, New York	107.6	Unweighted population density per sq mi
Parker, Arizona	140.1	Unweighted population density per sq mi
Sun Valley, Idaho	142.3	Unweighted population density per sq mi
Camp Verde, Arizona	255.2	Unweighted population density per sq mi
Shelbyville, Tennessee	257.5	Population-weighted density per sq mi
Payson, Arizona	263.4	Population-weighted density per sq mi
Mammoth Lakes, California	330.7	Unweighted population density per sq mi
Santa Teresa, NM	387.1	Unweighted population density per sq mi; Internet Atlas lists this as Santa Teresa, TX, but the city is actually in New Mexico near its border with Texas.
Coudersport, Pennsylvania	446.7	Unweighted population density per sq mi
Bishop, California	505.1	Population-weighted density per sq mi
Helena, Montana	512.5	Population-weighted density per sq mi
Truckee, California	522.1	Population-weighted density per sq mi
Sedona, Arizona	522.4	Unweighted population density per sq mi
Rocky Mount, North Carolina	525.7	Population-weighted density per sq mi
Fairfax, South Carolina	613.6	Unweighted population density per sq mi

[1] Wherever available, the chart shows population-weighted densities, which the U.S. Census Bureau considers to be a more accurate representation than raw population density. "Population-weighted density is derived from the densities of all the census tracts included within the boundary of the CBSA [Core Based Statistical Area]. A metro or micro area's population-weighted density can be thought of as the average of every inhabitant's census tract density. It was calculated using the formula $D=\sum(Pidi)/\sum Pi$, where D is the population-weighted density of a metro or micro area, and Pi and di are the population and density of the ith census tract, respectively." U.S. Census Bureau, Patterns of Metropolitan and Micropolitan Population Change: 2000 to 2010 (Sept. 2012) at 23.

[2] R. Durairajan, P. Barford, J.Sommers and W. Willinger. InterTubes: A Study of the US Long-haul Fiber-optic Infrastructure. In Proceedings of ACM SIGCOMM, 2015; R. Durairajan, S. Ghosh, X. Tang, P. Barford, and B. Eriksson. Internet Atlas: A Geographic Database of the Internet. In Proceedings of ACM HotPlanet, 2013.

Kingsport, Tennessee	633.5	Population-weighted density of Kingsport-Bristol-Bristol, TN-VA
Bristol, Tennessee	633.5	Population-weighted density of Kingsport-Bristol-Bristol, TN-VA
Chesapeake, Virginia	652.2	Unweighted population density per sq mi
Bullhead City, Arizona	665.7	Unweighted population density per sq mi
Manchester, Tennessee	687.2	Unweighted population density per sq mi
Staunton, Virginia	706.6	Population-weighted density per sq mi
Danville, Virginia	794.0	Population-weighted density per sq mi
Spartanburg, South Carolina	799.6	Population-weighted density per sq mi
Lynchburg, Virginia	808.3	Population-weighted density per sq mi
Ocala, Florida	824.0	Population-weighted density per sq mi
Fort Smith, Arkansas	832.9	Population-weighted density per sq mi
Johnson City, Tennessee	879.1	Population-weighted density per sq mi
Stratford, Texas	1,008.5	Unweighted population density per sq mi
Macon, Georgia	1,049.9	Population-weighted density per sq mi
Bandon, Oregon	1,095.0	Unweighted population density per sq mi
Augusta, Georgia	1,098.6	Population-weighted density per sq mi
Chattanooga, Tennessee	1,126.8	Population-weighted density per sq mi
Bentonville, Arkansas	1,127.8	Unweighted population density per sq mi
Lake Havasu City, Arizona	1,143.6	Population-weighted density of Lake Havasu City-Kingman, AZ
Kingman, Arizona	1,143.6	Population-weighted density of Lake Havasu City-Kingman, AZ
Battle Creek, Michigan	1,179.4	Population-weighted density per sq mi
Winston-Salem, North Carolina	1,202.6	Population-weighted density per sq mi
Wilmington, North Carolina	1,232.1	Population-weighted density per sq mi
St. Cloud, Minnesota	1,260.7	Population-weighted density per sq mi
Greenville, South Carolina	1,264.8	Population-weighted density per sq mi
Jackson, Mississippi	1,277.9	Population-weighted density per sq mi
Birmingham, Alabama	1,314.2	Population-weighted density per sq mi
Redding, California	1,334.2	Population-weighted density per sq mi
Eau Claire, Wisconsin	1,345.6	Population-weighted density per sq mi
Flagstaff, Arizona	1,348.4	Population-weighted density per sq mi
Bellport, New York	1,389.3	Unweighted population density per sq mi
Little Rock, Arkansas	1,404.3	Population-weighted density per sq mi
Columbia, South Carolina	1,428.0	Population-weighted density per sq mi
Eureka, California	1,439.6	Population-weighted density per sq mi
Cottonwood, California	1,441.7	Unweighted population density per sq mi
Winter Haven, Florida	1,462.8	Population-weighted density of Lakeland-Winter Haven, FL
Lakeland, Florida	1,462.8	Population-weighted density of Lakeland-Winter Haven, FL

Pensacola, Florida	1,471.9	Population-weighted density of Pensacola-Ferry Pass-Brent, FL
Ferry Pass, Florida	1,471.9	Population-weighted density of Pensacola-Ferry Pass-Brent, FL
Brent, Florida	1,471.9	Population-weighted density of Pensacola-Ferry Pass-Brent, FL
Roanoke, Virginia	1,483.4	Population-weighted density per sq mi
Greensboro-High Point, North Carolina	1,507.7	Population-weighted density per sq mi
Wichita Falls, Texas	1,526.2	Population-weighted density per sq mi
New London, Connecticut	1,529.2	Population-weighted density of Norwich-New London, CT
Shreveport, Louisiana	1,566.4	Population-weighted density per sq mi
Youngstown, Ohio	1,569.8	Population-weighted density of Youngstown-Warren-Boardman, OH-PA
Warren, Ohio	1,569.8	Population-weighted density of Youngstown-Warren-Boardman, OH-PA
Boardman, Pennsylvania	1,569.8	Population-weighted density of Youngstown-Warren-Boardman, OH-PA
Topeka, Kansas	1,595.3	Population-weighted density per sq mi
Baton Rouge, Louisiana	1,603.3	Population-weighted density per sq mi
Kalamazoo, Michigan	1,603.7	Population-weighted density per sq mi
Mobile, Alabama	1,659.3	Population-weighted density per sq mi
Princeton, New Jersey	1,682.0	Unweighted population density per sq mi
Bozeman, Montana	1,691.7	Population-weighted density per sq mi
Fayetteville, North Carolina	1,694.0	Population-weighted density per sq mi
Nashville, Tennessee	1,695.3	Population-weighted density per sq mi
Springfield, Illinois	1,719.1	Population-weighted density per sq mi
Bowling Green, Kentucky	1,730.3	Population-weighted density per sq mi
Waco, Texas	1,743.0	Population-weighted density per sq mi
Williamsport, Pennsylvania	1,747.5	Population-weighted density per sq mi
Punxsutawney, Pennsylvania	1,753.5	Unweighted population density per sq mi
Owatonna, Minnesota	1,761.8	Population-weighted density per sq mi
Abilene, Texas	1,771.8	Population-weighted density per sq mi
Savannah, Georgia	1,811.1	Unweighted population density per sq mi
West Palm Beach, Florida	1,813.4	Unweighted population density per sq mi
Cheyenne, Wyoming	1,817.7	Population-weighted density per sq mi
Indiana, Pennsylvania	1,833.6	Population-weighted density per sq mi
Raleigh, North Carolina	1,850.1	Population-weighted density per sq mi
Roachdale, Indiana	1,852.0	Unweighted population density per sq mi
Durham, North Carolina	1,860.4	Population-weighted density per sq mi
Harrisonburg, Virginia	1,861.9	Population-weighted density per sq mi
Green Bay, Wisconsin	1,869.1	Population-weighted density per sq mi

Daytona Beach, Florida	1,871.3	Population-weighted density per sq mi
Brookhaven, New York	1,874.4	Unweighted population density per sq mi
Gastonia, North Carolina	1,881.3	Population-weighted density of Charlotte-Gastonia-Rock Hill, NC-SC
Charlotte, North Carolina	1,881.3	Population-weighted density of Charlotte-Gastonia-Rock Hill, NC-SC
San Angelo, Texas	1,905.7	Population-weighted density per sq mi
Fort Myers, Florida	1,911.3	Population-weighted density of Cape Coral-Fort Myers, FL
Charleston, South Carolina	1,926.0	Population-weighted density per sq mi
Medford, Oregon	1,939.4	Population-weighted density per sq mi
Tallahassee, Florida	1,964.2	Population-weighted density per sq mi
Tulsa, Oklahoma	1,980.2	Population-weighted density per sq mi
Eagan, Minnesota	1,987.8	Unweighted population density per sq mi
Casper, Wyoming	2,003.6	Population-weighted density per sq mi
Grand Junction, Colorado	2,015.2	Population-weighted density per sq mi
South Bend, Indiana	2,015.6	Population-weighted density per sq mi
Charlottesville, Virginia	2,050.7	Population-weighted density per sq mi
Lebanon, Pennsylvania	2,053.6	Population-weighted density per sq mi
Burlington, Vermont	2,053.9	Population-weighted density per sq mi
McAllen, Texas	2,083.8	Population-weighted density per sq mi
Billings, Montana	2,109.9	Population-weighted density per sq mi
Chico, California	2,144.7	Population-weighted density per sq mi
Titusville, Florida	2,152.9	Population-weighted density of Palm Bay-Melbourne-Titusville, FL
Melbourne, Florida	2,152.9	Population-weighted density of Palm Bay-Melbourne-Titusville, FL
Jacksonville, Florida	2,158.7	Population-weighted density per sq mi
Atlanta, Georgia	2,173.0	Population-weighted density per sq mi
Richmond, Virginia	2,175.7	Population-weighted density per sq mi
Rome-Utica, New York	2,186.4	Population-weighted density per sq mi
Greeley, Colorado	2,212.5	Population-weighted density per sq mi
Dayton, Ohio	2,243.4	Population-weighted density per sq mi
Wichita, Kansas	2,265.6	Population-weighted density per sq mi
Indianapolis, Indiana	2,285.6	Population-weighted density per sq mi
San Luis Obispo, California	2,293.4	Population-weighted density per sq mi
York, Pennsylvania	2,306.4	Population-weighted density per sq mi
Boise, Idaho	2,310.2	Population-weighted density per sq mi
Poughkeepsie, New York	2,319.5	Population-weighted density per sq mi
Kansas City, Kansas	2,326.1	Population-weighted density per sq mi
Gainesville, Florida	2,330.5	Population-weighted density per sq mi
Grand Rapids, Michigan	2,330.9	Population-weighted density per sq mi
Fredericksburg, Virginia	2,335.2	Unweighted population density per sq mi
Memphis, Tennessee	2,372.3	Population-weighted density per sq mi

Des Moines, Iowa	2,375.0	Population-weighted density per sq mi
Sarasota, Florida	2,390.2	Population-weighted density of North Port-Bradenton-Sarasota, FL
Akron, Ohio	2,412.8	Population-weighted density per sq mi
Troy, Michigan	2,417.3	Unweighted population density per sq mi
Altoona, Pennsylvania	2,428.7	Population-weighted density per sq mi
Harrisburg, Pennsylvania	2,446.0	Population-weighted density of Harrisburg-Carlisle, PA
Carlisle, Pennsylvania	2,446.0	Population-weighted density of Harrisburg-Carlisle, PA
Louisville, Kentucky	2,477.3	Population-weighted density per sq mi
Ashburn, Virginia	2,559.5	Unweighted population density per sq mi
Middletown, Kentucky	2,563.6	Population-weighted density of Cincinnati-Middletown, OH-KY-IN
Cincinnati, Ohio	2,563.6	Population-weighted density of Cincinnati-Middletown, OH-KY-IN
Oklahoma City, Oklahoma	2,568.8	Population-weighted density per sq mi
Amarillo, Texas	2,591.4	Population-weighted density per sq mi
Midland, Texas	2,684.2	Population-weighted density per sq mi
Toledo, Ohio	2,701.9	Population-weighted density per sq mi
Fort Collins-Loveland, Colorado	2,711.9	Population-weighted density per sq mi
Palo Alto, California	2,717.4	Unweighted population density per sq mi
Framingham, Massachusetts	2,721.8	Unweighted population density per sq mi
Southfield, Michigan	2,738.1	Unweighted population density per sq mi
St. Louis, Missouri	2,742.5	Population-weighted density per sq mi
Syracuse, New York	2,749.3	Population-weighted density per sq mi
Fargo, North Dakota	2,770.1	Population-weighted density per sq mi
Orlando, Florida	2,774.6	Population-weighted density per sq mi
Eugene, Oregon	2,787.1	Population-weighted density per sq mi
Bryan, Texas	2,804.2	Population-weighted density of College Station-Bryan, TX
Harlingen, Texas	2,842.9	Population-weighted density of Brownsville-Harlingen, TX
Spokane, Washington	2,861.7	Population-weighted density per sq mi
Worcester, Massachusetts	2,885.2	Population-weighted density per sq mi
Wilkes-Barre, Pennsylvania	2,889.1	Population-weighted density of Scranton--Wilkes-Barre, PA
Scranton, Pennsylvania	2,889.1	Population-weighted density of Scranton--Wilkes-Barre, PA
Rochester, New York	2,909.0	Population-weighted density per sq mi
Lexington-Fayette, Kentucky	2,918.6	Population-weighted density per sq mi
Ogden, Utah	2,937.4	Population-weighted density per sq mi

Lancaster, Pennsylvania	2,940.2	Population-weighted density per sq mi
Troy, New York	2,944.9	Population-weighted density of Albany-Schenectady-Troy, NY
Schenectady, New York	2,944.9	Population-weighted density of Albany-Schenectady-Troy, NY
Albany, New York	2,944.9	Population-weighted density of Albany-Schenectady-Troy, NY
Salem, Oregon	2,958.1	Population-weighted density per sq mi
Pittsburgh, Pennsylvania	2,990.8	Population-weighted density per sq mi
Lubbock, Texas	3,077.6	Population-weighted density per sq mi
Colorado Springs, Colorado	3,092.5	Population-weighted density per sq mi
Boca Raton, Florida	3,102.6	Unweighted population density per sq mi
Round Rock, Texas	3,131.5	Population-weighted density of Austin-Round Rock-San Marcos, TX
Austin, Texas	3,131.5	Population-weighted density of Austin-Round Rock-San Marcos, TX
Omaha, Nebraska	3,138.1	Population-weighted density of Omaha-Council Bluffs, NE-IA
Council Bluffs, Iowa	3,138.1	Population-weighted density of Omaha-Council Bluffs, NE-IA
Harbour Pointe, Washington	3,164.7	Unweighted population density per sq mi of Mukilteo, WA
Springfield, Massachusetts	3,184.9	Population-weighted density per sq mi
Columbus, Ohio	3,186.0	Population-weighted density per sq mi
Frederick, Maryland	3,198.0	Unweighted population density per sq mi
Corpus Christi, Texas	3,204.0	Population-weighted density per sq mi
Tucson, Arizona	3,213.0	Population-weighted density per sq mi
Lansing, Michigan	3,222.2	Population-weighted density per sq mi
Hartford, Connecticut	3,250.9	Population-weighted density per sq mi
Erie, Pennsylvania	3,298.5	Population-weighted density per sq mi
Tampa, Florida	3,323.0	Population-weighted density of Tampa-St. Petersburg-Clearwater, FL
Saint Petersburg, Florida	3,323.0	Population-weighted density of Tampa-St. Petersburg-Clearwater, FL
Clearwater, Florida	3,323.0	Population-weighted density of Tampa-St. Petersburg-Clearwater, FL
Edison, New Jersey	3,343.4	Unweighted population density per sq mi
Minneapolis, Minnesota	3,383.4	Population-weighted density per sq mi
San Antonio, Texas	3,475.4	Population-weighted density per sq mi
Madison, Wisconsin	3,502.2	Population-weighted density per sq mi
Albuquerque, New Mexico	3,518.6	Population-weighted density per sq mi
Plano, Texas	3,629.1	Unweighted population density per sq mi
Boulder, Colorado	3,650.0	Population-weighted density per sq mi
Lompoc, California	3,658.1	Unweighted population density per sq mi

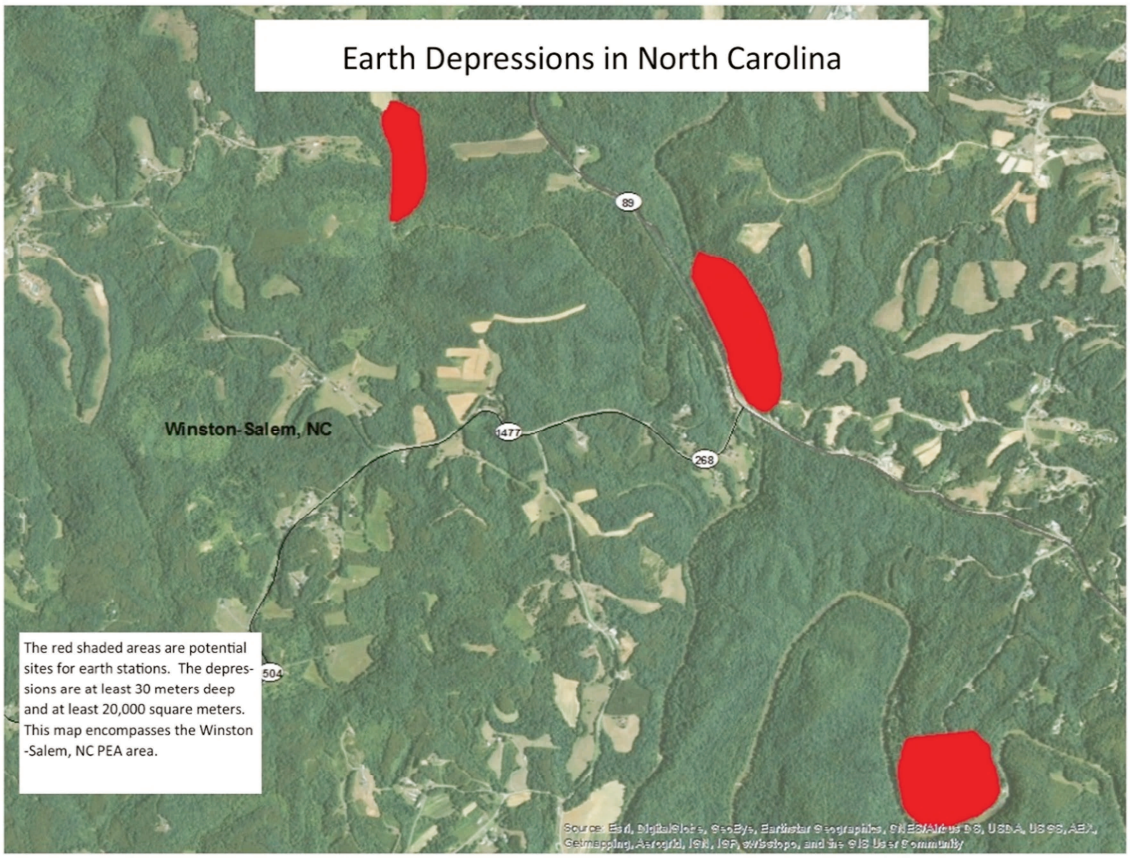
Bakersfield, California	3,711.5	Population-weighted density per sq mi
Reno, Nevada	3,714.7	Population-weighted density per sq mi
Lincoln, Nebraska	3,748.0	Population-weighted density per sq mi
Livonia, Michigan	3,800.4	Population-weighted density of Detroit-Warren-Livonia, MI
Detroit, Michigan	3,800.4	Population-weighted density of Detroit-Warren-Livonia, MI
Orange County, California	3,805.6	Unweighted population density per sq mi
Mentor, Ohio	3,808.4	Population-weighted density of Cleveland-Elyria-Mentor, OH
Elyria, Ohio	3,808.4	Population-weighted density of Cleveland-Elyria-Mentor, OH
Cleveland, Ohio	3,808.4	Population-weighted density of Cleveland-Elyria-Mentor, OH
Allentown, Pennsylvania	3,889.3	Population-weighted density per sq mi
Fort Worth, Texas	3,909.3	Population-weighted density of Dallas-Fort Worth-Arlington, TX
Dallas, Texas	3,909.3	Population-weighted density of Dallas-Fort Worth-Arlington, TX
New Haven, Connecticut	4,007.4	Population-weighted density per sq mi
Dearborn, Michigan	4,022.7	Unweighted population density per sq mi
Norfolk, Virginia	4,084.1	Population-weighted density of Virginia Beach-Norfolk-Newport News, VA-NC
Sugar Land, Texas	4,109.6	Population-weighted density of Houston-Sugar Land-Baytown, TX
Houston, Texas	4,109.6	Population-weighted density of Houston-Sugar Land-Baytown, TX
Baytown, Texas	4,109.6	Population-weighted density of Houston-Sugar Land-Baytown, TX
Niagara Falls, New York	4,129.4	Population-weighted density of Buffalo-Niagara Falls, NY
Buffalo, New York	4,129.4	Population-weighted density of Buffalo-Niagara Falls, NY
Fresno, California	4,216.1	Population-weighted density per sq mi
Provo, Utah	4,270.3	Population-weighted density per sq mi
San Bernardino, California	4,299.6	Population-weighted density of Riverside-San Bernardino-Ontario, CA
Riverside, California	4,299.6	Population-weighted density of Riverside-San Bernardino-Ontario, CA
El Paso, Texas	4,318.3	Population-weighted density per sq mi
Modesto, California	4,322.7	Population-weighted density per sq mi
State College, Pennsylvania	4,366.2	Population-weighted density per sq mi
New Orleans, Louisiana	4,370.2	Population-weighted density per sq mi

Vancouver, Washington	4,372.6	Population-weighted density of Portland-Vancouver-Hillsboro, OR-WA
Portland, Oregon	4,372.6	Population-weighted density of Portland-Vancouver-Hillsboro, OR-WA
Hillsboro, Oregon	4,372.6	Population-weighted density of Portland-Vancouver-Hillsboro, OR-WA
Phoenix, Arizona	4,394.9	Population-weighted density per sq mi
Sacramento, California	4,538.5	Population-weighted density of Sacramento-Arden-Arcade-Roseville, CA
Roseville, California	4,538.5	Population-weighted density of Sacramento-Arden-Arcade-Roseville, CA
Auburn, California	4,538.5	Population-weighted density of Sacramento-Arden-Arcade-Roseville, CA
Arden-Arcade, California	4,538.5	Population-weighted density of Sacramento-Arden-Arcade-Roseville, CA
Salt Lake City, Utah	4,563.5	Population-weighted density per sq mi
Reading, Pennsylvania	4,656.8	Population-weighted density per sq mi
Tacoma, Washington	4,721.6	Population-weighted density of Seattle-Tacoma-Bellevue, WA
Seattle, Washington	4,721.6	Population-weighted density of Seattle-Tacoma-Bellevue, WA
Bellevue, Washington	4,721.6	Population-weighted density of Seattle-Tacoma-Bellevue, WA
Providence, Rhode Island	4,763.7	Population-weighted density per sq mi
Denver, Colorado	4,803.7	Population-weighted density per sq mi
Stockton, California	4,889.1	Population-weighted density per sq mi
Bridgeport, Connecticut	5,122.2	Population-weighted density of Bridgeport-Stamford-Norwalk, CT
Stamford, Connecticut	5,122.4	Population-weighted density of Bridgeport-Stamford-Norwalk, CT
Norwalk, Connecticut	5,122.4	Population-weighted density of Bridgeport-Stamford-Norwalk, CT
Hollywood, Florida	5,156.3	Unweighted population density per sq mi
Milwaukee, Wisconsin	5,257.6	Population-weighted density per sq mi
Laredo, Texas	5,300.1	Population-weighted density per sq mi
Towson, Maryland	5,435.7	Population-weighted density of Baltimore-Towson, MD
Baltimore, Maryland	5,435.7	Population-weighted density per sq mi
Deerfield Beach, Florida	5,598.4	Unweighted population density per sq mi
Grover Beach, California	5,720.0	Unweighted population density per sq mi
White Plains, New York	5,801.3	Unweighted population density per sq mi
Trenton, New Jersey	5,864.6	Population-weighted density per sq mi
Santa Barbara, California	6,242.8	Population-weighted density per sq mi
Washington DC	6,388.1	Population-weighted density per sq mi

Salinas, California	6,402.3	Population-weighted density per sq mi
Las Vegas, Nevada	6,527.2	Population-weighted density per sq mi
Anaheim, California	6,752.3	Unweighted population density per sq mi
San Diego, California	6,920.5	Population-weighted density of San Diego-Carlsbad-San Marcos, CA
Carlsbad, California	6,920.5	Population-weighted density of San Diego-Carlsbad-San Marcos, CA
Pompano Beach, Florida	7,395.3	Population-weighted density of Miami-Fort Lauderdale-Pompano Beach, FL
Miami, Florida	7,395.3	Population-weighted density of Miami-Fort Lauderdale-Pompano Beach, FL
Fort Lauderdale, Florida	7,395.3	Population-weighted density of Miami-Fort Lauderdale-Pompano Beach, FL
Philadelphia, Pennsylvania	7,773.2	Population-weighted density per sq mi
San Mateo, California	7,967.8	Unweighted population density per sq mi
Boston, Massachusetts	7,980.1	Population-weighted density per sq mi
Sunnyvale, California	8,417.7	Population-weighted density of San Jose-Sunnyvale-Santa Clara, CA
San Jose, California	8,417.7	Population-weighted density of San Jose-Sunnyvale-Santa Clara, CA
Chicago, Illinois	8,613.4	Population-weighted density per sq mi
Newark, New Jersey	11,644.5	Unweighted population density per sq mi
Santa Ana, California	12,113.9	Population-weighted density of Los Angeles-Long Beach-Santa Ana, CA
Los Angeles, California	12,113.9	Population-weighted density of Los Angeles-Long Beach-Santa Ana, CA
San Francisco, California	12,144.9	Population-weighted density of San Francisco-Oakland-Fremont, CA
Oakland, California	12,144.9	Population-weighted density of San Francisco-Oakland-Fremont, CA
New York, New York	31,251.4	Population-weighted density per sq mi

APPENDIX C

Sources and Methods for Geographic Depressions Suitable for Terrain Shielding



This image depicts depressions that might provide suitable locations for gateway earth stations. With advice and guidance from Daniel Doctor and John Young of the U.S. Geological Survey (USGS), Commission staff identified these depressions using geographic information system (GIS) analytical tools available in ESRI's ARCGIS software to analyze USGS 90-meter digital elevation data from NASA's Shuttle Radar Topographic Mission. More specifically, Commission staff used the ARCGIS Spatial Analyst Hydrology Toolset Fill tool. The Hydrology toolset simulates water flow and thereby provides a method for identifying depressions that meet specific elevation criteria. In this case the staff specified parameters that would result in depressions with a minimum depth of 30 meters. The initial depressions that were identified were compared with GIS information about water features to eliminate depressions that are filled with water, and were further filtered to eliminate depressions that were less than 20,000 square meters. The remaining dry locations are completely surrounded by terrain that would create natural shielding and, therefore, might be ideal locations for earth stations, including ones required to point in any direction in order to track non-geosynchronous satellites. This method demonstrates one possible strategy for identifying suitable earth station locations that would minimize the potential impact on terrestrial services.

APPENDIX D

Coordination Contours for NASA and NSF sites in the 37-38.6 GHz band

Goldstone, CA

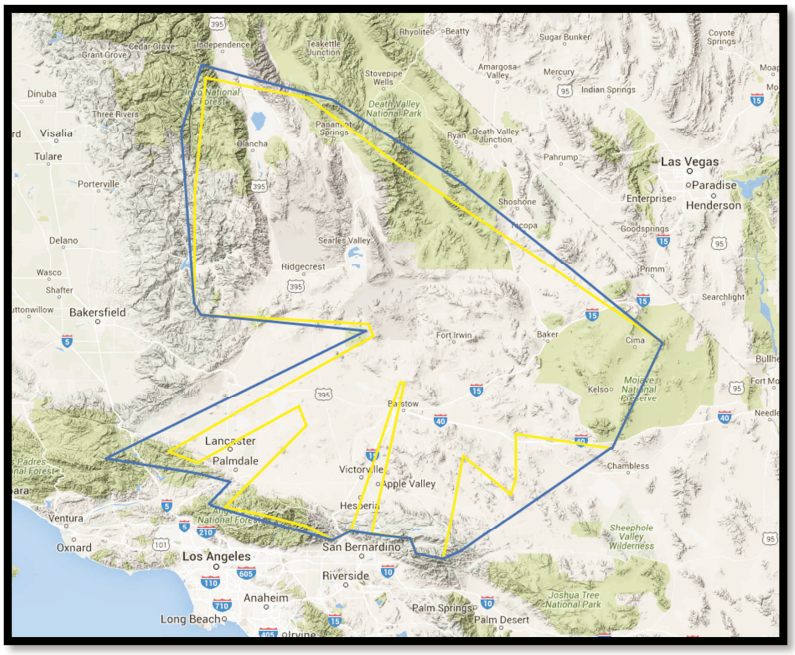
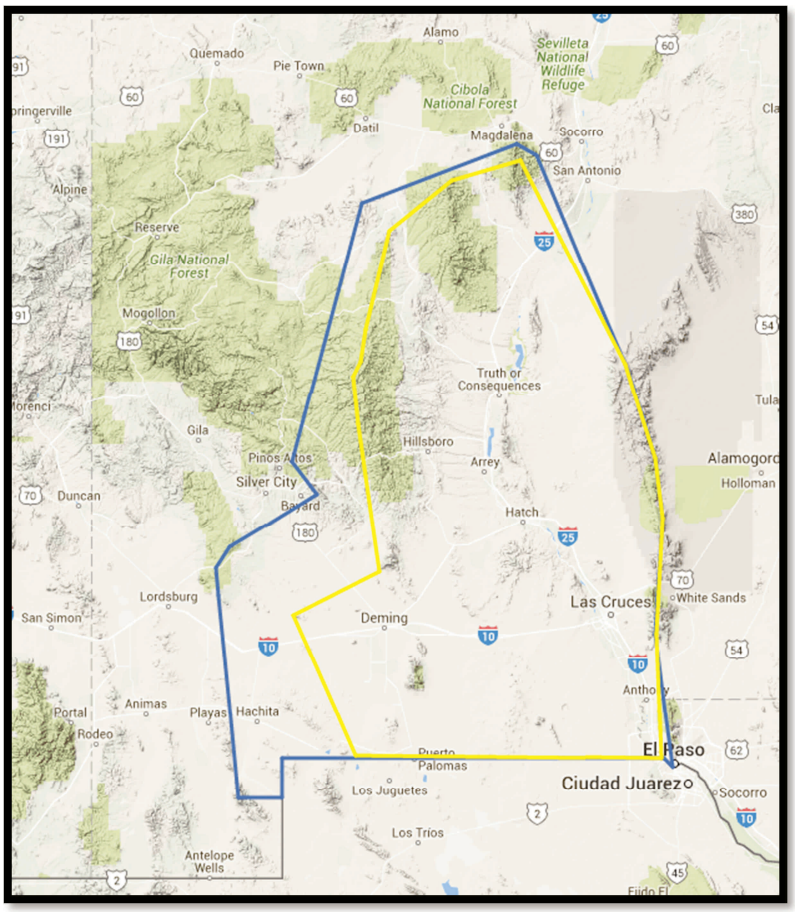


Table 4: Goldstone Coordination Zones

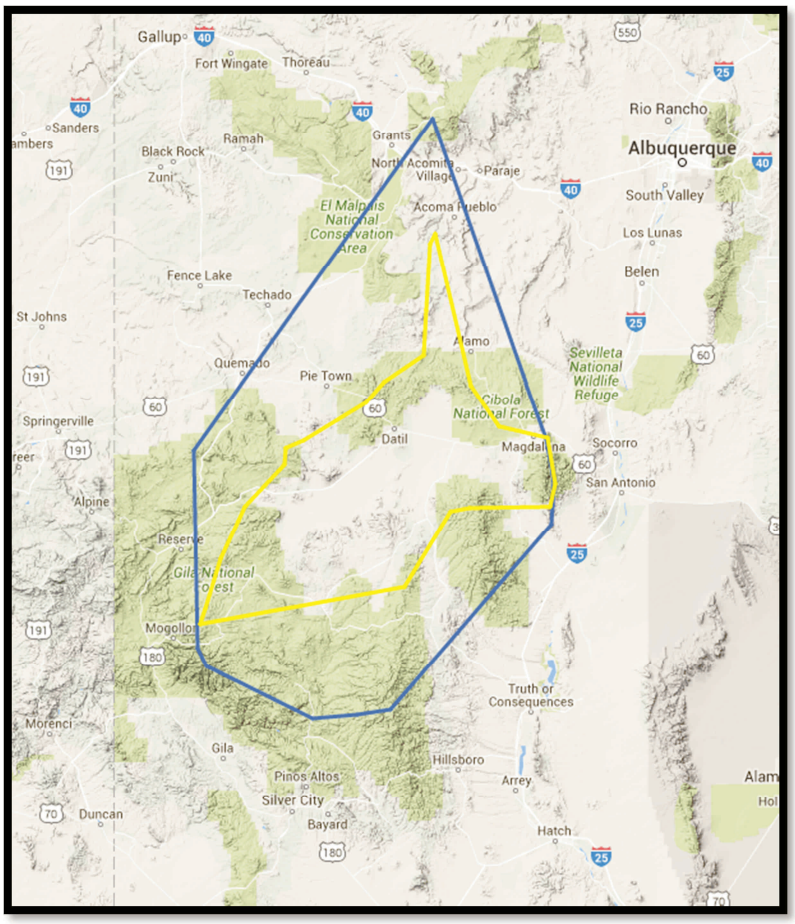
60 dBm/100 MHz EIRP (yellow)		75 dBm/100 MHz EIRP (blue)	
Latitude/Longitude (decimal degrees)	**Latitude/Longitude (decimal degrees)**	**Latitude/Longitude (decimal degrees)**	**Latitude/Longitude (decimal degrees)**
34.69217/-115.6491	34.19524/-117.47963	34.69217/-115.6491	34.19524/-117.47963
35.25746/-115.32041	34.24586/-117.36210	35.25746/-115.32041	34.24586/-117.36210
36.21257/-117.06567	35.04648/-117.03781	36.11221/-116.63632	34.21748/-117.12812
36.55967/-117.63691	35.04788/-117.00949	36.54731/-117.48242	34.20370/-116.97024
36.66297/-118.31017	34.22940/-117.22327	36.73049/-118.33683	34.12196/-116.93109
36.06074/-118.38528	34.20370/-116.97024	36.39126/-118.47307	34.09498/-116.75473
35.47015/-118.39008	34.12196/-116.93109	36.36891/-118.47134	34.13603/-116.64002
35.40865/-118.34353	34.09498/-116.75473	35.47015/-118.39008	34.69217/-115.6591
35.35986/-117.24709	34.19642/-116.72901	35.40865/-118.34353	34.69217/-115.6491
35.29539/-117.21102	34.64906/-116.62741	35.32048/-117.26386	
34.67607/-118.55412	34.44404/-116.31486	34.63725/-118.96736	
34.61532/-118.36919	34.52736/-116.27845	34.55789/-118.36204	
34.91551/-117.70371	34.76685/-116.27930	34.51108/-118.15329	
34.81257/-117.65400	34.69217/-115.6591	34.39220/-118.28852	
34.37411/-118.18385	34.69217/-115.6491	34.38546/-118.27460	
34.33405/-117.94189		34.37524/-118.24191	
34.27249/-117.65445		34.37039/-118.22557	

White Sands, New Mexico



60 dBm/100 MHz EIRP (yellow)		75 dBm/100 MHz EIRP (blue)	
Latitude/Longitude (decimal degrees)	**Latitude/Longitude (decimal degrees)**	**Latitude/Longitude (decimal degrees)**	**Latitude/Longitude (decimal degrees)**
33.98689/-107.15967	31.78455/-106.54058	31.7494/-106.49132	32.88382/-108.16588
33.91573/-107.46301	32.24710/-106.56114	32.24524/-106.56507	32.76255/-108.05679
33.73122/-107.73585	32.67731/-106.53681	32.67731/-106.53681	32.56863/-108.43999
33.37098/-107.84333	32.89856/-106.56882	32.89856/-106.56882	32.48991/-108.50032
33.25424/-107.86409	33.24323/-106.70094	33.04880/-106.62309	32.39142/-108.48959
33.19808/-107.89673	33.98689/-107.15967	33.21824/-106.68992	31.63664/-108.40480
33.02128/-107.87226		33.24347/-106.70165	31.63466/-108.20921
32.47747/-107.77963		34.00708/-107.08652	31.78374/-108.20798
32.31543/-108.16101		34.04967/-107.17524	31.78322/-106.52825
31.79429/-107.88616		33.83491/-107.85971	31.7494/-106.49132

Socorro, New Mexico



60 dBm/100 MHz EIRP (yellow)		75 dBm/100 MHz EIRP (blue)
Latitude/Longitude (decimal degrees)	**Latitude/Longitude (decimal degrees)**	**Latitude/Longitude (decimal degrees)**
34.83816/-107.66828	33.44401/-108.67876	33.10651/-108.19320
34.80070/-107.68759	33.57963/-107.79895	33.11780/-107.99980
34.56506/-107.70233	33.84552/-107.60207	33.13558/-107.85611
34.40826/-107.71489	33.85964/-107.51915	33.80383/-107.16520
34.31013/-107.88349	33.86479/-107.17223	33.94554/-107.15516
34.24067/-107.96059	33.94779/-107.15038	33.95665/-107.15480
34.10278/-108.23166	34.11122/-107.18132	34.08156/-107.18137
34.07442/-108.30646	34.15203/-107.39035	34.10646/-107.18938
34.01447/-108.31694	34.29643/-107.51071	35.24269/-107.67969
33.86740/-108.48706	34.83816/-107.66828	34.06647/-108.70438
33.81660/-108.51052		33.35946/-108.68902
33.67909/-108.58750		33.29430/-108.65004
33.50223/-108.65470		33.10651/-108.19320

APPENDIX E

Final Regulatory Flexibility Analysis

1. As required by the Regulatory Flexibility Act of 1980, as amended (RFA),[1] the Commission incorporated an Initial Regulatory Flexibility Analysis (IRFA) of the possible significant economic impact on a substantial number of small entities by the policies and rules proposed in the *Notice of Proposed Rulemaking (NPRM)*. No comments were filed addressing the IRFA. Because we amend the rules in this *Report and Order*, we have included this Final Regulatory Flexibility Analysis (FRFA) which conforms to the RFA.[2]

A. Need for, and Objectives of, the Proposed Rules

2. In the attached *Report and Order*, we increase the Nation's supply of spectrum for mobile broadband by adopting rules for fixed and mobile services in the 27.5-28.35 GHz band (28 GHz band), the 38.6-40 GHz band (39 GHz band), and the 37-38.6 GHz band (37 GHz band). We also authorize unlicensed operation pursuant to Part 15 of our rules in the 64-71 GHz band. These bands are known collectively as the "mmW bands."

3. Until recently, the mmW bands were generally considered unsuitable for mobile applications because of propagation losses at such high frequencies and the inability of mmW signals to propagate around obstacles. As increasing congestion has begun to fill the lower bands and carriers have resorted to smaller and smaller microcells in order to re-use the available spectrum, however, industry is taking another look at the mmW bands and beginning to realize that at least some of its presumed disadvantages can be turned to advantage. For example, short transmission paths and high propagation losses can facilitate spectrum re-use in microcellular deployments by limiting the amount of interference between adjacent cells. Furthermore, where longer paths are desired, the extremely short wavelengths of mmW signals make it feasible for very small antennas to concentrate signals into highly focused beams with enough gain to overcome propagation losses. The short wavelengths of mmW signals also make it possible to build multi-element, dynamic beam-forming antennas that will be small enough to fit into handsets—a feat that might never be possible at the lower, longer-wavelength frequencies below 6 GHz where cell phones operate today.

4. In the 28 GHz, 39 GHz, and 37 GHz bands, we create a new radio service in a new rule part that will authorize fixed and mobile services – the Part 30 Upper Microwave Flexible Use Service. This additional spectrum for mobile use will help ensure that the speed, capacity, and ubiquity of the nation's wireless networks keeps pace with the skyrocketing demand for mobile service. It will also make possible new types of services for consumers and businesses.

5. The service rules we adopt make additional spectrum available for flexible use. In creating service rules for these bands, which include technical rules to protect against harmful interference, licensing rules to establish geographic license areas and spectrum block sizes, and performance requirements to promote robust buildout, we advance toward enabling rapid and efficient deployment. We do so by providing flexible service, technical, assignment, and licensing rules for this spectrum, except where special provisions are necessary to facilitate shared use with other co-primary users.

6. For the 28 GHz 37 GHz, and 39 GHz bands, we propose to assign licenses by competitive bidding using counties as the area for geographic area licensing in the 28 GHz band and in a

[1] *See* 5 U.S.C. § 603. The RFA, *see* 5 U.S.C. § 601-612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996, (SBREFA) Pub. L. No. 104-121, Title II, 110 Stat. 857 (1996).

[2] *See* 5 U.S.C. § 604.

portion of 37 GHz band (37-37.6 GHz). We will award PEA-based licenses by competitive bidding for the 39 GHz and the upper portion of the 37 GHz band (37.6-38.6 GHz). In the 37-37.6 GHz band, we have created a 600 MHz shared access space with rule-based, non-interfering Shared Access Licenses (SALs) which will share the band with Federal fixed and mobile operations. SAL licensees are not guaranteed spectrum access or interference protection from individual licensees. We believe this system at 37 GHz will create an innovative shared space that can be used by a wide variety of Federal and non-Federal users, by new entrants and by established operators – and small businesses in particular – to experiment with new technologies in the mmW space and innovate.

7. At the same time, because the 28 GHz, 39 GHz, and 37 GHz bands are shared with satellite services, we have taken steps to facilitate sharing with satellite uses in ways that are consistent with fixed and mobile use of the bands. Specifically, we conclude we will authorize a limited number of satellite earth stations to operate on a co-primary basis – one in each county for the 28 GHz band and one in each PEA in the 37.5-40 GHz band – on a first-come, first-served basis. In the 28 GHz band we will grandfather pre-existing satellite earth stations in any county into a local interference zone with the right to operate under the terms of their existing authorizations. These FSS earth stations must comply with certain enumerated conditions to obtain an authorization for their specific locations, including coordinating their operations with any existing mmW licensees to ensure non-interference between the services. Additional earth stations can be located if the FSS operator acquires a Part 30 license, reaches a contractual agreement with the Part 30 licensee, or agrees to operate on a secondary basis.

8. Overall, the new provisions we are adopting are designed to allow licensees to choose their type of service offerings, to encourage innovation and investment in mobile and fixed use in this spectrum, and to provide a stable regulatory environment in which fixed, mobile, and satellite deployment will be able to develop through the application of flexible rules. The market-oriented licensing framework for these bands will ensure that this spectrum is efficiently utilized and will foster the development of new and innovative technologies and services, as well as encourage the growth and development of a wide variety of services, ultimately leading to greater benefits to consumers.

B. Summary of Significant Issues raised by Public Comments in Response to the IRFA

9. No comments were filed in direct response to the IRFA.

C. Response to Comments by the Chief Counsel for Advocacy of the Small Business Administration

10. Pursuant to the Small Business Jobs Act of 2010, which amended the RFA, the Commission is required to respond to any comments filed by the Chief Counsel for Advocacy of the Small Business Administration (SBA), and to provide a detailed statement of any change made to the proposed rules as a result of those comments.[3] The Chief Counsel did not file any comments in response to the proposed rules in this proceeding.

D. Description and Estimate of the Number of Small Entities To Which the Proposed Rules Will Apply

11. The RFA directs agencies to provide a description of, and where feasible, an estimate of the number of small entities that may be affected by the proposed rules and policies, if adopted.[4] The RFA generally defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction."[5] In addition, the term "small business" has

[3] 5 U.S.C. § 604(a)(3).

[4] 5 U.S.C. § 603(b)(3).

[5] 5 U.S.C. § 601(6).

the same meaning as the term "small business concern" under the Small Business Act.[6] A "small business concern" is one which: (1) is independently owned and operated; (2) is not dominant in its field of operation; and (3) satisfies any additional criteria established by the SBA.[7]

12. *Small Businesses, Small Organizations, and Small Governmental Jurisdictions.* Our action may, over time, affect small entities that are not easily categorized at present. We therefore describe here, at the outset, three comprehensive, statutory small entity size standards.[8] First, nationwide, there are a total of approximately 28.2 million businesses, 99.7 percent of which are small, according to the SBA.[9] In addition, a "small organization" is generally "any not-for-profit enterprise which is independently owned and operated and is not dominant in its field."[10] Nationwide, as of 2007, there were approximately 1,621,315 small organizations.[11] Finally, the term "small governmental jurisdiction" is defined generally as "governments of cities, towns, townships, villages, school districts, or special districts, with a population of less than fifty thousand."[12] Census Bureau data for 2011 indicate that there were 89,476 local governmental jurisdictions in the United States.[13] We estimate that, of this total, as many as 88,506 entities may qualify as "small governmental jurisdictions."[14] Thus, we estimate that most governmental jurisdictions are small.

13. *Wireless Telecommunications Carriers (except satellite)*. The appropriate size standard under SBA rules is for the category Wireless Telecommunications Carriers. Under that size standard, such a business is small if it has 1,500 or fewer employees.[15] Census Bureau data for 2012, show that there were 967 firms in this category that operated for the entire year. Of this total, 955 had employment of 999 or fewer, and 12 firms had employment of 1,000 employees or more. Thus under this category and the associated small business size standard, the Commission estimates that the majority of wireless

[6] 5 U.S.C. § 601(3) (incorporating by reference the definition of "small-business concern" in the Small Business Act, 15 U.S.C. § 632). Pursuant to 5 U.S.C. § 601(3), the statutory definition of a small business applies "unless an agency, after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definition(s) in the Federal Register."

[7] 15 U.S.C. § 632.

[8] *See* 5 U.S.C. §§ 601(3)–(6).

[9] *See* U.S. Small Business Administration, Office of Advocacy, *Frequently Asked Questions*, https://www.sba.gov/sites/default/files/FAQ_March_2014_0.pdf.

[10] 5 U.S.C. § 601(4).

[11] INDEPENDENT SECTOR, THE NEW NONPROFIT ALMANAC & DESK REFERENCE (2010).

[12] 5 U.S.C. § 601(5).

[13] U.S. CENSUS BUREAU, STATISTICAL ABSTRACT OF THE UNITED STATES: 2011, Table 427.

[14] The 2007 U.S Census data for small governmental organizations are not presented based on the size of the population in each such organization. There were 89,476 small governmental organizations in 2007. If we assume that county, municipal, township, and school district organizations are more likely than larger governmental organizations to have populations of 50,000 or less, the total of these organizations is 52,125. If we make the same assumption about special districts and also assume that special districts are different from county, municipal, township, and school districts, in 2007 there were 37,381 special districts. Therefore, of the 89,476 small governmental organizations documented in 2007, as many as 89,506 may be considered small under the applicable standard. This data may overestimate the number of such organizations that has a population of 50,000 or less. U.S. CENSUS BUREAU, STATISTICAL ABSTRACT OF THE UNITED STATES 2011, Tables 427, 426 (Data cited therein are from 2007).

[15] 13 CFR § 121.201, NAICS code 517210.

telecommunications carriers (except satellite) are small entities that may be affected by our action.[16]

14. *Fixed Microwave Services.* Microwave services include common carrier,[17] private-operational fixed,[18] and broadcast auxiliary radio services.[19] They also include the Local Multipoint Distribution Service (LMDS),[20] the Digital Electronic Message Service (DEMS),[21] the 39 GHz Service (39 GHz),[22] the 24 GHz Service,[23] and the Millimeter Wave Service[24] where licensees can choose between common carrier and non-common carrier status.[25] At present, there are approximately 61,970 common carrier fixed licensees, 62,909 private and public safety operational-fixed licensees, 20,349 broadcast auxiliary radio licensees, 412 LMDS licenses, 35 DEMS licenses, 870 39 GHz licenses, and five 24 GHz licenses, and 408 Millimeter Wave licenses in the microwave services.[26] The Commission has not yet defined a small business with respect to microwave services. For purposes of the FRFA, the Commission will use the SBA's definition applicable to Wireless Telecommunications Carriers (except satellite)—i.e., an entity with no more than 1,500 persons is considered small.[27] Under that size standard, such a business is small if it has 1,500 or fewer employees.[28] Census Bureau data for 2012, show that there were 967 firms in this category that operated for the entire year. Of this total, 955 had employment of 999 or fewer, and 12 firms had employment of 1,000 employees or more. Thus under this category and the associated small business size standard, the Commission estimates that the majority of wireless telecommunications carriers (except satellite) are small entities that may be affected by our proposed action.[29] The Commission notes that the number of firms does not necessarily track the number of licensees. The Commission estimates that virtually all of the Fixed Microwave licensees (excluding broadcast auxiliary licensees) would qualify as small entities under the SBA definition.

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[16] *See* United States Census Bureau, *American Fact Finder,* http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2012_US_51SSSZ5&prodType=table.

[17] *See* 47 CFR Part 10, Subpart I.

[18] Persons eligible under Parts 80 and 90 of the Commission's rules can use Private-Operational Fixed Microwave services. *See* 47 C.F.R. Parts 80 and 90. Stations in this service are called operational-fixed to distinguish them from common carrier and public fixed stations. Only the licensee may use the operational-fixed station, and only for communications related to the licensee's commercial, industrial, or safety operations.

[19] Auxiliary Microwave Service is governed by Part 74 and Part 78 of Title 47 of the Commission's rules. Available to licensees of broadcast stations, cable operators, and to broadcast and cable network entities. Auxiliary microwave stations are used for relaying broadcast television signals from the studio to the transmitter, or between two points such as a main studio and an auxiliary studio. The service also includes TV pickup and CARS pickup, which relay signals from a remote location back to the studio.

[20] *See* 47 CFR Part 101, Subpart L.

[21] *See* 47 CFR Part 101, Subpart G.

[22] *See* 47 CFR Part 101, Subpart N.

[23] *See id.*

[24] *See* 47 CFR Part 101, Subpart Q.

[25] *See* 47 CFR §§ 101.533, 101.1017.

[26] These statistics are based on a review of the Universal Licensing System on September 22, 2015.

[27] 13 CFR § 121.201, NAICS code 517210.

[28] 13 CFR § 121.201, NAICS code 517210.

[29] *See* United States Census Bureau, *American Fact Finder,* http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2012_US_51SSSZ5&prodType=table.

15. *Satellite Telecommunications and All Other Telecommunications.* Two economic census categories address the satellite industry. The first category has a small business size standard of $32.5 million or less in average annual receipts, under SBA rules.[30] The second also has a size standard of $32.5 million or less in annual receipts.[31]

16. The category of Satellite Telecommunications "comprises establishments primarily engaged in providing telecommunications services to other establishments in the telecommunications and broadcasting industries by forwarding and receiving communications signals via a system of satellites or reselling satellite telecommunications."[32] Census Bureau data for 2012 show that 333 Satellite Telecommunications firms operated for that entire year. Of this total, 275 firms had annual receipts of under $10 million, and 58 firms had receipts of $10 million to $24,999,999.[33] Consequently, the Commission estimates that the majority of Satellite Telecommunications firms are small entities that might be affected by our action.

17. The second category, i.e., "All Other Telecommunications," comprises "establishments primarily engaged in providing specialized telecommunications services, such as satellite tracking, communications telemetry, and radar station operation. This industry also includes establishments primarily engaged in providing satellite terminal stations and associated facilities connected with one or more terrestrial systems and capable of transmitting telecommunications to, and receiving telecommunications from, satellite systems. Establishments providing Internet services or voice over Internet protocol (VoIP) services via client-supplied telecommunications connections are also included in this industry."[34] For this category, Census Bureau data for 2012 show that there were a total of 1442 firms that operated for the entire year. Of this total, 1400 firms had annual receipts of under $25 million. and 42 firms had annual receipts of $25 million to $49, 999,999.[35] Consequently, the Commission estimates that the majority of All Other Telecommunications firms are small entities that might be affected by our action.

18. *Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing.* The proposed rules relating to Part 15 operation pertain to manufacturers of unlicensed communications devices. The Census Bureau defines this category as follows: "This industry comprises establishments primarily engaged in manufacturing radio and television broadcast and wireless communications equipment. Examples of products made by these establishments are: transmitting and receiving antennas, cable television equipment, GPS equipment, pagers, cellular phones, mobile communications equipment, and radio and television studio and broadcasting equipment."[36] The SBA has developed a small business size standard for firms in this category, which is: all such firms having 750 or fewer employees. According to Census Bureau data for 2007, there were a total of 939 establishments in this category that operated for part or all of the entire year. Of this total, 784 had less

[30] 13 CFR § 121.201, NAICS code 517410.

[31] 13 CFR § 121.201, NAICS code 517919.

[32] U.S. Census Bureau, 2012 NAICS Definitions, "517410 Satellite Telecommunications."

[33] *See* United States Census Bureau, *American Fact Finder,* http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2012_US_51SSSZ4&prodType=table.

[34] U.S. Census Bureau, 2012 NAICS Definitions, "517919 All Other Telecommunications."

[35] *See* United States Census Bureau, *American Fact Finder,* http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2012_US_51SSSZ4&prodType=table.

[36] *See* U.S. Census Bureau, 2012 NAICS Definitions, NAICS Code 334220, *available at* http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2012_US_31SA1&prodType=table.

than 500 employees and 155 had more than 100 employees.[37] Thus, under this size standard, the majority of firms can be considered small.

E. Description of Projected Reporting, Recordkeeping, and other Compliance Requirements

19. The projected reporting, recordkeeping, and other compliance requirements proposed in the *Report and Order* will apply to all entities in the same manner. The revisions the Commission adopts should benefit small entities by giving them more information, more flexibility, and more options for gaining access to wireless spectrum.

20. Any applicants for Upper Microwave Flexible Use Service licenses will be required to file license applications using the Commission's automated Universal Licensing System (ULS). ULS is an online electronic filing system that also serves as a powerful information tool, one that enables potential licensees to research applications, licenses, and antenna structures. It also keeps the public informed with weekly public notices, FCC rulemakings, processing utilities, and a telecommunications glossary. Upper Microwave Flexible Use Service applicants that must submit long-form license applications must do so through ULS using Form 601,[38] FCC Ownership Disclosure Information for the Wireless Telecommunications Services using FCC Form 602,[39] and other appropriate forms.[40]

21. Licensees in the Upper Microwave Flexible Use Service will be subject to performance requirements based on a series of metrics, tailored to each type of service a licensee may offer. Accordingly, mobile services will be required to provide service to 40 percent of the population of their license area by the end of their initial license terms. Geographic area licensees providing Fixed Service in the 28 GHz, 37 GHz and 39 GHz will be required to construct and operate at least 15 links per million persons in the population. Satellite operators will be able to meet their build-out requirement by deploying an operational earth station in the license area that provides service. Licensees deploying a mix of such services will be able to choose which performance metric – or combination thereof – they desire to meet. Performance will be assessed on a license area basis, regardless of license area size. For the 28 GHz band, licenses will terminate automatically if a licensee fails to meet the applicable performance requirements. For geographic area licenses in the 37 and 39 GHz bands, licensees will have the option of partitioning their licenses on a county basis to come into compliance with the relevant performance metric. Licensees will be required to provide information to the Commission on the facilities they have constructed, the nature of the service they are providing, and the extent to which they are providing coverage in their license area, to both facilitate sharing with other authorized services and to enable accurate assessment of their performance. Incumbent licensees will be granted time to transition to these new performance requirements. FSS operators will have to coordinate their operations with any existing mmW licensees to ensure non-interference between the services.

22. New licensees will also be required, within three years after receiving their licenses but no later than six months prior to deployment, to file with the Commission a security statement signed by a senior licensee executive with personal knowledge of the licensee's security plans and practice, which must include, at a minimum, the following elements: (1) a high-level, general description of the licensee's security approach designed to safeguard the planned network's confidentiality, integrity, and availability with respect to communications from: a device to the licensee's network; one element of the licensee's network to another element on the licensee's network; the licensee's network to another network; and device to device (with respect to telephone voice and messaging services); (2) a high-level, general description of the licensee's approach to assessing and mitigating cyber risk induced by the presence of

[37] *See id.*

[38] 47 CFR § 1.913(a)(1).

[39] 47 CFR § 1.919.

[40] 47 CFR § 1.2107.

multiple participants in the band. This should include the high level approach taken toward ensuring consumer network confidentiality, integrity, and availability security principles, which are to be protected in each of the following use cases: communications between a wireless device and the licensee's network; communications within and between each licensee's network; communications between mobile devices that are under end-to-end control of the licensee; and communications between mobile devices that are not under the end-to-end control of the licensee; (3) a high-level description of relevant cybersecurity standards and practices to be employed, whether industry-recognized or related to some other identifiable approach; (4) a description of the extent to which the licensee participates with standards bodies or industry-led organizations pursuing the development or maintenance of emerging security standards and/or best practices; (5) the high-level identification of any other approaches to security, unique to the services and devices the licensee intends to offer and deploy; and (6) plans to incorporate relevant outputs from Information Sharing and Analysis Organizations (ISAOs) as elements of the licensee's security architecture. Plans should include comment on machine-to-machine threat information sharing..

23. All of the filing, recordkeeping and reporting requirements associated with the demands described above, including professional, accounting, engineering or survey services used in meeting these requirements will be the same for large and small businesses that intend to utilize these new UMFUS licenses, but as described below, several steps have been taken that will alleviate burdens on small businesses in particular.

F. Steps taken to Minimize Significant Economic Impact on Small Entities, and Significant Alternatives Considered

24. The RFA requires an agency to describe any significant alternatives that it has considered in reaching its approach, which may include the following four alternatives (among others): (1) the establishment of differing compliance or reporting requirements or timetables that take into account the resources available to small entities; (2) the clarification, consolidation, or simplification of compliance or reporting requirements under the rule for small entities; (3) the use of performance, rather than design, standards; and (4) an exemption from coverage of the rule, or any part thereof, for small entities.[41]

25. As noted above, the various construction and performance requirements and their associated showings will be the same for large and small businesses that license the Upper Microwave Flexible Use Service bands. To the extent the same cost of complying with these burdens is relatively greater for smaller businesses than for large ones, these costs are necessary to effectuate the purpose of the Communications Act, namely to further the efficient use of spectrum and to prevent spectrum warehousing. Likewise compliance with our service and technical rules and coordination requirements are necessary for the furtherance of our goals of protecting the public while also providing interference free services. Large and small businesses must therefore comply with these rules and requirements, but we have taken steps to alleviate the burden on small businesses that seek to comply with these requirements, as discussed below.

26. The *Report and Order* provides that in the 28 GHz, 37 GHz and 39 GHz bands, mmW licensees will have the flexibility to provide any fixed or mobile service that is consistent with their spectrum allocation. This breaks with the recent past in which licensees were limited to only a single use licenses in these bands, and such new flexibility benefits small businesses by giving them more avenues for gaining access to valuable wireless spectrum. In addition, licensees will be able to make a showing based on a combination of fixed and mobile service, simplifying this process for all licensees including small businesses. The Commission has also extended the existing renewal deadlines for incumbent licensees in the 28 and 39 GHz bands, giving these licensees, including small businesses in these bands, additional time until 2024 to meet the performance requirements pertaining to their current licenses.

[41] 5 U.S.C. § 604(a)(6).

27. Furthermore, the license areas chosen in the *Report and Order* should provide spectrum access opportunities for smaller carriers by giving them access to less densely populated areas that match their footprints. For example, the *Report and Order* transitions the 28 GHz band from being licensed on the Basic Trading Area ("BTA") basis to a much smaller license area – counties. Similarly, we transition the 39 GHz band from being licensed via Economic Areas ("EAs") to the smaller Partial Economic Areas ("PEAs"). We also use PEAs for the 37 GHz band, which will be newly licensed. The Commission abandons its proposed "hybrid licensing scheme" in the 37 GHz band and has instead opted to use geographic area licensing with PEAs in the upper 37.6-38.6 GHz portion with county-based licensing in the lower band (37.0-37.6 GHz). Finally, the Commission has created an unlicensed space in the 64-71 GHz band. However, the *Report and Order* also permits partitioning and disaggregation by licensees in the mmW bands.[42] While PEAs and counties are small enough to provide spectrum access opportunities for smaller carriers and PEAs could even be further disaggregated, these units of area also nest within and may be aggregated to form larger license areas. Therefore, the benefits and burdens resulting from assigning spectrum in PEA and county license areas are equivalent for small and large businesses. The 400 MHz shared space the Commission has created in the lower 37 GHz band (37.0-37.6 GHz) should also provide ease-of-entry and plenty of space for opportunistic and innovative uses that could be developed by small businesses. These rules should enable providers, or any entities large or small providing service in the mmW bands, to more easily adjust their spectrum holdings and build their networks pursuant to individual business plans. We believe this should result in small businesses having an easier time acquiring or accessing spectrum.

28. Licensees may also adjust their geographic coverage through auction in those areas where we are permitting geographic area auctions or through the secondary markets. The *Report and Order* concludes it will auction licenses in the mmW bands in conformity with the general competitive bidding rules set forth in Part 1, Subpart Q, of the Commission's rules, and substantially consistent with the competitive bidding procedures that have been employed in previous auctions.[43] The procedures we have adopted contain provisions to assist small entities in competitive bidding.[44] The Commission will employ the Part 1 rules governing competitive bidding design, designated entity preferences, unjust enrichment, application and payment procedures, reporting requirements, and the prohibition on certain communications between auction applicants. Furthermore, qualifying "small businesses" – those with gross revenues for the preceding three years not exceeding $55 million – will be provided with a bidding credit of 15 percent, and "very small businesses" – those with average annual gross revenues for the preceding three years not exceeding $20 million – with a bidding credit of 25 percent.[45] Providing small businesses and very small businesses with bidding credits will provide an economic benefit to small entities by making it easier for small entities to acquire spectrum or access to spectrum in these bands.

29. Furthermore, the *Report and Order* provides for licensing of this spectrum under market-oriented rules.[46] This includes applying the Commission's secondary market policies and rules to all transactions involving the use of mmW bands, which will provide greater predictability and regulatory parity with bands licensed for mobile broadband service. These rules should make it easier for mmW providers to enter secondary market arrangements involving use of their spectrum. The secondary market rules apply equally to all entities, whether small or large. As a result, we believe that this will provide an economic benefit to small entities by making it easier for entities, whether large or small, to enter into secondary market arrangements for mmW spectrum.

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[42] *See* Section IV.F.9.a (Partitioning and Disaggregation).

[43] *See* 47 CFR §§ 1.2101-1.2114.

[44] *See Report and Order*, paras. 213-214.

[45] *See id.* at para. 249

[46] *See, e.g.*, 47 CFR §§ 27.1 *et seq*.

30. The *Report and Order* also adopts an operability requirement such that any device designed to operate within the 37 GHz and 39 GHz bands (37 – 40 GHz) must be capable of operating on all frequencies within those bands. This operability requirement will ensure that devices developed for the geographic area licensed portion of the band will also operate in the innovation shared space, making it easier for smaller businesses with fewer resources to find equipment that can operate across multiple bands The technical rules in the *Report and Order* will also allow licensees of the mmW spectrum to operate while protecting licensees in nearby spectrum from harmful interference, some of whom may be small entities

31. Finally, the proposals to facilitate satellite service in the 28 GHz and 37.5-40 GHz bands should also assist small satellite businesses.

A. Federal Rules that May Duplicate, Overlap, or Conflict with the Proposed Rules

32. None.

APPENDIX F

List of Commenters to Spectrum Frontiers NPRM

Commenters

5G Americas f/k/a 4G Americas (5G Americas)
Aeronet Global Communications, Inc. (Aeronet)
AT&T Services, Inc. (AT&T)
Avanti Communications Group PLC (Avanti)
The Boeing Company (Boeing)
Cisco Systems, Inc. (Cisco)
CTIA-The Wireless Association (CTIA)
Comsearch
Consumer Technology Association f/k/a Consumer Electronics Association (CTA)
CORF - NAS Committee on Radio Frequencies (CORF)
Dynamic Spectrum Alliance (DSA)
Echodyne Corp. (Echodyne)
EchoStar, Hughes, and Alta (EchoStar)
EMEA Satellite Operators Association (ESOA)
Ericsson
Facebook, Inc. (Facebook)
Federated Wireless, Inc. (Federated Wireless)
FiberTower Spectrum Holdings, LLC (FiberTower)
Fixed Wireless Communications Coalition (FWCC)
Global VSAT Forum
Google, Inc. (Google)
High Tech Spectrum Coalition (HTSC)
Huawei Technologies, Inc. (USA), Huawei Technologies Co., Ltd. (Huawei)
IEEE 802 LAN/MAN Standards Committee (IEEE 802)
Information Technology Industry Council (ITIC)
Inmarsat Mobile Networks, Inc. (Inmarsat)
Intel Corporation (Intel)
Interisle Consulting Group LLC (Interisle)
Iridium Communications, Inc. (Iridium)
Microsoft Corporation (Microsoft)
Mobile Future
Mobile Manufacturers Forum
National Cable & Television Association (NCTA)
National Radio Astronomy Observatory (NRAO)
Nokia
O3b Limited (O3b)
Open Technology Institute at New America (OTI)
Public Knowledge
PCIA-The Wireless Infrastructure Association (PCIA)
Qualcomm Incorporated (Qualcomm)
Rockwell Automation (Rockwell)
Samsung Electronics America, Inc. and Samsung Research America (Samsung)
Satellite Industry Association (SIA)
SES Americon, Inc. (SES Americom)
Skyriver Communications, Inc. (Skyriver)
Straight Path Communications Inc. (Straight Path)
Telecommunications Industry Association (TIA)
T-Mobile USA, Inc. (T-Mobile)

Verizon Communications, Inc. (Verizon)
ViaSat, Inc. (ViaSat)
Vubiq Networks (Vubiq)
Wi-Fi Alliance
XO Communications, LLC (XO)

Reply Commenters

AT&T Services, Inc. (AT&T)
Avanti Communications Group PLC (Avanti)
The Boeing Company (Boeing)
Competitive Carriers Association (CCA)
CTIA-The Wireless Association (CTIA)
Dynamic Spectrum Alliance (DSA)
EchoStar, Hughes and Alta (EchoStar)
EMEA Satellite Operators Association (ESOA)
Ericsson
Federated Wireless, Inc. (Federated Wireless)
FiberTower Spectrum Holdings, LLC (FiberTower)
Fixed Wireless Communications Coalition (FWCC)
IEEE Geoscience and Remote Sensing Society (GRSS) Technical Committee on Frequency Allocations in Remote Sensing (IEEE FARS)
Information Technology Industry Council (ITIC)
Inmarsat Mobile Networks, Inc. (Inmarsat)
Intel Corporation (Intel)
Iridium Communications, Inc. (Iridium)
Microsoft Corporation (Microsoft)
Mobile Future
National Cable & Telecommunications Association (NCTA)
Nokia
O3b Limited (O3b)
Open Technology Institute at New America (OTI)
Public Knowledge
Qualcomm Incorporated (Qualcomm)
Samsung Electronics America, Inc. and Samsung Research America (Samsung)
Satellite Industry Association (SIA)
SES Americom, Inc. (SES Americom)
Southern Company Services, Inc. (Southern Co.)
Sprint Corporation (Sprint)
Straight Path Communications, Inc. (Straight Path)
Sunshine LMDS Network, Inc., Broadband One of California, Inc., Broadband One of the Midwest, Inc., Broadband One North, Inc., Broadband One of the Southeast, Inc., and Verso LMDS, LLC (Joint LMDS Licensees)
TechFreedom
T-Mobile USA, Inc. (T-Mobile)
United States Cellular Corporation (US Cellular)
ViaSat, Inc. (ViaSat)
Verizon Communications, Inc. (Verizon)
Wi-Fi Alliance
The Wireless Internet Service Providers Association (WISPA)
XO Communications, LLC (XO)
Zodiac Inflight Innovations (ZII)

***Ex Parte* Filers**

5G Americas f/k/a 4G Americas (5G Americas)
Aeronet Global Communications, Inc. (Aeronet)
Airbus
Akbar Sayeed
AT&T Services Inc. (AT&T)
Bartlett D. Cleland
The Boeing Company (Boeing)
Broadcom
CTIA-The Wireless Association (CTIA)
Competitive Carriers Association (CCA)
CORF-NAS Committee on Radio Frequencies (CORF)
DISH Network Corporation (DISH)
Dynamic Spectrum Alliance (DSA)
EchoStar, Hughes and Alta (EchoStar)
EchoStar Satellite Operating Corporation (EchoStar)
Ericsson
FiberTower Spectrum Holdings, LLC (FiberTower)
GigaNets Project (GigaNets)
Google, Inc. (Google)
Information Technology Industry Council (ITIC)
Information Technology and Innovation Foundation (ITIF)
Inmarsat Mobile Networks, Inc. (Inmarsat)
Intel Corporation (Intel)
Intelsat Corporation (Intelsat)
Iridium Communications, Inc. (Iridium)
Lockheed Martin Corporation (Lockheed Martin)
National Spectrum Management Association (NSMA)
Nextlink Wireless, LLC (Nextlink)
Nokia
O3b Limited (O3b)
Open Technology Institute at New America (OTI)
PHAZR
Public Knowledge
Qualcomm Incorporated (Qualcomm)
Reed Hundt
Samsung Electronics America (Samsung)
Satellite Industry Association (SIA)
SES Americom, Inc. (SES Americom)
Space Exploration Technologies Corp. (SpaceX)
Sprint Corporation (Sprint)
Starry, Inc. (Starry)
Straight Path Communications, Inc. (Straight Path)
Sunshine LMDS Network, Inc., Telepak Networks, Inc., Broadband One of California, Inc., Broadband One of the Midwest, Inc., Broadband One North, Inc., Broadband One of the Southeast, Inc., and Verso LMDS, LLC (Joint LMDS Licensees)
Telesat Canada (Telesat)
T-Mobile USA, Inc. (T-Mobile)
Verizon Communications, Inc. (Verizon)
ViaSat, Inc. (ViaSat)
Wi-Fi Alliance
WorldVu Satellites Ltd./OneWeb (OneWeb)

APPENDIX G

Proposed Rules

For the reasons discussed in the preamble, the Federal Communications Commission proposes to amend 47 CFR parts 2, 25, 30 and 101 as follows:

PART 2 – FREQUENCY ALLOCATIONS AND RADIO TREATY MATTERS;

GENERAL RULES AND REGULATIONS

1. The authority citation for part 2 continues to read as follows:

AUTHORITY: 47 U.S.C. 154, 302a, 303, and 336, unless otherwise noted.

2. Section 2.106, the Table of Frequency Allocations, is amended by revising pages 54, 56, and 58-62 to read as follows:

§ 2.106 Table of Frequency Allocations.

* * * * *

24-24.05 AMATEUR AMATEUR-SATELLITE 5.150			24-24.05 5.150 US211	24-24.05 AMATEUR AMATEUR-SATELLITE 5.150 US211	ISM Equipment (18) Amateur Radio (97)
24.05-24.25 RADIOLOCATION Amateur Earth exploration-satellite (active) 5.150			24.05-24.25 RADIOLOCATION G59 Earth exploration-satellite (active) 5.150	24.05-24.25 Amateur Earth exploration-satellite (active) Radiolocation 5.150	RF Devices (15) ISM Equipment (18) Private Land Mobile (90) Amateur Radio (97)
24.25-24.45 FIXED	24.25-24.45 RADIONAVIGATION	24.25-24.45 FIXED MOBILE RADIONAVIGATION	24.25-24.45	24.25-24.45 FIXED MOBILE	RF Devices (15) Upper Microwave Flexible Use (30)
24.45-24.65 FIXED INTER-SATELLITE	24.45-24.65 INTER-SATELLITE RADIONAVIGATION 5.533	24.45-24.65 FIXED INTER-SATELLITE MOBILE RADIONAVIGATION 5.533	24.45-24.65 INTER-SATELLITE RADIONAVIGATION 5.533		RF Devices (15) Satellite Communications (25)
24.65-24.75 FIXED FIXED-SATELLITE (Earth-to-space) 5.532B INTER-SATELLITE	24.65-24.75 INTER-SATELLITE RADIOLOCATION-SATELLITE (Earth-to-space)	24.65-24.75 FIXED FIXED-SATELLITE (Earth-to-space) 5.532B INTER-SATELLITE MOBILE 5.533	24.65-24.75 INTER-SATELLITE RADIOLOCATION-SATELLITE (Earth-to-space)		
24.75-25.25 FIXED FIXED-SATELLITE (Earth-to-space) 5.532B	24.75-25.25 FIXED-SATELLITE (Earth-to-space) 5.535	24.75-25.25 FIXED FIXED-SATELLITE (Earth-to-space) 5.535 MOBILE		24.75-25.25 FIXED FIXED-SATELLITE (Earth-to-space) NG535 MOBILE	RF Devices (15) Satellite Communications (25) Upper Microwave Flexible Use (30)
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31-31.3 FIXED 5.338A 5.543A			31-31.3 Standard frequency and time	31-31.3 FIXED NG60	Fixed Microwave (101)

MOBILE Standard frequency and time signal-satellite (space-to-Earth) Space research 5.544 5.545 5.149			signal-satellite (space-to-Earth) US211 US342	MOBILE Standard frequency and time signal-satellite (space-to-Earth) US211 US342	
31.3-31.5 EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive) 5.340			31.3-31.8 EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY US74 SPACE RESEARCH (passive)		
31.5-31.8 EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive) Fixed Mobile except aeronautical mobile 5.149 5.546	31.5-31.8 EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive) 5.340	31.5-31.8 EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive) Fixed Mobile except aeronautical mobile 5.149	US246		
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FIXED-SATELLITE (space-to-Earth) 5.516B MOBILE MOBILE-SATELLITE (space-to-Earth) SPACE RESEARCH (Earth-to-space) Earth exploration-satellite (space-to-Earth)			FIXED-SATELLITE (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) SPACE RESEARCH (Earth-to-space) Earth exploration-satellite (space-to-Earth) G117		
40.5-41 FIXED FIXED-SATELLITE (space-to-Earth) BROADCASTING BROADCASTING-SATELLITE Mobile 5.547	40.5-41 FIXED FIXED-SATELLITE (space-to-Earth) 5.516B BROADCASTING BROADCASTING-SATELLITE Mobile Mobile-satellite (space-to-Earth) 5.547	40.5-41 FIXED FIXED-SATELLITE (space-to-Earth) BROADCASTING BROADCASTING-SATELLITE Mobile 5.547	40.5-41 FIXED-SATELLITE (space-to-Earth) Mobile-satellite (space-to-Earth) US211 G117	40.5-41 FIXED-SATELLITE (space-to-Earth) BROADCASTING BROADCASTING-SATELLITE Fixed Mobile Mobile-satellite (space-to-Earth) US211	
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47-47.2 AMATEUR AMATEUR-SATELLITE			47-48.2	47-47.2 AMATEUR AMATEUR-SATELLITE	Amateur Radio (97)
47.2-47.5 FIXED FIXED-SATELLITE (Earth-to-space) 5.552 MOBILE 5.552A				47.2-48.2 FIXED FIXED-SATELLITE (Earth-to-space) US297 MOBILE	Satellite Communications (25) Upper Microwave Flexible Use (30)
47.5-47.9 FIXED FIXED-SATELLITE (Earth-to-space) 5.552 (space-to-Earth) 5.516B 5.554A MOBILE	47.5-47.9 FIXED FIXED-SATELLITE (Earth-to-space) 5.552 MOBILE				
47.9-48.2 FIXED FIXED-SATELLITE (Earth-to-space) 5.552 MOBILE 5.552A					
48.2-48.54 FIXED FIXED-SATELLITE (Earth-to-space) 5.552 (space-to-Earth) 5.516B 5.554A 5.555B MOBILE	48.2-50.2 FIXED FIXED-SATELLITE (Earth-to-space) 5.338A 5.516B 5.552 MOBILE		48.2-50.2 FIXED FIXED-SATELLITE (Earth-to-space) US156 US297 MOBILE US264		
48.54-49.44 FIXED FIXED-SATELLITE (Earth-to-space) 5.552 MOBILE 5.149 5.340 5.555					
49.44-50.2 FIXED FIXED-SATELLITE (Earth-to-space) 5.338A 5.552 (space-to-Earth) 5.516B 5.554A 5.555B MOBILE	5.149 5.340 5.555		5.555 US342		
50.2-50.4 EARTH EXPLORATION-SATELLITE (passive) SPACE RESEARCH (passive) 5.340			50.2-50.4 EARTH EXPLORATION-SATELLITE (passive) SPACE RESEARCH (passive) US246		

50.4-51.4 FIXED FIXED-SATELLITE (Earth-to-space) 5.338A MOBILE Mobile-satellite (Earth-to-space)	50.4-51.4 FIXED FIXED-SATELLITE (Earth-to-space) US156 MOBILE MOBILE-SATELLITE (Earth-to-space) G117	50.4-51.4 FIXED FIXED-SATELLITE (Earth-to-space) US156 MOBILE MOBILE-SATELLITE (Earth-to-space)	Upper Microwave Flexible Use (30)
51.4-52.6 FIXED 5.338A MOBILE 5.547 5.556	51.4-52.6 FIXED US157 MOBILE		
52.6-54.25 EARTH EXPLORATION-SATELLITE (passive) SPACE RESEARCH (passive) 5.340 5.556	52.6-54.25 EARTH EXPLORATION-SATELLITE (passive) SPACE RESEARCH (passive) US246		
54.25-55.78 EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE 5.556A SPACE RESEARCH (passive) 5.556B	54.25-55.78 EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE 5.556A SPACE RESEARCH (passive)		Satellite Communications (25)
55.78-56.9 EARTH EXPLORATION-SATELLITE (passive) FIXED 5.557A INTER-SATELLITE 5.556A MOBILE 5.558 SPACE RESEARCH (passive) 5.547 5.557	55.78-56.9 EARTH EXPLORATION-SATELLITE (passive) FIXED US379 INTER-SATELLITE 5.556A MOBILE 5.558 SPACE RESEARCH (passive) US353 US532		
56.9-57 EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE 5.558A MOBILE 5.558 SPACE RESEARCH (passive) 5.547 5.557	56.9-57 EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE G128 MOBILE 5.558 SPACE RESEARCH (passive) US532	56.9-57 EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE 5.558 SPACE RESEARCH (passive) US532	
57-58.2 EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE 5.556A MOBILE 5.558 SPACE RESEARCH (passive) 5.547 5.557	57-58.2 EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE 5.556A MOBILE 5.558 SPACE RESEARCH (passive) US532		RF Devices (15) Satellite Communications (25)
58.2-59 EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE SPACE RESEARCH (passive) 5.547 5.556	58.2-59 EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE SPACE RESEARCH (passive) US353 US354		RF Devices (15)

International Table			United States Table		FCC Rule Part(s)
Region 1 Table	Region 2 Table	Region 3 Table	Federal Table	Non-Federal Table	
59-59.3 EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE 5.556A MOBILE 5.558 RADIOLOCATION 5.559 SPACE RESEARCH (passive)			59-59.3 EARTH EXPLORATION-SATELLITE (passive) FIXED INTER-SATELLITE 5.556A MOBILE 5.558 RADIOLOCATION 5.559 SPACE RESEARCH (passive) US353	59-59.3 EARTH EXPLORATION-SATELLITE (passive) FIXED MOBILE 5.558 RADIOLOCATION 5.559 SPACE RESEARCH (passive) US353	RF Devices (15)
59.3-64 FIXED INTER-SATELLITE MOBILE 5.558 RADIOLOCATION 5.559 5.138			59.3-64 FIXED INTER-SATELLITE MOBILE 5.558 RADIOLOCATION 5.559 5.138 US353	59.3-64 FIXED MOBILE 5.558 RADIOLOCATION 5.559 5.138 US353	RF Devices (15) ISM Equipment (18)
64-65 FIXED INTER-SATELLITE MOBILE except aeronautical mobile 5.547 5.556			64-65 FIXED INTER-SATELLITE MOBILE except aeronautical mobile	64-65 FIXED MOBILE except aeronautical mobile	RF Devices (15)
65-66 EARTH EXPLORATION-SATELLITE FIXED INTER-SATELLITE MOBILE except aeronautical mobile SPACE RESEARCH 5.547			65-66 EARTH EXPLORATION-SATELLITE FIXED MOBILE except aeronautical mobile SPACE RESEARCH	65-66 EARTH EXPLORATION-SATELLITE FIXED INTER-SATELLITE MOBILE except aeronautical mobile SPACE RESEARCH	RF Devices (15) Satellite Communications (25)
66-71 INTER-SATELLITE MOBILE 5.553 5.558 MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE 5.554			66-71 MOBILE 5.553 5.558 MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE 5.554	66-71 INTER-SATELLITE MOBILE 5.553 5.558 MOBILE-SATELLITE RADIONAVIGATION RADIONAVIGATION-SATELLITE 5.554	
71-74 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE MOBILE-SATELLITE (space-to-Earth)			71-74 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE MOBILE-SATELLITE (space-to-Earth) US389		Upper Microwave Flexible Use (30)
74-76 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE BROADCASTING BROADCASTING-SATELLITE Space research (space-to-Earth) 5.561			74-76 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE Space research (space-to-Earth) US389	74-76 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE BROADCASTING BROADCASTING-SATELLITE Space research (space-to-Earth) US389	RF Devices (15) Upper Microwave Flexible Use (30)
76-77.5 RADIO ASTRONOMY			76-77.5 RADIO ASTRONOMY	76-77 RADIO ASTRONOMY	RF Devices (15)

RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth) 5.149	RADIOLOCATION Space research (space-to-Earth) US342	RADIOLOCATION Amateur Space research (space-to-Earth) US342	
		77-77.5 RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth) US342	RF Devices (15) Amateur Radio (97)
77.5-78 AMATEUR AMATEUR-SATELLITE Radio astronomy Space research (space-to-Earth) 5.149	77.5-78 Radio astronomy Space research (space-to-Earth) US342	77.5-78 AMATEUR AMATEUR-SATELLITE Radio astronomy Space research (space-to-Earth) US342	
78-79 RADIOLOCATION Amateur Amateur-satellite Radio astronomy Space research (space-to-Earth) 5.149 5.560	78-79 RADIO ASTRONOMY RADIOLOCATION Space research (space-to-Earth) 5.560 US342	78-79 RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth) 5.560 US342	
79-81 RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth) 5.149	79-81 RADIO ASTRONOMY RADIOLOCATION Space research (space-to-Earth) US342	79-81 RADIO ASTRONOMY RADIOLOCATION Amateur Amateur-satellite Space research (space-to-Earth) US342	
81-84 FIXED 5.338A FIXED-SATELLITE (Earth-to-space) MOBILE MOBILE-SATELLITE (Earth-to-space) RADIO ASTRONOMY Space research (space-to-Earth) 5.149 5.561A	81-84 FIXED FIXED-SATELLITE (Earth-to-space) US297 MOBILE MOBILE-SATELLITE (Earth-to-space) RADIO ASTRONOMY Space research (space-to-Earth) US161 US342 US389		RF Devices (15) Upper Microwave Flexible Use (30)
84-86 FIXED 5.338A FIXED-SATELLITE (Earth-to-space) 5.561B MOBILE RADIO ASTRONOMY 5.149	84-86 FIXED FIXED-SATELLITE (Earth-to-space) MOBILE RADIO ASTRONOMY US161 US342 US389		Page 62

PART 25 – SATELLITE COMMUNICATIONS

3. The authority citation for part 25 continues to read as follows:

AUTHORITY: Interprets or applies Sections 4, 301, 302, 303, 307, 309, 319, 332, 705, and 721 of the Communications Act, as amended, 47 U.S.C. 154, 301, 302, 303, 307, 309, 319, 332, 605, and 721, unless otherwise noted.

4. Amend § 25.208 by revising paragraphs (q) and (r) to read as follows:

§ 25.208 Power flux density limits.

* * * * *

(q) In the band 37.5-40.0 GHz, the power flux-density at the Earth's surface produced by emissions from a geostationary space station for all methods of modulation shall not exceed the following values:

-127 dB(W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;

$-127 + 4/3\ (\delta - 5)$ dB(W/m^2) in any 1 MHz band for angles of arrival δ (in degrees) between 5 and 20 degrees above the horizontal plane; and

$-107 + 0.4\ (\delta - 20)$ dB(W/m^2) in any 1 MHz band for angles of arrival δ (in degrees) between 20 and 25 degrees above the horizontal plane;

-105 dB(W/m^2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

(r) In the band 37.5-40.0 GHz, the power flux-density at the Earth's surface produced by emissions from a non-geostationary space station for all methods of modulation shall not exceed the following values:

-120 dB(W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;

$-120 + 0.75\ (\delta - 5)$ dB(W/m^2) in any 1 MHz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane; and

-105 dB(W/m^2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

* * * * *

PART 30 – UPPER MICROWAVE FLEXIBLE USE SERVICE

5. The authority citation for part 30 continues to read:

Authority: 47 U.S.C. 151, 152, 153, 154, 301, 303, 304, 307, 309, 310, 316, 332, 1302.

6. Revise Section 30.4 by adding paragraphs (d) through (j) to read as follows:

§ 30.4 Frequencies.

* * * * *

(d) 24.25-24.45 GHz band;

(e) 24.75-25.25 GHz band: 24.75-25.00 GHz, 25.00-25.25 GHz;

(f) 31.8-33.4 GHz band:

Channel Number	Frequency
1	31,000-32,000
2	32,000-32,200
3	32,200-32,400
4	32,400-32,600
5	32,600-32,800
6	32,800-33,000
7	33,000-33,200
8	33,200-33,400

(g) 42-42.5 GHz band:

(h) 47.2-50.2 GHz band:

Channel Number	Frequency
1	47,200-47,700
2	47,700-48,200
3	48,200-48,700
4	48,700-49,200
5	49,200-49,700
6	49,700-50,200

(i) 50.4-52.6 GHz band:

Channel Number	Frequency
1	50,400-50,600
2	50,600-50,800
3	50,800-51,000
4	51,000-51,200
5	51,200-51,400
6	51,400-51,600
7	51,600-51,800
8	51,800-52,000
9	52,000-52,200
10	52,200-52,400
11	52,400-52,600

(j) The 71-76 GHz and 81-86 GHz bands shall be available on a shared basis pursuant to the rules in subpart F of this part.

7. Amend § 30.5 by revising paragraph (a) to read as follows:

§ 30.5 Service areas.

(a) Except as noted in paragraphs (b) and (c) of this section, and except for the shared 37-37.6 GHz, 71-76 GHz, and 81-86 GHz bands, the service areas for the Upper Microwave Flexible Use Service are

Partial Economic Areas.

* * * * *

8. Amend § 30.7 by adding paragraphs (d) through (g) to read as follows:

§ 30.7 37-37.6 GHz Band – Shared Coordinated Service.

* * * * *

(d) The minimum authorized channel bandwidth in this band is 100 megahertz.

(e) Registered non-Federal sites must be put placed service within seven days of coordination.

(f) Equipment in this band must be capable of notifying the database that it is active on the channel. At least once every seven days, the equipment must be capable of notifying the coordination mechanism that the equipment is active and operating. If the equipment fails to make such a notification, the registration to operate that equipment is automatically terminated.

(g) Federal licensees may claim access to 200 megahertz of spectrum in this area on a priority basis.

* * * * *

9. Amend § 30.202 by revising paragraphs (a), (b) and (c) and adding paragraph (e) to read as follows:

§ 30.202 Power limits.

(a) For fixed and base stations operating in connection with mobile systems, the average power of the sum of all antenna elements is limited to a maximum equivalent isotopically radiated power (EIRP) density of +75dBm/100MHz , except as specified in paragraph (e) below.

(b) For mobile stations, the average power of the sum of all antenna elements is limited to a maximum EIRP density of +43 dBm/100MHz

(c) For transportable stations, as defined in § 30.2, the average power of the sum of all antenna elements is limited to a maximum EIRP density of +55 dBm/100MHz.

* * * * *

(e) Antenna Height Limits

Antenna height (AAT) in meters (feet)	Effective isotropic radiated power density (EIRP) (dBm/ 100 MHz)
Above 1372 (4500)	62

Above 1220 (4000) To 1372 (4500)	63
Above 1067 (3500) To 1220 (4000)	64
Above 915 (3000) To 1067 (3500)	65
Above 763 (2500) To 915 (3000)	67
Above 610 (2000) To 763 (2500)	69
Above 458 (1500) To 610 (2000)	71
Above 305 (1000) To 458 (1500)	73
Up to 305 (1000)	75

10. Add Section 30.210 to read as follows:

§ 30.210 Information sharing requirements in the 48.2-50.2 GHz band.

(a) Each operator of a Fixed Service or Mobile Service system in the 48.2-50.2 GHz band will make the technical information about its system listed in paragraphs (b) and (c) of this section available to FSS operators by one or more of the following means:

(1) An online database operated by the Upper Microwave Flexible Use licensee;

(2) An online database operated by a third-party database manager, or

(3) A continuously transmitted pilot signal receivable throughout the terrain within which a FSS facility could cause interference to or receive interference from the terrestrial system.

(b) All licensees deploying fixed systems in the48.2-50.2 GHz bands will make the following information about each such system available to FSS operators in those bands by one or more of the means described in paragraph (a) of this section:

(1) Licensee's name and address.

(2) Transmitting station name.

(3) Transmitting station coordinates.

(4) Frequencies and polarizations.

(5) Transmitting equipment, its stability, effective isotropic radiated power, emission designator, and type of modulation (digital).

(6) Transmitting antenna(s), model, gain, and a radiation pattern provided or certified by the manufacturer.

(7) Transmitting antenna center line height(s) above ground level and ground elevation above mean sea level.

(8) Transmitting antenna boresight(s) angle of elevation with respect to the horizon.

(9) Receiving station name.

(10) Receiving station coordinates.

(11) Receiving antenna(s), model, gain, and, if required, a radiation pattern provided or certified by the manufacturer.

(12) Receiving antenna center line height(s) above ground level and ground elevation above mean sea level.

(13) Receiving antenna boresight(s) angle of elevation with respect to the horizon.

(14) Path azimuth and distance.

(c) All licensees deploying mobile service base stations in the 48.2-50.2 GHz bands will make the following information about each such base station available to FSS operators by one or both of the means described in paragraph (a) of this section:

(1) Licensee's name and address.

(2) Transmitting station name.

(3) Transmitting station coordinates.

(4) Frequencies and polarizations.

(5) Transmitting equipment, its stability, maximum effective isotropic radiated power, emission designator, and types of modulation.

(6) Transmitting antenna(s), model, maximum gain, and maximum extent of all possible radiation patterns provided or certified by the manufacturer.

(7) Transmitting antenna center line height(s) above ground level and ground elevation above mean sea level.

(8) Transmitting antenna boresight(s) maximum and minimum angles of elevation with respect to the horizon.

(9) Transmitting antenna boresight minimum and maximum azimuths, or designation of omnidirectionality.

(10) Boundary of the area served by the base station for purposes of communication with mobile user equipment.

(11) Receiving antenna(s), model, gain, and maximum extent of all possible radiation patterns provided or certified by the manufacturer.

(12) Receiving antenna center line height(s) above ground level and ground elevation above mean sea level.

(13) Receiving antenna boresight maximum and minimum angles of elevation with respect to the horizon.

(14) Receiving antenna boresight minimum and maximum azimuths, or designation of omnidirectionality.

11. Add subpart F to part 30 to read as follows:

Subpart F – Shared operation in the 71-76 GHz and 81/86 GHz bands

Sec.

§ 30.501 Scope.

(a) This section sets forth the regulations governing use of devices in the 71-76 GHz and 81-86 GHz bands. The operation of all equipment in this band shall be coordinated by one or more authorized

Spectrum Access Systems (SASs).

(b) Operations in this band include Priority Access and General Authorized Access tiers of service. Priority Access Licensees and General Authorized Access Users must not cause harmful interference to Incumbent Users and must accept interference from Incumbent Users. General Authorized Access Users must not cause harmful interference to Priority Access Licensees and must accept interference from Priority Access Licensees.

§ 30.502 Authorization required.

(a) Devices must be used and operated consistent with the rules in this subpart.

(b) Authorizations for PALs may be granted upon proper application, provided that the applicant is qualified in regard to citizenship, character, financial, technical and other criteria established by the Commission, and that the public interest, convenience and necessity will be served. See 47 U.S.C. 301, 308, 309, and 310. The holding of an authorization does not create any rights beyond the terms, conditions, and period specified in the authorization and shall be subject to the provisions of the Communications Act of 1934, as amended, and the Commission's rules and policies thereunder.

(c) Grandfathered registered fixed links are authorized to operate consistent with § 101.1529 of this chapter.

§ 30.503 Frequency assignments.

(a) Any frequencies designated for Priority Access that are not in use by a Priority Access Licensee may be utilized by General Authorized Access Users.

(b) An SAS shall assign authorized devices to specific frequencies, which may be reassigned by that SAS, consistent with this part.

§ 30.504 Technical rules.

Devices in these bands shall be subject to the technical rules in subpart C of this part.

§ 30.505 Protection of Federal incumbents.

Prior to commencing operation, all operations in these bands must complete coordination with Federal Government links according to the coordination standards and procedures adopted in Report and Order,

FCC 03-248, and as further detailed in subsequent implementation public notices issued consistent with that order.

§ 30.506 Priority Access Licenses.

(a) Applications for Priority Access Licenses must:

(1) Demonstrate the applicant's qualifications to hold an authorization;

(2) State how a grant would serve the public interest, convenience, and necessity;

(3) Contain all information required by FCC rules and application forms;

(4) Propose operation of a facility or facilities in compliance with all applicable rules; and

(5) Be amended as necessary to remain substantially accurate and complete in all significant respects, in accordance with the provisions of § 1.65 of this chapter.

(b) Devices used for Priority Access must register with a Spectrum Access System and comply with its instructions pursuant to § 30.508.

(c) Records pertaining to PALs, including applications and licenses, shall be maintained by the Commission in a publicly accessible system.

§ 30.507 General Access.

(a) Devices used for General Authorized Access must register with the Spectrum Access System and comply with its instructions.

(b) General Authorized Access Users shall be permitted to use frequencies assigned to Priority Access Licenses when such frequencies are not in use, as determined by the Spectrum Access System.

(c) Frequencies that are available for General Authorized Access Use shall be made available on a shared basis.

(d) General Authorized Access Users shall have no expectation of interference protection from other General Authorized Access Users operating in accordance with this part.

(e) General Authorized Access Users must not cause harmful interference to and must accept interference from Priority Access Licensees and Grandfathered Registered Links in accordance with this part.

§ 30.508 Spectrum access system purposes and functionality.

The Spectrum Access System shall:

(a) Enact and enforce all policies and procedures developed by the SAS Administrator.

(b) Determine and provide to devices the permissible channels or frequencies at their location.

(c) Determine and provide to devices the maximum permissible transmission power level at their location.

(d) Register and authenticate the identification information and location of devices.

(e) Ensure that devices protect Grandfathered Register Links from harmful interference.

(f) Protect Priority Access Licensees from interference caused by other Priority Access Licenses and from General Authorized Access Users.

(g) Resolve conflicting uses of the band while maintaining, as much as possible, a stable radio frequency environment.

(h) Ensure secure and reliable transmission of information between the SAS and devices.

(i) Protect Grandfathered Registered Links consistent with § 101.1529 of this chapter.

(n) Implement the terms of applicable current and future international agreements.

§ 30.509 Registration, authentication, and authorization of devices.

(a) A Spectrum Access System must register, authenticate, and authorize operations of devices consistent with this part.

(b) Devices composed of a network of base and fixed stations may employ a subsystem for aggregating and communicating all required information exchanges between the SAS and devices.

(c) A Spectrum Access System must also verify that the FCC identifier (FCC ID) of any device seeking access to its services is valid prior to authorizing it to begin providing service. A list of devices with valid FCC IDs and the FCC IDs of those devices is to be obtained from the Commission's Equipment Authorization System.

PART 101 – FIXED MICROWAVE SERVICES

12. The authority citation for part 101 continues to read as follows:

Authority: 47 U.S.C. 154, 303.

13. Add § 101.1529 to read as follows:

§ 101.529 Grandfathered operation and transition to upper microwave flexible use service.

Links registered with a third party database administrator on or before [**insert effective date of rules**] that are constructed, in service, and fully compliant with the rules in part 101, subpart Q as of [**insert date one year after effective date of rules**] will be afforded protection from harmful interference caused by Upper Microwave Flexible Use users until the end of their license term.

APPENDIX H

Initial Regulatory Flexibility Analysis

1. As required by the Regulatory Flexibility Act of 1980, as amended (RFA),[1] the Commission has prepared this present Initial Regulatory Flexibility Analysis (IRFA) of the possible significant economic impact on a substantial number of small entities by the policies and rules proposed in the attached *Further Notice of Proposed Rulemaking (FNPRM)*. Written public comments are requested on this IRFA. Comments must be identified as responses to the IRFA and must be filed by the deadlines specified in the *FNPRM* for comments. The Commission will send a copy of this *FNPRM*, including this IRFA, to the Chief Counsel for Advocacy of the Small Business Administration (SBA).[2] In addition, the *FNPRM* and IRFA (or summaries thereof) will be published in the Federal Register.[3]

B. Need for, and Objectives of, the Proposed Rules

2. In this *Further Notice of Proposed Rulemaking*, we propose to authorize mobile operations in the 24.25-24.45 and 24.75-25.25 GHz band (24 GHz band), the 31.8-33.4 GHz band (32 GHz band), the 42-42.5 GHz band (42 GHz band), the 47.2-50.2 GHz band (47 GHz band), the 50.4-52.6 GHz band (50 GHz band) and the 71-76 and 81-86 GHz bands (70/80 GHz bands). We are also seeking comment on possible uses of bands above 95 GHz. Together with the bands that are the subject of our *Report and Order* – namely the 28, 37, 39 and 57-71 GHz bands, these bands are known as the "mmW bands".

3. Until recently, the mmW bands were generally considered unsuitable for mobile applications because of propagation losses at such high frequencies and the inability of mmW signals to propagate around obstacles. As increasing congestion has begun to fill the lower bands and carriers have resorted to smaller and smaller microcells in order to re-use the available spectrum, however, industry is taking another look at the mmW bands and beginning to realize that at least some of its presumed disadvantages can be turned to advantage. For example, short transmission paths and high propagation losses can facilitate spectrum re-use in microcellular deployments by limiting the amount of interference between adjacent cells. Furthermore, where longer paths are desired, the extremely short wavelengths of mmW signals make it feasible for very small antennas to concentrate signals into highly focused beams with enough gain to overcome propagation losses. The short wavelengths of mmW signals also make it possible to build multi-element, dynamic beam-forming antennas that will be small enough to fit into handsets—a feat that might never be possible at the lower, longer-wavelength frequencies below 6 GHz where cell phones operate today.

4. We propose to include the 24 GHz, 32 GHz, 42 GHz, 47 GHz, 50 GHz and 70/80 GHz bands in the Part 30 Upper Microwave Flexible Use Service. We also propose to add a mobile allocation in the 24 GHz and 32 GHz bands. This additional spectrum for mobile use will help ensure that the speed, capacity, and ubiquity of the nation's wireless networks keeps pace with the skyrocketing demand for mobile service. It could also make possible new types of services for consumers and businesses.

5. In proposing service rules for these bands, which include technical rules to protect against harmful interference, licensing rules to establish geographic license areas and spectrum block sizes, and performance requirements to promote robust buildout, we advance toward enabling rapid and efficient deployment. We do so by proposing flexible service, technical, assignment, and licensing rules for this spectrum, except where special provisions are necessary to facilitate shared use with other co-primary users.

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[1] *See* 5 U.S.C. § 603. The RFA, *see* 5 U.S.C. § 601-612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996, (SBREFA) Pub. L. No. 104-121, Title II, 110 Stat. 857 (1996).

[2] *See* 5 U.S.C. § 603(a).

[3] *See* 5 U.S.C. § 603(a).

6. For the 24 GHz, 32 GHz, 42 GHz, 47 GHz and 50 GHz bands we propose to assign PEA-based licenses through competitive bidding. In the 48.2-50.2 GHz portion of the 47 GHz band, we propose to require licensees to provide information on their facilities to enable sharing with FSS user equipment. Finally, in the 71-76/81-86 GHz bands, we seek comment on various systems managed by database operators which will coordinate use as between mmW base stations, fixed point-to-point links used for backhaul, and Federal operations.

7. A portion of the 24 GHz band is allocated for satellite service but is limited to only feeder links for the Broadcast Satellite Service (BSS), and we have proposed to either retain existing coordination procedures or to adopt the sharing regime used for the 28 GHz band to manage interference between terrestrial and satellite operations. Meanwhile, the 47 GHz band is also allocated for satellite and is intended to be used for FSS user equipment. We have proposed that FSS operation at 47 GHz be limited to individually licensed earth stations subject to the same sharing framework we adopt today in the 28 GHz band except with SAS-based sharing between terrestrial and satellite operations. Finally, although the 50 GHz band is also allocated for satellite, it contains no present satellite use and the Commission is exploring sharing mechanisms for the band in the future, including SAS.

8. Overall, these proposals are designed to provide for flexible use of this spectrum by allowing licensees to choose their type of service offerings, to encourage innovation and investment in mobile broadband use in this spectrum, and to provide a stable regulatory environment in which fixed, mobile, and satellite deployment would be able to develop through the application of flexible rules. The market-oriented licensing framework for these bands would ensure that this spectrum is efficiently utilized and will foster the development of new and innovative technologies and services, as well as encourage the growth and development of a wide variety of services, ultimately leading to greater benefits to consumers.

9. In the *FNPRM*, we also seek comment on various proposals for refining the rules we have adopted in the *Report and Order*. We seek comment on various ways of developing the shared access framework we have adopted for the 37-37.6 GHz band. That framework creates an innovative shared space that can be used by a wide variety of Federal and non-Federal users, by new entrants and by established operators – and smaller businesses in particular – to experiment with new technologies in the mmW space. We propose to adopt additional performance requirement metrics for uses such as Internet of Things and machine-to-machine communications. Adopting these additional metrics will allow licensees to use the mmW bands for innovative uses with the certainty that they can meet performance requirements and renew their licenses. For example, we seek further comment on whether we should impose a "use-or-share" obligation on UMFUS licensees in order to efficiently make as much unused spectrum available as possible. Such a "use-or-share" regime could take varying forms, such as a fully dynamic sharing solution whereby opportunistic users could indefinitely deploy outside a licensee's geographic build-out area subject to the latter's potential expansion - as coordinated by a third-party database administrator; a modified shared access system whereby meeting a defined level of deployment in a set of geographic areas would foreclose their opportunistic use; and, an unlicensed shared access approach whereby opportunistic users would operate wherever licensees were not actually deployed.

10. We seek comment on whether we can allow FSS satellites in the 37.5-40 GHz band to operate at higher power and transmit a higher power flux density at the Earth's surface. If we can allow such higher power without causing interference to terrestrial operations, this change could allow FSS operators to make greater use of the band. We also ask whether we should repeal the prohibition on satellite (FSS) user equipment in the 37.5-40 GHz band and seek comment on whether terrestrial operators should have to divulge their deployments to FSS providers through a database in order to allow individual users to install their own receiving equipment without interfering with terrestrial operations. In addition, we ask whether we should adopt a requirement that millimeter wave band systems transmit an ID identifying themselves to enable better identification and control of sources of interfering signals much the same way that TV, radio or even WiFi systems presently identify themselves. Finally, we seek comment on revisions to the technical rules for the Upper Microwave Flexible Use Service, including revising coordination criteria between adjacent licensees for point-to-point operations; establishing a minimum bandwidth and bandwidth scaling factor corresponding to various power levels; proposing a

reduction in transmit power limits responsive to increasing antenna height, and obtaining further information on millimeter wave propagation models, and whether Part 15 operations in the 57-71 GHz band can be allowed on board aircraft. These portions of the *FNPRM* will help ensure that licensees have maximum flexibility to operate while not causing interference to other licensees.

C. Legal Basis

11. The proposed action is authorized pursuant to Sections 1, 2, 3, 4, 5, 7, 10, 201, 225, 227, 301, 302, 302a, 303, 304, 307, 309, 310, 316, 319, 332, and 336 of the Communications Act of 1934, 47 U.S.C. §§ 151, 152, 153, 154, 155, 157, 160, 201, 225, 227, 301, 302, 302a, 303, 304, 307, 309, 310, 316, 319, 332, 336 and Section 706 of the Telecommunications Act of 1996, as amended, 47 U.S.C. § 1302.

D. Description and Estimate of the Number of Small Entities To Which the Proposed Rules Will Apply

12. The RFA directs agencies to provide a description of, and, where feasible, an estimate of the number of small entities that may be affected by the proposed rules and policies, if adopted.[4] The RFA generally defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction."[5] In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.[6] A "small business concern" is one which: (1) is independently owned and operated; (2) is not dominant in its field of operation; and (3) satisfies any additional criteria established by the SBA.[7]

13. *Small Businesses, Small Organizations, and Small Governmental Jurisdictions.* Our action may, over time, affect small entities that are not easily categorized at present. We therefore describe here, at the outset, three comprehensive, statutory small entity size standards.[8] First, nationwide, there are a total of approximately 28.2 million businesses, 99.7 percent of which are small, according to the SBA.[9] In addition, a "small organization" is generally "any not-for-profit enterprise which is independently owned and operated and is not dominant in its field."[10] Nationwide, as of 2007, there were approximately 1,621,315 small organizations.[11] Finally, the term "small governmental jurisdiction" is defined generally as "governments of cities, towns, townships, villages, school districts, or special districts, with a population of less than fifty thousand."[12] Census Bureau data for 2011 indicate that there were 89,476 local governmental jurisdictions in the United States.[13] We estimate that, of this total, as many as 88, 506

[4] 5 U.S.C. § 603(b)(3).

[5] 5 U.S.C. § 601(6).

[6] 5 U.S.C. § 601(3) (incorporating by reference the definition of "small-business concern" in the Small Business Act, 15 U.S.C. § 632). Pursuant to 5 U.S.C. § 601(3), the statutory definition of a small business applies "unless an agency, after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definition(s) in the Federal Register."

[7] 15 U.S.C. § 632.

[8] *See* 5 U.S.C. §§ 601(3)–(6).

[9] *See* SBA, Office of Advocacy, "Frequently Asked Questions," *available at* https://www.sba.gov/sites/default/files/FAQ_March_2014_0.pdf.

[10] 5 U.S.C. § 601(4).

[11] INDEPENDENT SECTOR, THE NEW NONPROFIT ALMANAC & DESK REFERENCE (2010).

[12] 5 U.S.C. § 601(5).

[13] U.S. CENSUS BUREAU, STATISTICAL ABSTRACT OF THE UNITED STATES: 2011, Table 427.

entities may qualify as "small governmental jurisdictions."[14] Thus, we estimate that most governmental jurisdictions are small.

14. *Wireless Telecommunications Carriers (except satellite)*. The appropriate size standard under SBA rules is for the category Wireless Telecommunications Carriers. Under that size standard, such a business is small if it has 1,500 or fewer employees.[15] Census Bureau data for 2012, show that there were 967 firms in this category that operated for the entire year. Of this total, 955 had employment of 999 or fewer, and 12 firms had employment of 1,000 employees or more. Thus under this category and the associated small business size standard, the Commission estimates that the majority of wireless telecommunications carriers (except satellite) are small entities that may be affected by our action.[16]

15. *Fixed Microwave Services.* Microwave services include common carrier,[17] private-operational fixed,[18] and broadcast auxiliary radio services.[19] They also include the Local Multipoint Distribution Service (LMDS),[20] the Digital Electronic Message Service (DEMS),[21] the 39 GHz Service (39 GHz),[22] the 24 GHz Service,[23] and the Millimeter Wave Service[24] where licensees can choose between common carrier and non-common carrier status.[25] At present, there are approximately 61,970 common carrier fixed licensees, 62,909 private and public safety operational-fixed licensees, 20,349 broadcast auxiliary radio licensees, 412 LMDS licenses, 35 DEMS licenses, 870 39 GHz licenses, and

[14] The 2007 U.S Census data for small governmental organizations are not presented based on the size of the population in each such organization. There were 89,476 small governmental organizations in 2007. If we assume that county, municipal, township, and school district organizations are more likely than larger governmental organizations to have populations of 50,000 or less, the total of these organizations is 52,125. If we make the same assumption about special districts and also assume that special districts are different from county, municipal, township, and school districts, in 2007 there were 37,381 special districts. Therefore, of the 89,476 small governmental organizations documented in 2007, as many as 89,506 may be considered small under the applicable standard. This data may overestimate the number of such organizations that has a population of 50,000 or less. U.S. CENSUS BUREAU, STATISTICAL ABSTRACT OF THE UNITED STATES 2011, Tables 427, 426 (Data cited therein are from 2007).

[15] 13 CFR § 121.201, NAICS code 517210.

[16] *See* http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2012_US_51SSSZ5&prodType=table.

[17] *See* 47 C.F.R. Part 10, Subpart I.

[18] Persons eligible under Parts 80 and 90 of the Commission's rules can use Private-Operational Fixed Microwave services. *See* 47 CFR Parts 80 and 90. Stations in this service are called operational-fixed to distinguish them from common carrier and public fixed stations. Only the licensee may use the operational-fixed station, and only for communications related to the licensee's commercial, industrial, or safety operations.

[19] Auxiliary Microwave Service is governed by Part 74 and Part 78 of Title 47 of the Commission's rules. Available to licensees of broadcast stations, cable operators, and to broadcast and cable network entities. Auxiliary microwave stations are used for relaying broadcast television signals from the studio to the transmitter, or between two points such as a main studio and an auxiliary studio. The service also includes TV pickup and CARS pickup, which relay signals from a remote location back to the studio.

[20] *See* 47 CFR Part 101, Subpart L.

[21] *See* 47 CFR Part 101, Subpart G.

[22] *See* 47 CFR Part 101, Subpart N.

[23] *See id.*

[24] *See* 47 CFR Part 101, Subpart Q.

[25] *See* 47 CFR §§ 101.533, 101.1017.

five 24 GHz licenses, and 408 Millimeter Wave licenses in the microwave services.[26] The Commission has not yet defined a small business with respect to microwave services. For purposes of the FRFA, the Commission will use the SBA's definition applicable to Wireless Telecommunications Carriers (except satellite)—i.e., an entity with no more than 1,500 persons is considered small.[27] Under that size standard, such a business is small if it has 1,500 or fewer employees.[28] Census Bureau data for 2012, show that there were 967 firms in this category that operated for the entire year. Of this total, 955 had employment of 999 or fewer, and 12 firms had employment of 1,000 employees or more. Thus under this category and the associated small business size standard, the Commission estimates that the majority of wireless telecommunications carriers (except satellite) are small entities that may be affected by our proposed action.[29] The Commission notes that the number of firms does not necessarily track the number of licensees. The Commission estimates that virtually all of the Fixed Microwave licensees (excluding broadcast auxiliary licensees) would qualify as small entities under the SBA definition.

16. *Satellite Telecommunications and All Other Telecommunications.* Two economic census categories address the satellite industry. The first category has a small business size standard of $32.5 million or less in average annual receipts, under SBA rules.[30] The second also has a size standard of $32.5 million or less in annual receipts.[31]

17. The category of Satellite Telecommunications "comprises establishments primarily engaged in providing telecommunications services to other establishments in the telecommunications and broadcasting industries by forwarding and receiving communications signals via a system of satellites or reselling satellite telecommunications."[32] Census Bureau data for 2012 show that 333 Satellite Telecommunications firms operated for that entire year. Of this total, 275 firms had annual receipts of under $10 million, and 58 firms had receipts of $10 million to $24,999,999.[33] Consequently, the Commission estimates that the majority of Satellite Telecommunications firms are small entities that might be affected by our action.

18. The second category, i.e., "All Other Telecommunications," comprises "establishments primarily engaged in providing specialized telecommunications services, such as satellite tracking, communications telemetry, and radar station operation. This industry also includes establishments primarily engaged in providing satellite terminal stations and associated facilities connected with one or more terrestrial systems and capable of transmitting telecommunications to, and receiving telecommunications from, satellite systems. Establishments providing Internet services or voice over Internet protocol (VoIP) services via client-supplied telecommunications connections are also included in this industry."[34] For this category, Census Bureau data for 2012 show that there were a total of 1442 firms that operated for the entire year. Of this total, 1400 firms had annual receipts of under $25 million.

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[26] These statistics are based on a review of the Universal Licensing System on September 22, 2015.

[27] 13 CFR § 121.201, NAICS code 517210.

[28] 13 CFR § 121.201, NAICS code 517210.

[29] *See* http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2012_US_51SSSZ5&prodType=table.

[30] 13 CFR § 121.201, NAICS code 517410.

[31] 13 CFR § 121.201, NAICS code 517919.

[32] U.S. Census Bureau, 2012 NAICS Definitions, "517410 Satellite Telecommunications."

[33] *See* http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2012_US_51SSSZ4&prodType=table.

[34] U.S. Census Bureau, 2012 NAICS Definitions, "517919 All Other Telecommunications."

and 42 firms had annual receipts of $25 million to $49, 999,999.[35] Consequently, the Commission estimates that the majority of All Other Telecommunications firms are small entities that might be affected by our action.

19. *Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing.* The proposed rules relating to Part 15 operation pertain to manufacturers of unlicensed communications devices. The Census Bureau defines this category as follows: "This industry comprises establishments primarily engaged in manufacturing radio and television broadcast and wireless communications equipment. Examples of products made by these establishments are: transmitting and receiving antennas, cable television equipment, GPS equipment, pagers, cellular phones, mobile communications equipment, and radio and television studio and broadcasting equipment."[36] The SBA has developed a small business size standard for firms in this category, which is: all such firms having 750 or fewer employees. According to Census Bureau data for 2007, there were a total of 939 establishments in this category that operated for part or all of the entire year. Of this total, 784 had less than 500 employees and 155 had more than 100 employees.[37] Thus, under this size standard, the majority of firms can be considered small.

E. Description of Projected Reporting, Recordkeeping, and other Compliance Requirements

20. The projected reporting, recordkeeping, and other compliance requirements proposed in the *Further Notice of Proposed Rulemaking* will apply to all entities in the same manner. The revisions the Commission adopts should benefit small entities by giving them more information, more flexibility, and more options for gaining access to wireless spectrum.

21. Any applicants for Upper Microwave Flexible Use Service licenses will be required to file license applications using the Commission's automated Universal Licensing System (ULS). ULS is an online electronic filing system that also serves as a powerful information tool, one that enables potential licensees to research applications, licenses, and antenna structures. It also keeps the public informed with weekly public notices, FCC rulemakings, processing utilities, and a telecommunications glossary. Upper Microwave Flexible Use Service applicants that must submit long-form license applications must do so through ULS using Form 601,[38] FCC Ownership Disclosure Information for the Wireless Telecommunications Services using FCC Form 602,[39] and other appropriate forms.[40]

22. Applicants in the Upper Microwave Flexible Use Service will be required to meet buildout requirements at the end of their initial license terms. In doing do, they will be required to provide information to the Commission on the facilities they have constructed, the nature of the service they are providing, and the extent to which they are providing coverage in their license area.

23. We also propose to require Upper Microwave Flexible Use Service licensees to provide information on their proposed operations in order to facilitate sharing with other authorized services. This may include the possibility that UMFUS licensees will have to digitally identify their stations in order to help identify and eliminate causes of interference. In the 48.2-50.2 GHz band, terrestrial licensees may

[35] *See* http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2012_US_51SSSZ4&prodType=table.

[36] *See* U.S. Census Bureau, 2012 NAICS Definitions, NAICS Code 334220, *available at* http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2012_US_31SA1&prodType=table.

[37] *See id.*

[38] 47 CFR § 1.913(a)(1).

[39] 47 CFR § 1.919.

[40] 47 CFR § 1.2107.

have to report their deployment information to FSS providers to facilitate the deployment of FSS user equipment. We seek comment on the scope of the information to be provided and the manner in which it should be provided.

24. We expect that all of the filing, recordkeeping and reporting requirements associated with the demands described above, including professional, accounting, engineering or survey services used in meeting these requirements will be the same for large and small businesses that intend to utilize these new UMFUS licenses, but we seek comment on any steps that could be taken to minimize any significant economic impact on small businesses.

F. Steps taken to Minimize Significant Economic Impact on Small Entities, and Significant Alternatives Considered

25. The RFA requires an agency to describe any significant alternatives that it has considered in reaching its approach, which may include the following four alternatives (among others): (1) the establishment of differing compliance or reporting requirements or timetables that take into account the resources available to small entities; (2) the clarification, consolidation, or simplification of compliance or reporting requirements under the rule for small entities; (3) the use of performance, rather than design, standards; and (4) an exemption from coverage of the rule, or any part thereof, for small entities.[41] Accordingly, we seek comment on whether any of burdens associated the filing, recordkeeping and reporting requirements described above can be minimized for small businesses. In particular, we seek comment on whether any of the costs associated with our construction or performance requirements in these bands can be alleviated for small businesses.

26. We intend to license the 24 GHz, 32 GHz, 42 GHz, and 50 GHz bands on a PEA basis, but we will also permit partitioning and disaggregation by licensees in the mmW bands.[42] As we noted above in the *Report and Order*, while PEAs are small enough to provide spectrum access opportunities for smaller carriers and PEAs could even be further disaggregated, PEAs also nest within, and may be aggregated to form, larger license areas. Therefore, the benefits and burdens resulting from assigning spectrum in PEA license areas would be equivalent for small and large businesses. Depending on the licensing mechanisms we adopt for these bands, licensees may adjust their geographic coverage through auction or through the secondary markets. This proposal should enable providers, or any entities, whether large or small, providing service in the mmW bands to more easily adjust their spectrum to build their networks pursuant to individual business plans. And we believe this ability to adjust spectrum holdings will make it easier for small entities to acquire or access spectrum. We seek comment from the public concerning whether these license area determinations would indeed benefit the small businesses or whether there are other alternatives we should consider.

27. For UMFUS bands for which we accept mutually exclusive initial applications, we will resolve such applications by competitive bidding conducted pursuant to Part 1 Subpart Q of the Commission's rules, including rules governing designated entity preferences.[43] In the *Report and Order*, we adopted bidding credits for applicants for UMFUS licenses who qualify as small businesses. An entity with average annual gross revenues for the preceding three years not exceeding $55 million will qualify as a "small business" and be eligible to receive a 15 percent discount on its winning bid. An entity with average annual gross revenues for the preceding three years not exceeding $20 million will qualify as a "very small business" and be eligible to receive a 25 percent discount on its winning bid.[44] The *FNPRM* seeks comment on whether to apply the these same small business definitions and associated bidding credits to the auction of licenses in the additional bands the *FNPRM* proposes, as well as any

[41] 5 U.S.C. § 604(a)(6).

[42] *See supra* Section IV.F.9.a (Partitioning and Disaggregation).

[43] *See* 47 CFR §§ 1.2101-1.2114.

[44] *See supra* Section IV.F.11.b (Small Business Provisions for Geographic Area Licenses).

other spectrum bands we may subsequently decide to include in the UMFUS. We believe providing small businesses and very small businesses with bidding credits, in addition to the protections built into the auction rules themselves should provide an economic benefit to small businesses by making it easier for them to acquire or access spectrum in these bands. We seek comment on this assessment and on whether there are any alternative steps we could take to better assist small businesses.

28. In the *Report and Order*, the Commission adopted service rules that will permit licensees the flexibility to provide any fixed or mobile service that is consistent with their spectrum allocation. We propose that the same flexibility shall apply to the 24 GHz, 32 GHz, 42 GHz, 47 GHz, and 50 GHz bands and we seek comment concerning whether this flexibility will benefit small businesses by giving them more avenues for gaining access to valuable wireless spectrum. Finally, as noted above, we are proposing to create a Spectrum Access System (SAS)-based regulatory framework in the 70/80 GHz band that will permit an innovative shared space in these bands. The SAS serves as an advanced, highly automated frequency coordinator across the band, potentially allowing this shared space to be used by a wide variety of Federal and non-Federal users, by new entrants, by established operators, and small businesses in particular – to experiment with new technologies in the mmW space and innovate. Our proposals require that small businesses register with an SAS and comply with the rules established for the service and in return they receive the ability to access spectrum currently unavailable to them. We believe this should constitute a significant benefit for small businesses, and we seek comment on this proposal.

29. The technical rules we now propose will allow licensees of mmW band spectrum to operate while also protecting licensees of nearby spectrum, some of whom are small entities, from harmful interference, and we also seek comment on these proposals.

G. Federal Rules that May Duplicate, Overlap, or Conflict with the Proposed Rules

30. None.

STATEMENT OF
CHAIRMAN TOM WHEELER

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

On my first day as Chairman, I described the FCC as the nation's "Optimism Agency." Today's Spectrum Frontiers Order is exactly what I had in mind when I made that statement.

Our broadband networks – wired and wireless – will define what our world is going to be like. From job creation, to education, to healthcare, to energy and on down the line, these networks will unleash new innovations, making the impossible possible. We have the incredible privilege of helping to shape that connected future. Today, we take the most significant steps yet to enable the next generation of wireless connectivity.

Fifth-generation, or 5G, connectivity will likely be more than an incremental evolutionary step forward in wireless technology. It promises quantum leaps forward in three key areas: speeds resembling fiber that are at least 10 times and maybe 100-times faster than today's 4G LTE networks; responsiveness less than one-thousandth of a second, which enables real-time communication; and network capacity multiples of what is available today.

Coupling this ultra-fast, low-latency, high-capacity connectivity with the almost unlimited processing power of the cloud will enable super fast wireless broadband, smart-city energy grids and water systems, immersive education and entertainment, and an unknowable number of innovations. In a 5G world, the Internet of Everything will be fully realized; everything that can be connected will be connected. Most important, 5G will enable killer applications yet to be imagined.

We are already seeing industry gearing up to seize this opportunity. AT&T, Sprint, T-Mobile and Verizon are all moving forward with plans to test and develop 5G technologies. For example, last month, Sprint demonstrated 5G connectivity offering speeds up to 4 Gbps at the Copa America soccer tournament in Philadelphia. Verizon recently announced the completion of its 5G radio specification, which provides guidelines to test and validate 5G technical components. These efforts will help inform the standards process by putting stakes in the ground. And the first commercial deployments at scale are expected in 2020.

Without question, 5G is a national priority. The interconnected world of the future will be the result of decisions we make today.

With today's Order, we are repeating the proven formula that made the United States the world leader in 4G: one, make spectrum available quickly and in sufficient amounts; two, encourage and protect innovation-driving competition; and three, stay out of the way of market-driven, private sector technological development.

Today's Order will make the United States the first country in the world to identify and open up vast amounts of high frequency spectrum for 5G applications. The big game-changer is that we are using much higher-frequency bands than previously thought viable for flexible uses, including mobile.

The ability to use this high-frequency spectrum opens much bigger chunks of spectrum. Current blocks of licensed low-band spectrum are usually 5 to 10 megahertz in width. With 5G, however, we are looking at blocks of at least 200 megahertz in width. This will allow networks to carry much more traffic per user – gigabits of throughput instead of megabits. We're talking about fiber-like capacity to wireless users.

By opening up these higher-frequency bands, we are making available over four times the total amount of licensed spectrum currently available for mobile. And we're not done. We're asking questions about opening up a significant number of other bands.

We are not prognosticating about the technology that has to be deployed in these bands. We are setting flexible rules that will allow the market to best determine how the technology will evolve, without having to ask our permission.

The new high bands we are opening up will be woven with the existing mid and low bands into networks that will provide coverage and high capacity for consumers and businesses We aren't going to say "this band is to be used for 3G, this band for 4G and this band is for 5G." Our strength is in providing the flexibility to use all of the spectrum resources in the way that provides the best services.

And it's not just licensed spectrum; unlicensed will continue to play a critical role in future networks, as will shared spectrum. Today's Order will add to an existing unlicensed band to create a massive 14 gigahertz unlicensed band. Consider that – 14,000 megahertz of unlicensed spectrum, with the same flexibility that has allowed unlicensed to become a breeding ground for innovation. It also provides 600 megahertz within the 37 GHz band for shared access between commercial users and federal users. This band can provide access to spectrum where and when it's needed, and it will serve as a proving ground for policy and technical innovations to enable new forms of spectrum sharing between commercial and federal users.

Opening up spectrum and offering flexibility to operators and innovators is the most important thing we can do to enable the 5G revolution, but it's not the only thing.

We also needed to work out sharing issues between terrestrial and satellite operators. Sharing is essential for the future of spectrum utilization. Many of the high-frequency bands we are making available for 5G currently have some satellite users, or at least the possibility of future satellite users. Our rules strike a balance that offers flexibility for satellite users to expand, while providing terrestrial licensees with predictability about the areas in which satellite will locate.

To live up to its potential, 5G networks must also be secure. Cybersecurity issues need to be addressed during the design phase for the entire 5G ecosystem, including devices. For the FCC's part, our policy approach will emphasize that industry must develop and communicate cybersecurity standards. We anticipate that a continuous dialogue between the FCC, industry, and standards bodies will stimulate industry development of a security framework for 5G and the Internet of Things that will evolve to accommodate new functions and security threats.

If we've learned anything in the generational march through wireless connectivity, it is that we have always underestimated the innovation that would result from new generations of wireless networks.

Thank you to all the Commission staff who worked to craft this item and shape this next chapter in our wireless future.

STATEMENT OF
COMMISSIONER MIGNON L. CLYBURN

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

So I am about to ask a question that may seem odd coming from this side of the bench, particularly since this body stands minutes away from taking "a significant step towards securing the Nation's future in the next generational evolution of wireless technology": Just what is 5G?

Today's vote is both a monumental step, as well as a perfect example of why I am so excited about the direction we are headed when it comes to spectrum policy. Breaking away from the conventional model of exclusive, indefinite licenses; innovative sharing rules for bands, and in frequencies we never dreamed possible . . . all of this affirms just how serious we are about meeting the communications bandwidth needs of our citizens.

But I am willing to bet that your answer to the question "what is 5G?" would be different from the person sitting next to you, and the next person, and the next. Nonetheless, what we do know, and can all agree on, is that the next wireless evolution promises to fundamentally change the way we live, interact, and engage with our communities. Indeed, there is seemingly no limit on how what we refer to as 5G could impact our everyday existence.

A refrigerator that not only alerts you to a near empty egg carton, but automatically adds that item to a virtual shopping list, enabling a delivery to your door by week's end, without any action from you. Or a piece of equipment in a factory that automatically pings a repair person at headquarters about a potential malfunction well before the machine shuts down. Or remote surgery being performed in the Alaskan Bush by a preeminent surgeon thousands of miles away.

Some of our cities already have smart technologies, such as New York City's LinkNYC free public WiFi network, which I had the pleasure of seeing in May as part of my #ConnectingCommunities tour, or Boston's solar powered benches, that not only charge gadgets, but also monitor air quality and sound levels – and all of this will become even more prevalent in a 5G world.

But what is inspiring to many, and to me, are the possibilities we have yet to conceive . . . those truly extraordinary use cases that we are on the cusp of realizing. What an exciting new frontier, and today's *Order* provides a strong framework that promises to unleash more innovation, spur additional competition and incite boundless creativity. And if that were not enough, what is even more thrilling, is the fact that America is leading the way.

Each of us has worked diligently to craft a regulatory regime that carefully balances the needs of all stakeholders invested in the future of the 28 GHz, 37 GHz and 39 GHz bands. This *Order* also provides room for innovators to develop pioneering products in the 64-71 GHz unlicensed band, which

opens up a whole new range of possibilities. And in the *Further Notice,* we identify 18 gigahertz of additional spectrum for 5G use cases, and seek comment on the use of bands above 95 GHz.

But in the midst of all this excitement and promise, as we collectively figure out just what 5G is, let us not forget that there are pockets in this nation, where people are still living in a 2G and 3G reality. They include the unserved and underserved who are just as anxious to reap the benefits of successful spectrum policies as you and me.

When we think about what the goals of our next generation networks should be, ubiquity and affordability have to be a part of the success matrix, for we must be sure that we are not just giving those who already have the most even more, while doubling down and widening the digital divide for those with none or not enough because of a lack of forethought when setting the standards and business cases for 5G. We need to be as creative, flexible and forward thinking on the community and opportunities inclusion fronts as we are on the technological innovations front.

There must be room for service offerings that benefit those in the urban high-rent district as well as those who are struggling on the rural prairies. We must think of ways to leverage both fixed and mobile 5G for the currently un-connected, and make a solid commercial case for doing so. America will only truly win the 5G race if all of our citizens benefit, and it is my sincere hope as we strive to ensure competitive opportunities that we deliver ubiquitous rewards to everyone.

I would like to thank Jon Wilkins, Julie Knapp, Mindel De La Torre and their staff at the Wireless Telecommunications Bureau, Office of Engineering and Technology, and International Bureau for their commendable work on this item, and a special thank you goes to Brian Regan and Jose Albuquerque. I am grateful for your tireless efforts on this item, and ever more excited to discover, along with you, all the cutting-edge innovations that await us in 2020 and beyond.

STATEMENT OF
COMMISSIONER JESSICA ROSENWORCEL

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

Today, the United States leads the world in the deployment of the current generation of wireless technology—known as 4G. While we are home to less than five percent of the globe's population, we have one-third of all 4G subscriptions worldwide.

So far, so good. But if we want our wireless future to be bold, we need to do more than rest on our 4G laurels. We need to focus on what's next. 5G services are poised to provide speeds more than 10 times faster than today's 4G networks. The increased speeds of 5G service will change the way we communicate, multiplying the ways we use video—as images increasingly replace what is done today by text. The reduced latency of 5G service will clear the way for augmented and virtual reality—creating new teaching tools and entertainment experiences. And the lower energy demands of 5G service will lay the groundwork for new efficiency gains from the Internet of Things.

The race to 5G is on. The world's wireless economies are busy planning for 5G. South Korea and Japan have plans to deploy 5G services by the time they hold the Olympics in 2018 and 2020, respectively. To meet this goal, carriers in these countries are already conducting field trials. Earlier this year, the European Commission announced work on a 5G Action Plan in addition to work they are doing with China, where three of the nation's ministries have jointly established a group to promote the development of 5G services.

So even though standardization is still underway and commercialization may not occur until the end of the decade—work is being done worldwide. I saw some of this myself, in our own backyard, when I spent time at the National Institute of Standards and Technology last week. We have cutting edge millimeter wave research that is taking place with assistance from both academia and industry. We are making progress.

But for 5G technology to takeoff, for the United States to win this race, we need spectrum—and lots of it. So I am pleased to support our efforts today to authorize mobile use in the 28, 37, and 39 GHz bands. Collectively, this represents over 3 gigahertz of spectrum that will become available for licensed use. We also have a cut for unlicensed, or what I call the Wi-Fi dividend, in the 64-71 GHz band. These airwaves can be combined with a swath of unlicensed spectrum that is nearby—meaning new and exciting possibilities for Wi-Gig innovation. We also seek comment on opportunities in spectrum above 95 GHz.

At the same time, we take steps to protect incumbent satellite operations that rely on this high-band spectrum. We allow for their continued growth and commit to carefully monitoring the impact of terrestrial use on their operations. This is important.

However, we need to remember airwaves alone are not enough. In wireless policy, spectrum gets all the glory—but if we want to be bold with 5G service, we need to focus our efforts on the ground as well as the skies.

Here's why: Today, the bulk of our 4G wireless networks are built on spectrum frequencies from 600 MHz to 3 GHz. But our 5G future is going to look different—very different. That's because today we are busting through this old 3 GHz ceiling and developing opportunities in much higher-band airwaves. This spectrum is way, way up there. These are the airwaves that will take us to infinity and beyond. But with these stratospheric frequencies we have propagation challenges. While these super-high signals carry a significant amount of data, they do not go far. But we can turn this limitation into a strength by combining these frequencies with small cells packed close together, densifying networks at lower cost.

This all works—if we come up with policies and practices that facilitate small cell deployment. In other words, with 5G networks small cells are a big thing. So we need to think beyond traditional tower siting. Already, we have taken steps to streamline our historic preservation and environmental review process for small cells. We also have adopted rules to implement the parts of the Middle Class Tax Relief and Job Creation Act that tighten the local review process for facilities that do not substantially change the dimensions of existing structures. This is good—but more work is necessary.

By law and tradition, we honor local control in this country. At the same time we should reward communities that take steps to put in place the infrastructure we need for our 5G future.

For outdoor deployments, we should work with communities across the country and help develop model practices. We could also hold a contest—and reward the cities that put 5G infrastructure in place as part of the broader Smart Cities Initiative that was kicked-off last year.

In addition, we need to look at the in-building equation. I think the time has come for the broadband and wireless equivalent of LEED certification. Because the market should reward buildings that have dense networks of small cells and fiber backhaul needed for 5G service. New York City already has a similar program in place thanks to the efforts of Mayor Michael Bloomberg—who started a program to identify buildings with truly high-speed broadband. We need to build on this idea and extend it to communities across the country. Because as we all know about the Big Apple, if you can make it there, you can make it anywhere.

There are a lot of challenges ahead. But we are on the cusp of cars that drive themselves, streets that can be safer, emergency services that are more effective, healthcare that is more personalized, and more capability across the board because we are more connected.

Because while 4G technology brought the smartphone to pockets and purses everywhere, the benefits of 5G technology are bigger, bolder—and more diffuse. They will be felt throughout the economy.

How? We are just getting started. But there are possibilities everywhere.

Imagine if we rewarded the city that cut commute times the most. It would take sensors in streetlights, roadside architecture, and cars to see where traffic patterns could be more efficient, and public transportation more effective. 5G technology can make it happen.

Imagine if we introduced cameras in the helmets of firefighters. They could relay video back to colleagues outside who could direct a team of firefighters in real time, enhancing safety for first responders and those they rescue. 5G technology can make it happen.

Imagine if we monitored urban trees with sensors to help assess air quality and develop strategies for dealing with drought. Los Angeles is already looking at this in a project called the Internet of Trees. And 5G technology can make it happen.

That's what the wireless future looks like. It is so much more than the devices in our palms today. To get there we need to do more than rest on our 4G laurels—and with our efforts here with millimeter wave spectrum—we do that today. Because the race to 5G is on—and the future belongs to the connected.

STATEMENT OF
COMMISSIONER AJIT PAI

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

A decade ago, the smartphone didn't exist. Today, over 70% of American consumers cradle them in the palms of their hands, and an artist like Adele is subjected to intense scrutiny when she uses a flip phone to say "Hello" in a music video.[45] Not long ago, cars, appliances, and other machines were analog islands unto themselves. Today, we are at the dawn of the Internet of Things, with 15 billion Internet-connected devices and 50 billion expected by 2020. Many years ago, wireless was a fraction of all IP traffic, and only spectrum below 3 GHz was thought to be suitable for mobile. Today, the forecast is that wireless devices will account for two-thirds of all IP traffic, and the vistas for spectrum extend up into the triple digits. Changes like these are forcing everyone to rethink our wireless networks and to start planning for our 5G future.

Thankfully, American entrepreneurs and innovators are rising to meet the challenge of our highly interconnected world. They are investing in the research and development necessary for the United States to extend its leadership in the mobile space to the next generation of wireless technologies. I have seen these efforts firsthand—from Samsung's 5G research lab near Dallas, Texas, to Intel's demonstration of its millimeter wave technology here at the FCC's headquarters. And just this week, Verizon completed the technical specifications for its 5G deployment, which should help accelerate the technological push forward.

Today, the FCC does its part to pace the wireless revolution. In this *Order*, we open up over 10 GHz of high-band spectrum for innovative mobile use. In the *Further Notice*, we start the process of bringing perhaps twice that much spectrum online. And on many of the most important policy questions, we supply answers that should allow American consumers to continue to enjoy a mobile experience that is the envy of the world.

I want to highlight just a few of those decisions.

First, I'm glad that we're including a number of additional spectrum bands in our *Further Notice*. In particular, I'm pleased that we now have the votes to examine the 12,500 MHz of spectrum in the 24 GHz, 32 GHz, 42 GHz, 70 GHz, and 80 GHz bands. Commissioner O'Rielly and I urged our colleagues to include those bands in last year's *Notice*. In our view, the Commission should have teed up as many

[45] *See, e.g.*, "11 people coming to terms with Adele using a flip phone in the Hello video," *Metro.co.uk* (Oct. 23, 2015), *available at* http://metro.co.uk/2015/10/23/11-people-coming-to-terms-with-adele-using-a-flip-phone-in-the-hello-video-5459142/#ixzz4EKF4RPwD ("Adele's stunning video for her comeback single Hello might have taken the world by storm – but it has left viewers with just one question: just why is she using a flip phone?").

bands as possible and let innovators and entrepreneurs tell us what might work. Happily, our persistence has paid off. The Commission speaks with one voice today in promoting the potential of those 12,500 MHz of spectrum for flexible, mobile use.

Likewise, I want to take a minute to thank my colleagues for agreeing to expand the *Further Notice* to include spectrum bands above 95 GHz. Getting to this point was no small feat. Petitioners asked the FCC to adopt service rules for these bands years ago. (It shouldn't have taken this long for us to move forward, especially since we have the duty under section 7 of the Communications Act to "determine whether any new technology or service proposed in a petition or application is in the public interest within one year after such petition or application is filed."[46]) In the meantime, other countries, as well as companies here in the United States, have been looking for ways to put this spectrum to more productive use. I've been told that our lack of service rules might be holding us back. Now, one might think that these bands are way out there (spectrally speaking), but that's not a reason to artificially restrict their use. Again, let's get the spectrum out there and let the engineers help us decide. I'm happy to report that we were able to reach a compromise that puts these bands on the table.

Second, I'm glad that we are now placing an even greater emphasis on fostering investment and innovation in the millimeter wave bands. For instance, the *Order* abandons the so-called "hybrid" licensing scheme that the 2015 *Notice* proposed for the 37 GHz band. In my view, that complex regime would have inhibited investment and innovation in the band. We also appropriately leave behind the complicated performance metrics proposed in the 2015 *Notice*. At the time, I urged my colleagues to include questions about more straightforward approaches. The *Order* now adopts those simpler, well-established methods of determining whether licensees are putting their spectrum to use. We also adopt renewal expectancies for the licensed bands, which should help encourage investment. And in another positive step, the *Further Notice* now seeks comment on whether we should apply our traditional licensing mechanisms to the additional spectrum bands, rather than experimenting with far more complicated regimes.

Third, I am glad that the relief we're providing today is not limited solely to traditional mobile technologies. Earlier this year, I had the pleasure of visiting with Google's Advanced Technology and Projects (ATAP) group.[47] One of the most intriguing things they showed me was Project Soli. Founder and team lead Ivan Poupyrev described how Project Soli has created a sensing technology that uses miniature radar to detect the smallest of hand gestures. Imagine being able to control your smartphone, watch, or virtually any similar device with a slight movement of your clasped thumb and index finger.[48] Imagine the benefits that these technologies could bring to individuals with disabilities. One testbed is in the 60 GHz band, which is technically well-suited for enabling machines to "see" subtle physical gestures. So I'm glad that my colleagues agreed with my suggestion to take additional steps today that will make it easier for entrepreneurs at ATAP and elsewhere to experiment with joining the physical and digital worlds.

None of this is to say that I agree with every decision the Commission makes today. Take the cybersecurity section of the *Order*. We lack the expertise and authority to dive headlong into this issue, and I don't think *any* agency should take a band-by-band approach to cyber. These are issues that are better left for security experts to handle in a more comprehensive way. However, I do appreciate that my colleagues revised portions of the cybersecurity discussion in light of some of my concerns. Another area

[46] Communications Act § 7(b).
[47] *See* https://twitter.com/AjitPaiFCC/status/684905286843248640.

[48] *See* "Welcome to Project Soli," https://www.youtube.com/watch?v=0QNiZfSsPc0. Developers are already thinking about more advanced use cases. *See, e.g.*, "Project Soli App Developers Showcase," https://www.youtube.com/watch?v=H41A_IWZwZI.

where I would have taken a different approach is mobile spectrum holdings. As I've emphasized, experience shows that markets distorted by preemptive government dictates don't ultimately benefit consumers. Nonetheless, because we could be years away from any high-band spectrum auctions, I hope that we'll have time to correct course before these limits apply. I also would have struck a slightly different balance when it comes to spectrum held by the federal government. We must continue to be as aggressive as possible when it comes to identifying and freeing up spectrum bands that could serve American consumers. But none of the concerns I've just expressed overshadow the merits of the broader compromise that we reached today, so I will be concurring with these portions of the decision.

Additionally, one observation. Today, we put in place a key piece of the 5G puzzle. But as important as it is, it is only one piece. Another critical one, given the imperative for "densified," higher-capacity networks, is infrastructure. Last year, I laid out my vision for a regulatory framework that will ensure our wireless leadership continues into the 5G future.[49] In addition to opening up these spectrum bands, that plan includes removing the barriers to infrastructure deployment. That means completing our small cell proceeding. That means pressing ahead on the IP Transition. And that means giving providers large and small the maximum incentive and flexibility to invest in fiber and other building blocks of tomorrow's networks. I look forward to working with my colleagues on doing just that.

Finally, I want to say a word about the professional staff of the FCC—the engineers, lawyers, and others who put in the countless hours necessary to move this proceeding forward. You deserve tremendous credit. It is one thing for us to pontificate; it's quite something else for you to produce. And produce you did: In less than two years, you pushed this proceeding from a *Notice of Inquiry* to an *Order*, and this country from virtually no high-band, mobile spectrum to over 10 GHz of it. In the regulatory context, that is moving at the speed of light. I know that it took a lot of negotiating and a good deal of compromise with federal users, and I want to commend you for your efforts. When the United States hopefully takes the worldwide lead in 5G technologies, it will be due in no small part to the incredible efforts you made—efforts that match the speed of change in the marketplace itself. So thank you.

Thank you to the staff of the Wireless Telecommunications Bureau, including Simon Banyai, Stephen Buenzow, Chris Helzer, Tim Hilfiger, Paul Malmud, Charles Mathias, Catherine Matraves, Elizabeth McIntyre, Gary Michaels, Charles Oliver, Matthew Pearl, Paul Powell, Brian Regan, John Schauble, Jim Schlicting, Catherine Schroeder, Blaise Scinto, Christian Segura, Karen Sprung, Joel Taubenblatt, and Nancy Zaczek.

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Thank you to the staff in the Office of General Counsel, including William Richardson, Anjali Singh, and David Horowitz.

And thank you to the staff in the Enforcement Bureau, including William Davenport and Jeremy Marcus.

[49] Remarks of FCC Commissioner Ajit Pai at 4G Americas' Technology Symposium (Nov. 5, 2015), http://go.usa.gov/xxWu3.

STATEMENT OF
COMMISSIONER MICHAEL O'RIELLY

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

After much hard work, the item before us is in fairly good shape.

While we are at the early stages of development, most industry participants believe that next generation, or 5G, networks will incorporate millimeter wave spectrum to achieve the capacity, speed and latency needs of Americans' wireless usage. Not only will these frequencies likely be used to provide data-intensive applications, such as advanced video downloads and gaming capabilities, but will also be used with our current 4G deployments to incorporate the vast and expanding Internet of Things and allow Americans to conduct business, communicate with loved ones, access the Internet and utilize apps wherever they may be.

Today, the U.S. becomes the first country to allocate spectrum for next generation wireless networks. I have stated repeatedly – and my colleagues agree – that we must maintain our position as the world leader in wireless innovation. Other nations, such as South Korea, China and Japan, seek to challenge our status, but we are ideally situated to usher in the next wave of wireless technologies based on our preeminence and experience gained in deploying 4G technologies. We are solidifying this leadership role by opening up the 28, 37, 39 and 64-71 GHz for mobile use.

I appreciate that the item, as promised to me, seeks comment, in the further notice, on seven new bands to open up for additional wireless uses. However, I am sure that no one is surprised that I will continue to push for even more bandwidth. I want to make it clear that I understand that we may not find all spectrum suitable, but this is a necessary exercise to ensure that our spectrum resources are being used efficiently and put to their best use.

This is why I sought to include more bands in the further notice, especially those that are being studied in preparation for the next World Radio Conference (WRC). While I have been critical of the events that I witnessed at WRC-15 and its decision to not study certain frequencies, such as 28 GHz, this does not mean that we should ignore the spectrum they did identify. While we do not include some of these bands today, we should move forward to consider such frequencies as 42.5-43.5 and 45.5-47 GHz to see if mobile services can be offered and global harmonization achieved. We also should have inquired about the 40-42 GHz bands and the LMDS frequencies (29.1-29.25 and 31-31.3 GHz) outside of the 28 GHz band, so that these licensees are not following two separate sets of rules.

A main role of the Commission is to provide the necessary spectrum resources and then let the private sector release technology into the marketplace to meet consumer demand. In the same vein, we must provide a regulatory environment that offers licensees with the necessary flexibility and certainty to

allow investment, innovation and deployment of next generation systems. While I am supportive of the action we take today, there are several licensing issues that, in my opinion, would have benefitted from further consideration and that I suspect we will be revisiting in the future.

For example, licensing 28 GHz by counties as opposed to larger market areas, such a PEAs, has been rejected by almost everyone in the record. There is also opposition to the shared use of the lower 600 MHz of the 37 GHz band between the federal government and multiple commercial users and concerns that the operability requirement for the 37-40 GHz band may slow down deployment. Issues have also been raised about how Fixed-Satellite Service (FSS) earth stations should be protected and how they should be sited going forward.

I also have serious concerns about the potential direction of some of the sharing proposals raised in the further notice. Going forward, I am unlikely to support any sharing mechanism that resembles the unproven 3.5 GHz experiment or the indoor "hybrid" approach that was proposed and rejected for the 37 GHz band. I also do not agree that any sharing paradigm with the federal government should be extended to the upper portion of the 37 GHz band, nor should the federal government obtain an allocation in the 42-42.5 GHz band. In fact, the further notice states that the government has access to the 47.2-50.2 and 50.4-52.6 GHz bands, but is not using the spectrum. The federal government needs to decrease – not increase – its footprint. This is why I have been outspoken about the need for spectrum fees for federal users as one solution.

I must dissent, however, to the spectrum aggregation limits imposed in this order and the mobile spectrum holdings discussion in the further notice. Generally, I oppose spectrum caps in favor of the free market but, in this case, it makes absolutely no sense to impose any limits. We do not have a consensus definition of 5G, finalized standards, a full understanding of what services will be offered, or any idea of how much spectrum is needed to achieve the capacity, speed and latency goals for particular spectrum bands, but we adopt foolish policy anyway. Moreover, this makes the proposal, in the further notice, of a potential holding period precluding certain secondary market transactions utterly preposterous. Transferability restrictions are used when small businesses or other favored entities have access to spectrum set asides, not when licensees pay full price for spectrum at auction.

Although improvements have been made since the item was originally circulated, I also cannot support the security section of this order requiring a high-level statement of every licensee's security plans. While I fully support secure networks, wireless providers have every incentive to ensure the soundness of their networks. A lack of security measures, or even worse a security breach, results in a loss of subscribers, which is not a successful business plan. Therefore, I don't think that this reporting requirement is necessary or all that helpful. Once again, this is the Commission gathering data for the purposes of monitoring, but it is really a means for the Commission to interfere in the design and operations of networks and the starting point for future regulation. I also cannot support the delegation of authority to the Public Safety Bureau to release an NOI seeking comment on the "security implications and solutions in future 5G networks."

Now that the Commission has identified spectrum for next generation networks, we must finish up the proceeding to further reduce regulatory burdens on small cell deployments. I understand that we are getting close, and I commend the Bureau for its work. Once this is done, we must refocus our energy on ensuring that localities cannot put unnecessary roadblocks in front of small cell siting.

I thank the Chairman for incorporating some of my edits and suggestions. And, a special thanks to the multi-bureau and office team who worked tirelessly to get this item to us so quickly. Although I may have made some different choices along the way, I recognize the amount of effort that went into this work product.