

**FCC FACT SHEET\***

**Spectrum Horizons**

Notice of Proposed Rulemaking – ET Docket No. 18-21

**Background:** The spectrum above 95 GHz has long been considered the outermost edge of usable spectrum. But the FCC is beginning to see an uptick in interest in these bands. Currently, the Commission has no rules to permit licensed or unlicensed communications use in these spectrum bands, other than by amateur operators or on an experimental basis.

The goal of this Spectrum Horizons proceeding would be to enable innovators and entrepreneurs to develop technology that can make effective use of this spectrum. Because the FCC cannot predict how technology will develop in this space, it would propose multiple options (licensed, unlicensed, and experimental) to encourage the deployment of new services and devices in this space and promote innovation.

**What the Notice of Proposed Rulemaking Would Do:**

- Seek comment on adopting rules for fixed point-to-point use of up to 102.2 gigahertz of spectrum in various bands.
  - Propose to base these rules on our existing 70/80/90 GHz rules under which licensees obtain a nationwide non-exclusive license and register each link with a database manager.
  - Seek general comment on the deployment of point-to-multipoint systems and mobile services in this spectrum.
- Seek comment on making up to 15.2 gigahertz of spectrum available for unlicensed use in several band segments.
  - Propose to base these rules on the existing rules for unlicensed use of the 57-71 GHz band.
- Seek comment on creating a new category of experimental licenses for the 95 GHz to 3 THz range.
  - Propose that in light of the uncharted nature of the bands, these licenses would offer more benefits than are available under conventional experimental licenses, such as longer license terms, license transferability, and the sale of equipment during market trials.

\* This document is being released as part of a “permit-but-disclose” proceeding. Any presentations or views on the subject expressed to the Commission or its staff, including by email, must be filed in ET Docket No. 18-21, which may be accessed via the Electronic Comment Filing System (<https://www.fcc.gov/ecfs/>). Before filing, participants should familiarize themselves with the Commission’s *ex parte* rules, including the general prohibition on presentations (written and oral) on matters listed on the Sunshine Agenda, which is typically released a week prior to the Commission’s meeting. See 47 CFR § 1.1200 *et seq.*

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

In the Matter of )
Spectrum Horizons ) ET Docket No. 18-21
Battelle Memorial Institute Petition for ) RM-11713
Rulemaking to Adopt Fixed Service Rules in the ) (Terminated)
102-109.5 GHz Band )
Request for Waiver of ZenFi Networks, Inc. and ) WT Docket No. 15-245
Geneva Communications LLC ) (Terminated)
James Edwin Whedbee Petition for Rulemaking to ) RM-11795
Allow Unlicensed Operation in the 95-1,000 GHz )
Band )

NOTICE OF PROPOSED RULEMAKING AND ORDER\*

Adopted: []

Released: []

Comment Date: (30 days after date of publication in the Federal Register)
Reply Comment Date: (45 days after date of publication in the Federal Register)

By the Commission:

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\* This document has been circulated for tentative consideration by the Commission at its February 2018 open meeting. The issues referenced in this document and the Commission’s ultimate resolutions of those issues remain under consideration and subject to change. This document does not constitute any official action by the Commission. However, the Chairman has determined that, in the interest of promoting the public’s ability to understand the nature and scope of issues under consideration, the public interest would be served by making this document publicly available. The Commission’s ex parte rules apply and presentations are subject to “permit-but-disclose” ex parte rules. See, e.g., 47 CFR §§ 1.1206, 1.1200(a). Participants in this proceeding should familiarize themselves with the Commission’s ex parte rules, including the general prohibition on presentations (written and oral) on matters listed on the Sunshine Agenda, which is typically released a week prior to the Commission’s meeting. See 47 CFR §§ 1.1200(a), 1.1203.

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**I. INTRODUCTION**

1. In this Notice of Proposed Rulemaking (Notice), we seek comment on a plan to make the spectrum above 95 GHz more readily accessible for new innovative services and technologies. Throughout its history, when the Commission has expanded access to what was thought to be the upper reaches of the usable spectrum, new technological advances have emerged to push the boundary of usable spectrum even further. The frequencies above 95 GHz are today’s spectrum horizons. The Notice seeks comment on proposed rules to permit licensed fixed point-to-point operations in a total of 102.2 gigahertz of spectrum; on making 15.2 gigahertz of spectrum available for unlicensed use; and on creating a new category of experimental licenses to increase opportunities for entities to develop new services and technologies from 95 GHz to 3 THz with no limits on geography or technology. We also grant, in part, two petitions for rulemaking and deny two requests for waiver.

**II. BACKGROUND**

2. We focus this *Notice* on providing licensed and unlicensed spectrum use opportunities in the 95 GHz to 275 GHz range, with additional provisions for experimental licensing up to 3000 GHz in a manner that would not foreclose future federal and non-federal access to opportunities and technologies. The frequencies in the 95 GHz to 275 GHz range are allocated for federal government and non-federal government use across multiple services on a co-primary basis, while the frequencies above 275 GHz are not allocated. Because we presently have no licensed service rules in these bands, and these bands are currently “restricted” under Part 15 rules for unlicensed devices, there is limited Commission-authorized use above 95 GHz, other than for experimental and amateur radio operations. In developing our proposals, we therefore draw from many inputs, including the present use of the band, our prior inquiries seeking information on potential use of this spectrum (including adjacent and nearby frequencies that can serve as useful comparisons), recent technical and international developments, our analysis of the engineering issues and propagation characteristics associated with the use of these frequencies, and applications for experimental licenses and rulemaking petitions that we have received. Our proposed approach is intended to provide incentives and opportunities for investment in the development of innovative new technologies and services while remaining cognizant of the flexible international, federal

and non-federal allocations, and the already extensive and planned passive uses of these bands. Developing rules in these bands serves the public interest; not only can it lead to new and novel communications opportunities in an uncrowded frequency range, it could also pay dividends by reducing pressures in lower parts of the spectrum. We also recognize that all the potential services and devices that might be developed in this spectrum are not yet known. Thus, while we are proposing a wide range of expanded licensed, unlicensed and experimental use opportunities now, we also leave room to enable future federal and non-federal access opportunities and technologies. We describe our specific proposals in greater detail below.

#### A. Allocations and authorized uses

3. In the Commission's Allocation Table,<sup>1</sup> the 95-275 GHz range (180 gigahertz) is divided into forty frequency bands that are allocated for federal/non-federal shared use.<sup>2</sup> Most (106.9 gigahertz)

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<sup>1</sup> Section 2.106 of the Commission's rules contains the Table of Frequency Allocations, consisting of an International Table (described in Section 2.104) and a United States Table (U.S. Table), split into federal and non-federal portions (described in Section 2.105). We note that stations in secondary services must not cause harmful interference to, and must accept interference from, primary services. 47 CFR §§ 2.104, 2.105, 2.106. *See also*, FCC, Office of Engineering and Technology, Policy and Rules Division, FCC Allocation History File, at <https://www.fcc.gov/oet/spectrum/table/FAHF.pdf>. This staff-maintained reference document is regularly updated to memorialize amendments and proposed amendments to the Table of Frequency Allocations. The relevant Commission decisions and associated materials (such as news releases) are listed in chronological order. The Allocation History File contains the complete citation for each document, including information concerning its publication in the Federal Register and in the FCC Record, and provides hyperlinks to these documents where available.

<sup>2</sup> All of these bands are allocated on a primary basis to the same radio services for federal/non-federal shared use, with two exceptions; and certain of these bands are also allocated to secondary services (e.g., the radio astronomy service (RAS) in the 123-130, 134-136, and 248-250 GHz bands). The two exceptions are the 134-136 GHz and 248-250 GHz bands, which are allocated to the amateur service (ARS) and the amateur-satellite service (ARSS) on a primary basis for non-federal use and to the RAS on a secondary basis for federal/non-federal shared use. The ITU has convened six radio conferences that addressed allocation changes in the 95-275 GHz range, and the Commission reflected these changes in its Allocation Table in the following implementation documents: First, the World Administrative Radio Conference for Space Telecommunications (Geneva, 1971) ([Space WARC](#)) extended the ITU's Table of Frequency Allocations (Article 5, Section IV of the Radio Regulations, which is codified in 47 C.F.R. § 2.106 as the "International Table") from 40 GHz to 275 GHz. *See Amendment of Part 2 of the Commission's rules to conform, to the extent practicable, with the Geneva Radio Regulations, as revised by the Space WARC, Geneva, 1971*, Report and Order (R&O), 38 Fed. Reg. 5561 ([March 1, 1973](#)). Second, the World Administrative Radio Conference (Geneva, 1979) ([WARC-79](#)) significantly revised the 95-275 GHz range. *See Implementation of the Final Acts of the World Administrative Radio Conference, Geneva, 1979*, First R&O, 48 Fed. Reg. 27541 ([June 16, 1983](#)); Second R&O, 49 Fed. Reg. 2358 ([Jan. 19, 1984](#)). Third, the World Administrative Radio Conference for Dealing with Frequency Allocations in Certain Parts of the Spectrum (Málaga-Torremolinos, 1992) ([WARC-92](#)) revised the 151-164 GHz range. *See Amendment of Part 2 of the Commission's Rules to make Non-Substantive Revisions to the Table of Frequency Allocations*, Memorandum Opinion and Order, 15 FCC Rcd 3459 ([2000](#)). Fourth, the World Radiocommunication Conference (Istanbul, 2000) ([WRC-2000](#)) realigned the 95-275 GHz range. *See Amendment of Part 2 of the Commission's Rules to Make Non-Substantive Revisions to the Table of Frequency Allocations*, Order, 17 FCC Rcd 15263 ([2002](#)); and *Amendment of Part 2 of the Commission's Rules to Realign the 76-81 GHz band and the Frequency Range Above 95 GHz Consistent with International Allocation Changes*, R&O, 19 FCC Rcd 3237 ([2004](#)). Fifth, the World Radiocommunication Conference (Geneva, 2007) ([WRC-07](#)) revised the 155.5-158.5 GHz band. *See Amendment of Parts 1, 2, 15, 25, 73, and 90 of the Commission's Rules to Make Non-Substantive Editorial Revisions to the Table of Frequency Allocations and to Various Other Rules*, Order, 25 FCC Rcd 9712 ([2010](#)); and *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*, R&O, 30 FCC Rcd 4183 ([2015](#)). Finally, the World Radiocommunication Conference (Geneva, 2012) ([WRC-12](#))

(continued....)

of this spectrum is allocated on a primary basis to both active (transmitting and receiving) and passive (receive-only) services;<sup>3</sup> the remainder of this spectrum is allocated on a primary basis to active services only (39.75 gigahertz) or exclusively to passive services (33.35 gigahertz). The passive services are the radio astronomy service (RAS), the Earth exploration-satellite service (EESS) (passive), and the space research service (SRS) (passive).<sup>4</sup> Table 1, on the following page, summarizes how these frequency bands are allocated in the United States.<sup>5</sup> We observe that 102.2 gigahertz is allocated to the fixed and mobile services (shown as FS/MS in Table 1), 76.2 gigahertz is allocated to the fixed-satellite and/or mobile-satellite services (shown as FSS, MSS, or FSS/MSS), and the majority (66.2 gigahertz) of this spectrum is shared between these services. These broad and flexible allocations enable a wide range of potential federal and non-federal uses and none of these services should be foreclosed by the rule changes on which we seek comment below. Finally, we observe that most of the spectrum allocated for FS/MS use is shared with the RAS (73.45 gigahertz) or with SRS space-based radio astronomy (15.95 gigahertz).<sup>6</sup>

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revised the 81-86 and 92-94 GHz bands and extended the “Not allocated” portion of the International Table from 275-1000 GHz to 3000 GHz. *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)(WRC-12), Other Allocation Issues, and Related Rule Updates*, Order and Notice of Proposed Rulemaking, 30 FCC Rcd 4183 (2015); R&O, 32 FCC Rcd 2703 ([2017](#)).

<sup>3</sup> Active services share 69.5 gigahertz of spectrum with only the RAS, 21.45 gigahertz with the both the Earth exploration-satellite service (EESS) (passive) and space research service (SRS) (passive), and 15.95 gigahertz with the RAS and space-based radio astronomy, which is an application of the SRS (passive).

<sup>4</sup> The EESS and SRS can be active or passive, but the allocations for the frequencies above 95 GHz are limited to passive use only. *See* 47 CFR § 2.104(d)(4) (describing how a parenthetical addition to an allocation indicates that the service allocation is restricted to the type of operation so indicated). Because all RAS operations are passive by their nature, such a parenthetical addition is unnecessary. The ten frequency bands (33.35 gigahertz) that are allocated exclusively for passive service use are listed in footnote US246. This U.S. footnote states that no station may transmit in the 100-102 GHz, 109.5-111.8 GHz, 114.25-116 GHz, 148.5-151.5 GHz, 164-167 GHz, 182-185 GHz, 190-191.8 GHz, 200-209 GHz, 226-231.5 GHz, and 250-252 GHz bands. Most (9) of the bands listed in footnote US246 are allocated to all three passive services; the exception is the 190-191.8 GHz band, which is allocated to the EESS (passive) and SRS (passive), but not to the RAS.

<sup>5</sup> The other active services in the 95-275 GHz range are the amateur service (ARS), amateur-satellite service (ARSS), EESS (active), inter-satellite service (ISS), radiolocation service (RLS), radionavigation service (RNS), radionavigation-satellite service (RNSS), and SRS (active). *See* Section 2.1 of the rules for the definitions of the radio services. 47 CFR § 2.1.

<sup>6</sup> With regard to Table 1, note that, use of the SRS (passive) allocation is limited to space-based radio astronomy in the 105-109.5 GHz, 111.8-114.25 GHz, and 217-226 GHz bands (per footnote 5.562B); stations in the aeronautical mobile service may be operated subject to not causing harmful interference to the inter-satellite service in the 122.25-123 GHz, 130-134 GHz, 167-174.8 GHz, and 191.8-200 GHz bands (5.558); the EESS (active) allocation in the 130-134 GHz band is limited to the band 133.5-134 GHz (5.562E); and the 237.9-238 GHz band is also allocated to the EESS (active) and the SRS (active) for spaceborne cloud radars only (5.563B).

**Table 1: Summary of U.S. Allocation Table for the 95-275 GHz Range<sup>6</sup> (180 GHz)  
(P=primary S=secondary)**

Band (Amount), both in GHz	Terrestrial Services				Active Satellite Services					Passive Services		
	FS/ MS	RLS	RNS	ARS	FSS	MSS	ISS	RNSS	ARSS	RAS	EESS (passive)	SRS (pas.)
95-100 (5)	P	P	P	-	-	-	-	P	-	P	-	-
100-102 (2)	-	-	-	-	-	-	-	-	-	P	P	P
102-105 (3)	P	-	-	-	-	-	-	-	-	P	-	-
105-109.5 (4.5)	P	-	-	-	-	-	-	-	-	P	-	P
109.5-111.8 (2.3)	-	-	-	-	-	-	-	-	-	P	P	-
111.8-114.25 (2.45)	P	-	-	-	-	-	-	-	-	P	-	P
114.25-116 (1.75)	-	-	-	-	-	-	-	-	-	P	P	P
116-122.25 (6.25)	-	-	-	-	-	-	P	-	-	-	P	P
122.25-123 (0.75)	P	-	-	S	-	-	P	-	-	-	-	-
123-130 (7)	-	-	P	-	P ↓	P ↓	-	P	-	S	-	-
130-134 (4)	P	-	-	-	-	-	P	-	-	P	-	-
134-136 (2)	-	-	-	P	-	-	-	-	P	S	-	-
136-141 (5)	-	P	-	S	-	-	-	-	S	P	-	-
141-148.5 (7.5)	P	P	-	-	-	-	-	-	-	P	-	-
148.5-151.5 (3)	-	-	-	-	-	-	-	-	-	P	P	P
151.5-155.5 (4)	P	P	-	-	-	-	-	-	-	P	-	-
155.5-158.5 (3)	P	-	-	-	-	-	-	-	-	P	-	-
158.5-164 (5.5)	P	-	-	-	P ↓	P ↓	-	-	-	-	-	-
164-167 (3)	-	-	-	-	-	-	-	-	-	P	P	P
167-174.5 (7.5)	P	-	-	-	P ↓	-	P	-	-	-	-	-
174.5-174.8 (0.3)	P	-	-	-	-	-	P	-	-	-	-	-
174.8-182 (7.2)	-	-	-	-	-	-	P	-	-	-	P	P
182-185 (3)	-	-	-	-	-	-	-	-	-	P	P	P
185-190 (5)	-	-	-	-	-	-	P	-	-	-	P	P
190-191.8 (1.8)	-	-	-	-	-	-	-	-	-	-	P	P
191.8-200 (8.2)	P	-	P	-	-	P	P	P	-	-	-	-
200-209 (9)	-	-	-	-	-	-	-	-	-	P	P	P
209-217 (8)	P	-	-	-	P ↑	-	-	-	-	P	-	-
217-226 (9)	P	-	-	-	P ↑	-	-	-	-	P	-	P
226-231.5 (5.5)	-	-	-	-	-	-	-	-	-	P	P	P
231.5-232 (0.5)	P	S	-	-	-	-	-	-	-	-	-	-
232-235 (3)	P	S	-	-	P ↓	-	-	-	-	-	-	-
235-238 (3)	-	-	-	-	P ↓	-	-	-	-	-	P	P
238-240 (2)	P	P	P	-	P ↓	-	-	P	-	-	-	-
240-241 (1)	P	P	-	-	-	-	-	-	-	-	-	-
241-248 (7)	-	P	-	S	-	-	-	-	S	P	-	-
248-250 (2)	-	-	-	P	-	-	-	-	P	S	-	-
250-252 (2)	-	-	-	-	-	-	-	-	-	P	P	P
252-265 (13)	P	-	P	-	-	P ↑	-	P	-	P	-	-
265-275 (10)	P	-	-	-	P ↑	-	-	-	-	P	-	-

Existing federal operations in this spectrum include thirty-seven assignments for passive sensors in the EESS (from 115.3 GHz to 247.46 GHz) and four non-EES assignments in the 95-100 GHz band.<sup>7</sup> Additionally, Appendix B contains a list of existing and planned passive satellite operations both within and outside the United States, which was provided by the National Aeronautics and Space Administration during the inter-governmental coordination process for this proceeding. Furthermore, while there are currently no specific allocations above 275 GHz, several spectral regions (i.e., frequency bands) have been identified for spectral line measurements for passive services (RAS, EESS, and SRS). Although the identified regions are not precluded from active use, it should be noted that any development of technology should take all practicable steps to protect the passive services in these identified bands.<sup>8</sup> The Commission recognizes that any proposed rules adopted will have to ensure Federal access and future growth requirements in these shared co-primary allocations.

4. The Commission has not adopted service rules to license radio services on a primary basis in the 95 GHz to 275 GHz range. However, our rules permit operation on a secondary basis by amateur radio licensees in the 122.25-123 GHz, 134-141 GHz, and 241-250 GHz bands.<sup>9</sup> In addition, industrial, scientific, and medical (ISM)<sup>10</sup> uses may occur in the 122-123 GHz and 244-246 GHz bands, subject to the provisions of footnote 5.138.<sup>11</sup> All other operations in these bands have been permitted by the Commission only under our Part 5 experimental licensing rules.<sup>12</sup> While the experimental licensing program provides the opportunity to develop innovative new products and services and offers licensees the flexibility to select the frequencies, power, and sites, experimental licensing does not permit the establishment of commercial deployments other than those that meet specific marketing limitations. Moreover, experimental licenses are issued on a non-interference basis, and thus must not cause harmful interference to stations of authorized services.<sup>13</sup> Further, such licenses are typically authorized only for a period of two years, and are subject to cancellation at any time without notice or hearing.<sup>14</sup>

#### **B. Commission proceedings**

5. We trace the Commission's first substantive investigation into the potential use of these

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<sup>7</sup> In frequency bands allocated for shared Federal/non-Federal use, the Commission develops regulations for those services in which it may license non-Federal stations, and NTIA develops regulations for those services in which it may authorize Federal stations to prevent interference between Commission-licensed stations and Federal stations.

<sup>8</sup> The specific bands may be found in allocation table footnote US565. See 47 CFR § 2.106, note US565.

<sup>9</sup> 47 CFR § 97.301(a).

<sup>10</sup> 47 CFR § 18.305(a). ISM equipment is designed to generate and use local radio frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunication. Typical ISM applications are the production of physical, biological, or chemical effects such as heating, ionization of gases, mechanical vibrations, hair removal and acceleration of charged particles. 47 CFR 18.107(c).

<sup>11</sup> 47 CFR § 2.106, note 5.138.

<sup>12</sup> The passive services (i.e. SRS (passive), EESS (passive), and RAS) do not involve the transmission of radio frequencies and thus are not subject to traditional licensure under our service rules. Instead, we generally protect these services through specific footnotes in the Allocation Table (see, e.g., 47 CFR § 2.106 footnote US342) and provisions in our service rules that impose limitations on licensed services that co-exist with the passive services (see, e.g., 47 CFR § 97.303(f)).

<sup>13</sup> 47 CFR § 5.84.

<sup>14</sup> 47 CFR §§ 5.71, 5.83(b). See, e.g., *Promoting Expanded Opportunities for Radio Experimentation and Market Trials under Part 5 of the Commission's Rules and Streamlining Other Related Rules (Experimental Streamlining Order)*, ET Docket Nos. 06-155, 10-236, Report and Order, FCC 13-15, 28 FCC Rcd 758 (2013).

(continued....)

frequencies to a 1994 proceeding that explored opening portions of the millimeter wave bands<sup>15</sup> above 40 GHz for commercial development.<sup>16</sup> Similar to the current situation above 95 GHz today, the radio spectrum above 40 GHz had little non-Federal use at that time and was seen as well-positioned for further development. Noting technological advances, and its prior success in providing for both licensed and unlicensed operations in lower frequency bands, the Commission expressed hope that taking action to open up portions of the millimeter wave bands for licensed and unlicensed use would similarly stimulate new technology developments and create opportunities for economic growth and jobs.<sup>17</sup> Thus, in the Above 40 GHz NPRM, the Commission proposed specific frequency bands for licensed services and other bands for use on an unlicensed basis, including a number of frequency bands above 95 GHz.<sup>18</sup> In deciding which bands to propose for particular purposes, the Commission considered the use of spectrum adjacent to existing allocations and the propagation properties of the different regions of the spectrum, and also considered pending proposals made for vehicular radars in these bands.<sup>19</sup> The Commission in that proceeding ultimately adopted provisions in Part 15 for general unlicensed use at 57-64 GHz and for unlicensed vehicular radars at 76-77 GHz.<sup>20</sup>

6. In 2003 the Commission initiated a new proceeding that led to the adoption of provisions in Part 101 for licensed fixed operations in the 71-76 GHz, 81-86 GHz, and 92-95 GHz bands as well as provisions in Part 15 for unlicensed operation in the 92-95 GHz band limited to indoor use.<sup>21</sup> The provisions for licensed fixed use in the 2003 proceeding provided for a Link Registration System administered by third-party database managers and a streamlined method for determining whether a proposed communications link might cause harmful interference to federal operations or might otherwise require modification.<sup>22</sup> These came to be known as the 70/80/90 GHz rules. None of the various other frequency bands discussed in the Above 40 GHz NPRM were specifically addressed in either the 1994 or 2003 proceeding.

7. More recently, as part of the July 2016 Spectrum Frontiers Further Notice of Proposed Rulemaking (Further Notice) in the ongoing proceeding on spectrum bands above 24 GHz, the Commission sought comment on use of spectrum above 95 GHz.<sup>23</sup> The Further Notice sought

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<sup>15</sup> The spectrum between 30 GHz and 300 GHz is often referred to as the “millimeter wave bands,” reflecting the range of associated wavelengths, 1 mm to 10 mm.

<sup>16</sup> *Amendment of Parts 2 and 15 of the Commission’s Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications*, Notice of Proposed Rulemaking (*Above 40 GHz NPRM*), 9 FCC Rcd 7078 (1994).

<sup>17</sup> *Id.* at 7080, para. 7.

<sup>18</sup> With respect to frequencies above 95 GHz, the *Above 40 GHz NPRM* proposed to make the 103-103.5 GHz, 116-116.5 GHz, 122-122.5 GHz, 126-126.5 GHz, and 152-152.5 GHz bands available for licensed use, the 103.5-104 GHz, 116.5-117 GHz, 122.5-123 GHz, 126.5-127 GHz, and 152.5-153 GHz bands available for unlicensed use, and the 94.7-95.7 GHz and 139-140 GHz bands available for vehicular radars. *Above 40 GHz NPRM*, 9 FCC Rcd at 7086-91, paras. 18, 20 and 30.

<sup>19</sup> *Id.* at 7085, para. 17.

<sup>20</sup> See First Report and Order and Second Notice of Proposed Rule Making in ET Docket 94-124, 11 FCC Rcd 4481 (1995).

<sup>21</sup> See *Allocations and Service Rules for the 71-76 GHz, 81-86 GHz and 92-95 GHz Bands*, Report and Order, WT Docket No. 02-146, 18 FCC Rcd 233, para. 18 (2003).

<sup>22</sup> See Millimeter Wave 70/80/90 GHz Service at <https://www.fcc.gov/wireless/bureau-divisions/broadband-division/millimeter-wave-708090-ghz-service>.

<sup>23</sup> *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd 8014, 8169-70, paras. 444-445 (2016) (*Above 24 GHz R&O*). On Nov. 16, 2017 the Commission adopted final rules in this proceeding, which do not address spectrum above 95 GHz. *Use of* (continued....)



information on the specific parts of the spectrum that would be most attractive from the standpoint of technology development while providing for successful coexistence with the incumbent radio communications services. The Further Notice also asked for specific analyses to justify any claims that allowing expanded use of these bands would not pose a risk of harmful interference to other radio services and asked which bands should be made available for licensed or unlicensed use.<sup>24</sup>

8. Several parties filed comments in the Spectrum Frontiers docket regarding the spectrum above 95 GHz. Marcus Spectrum Solutions emphasized the need for large contiguous spectrum blocks for terrestrial fixed service.<sup>25</sup> Dash Networks recommended that the Commission adopt rules for point-to-point communications in the 95-107 GHz, 115-180 GHz, 200-320 GHz, 340-380 GHz, 400-450 GHz, 600-700 GHz, and 800-920 GHz bands, asserting that there is an urgent market demand for 50 to 400 gigabit per second wireless backhaul for 5G systems which this spectrum could support.<sup>26</sup> The Wireless Innovation Forum urged that the Commission adopt service rules in bands above 95 GHz for backhaul to support Commercial Mobile Radio Systems.<sup>27</sup> The Wi-Fi Alliance pointed out that the propagation characteristics of spectrum above 95 GHz make it particularly attractive for unlicensed use.<sup>28</sup> The Satellite Industry Association advocated adopting measures to allow FSS operations in these bands.<sup>29</sup> The National Academy of Sciences (NAS) Committee on Radio Frequencies (CORF) supported shared use of bands where avoidance of interference to passive and active space operations is practical.<sup>30</sup> Several parties also provided comment on technology considerations relevant to deployment in these bands. Giganet (UCSB) suggested that any regulations adopted for bands above 95 GHz should be compatible with low-cost phased arrays and avoid constraints on main beam and side lobes that have limited widespread operations in the 70/80 GHz band.<sup>31</sup> EchoStar pointed to research that antenna arrays in the 120-240 GHz range would be more cost effective and perform better than those that operate at lower frequencies.<sup>32</sup> Google suggested that the Commission take steps to clarify its rules above 95 GHz even in the absence of specific proposals for use of particular frequency bands. Google asserted that clarification of the radiofrequency exposure rules and the protection of passive services would assist researchers, businesses, and investors who are considering technologies capable of using these bands.<sup>33</sup>

9. Collectively, the comments filed in response to the Further Notice demonstrate active interest in making the frequencies above 95 GHz more readily available and identify a wide range of technologies and services that would be appropriate for these bands. Commenters nevertheless offered little in the way of specific proposed rules or technical analyses, likely due to the general nature of the questions about these bands posed by the Further Notice. In initiating this proceeding to focus

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*Spectrum Bands Above 24 GHz for Mobile Radio Services*, Second Report and Order, Second Further Notice of Proposed Rulemaking, Order on Reconsideration, and Memorandum Opinion and Order, FCC 17-152 (2017).

<sup>24</sup> *Id.*

<sup>25</sup> Marcus Spectrum Solutions Comments, GN Docket No 14-177, at 22-24 (filed Sept. 30, 2016).

<sup>26</sup> Dash Networks Comments, GN Docket No 14-177, at 3-4 (filed Sept. 30, 2016).

<sup>27</sup> Wireless Innovation Forum Comments, GN Docket No 14-177, at 6 (filed Jan. 14, 2015).

<sup>28</sup> Wi-Fi Alliance Comments, GN Docket No 14-177, at 8 (filed Sept. 30, 2016).

<sup>29</sup> SIA Comments, GN Docket No 14-177, at 19-20 (Oct. 3, 2016).

<sup>30</sup> NAS CORF Comments, GN Docket No 14-177, at 16 (Sept. 29, 2016).

<sup>31</sup> Giganet Comments, GN Docket No 14-177, at 3 (filed Dec. 22, 2015).

<sup>32</sup> EchoStar Ex Parte, GN Docket No 14-177, at 2 (filed Sept. 15, 2015).

<sup>33</sup> Google Reply, GN Docket No 14-177, at 7 (Oct. 31, 2016).

(continued....)

exclusively on the bands above 95 GHz, we seek to develop a robust new record. While parties are welcome to reprise their observations and recommendations to the extent that they remain relevant, we also encourage commenters to react to the specific objectives, proposals, and draft rules that we describe in greater detail herein.<sup>34</sup>

### C. Technology developments

10. Both industry and academia have expressed interest in the bands above 95 GHz, as evidenced by the wide range of ongoing research and experimentation. For example, Brown University is conducting propagation measurements around 100 GHz, 200 GHz, 300 GHz, and 400 GHz, and New York University Tandon School is conducting propagation measurements in the 140-160 GHz band.<sup>35</sup> Boeing is testing antennas at 148.5-151.5 GHz and 185-190 GHz and Raytheon is testing radar receivers at 92-100 GHz and 102-105 GHz.<sup>36</sup>

11. Instantaneous temporary link broadcasting is one particular high bandwidth technology under study that potentially could be implemented above 95 GHz. This technology could enable the transmission of large bandwidth uncompressed high-definition (HD) video signals.<sup>37</sup> The microwave radio devices that broadcasters typically use in the field have limited capacity and must compress the signal to a few tens of megabits per second, which can introduce delay and distortion that degrades the quality of the video.<sup>38</sup> In 2008, Japan's NTT used a 120 GHz band wireless link in a 1 km transmission trial of material to provide live TV coverage of the 2008 Beijing Olympics,<sup>39</sup> and in 2014 Japan's Ministry of Internal Affairs and Communications officially revised its radio regulations to allocate an 18 gigahertz-wide band at 116 GHz to 134 GHz to accommodate such service.<sup>40</sup>

12. Another potential high bandwidth long-range application that is being studied is wireless transmission for future networks, such as those providing for disaster recovery operations, temporary replacement for a damaged optical network, or wireless backhaul in locations where installation of a fiber optic line is difficult.<sup>41</sup> Short range applications include Wireless Local Area Networks (WLAN),

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<sup>34</sup> The Commission is not incorporating comments filed in the Spectrum Frontiers proceeding into the docket for this proceeding; thus, any party that wishes to ensure that its previous comments regarding the above 95 GHz bands should refile their comments in this docket.

<sup>35</sup> Experimental License, Brown University, File No. 0154-EX-CM-2017, Call Sign WI2XVS; Experimental License, NYU Tandon School of Engineering, File No. 0015-EX-CN-2017, Call Sign WI2XSY.

<sup>36</sup> Experimental License, The Boeing Company, File No. 0102-EX-RR-2016, Call Sign KB2XEU; Experimental License, Raytheon Missile Systems, File No. 0267-EX-CR-2017, Call Sign WB2XGB.

<sup>37</sup> For example, uncompressed HD video requires a data transmission capacity of 1.5 Gbit/s, whereas 4K video requires four times as much capacity (6 Gbit/s), and ultra-high definition (UHD) 3D requires transmission capacity of 100 Gbit/s. See Tadao Nagatsuma, "THz Communications Systems," Optical Fiber Communications Conference and Exhibition, March 2017, at 9.

<sup>38</sup> See Akihiko Hirata et al., "Transmission Trial of Television Broadcast Materials Using 120-GHz-band Wireless Link," NTT Technical Review, Vol. 7 No. 3 Mar. 2009, at 1.

<sup>39</sup> *Id.* at 5.

<sup>40</sup> See Tadao Nagatsuma, "Breakthroughs in Photonics 2013: THz Communications Based on Photonics," IEEE Photonics Journal, Vol. 6, No. 2, April 2014, at 1. See also <http://www.tele.soumu.go.jp/resource/e/search/share/pdf/t3.pdf>; <http://www.tele.soumu.go.jp/resource/e/search/share/pdf/fj.pdf>.

<sup>41</sup> See N. Kukutsu et al., "Toward practical applications over 100 GHz", IEEE, 2010, at 2.

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Wireless Personal Area Networks (WPAN),<sup>42</sup> Kiosk downloading,<sup>43</sup> wireless connections in data centers,<sup>44</sup> chip-to-chip communications,<sup>45</sup> and Nano cells.<sup>46</sup>

13. The shorter wavelengths of frequencies above 95 GHz may be particularly well suited for non-communication sensing applications such as spectroscopy and imaging. For example, studies have shown that specific molecular rotation, vibration, liberation of molecules, and molecular aggregates occur in the terahertz band, which enables a large variety of applications for the detection and/or identification of molecules in diverse areas.<sup>47</sup> Other potential applications of terahertz technology include detection of drugs and explosives, detection of cancerous tissue, as well as materials analysis and quality control.<sup>48</sup>

14. There is also interest in fixed deployments above 95 GHz. For example, the European Conference of Postal and Telecommunications Administrations European Communications Office (CEPT/ECC) is developing a recommendation containing guidelines for deployment of fixed services operating in bands from 92 GHz to 174 GHz.<sup>49</sup>

#### **D. Experimental licenses, petitions and other requests**

15. As discussed above, we have granted several experimental licenses that are being used to support active commercial and educational research in the bands under consideration here. A review of our licensing database indicates that there are currently eleven active experimental licenses for spectrum above 95 GHz. Four of these licenses are for 95.5-96 GHz, four are for 100-105 GHz, and three are for higher bands ranging up to 400 GHz.<sup>50</sup>

16. We have also received petitions and waiver requests to enable spectrum use above 95 GHz on a non-experimental basis. Battelle Memorial Institute, Inc. (Battelle) filed a petition for rulemaking in February 2014 asking the Commission to adopt service rules for non-federal fixed use of the 102-109.5 GHz band.<sup>51</sup> Battelle states that it has developed technology that can wirelessly deliver 10-gigabit/second Ethernet (10GE) data streams within the proposed 7.5 gigahertz-wide band.<sup>52</sup> Battelle suggests that the Commission use the existing licensing procedures contained in the 70/80/90 GHz rules

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<sup>42</sup> WPAN means ultra-high-speed ad-hoc connections between devices over short distances, for example between a camera and a notebook or between an external hard-disk and a laptop. *See* Thomas Kurner et al., “Towards THz Communications - Status in Research, Standardization and Regulation”, *Journal of Infrared, Millimeter, and Terahertz Waves*, August 2013, at 1.

<sup>43</sup> Kiosk downloading is a special application of a WPAN, where one device is connected to a fixed kiosk download station offering ultra-high downloads of multimedia-content, e.g. a movie, to a mobile device. *Id.*, at 3.

<sup>44</sup> Wireless connections in data centers facilitate dynamic reconfiguration of systems architecture.

<sup>45</sup> Chip-to-chip communications involve wireless links inside computers or any other electronic devices.

<sup>46</sup> Nano cells consist of ultra-high data rate “pipes” within a cellular network and would function like to today’s WLAN hotspots. Deployment can be outdoors and indoors.

<sup>47</sup> *See* P. de Maagt, “Terahertz Applications and Technology”, *International Conference on Microwave Technology and Computational Electromagnetics*, November 2009 at 2. A summary of Terahertz research progress is available at <http://iopscience.org/article/10.1088/1361-6463/50/4/043001/pdf>.

<sup>48</sup> *Id.* at 2.

<sup>49</sup> ECC Work Programs Database, Reference SE19\_37, SE 19\_38, <http://eccwp.cept.org/>; [http://eccwp.cept.org/WI\\_Detail.aspx?wiid=534](http://eccwp.cept.org/WI_Detail.aspx?wiid=534); [http://eccwp.cept.org/WI\\_Detail.aspx?wiid=535](http://eccwp.cept.org/WI_Detail.aspx?wiid=535).

<sup>50</sup> *See infra* note 160.

<sup>51</sup> Petition of Battelle Memorial Institute, Inc. for Rulemaking, RM-11713 (Feb. 6, 2014) (*Battelle Petition*).

<sup>52</sup> *Battelle Petition* at 3.

(continued....)

as the basis for licensing the 102-109.5 GHz band.<sup>53</sup> Under the 70/80/90 GHz rules, licensees receive a nationwide license and must register their individual point-to-point links with a data base manager prior to deployment.<sup>54</sup> McKay Brothers, LLC, which holds a nationwide, non-exclusive license in the 70/80/90 GHz bands, seeks a waiver to enable its Geneva Communications subsidiary to operate in the band.<sup>55</sup> Additionally, ZenFi Networks, Inc. (ZenFi), which also holds a 70/80/90 GHz license, seeks a waiver of our Part 101 rules to permit use of the 102-109.5 GHz band in a number of cities under the 70/80/90 GHz band rules.<sup>56</sup>

17. Other petitioners have taken a broader approach, suggesting that the Commission implement more comprehensive changes to the authorization and licensing processes for frequencies above 95 GHz. IEEE-USA claims that the lack of service rules above 95 GHz inhibits market entry for new technologies and impedes the acquisition of funding for research and development to move new technologies into the marketplace. On this basis it has submitted a request for the Commission to make a declaratory ruling that any application for use of technology above 95 GHz is presumed to be a “new technology” under Section 7 of the Communications Act of 1934, and is thus subject to the one-year timeframe for determining whether the proposal is in the public interest.<sup>57</sup> IEEE-USA also requests that the Commission declare that, if it finds a proposal to use above 95 GHz spectrum is in the public interest, it will adopt rules that enable provisioning of that new technology or service within a one-year period.<sup>58</sup> James Whedbee, in a petition for rulemaking, asks us to create a rule for operation of unlicensed intentional radiator devices in the 95-1,000 GHz band.<sup>59</sup> Whedbee states that his proposed rule is identical in most respects to those used for other Extremely High Frequency (30-300 GHz) bands regulated under Part 15. The Commission has yet to take action on these various petitions or waiver requests.

### III. DISCUSSION

18. Given the growth in interest in millimeter wave spectrum, we believe it is now appropriate to make spectrum above 95 GHz more readily available for the deployment of fixed and mobile wireless technologies. The active research and development in this area, the interest expressed when we have invited comment on the potential use of bands above 95 GHz, and the submission of petitions and pleadings relating to these frequencies all support our view that the pace of development of technology for spectrum use above 95 GHz shall continue to increase. We want to ensure that we have appropriate authorization mechanisms available so that when new devices that use these frequencies

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<sup>53</sup> *Battelle Petition* at 4-5.

<sup>54</sup> 47 CFR §§ 101.1501, 101.1513, 101.1523.

<sup>55</sup> McKay Brothers supports Battelle’s rulemaking petition and requests the waiver as an alternative if the Commission decides not to conduct a rulemaking for the 100 GHz band. *Ex Parte Support of Petition for Rulemaking or, in the Alternative Request for Waiver, McKay Brothers, RM-11713, Oct 8, 2015, 5-7. See para. 91, supra.*

<sup>56</sup> Request for Waiver, ZenFi Networks Inc., WT Docket No. 15-245, at 9 (filed Oct 8, 2015); Call Sign WQUN758.

<sup>57</sup> Petition for Declaratory Ruling of IEEE-USA, filed July 1, 2013 (*IEEE Petition*). IEEE-USA is a unit of the Institute of Electrical and Electronics Engineers, Inc., a transnational engineering society. Section 7 includes a provision that directs the Commission to determine within one year whether any new technology or service proposed in a petition or application is in the public interest. 47 U.S.C. § 157.

<sup>58</sup> We intend to address IEEE’s petition as part of a separate proceeding.

<sup>59</sup> Petition for Rulemaking of James Edwin Whedbee, filed November 5, 2013 (Whedbee Petition) (stating, among other things, that if IEEE-USA’s positions are correct then the licensing of transmissions in the spectrum above 95 GHz may hinder technological development that his proposed unlicensed rule would permit).

(continued....)

become available, users will be able to begin operations without delay and without foreclosing longer-term development in conjunction with the necessary coordination with NTIA, as part of the co-primary allocation of Federal and non-Federal use.

19. The Commission tentatively concludes that finding new ways to promote the development of bands above 95 GHz will also serve the public interest. The development of 5G technology, which has been driven by the ever-increasing data appetite of smartphones and other consumer devices, has created demand for more spectrum. In addition, numerous large constellation non-geostationary satellite orbit (NGSO) networks have been proposed that will require large swaths of spectrum. The demand for spectrum also continues for other uses such as weather and air-traffic control radars, automotive safety, scientific research, and defense-related purposes. The development of the bands above 95 GHz could also ease the “spectrum crunch” in the lower frequency bands. Moreover, a review of academic publications indicates that the demand for wireless data will continue to expand. According to Edholm’s law of bandwidth, the data rates provided by wireless systems will grow exponentially.<sup>60</sup> For example, in cellular networks, in the year 2000 3G systems began offering data rates of 384 kilobits per second (kbps), by 2010 this rate had increased to 75 megabits per second (Mbps) for 4G systems, and in 2018 5G systems are expected to offer 6 gigabits per second (Gbps).<sup>61</sup> If this same trend continues in the future, around the year 2020 wireless data rates of around 100 Gbps will be achieved.<sup>62</sup> However, achieving this target using realistic spectral efficiencies of a few bits/seconds/Hertz requires ultra-high bandwidths far beyond 10 gigahertz.<sup>63</sup> Because trends suggest that lower frequency spectrum will continue to become more congested and research foresees exponential growth in data rates, there is a real need to provide new capacity in the frequencies above 95 GHz.

20. In proposing to make spectrum above 95 GHz available, we are following in the footsteps of the Commission’s earlier Above 40 GHz proceeding.<sup>64</sup> As noted above, that proceeding led to the allocation and adoption of service rules for spectrum for vehicular radars and fixed links and the opening of a large band for unlicensed use. We believe that some of the approaches the Commission took in that proceeding have relevance to our present inquiry, even if the Commission did not end up adopting rules for any of the frequency bands above 95 GHz as part of that inquiry. For example, stressing the importance of adopting rules for new services based on the status of proximate services, the Commission proposed to designate the 40.5-42.5 GHz and 47.2-48.2 GHz bands for licensed services because these frequencies were less than ten gigahertz away from an existing licensed band. It also identified the 59-64 GHz range as suitable for unlicensed devices because those frequencies had the most severe propagation losses of the bands explored in the Above 40 GHz NPRM, which reduced the likelihood for licensed operations on those frequencies to cause interference to unlicensed devices.<sup>65</sup> As with the Above 40 GHz proceeding, we intend that this proceeding will spur innovation in spectrum that until now has seen relatively little deployment.

21. *Technical considerations.* The technologies that are ultimately deployed above 95 GHz

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<sup>60</sup> See Steven Cherry, “Edholm’s Law of Bandwidth,” IEEE Spectrum, July 2004, at 58.

<sup>61</sup> See Theodore Rappaport, “5G America Conference Technical Briefing,” November 2, 2016, at 3.

<sup>62</sup> See Thomas Kurner et al., “Towards THz Communications - Status in Research, Standardization and Regulation,” Journal of Infrared, Millimeter, and Terahertz Waves, August 2013, at 1; Steven Cherry, “Edholm’s Law of Bandwidth,” IEEE Spectrum, July 2004, at 60. Edholm suggests that this trend will continue until a fundamental human limit is reached, such as, for example, the number of pixels per second the human eye can process.

<sup>63</sup> *Id.*, at 2.

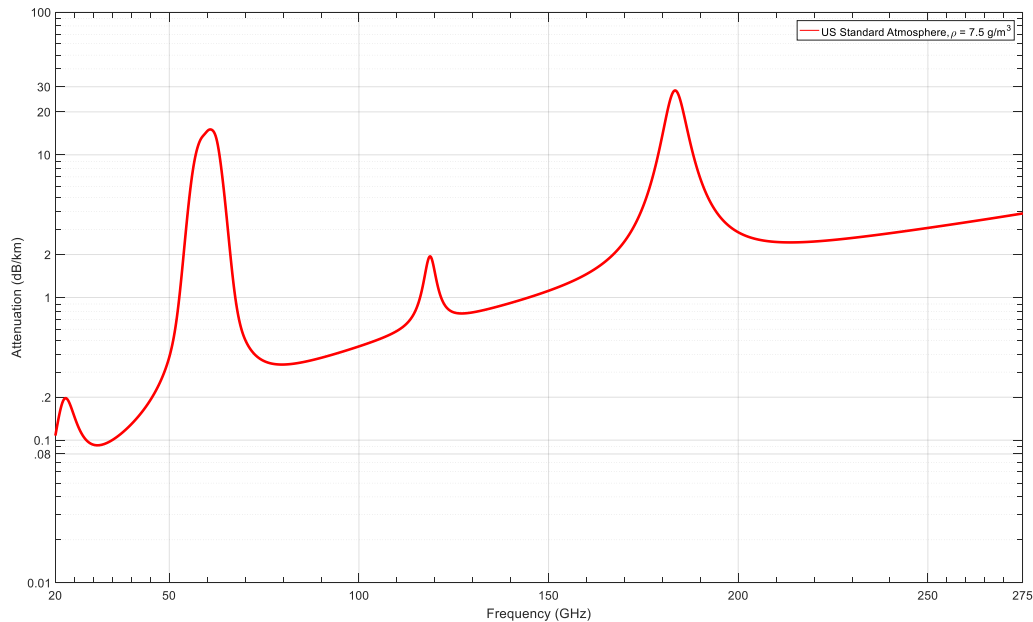
<sup>64</sup> See para 6, *supra*.

<sup>65</sup> *Above 40 GHz NPRM* at 7085-86.

(continued....)

will depend on the propagation properties of the spectrum in which those technologies will operate. The propagation of millimeter wave radio signals is limited when compared to that associated with lower-frequency radio signals. Signals in millimeter wave bands are significantly affected by the presence of oxygen and water vapor within the atmosphere, although the amount of signal attenuation due to oxygen and water vapor varies with frequency and other factors. Attenuation caused by oxygen is significant throughout the millimeter wave spectrum, but increases dramatically around 60 GHz, 120 GHz, and 183 GHz. The following graph shows the attenuation of radio waves per kilometer (km) traveled caused by atmospheric absorption as a function of frequency, during typical conditions.<sup>66</sup>

Fig. 1 Specific attenuation due to atmospheric gases



22. The Commission's examination of this curve, considered along with our knowledge of the commercial uses of the bands below 95 GHz, suggests that it should be possible to deploy communication services throughout much of the spectrum between 95 GHz and 275 GHz. From 80 GHz to 115 GHz, the atmospheric loss increases by only 0.5 decibel (dB) per km. Even up to 145 GHz, the loss is less than 1 dB/km and less than 2 dB/km below 170 GHz. Above the sharp peak at 183 GHz, the propagation loss falls to below 4 dB/km until above 250 GHz. Because fixed point-to-point links have been successfully deployed in the 70/80/90 GHz band, it is realistic to presume that similar services might be deployed up to 115 GHz, where the additional propagation loss is less than 0.5 dB/km. In fact, point-to-point links could potentially be deployed from 115 GHz to 170 GHz and from 191 GHz to 275 GHz with only a relatively small reduction in the maximum path length of the links caused by the increased atmospheric loss. The curve also suggests that mobile services may also be possible in some bands above 95 GHz. From 39 GHz to 105 GHz, the atmospheric loss increases by only 0.15-0.5 dB/km. However, active service use of these bands has to be evaluated to determine coexistence with the passive services

<sup>66</sup> *Attenuation by Atmospheric Gases*, Recommendation ITU-R P.676-10 (Sept. 2013), 3. While the graph in Figure 1 is intended to represent standard atmosphere (which includes oxygen and water vapor), it does not include the effects of rain, snow, and fog, which can all also affect the range of millimeter wave transmissions.

authorized in portions of this spectrum. For example, the possibility of interference to satellite-borne EESS (passive) observations from terrestrial services will depend upon the atmospheric absorption along the Earth-to-space path and the parameters of active service operations.

23. The atmospheric loss curve also suggests that portions of the spectrum may not be suitable for sending signals over significant distances. Around the peak at 183 GHz, where the propagation loss increases to almost 30 dB/km, only transmissions over short distances will be possible using current technology. While this high-level of atmospheric loss does make transmission over long distances difficult, this frequency range has the advantage that interference between devices will be less likely. The Commission took advantage of this fact when adopting rules permitting unlicensed devices to operate around the propagation loss peak at 60 GHz. In deciding to make the 59-64 GHz band available for unlicensed use, in the *Above 40 GHz* proceeding, the Commission was primarily motivated by the characteristics of the spectrum, noting the limited potential for interference due to oxygen absorption.<sup>67</sup> For similar reasons, the propagation loss around 120 GHz may also make frequencies in that range good candidates for unlicensed use, although the 2 dB/km attenuation at that peak is low enough that longer distance radio links should also be able to use that spectrum.

24. Another potential factor that could affect deployments in spectrum above 95 GHz is that antenna beams in these bands using current technology tend to be very narrow. For example, backhaul links operating in outdoor environments may require automatic (optical) alignment tracking and a closed loop pointing control to maintain connectivity.<sup>68</sup> The narrow beams greatly reduce the likelihood of alignments that would produce main beam coupling with other users of the spectrum. In addition, free space propagation loss is very high above 95 GHz, and in certain parts of the spectrum atmospheric attenuation further exacerbates the propagation loss. Because of these properties, we believe bands above 95 GHz generally can accommodate spectrum sharing without requiring complex sharing arrangements. We seek comments on the above assessment.

25. *Multi-platform Proposal.* We believe that the best way to promote the goals of this proceeding is to seek comment on different mechanisms for authorizing operations on these frequencies. A multi-platform approach can unleash the innovation to bring forth a new generation of radio frequency (RF) technology in the bands above 95 GHz. To this end, we also address two pending rulemaking petitions and two waiver requests to seek comment on whether to authorize a licensed service in these bands that would permit point-to-point fixed links in a portion of the spectrum, and seek comment on whether spectrum should also be made available for licensed mobile services.<sup>69</sup> Given the role of unlicensed devices as a driver of innovation and the low risk of interference between such low-powered systems operating in this spectrum, we also seek comment on whether we should make four bands above 95 GHz available for unlicensed devices<sup>70</sup> and will entertain comment—despite our reservations about its feasibility—on a rulemaking proposal suggested by one petitioner to allow unlicensed operations throughout the 95-1,000 GHz bands.<sup>71</sup> Finally, to provide new opportunities for products that do not fit under our traditional service rule framework to be quickly made available to the public, we seek comment

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<sup>67</sup> *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*, ET Docket No. 94-124, First Report and Order and Second Notice of Proposed Rulemaking, 11 FCC Rcd 4481, 4496 para. 33 (1995).

<sup>68</sup> See Thomas Kurner et al., "Towards THz Communications - Status in Research, Standardization and Regulation", *Journal of Infrared, Millimeter, and Terahertz Waves*, August 2013.

<sup>69</sup> See notes 51, 55, and 56, *supra*.

<sup>70</sup> See *infra* at paras. 52-54.

<sup>71</sup> See Petition for Rulemaking of James Edwin Whedbee (filed Nov. 4, 2013) (Whedbee Petition); see also *infra* at para. 57.

on ways to expand our experimental licensing rules to give licensees greater flexibility to market commercial products designed to operate in the bands above 95 GHz. We discuss each of these issues in greater detail, below.

26. Our consideration of these issues is informed by the unique status and physical properties of the bands above 95 GHz relative to most bands below 95 GHz, and we seek to develop a regulatory framework that strikes an appropriate balance between the specificity needed to encourage further investment and the generality required for spectrum bands whose potential use is largely undefined at this time. While we recognize that the absence of service rules may limit investment in technologies that operate in these frequencies, we are likewise cognizant that we do not know the full range of technologies and services that will be developed and deployed in this new frontier over the long run. Subject only to the prior allocations and the reasonable expectations thereunder, the spectrum above 95 GHz currently presents a largely blank slate upon which bold new technologies can be written, and the large channel sizes potentially available could enable new innovative services. The authorization models we propose below – licensed, unlicensed and experimental – as well as the specific service rules are designed to provide the right balance between generality and specificity. Because we do not want to constrain the ways in which the bands above 95 GHz can develop or foreclose innovation through too-rigid service rules, we are consciously limiting the areas where we would potentially specify licensed and unlicensed operations to the bands that are best suited for such operations based on both current knowledge and the lack thereof. As we learn more about how the bands are likely to be used in the short term– including through the results of the experimental licensing process – we can decide whether and how to expand licensed and unlicensed operations to additional bands above 95 GHz without impacting longer-term technology developments or the meaningful implementation of the co-primary Federal allocation in most of the spectrum bands in this range.

#### A. Licensed service

27. We seek comment on whether to adopt rules for fixed point-to-point operations in the 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz band based on the rules currently in place for the 70/80/90 GHz band. In addition, we also seek comment on applying these rules to several other frequency bands above 95 GHz that may be suitable for licensed fixed operations, including 158.5-164 GHz, 167-174.5 GHz, 191.8-200 GHz, 209-226 GHz, 232-235 GHz, 238-240 GHz, and 252-275 GHz. We also inquire into whether mobile operations may be appropriate for any bands above 95 GHz with mobile allocations.

28. *Fixed Point-to-Point Services:* In the 70/80/90 GHz bands, the Commission has created a two-pronged authorization process for non-federal entities to avoid causing interference to federal operations when deploying fixed point-to-point links. Non-federal licensees first obtain a non-exclusive nationwide license from the Commission and then register individual point-to-point links with a third-party database manager.<sup>72</sup> Third-party database managers maintain a database of all registered links for the purposes of interference protection and establishing first-in-time rights. Third-party database managers are also responsible for coordinating with NTIA through an automated “green light/yellow light” mechanism to avoid harmful interference to federal operations which share the spectrum.<sup>73</sup> A “green light” response from NTIA indicates that the link has been successfully coordinated with the federal Government and can be deployed; a “yellow light” response indicates a potential for the proposed

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<sup>72</sup> *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 R&O).

<sup>73</sup> *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) (70-80-90 PN).

(continued....)



links to cause interference to federal Government or certain other operations.<sup>74</sup> In the case of a “yellow light,” the licensee must file a separate application for the requested link with the Commission, which in turn will submit the application to the Interdepartment Radio Advisory Committee (IRAC) for individual coordination with federal users.<sup>75</sup> This automated process is designed to streamline the administrative process by which non-federal users can gain access to these bands.

29. Unlike fixed microwave links used in other bands,<sup>76</sup> point-to-point links in the 70/80/90 GHz band are not coordinated with other licensees prior to deployment. Instead, when registering a point-to-point link, licensees are required to submit an interference analysis to the database manager that demonstrates that the proposed link will neither cause nor receive harmful interference relative to previously registered non-federal links.<sup>77</sup> If harmful interference does occur, the earliest registered link will have the right to interference-free operation.<sup>78</sup> Because the 70/80/90 GHz rules require antennas with narrow “pencil-beams” and the propagation properties at these frequencies limit the length of the links, the Commission has found that the likelihood of interference occurring is small.

30. As we mentioned above, based on the propagation properties of the spectrum the Commission believes that large portions of the spectrum in the 95-275 GHz range are potentially suitable for deploying fixed point-to-point links. While we have no intention of changing the current allocations of any of this spectrum, we note that there are numerous bands below 275 GHz that are already allocated for the fixed service. Consequently, we are seeking comments on proposed rules for fixed point-to-point operations in 36 gigahertz of spectrum in the 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz bands based on the 70/80/90 GHz rules. These “proposed fixed bands” are all the bands below 275 GHz with a fixed service allocation that are not shared with either the FSS or MSS. Below, we seek comment on whether we should also include the bands shared with the FSS or MSS in our proposal.<sup>79</sup> We are making this proposal to open up these bands for fixed use because we believe that there will be increased demand for point-to-point links in the future. As the Commission noted in the ongoing Microwave Backhaul proceeding, as “mobile data traffic increases, carriers will need to increase their backhaul capacity, including microwave backhaul, to accommodate that traffic.”<sup>80</sup> The Commission also noted in that proceeding that microwave may be the only practical high-capacity backhaul solution available to serve certain rural and remote locations.<sup>81</sup> The petitions by Battelle and ZenFi demonstrate

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<sup>74</sup> See generally 47 CFR § 2.106 n.US388, US389.

<sup>75</sup> 70-80-90 GHz R&O, 18 FCC Rcd at 23341-43, paras. 52, 54, 58.

<sup>76</sup> Under Part 101 applicants are required to prior-coordinate with existing licensees, permittees and applicants in the area, and other applicants with previously filed applications, whose facilities could affect or be affected by the new proposal in terms of frequency interference on active channels, applied-for channels, or channels coordinated for future growth. Coordination must be completed prior to filing an application for regular authorization, or a major amendment to a pending application, or any major modification to a license. 47 CFR § 101.103(d).

<sup>77</sup> 47 CFR § 101.1523(b)(2); *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, 4895-96, para. 12 (2005) (70-80-90 MO&O).

<sup>78</sup> 70-80-90 MO&O, 20 FCC Rcd at 4896, para. 13; 70-80-90 GHz R&O, 18 FCC Rcd at 23343, para. 58.

<sup>79</sup> See para. 37, *supra*.

<sup>80</sup> *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*, Notice of Proposed Rulemaking and Notice of Inquiry, 25 FCC Rcd 11246, 11247, para. 3 (2010).

<sup>81</sup> *Id.* at 11246-47, para. 2.

(continued....)

that there is interest in additional spectrum for point-to-point use.<sup>82</sup> The Commission also believes that the 70/80/90 GHz rules in place since 2003, which have proven effective in efficiently providing access to spectrum in that frequency range, provide a useful model for the rules contemplated here. The propagation characteristics and technical rules associated with the 70/80/90 GHz frequencies allow for the sharing of spectrum by multiple users in close geographic proximity, as the Commission contemplates would be the case with the above 95 GHz frequencies proposed here. The 70/80/90 GHz rules also allow for sharing with federal users and the protection of radio astronomy that shares many of these bands, which we anticipate would also be important for the use of the bands contemplated in this proceeding.

31. We seek comment on draft rules for the proposed fixed bands, which would be mostly identical to the rules for 70/80/90 GHz band contained in Part 101. Briefly summarizing, both sets of rules provide that:

- The Commission will issue non-exclusive nationwide licenses for ten-year terms.<sup>83</sup>
- Each fixed point-to-point link must be registered through a link registration system maintained by a database manager.<sup>84</sup> An interference analysis for the link must be submitted to the database manager when registering the link.
- The licensee must apply to the Commission for coordination of a link if: 1) the link receives a “yellow light” from NTIA’s automated mechanism as part of the registration process; 2) it requires an environmental assessment; 3) it requires international coordination; or 4) it operates in a quiet zone.<sup>85</sup>
- An applicant may request a license for any portion of any band.<sup>86</sup>
- Interference protection is granted to the first-in-time registered non-federal link.<sup>87</sup> Existing digital links are protected to a threshold-to-interference ratio (T/I) level of 1.0 dB of degradation to the static threshold. Existing analog links shall not experience more than a 1.0 dB degradation of the baseband signal-to-noise ratio required to produce an acceptable signal in the receiver.<sup>88</sup>
- Construction of links must be completed within 12 months of link registration.<sup>89</sup>
- Transmitters may operate at a maximum Equivalent Isotropically Radiated Power (EIRP) of 25 decibel watts per megahertz (dBW/MHz).<sup>90</sup>
- Transmitters must have a minimum antenna gain of 43 decibels (isotropic) (dBi) with a half-power beamwidth of 1.2 degrees, but the maximum EIRP is reduced by 2 decibels for each

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<sup>82</sup> McKay Brothers’ *ex parte* filing in support of Battelle’s petition included an alternative request for waiver if the Commission did not open a rulemaking proceeding for the 100 GHz band.

<sup>83</sup> 47 CFR §§ 101.1501, 101.1513.

<sup>84</sup> 47 CFR § 101.1523(b)(2); *70-80-90 PN*, 20 FCC Rcd at 2262-63.

<sup>85</sup> 47 CFR § 101.1523(b)(1), (c); *70-80-90 PN*, 20 FCC Rcd at 2264-65.

<sup>86</sup> 47 CFR § 101.1505.

<sup>87</sup> *70-80-90 GHz R&O*, 18 FCC Rcd at 23343, para. 58.

<sup>88</sup> 47 CFR §§ 101.105(a)(5),(c)(2), 101.147(z)(2); *70-80-90 MO&O*, 20 FCC Rcd at 4900-01, paras. 23-25.

<sup>89</sup> 47 CFR § 101.63(b); *70-80-90 GHz R&O*, 18 FCC Rcd at 23349, para. 80.

<sup>90</sup> Proposed rule 47 CFR § 101.113(a). As discussed below, the current 70/80/90 GHz rules have a different transmit power limit.

(continued....)

decibel the antenna gain is less than 50 dBi.<sup>91</sup>

- Out-of-band emissions are limited as specified in Section 101.111 of our rules for signals above 24 GHz with the value of B (bandwidth) set for 500 megahertz.<sup>92</sup>
- Systems using digital modulation must have a minimum bit rate of 0.125 bits/second/Hz.<sup>93</sup>
- Licensees may provide service on either a common carrier or non-common carrier basis and are subject to the eligibility requirements of Section 101.7 (foreign ownership).<sup>94</sup>
- Coordination with Mexico or Canada is required for certain stations located near the borders.<sup>95</sup>

We seek comment generally on adopting these rules for the identified fixed bands and discuss in more detail below some aspects of these proposed rules. Should identical rules be adopted for each of the individual bands or should the rules be adjusted for the characteristics of each band?

32. Certain rules for the 70/80/90 GHz band contained in Part 101 are different for the 70/80 GHz bands as opposed to the 90 GHz band.<sup>96</sup> For example, transmitters in the 90 GHz band are required to have an antenna gain of 50 dBi while in the 70/80 GHz band the limit is only 43 dBi. The 90 GHz band also has an additional interference protection requirement that a new link must not decrease an existing link's desired to undesired signal ratio below 36 dB.<sup>97</sup> Digital systems in the 90 GHz band are required to have a bit rate of 1 bit/second/Hz instead of 0.125 bits/second/Hz in the 70/80 GHz bands.<sup>98</sup> In these instances where the current rules vary we seek comment on whether to adopt the 70/80 GHz rules because these rules are less restrictive. Adopting less restrictive rules will encourage greater use of these bands because equipment will likely be less expensive and licensees will have more flexibility in the uses they can make of this spectrum. We believe it is appropriate to provide for greater flexibility in our rules unless there is good reason to be more restrictive. We seek comment on this approach.

33. While we are proposing to adopt most of the 70/80/90 GHz service and technical rules for the proposed fixed bands, we are proposing to adopt a different transmitted power limit. Under the 70/80/90 GHz rules, the transmitted power is limited to 55 dBW irrespective of the bandwidth of the signal.<sup>99</sup> Because these rules will apply to frequency bands of varying sizes and we are proposing to allow the transmissions to use the full bandwidth of each frequency band, we do not believe a fixed power limit would be appropriate. Instead, we are proposing to specify the power limit in terms of a maximum EIRP density. This will permit the licensee to transmit a higher signal power if they are using a large bandwidth signal. We note that the Commission has specified an EIRP density under our Part 101 rules

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<sup>91</sup> 47 CFR § 101.115(b); *70-80-90 MO&O*, 20 FCC Rcd at 4904-06, paras. 32-34.

<sup>92</sup> 47 CFR § 101.111(a)(2)(ii); *70-80-90 GHz R&O*, 18 FCC Rcd at 23353, para. 92.

<sup>93</sup> 47 CFR § 101.147(z)(2); *70-80-90 MO&O*, 20 FCC Rcd at 4899, para. 20.

<sup>94</sup> 47 CFR § 101.1511; *70-80-90 GHz R&O*, 18 FCC Rcd at 23345, 23346-47, paras. 66, 70.

<sup>95</sup> 47 CFR § 101.1527; *70-80-90 GHz R&O*, 18 FCC Rcd at 23348, para. 75.

<sup>96</sup> These modifications to the rules for the 70/80 GHz band were made in response to a petition for reconsideration. *70-80-90 MO&O*, 20 FCC Rcd at 4897-99, 4900-01, 4902-06 paras. 17-20, 22-25, 30-34.

<sup>97</sup> 47 CFR § 101.105(a)(6).

<sup>98</sup> 47 CFR § 101.105(b)(2). Battelle suggest that we adopt the 1 bps per hertz limit used in the 90 GHz band for the 102-109.5 GHz band. Battelle Petition at 11.

<sup>99</sup> 47 CFR § 101.113(a).

(continued....)

in one other band.<sup>100</sup> Under our proposal, licensees will be limited to a maximum EIRP of 25 dBW/MHz, which is equivalent to the 75 decibel milliwatts per 100 megahertz (75 dBm/100 MHz EIRP limit the Commission recently adopted for base stations in our Part 30 rules.<sup>101</sup> We seek comment on this proposal; would another EIRP be more appropriate?

34. As with the 70/80/90 GHz bands, we are proposing that individual links be registered with a database manager. In the 70/80/90 GHz bands, the Commission's Wireless Telecommunications Bureau (WTB) has designated four database managers.<sup>102</sup> Can and should we require or invite the current 70/80/90 GHz database managers to extend their duties to additional bands above 95 GHz or should WTB identify one or more database managers for these bands through an independent process? Is the requirement that licensees submit an interference analysis to the database manager when registering a link necessary to prevent interference given the propagation characteristics above 95 GHz?

35. We seek comment generally on extending the 70/80/90 GHz service and technical rules to the proposed fixed bands. Should any of the proposed rules be modified for bands above 95 GHz based on licensees' experiences with the 70/80/90 GHz rules or for other reasons?<sup>103</sup> Are modifications to the rules needed to encourage more efficient use of spectrum or to avoid harmful interference? Should a higher EIRP be permitted to compensate for the atmospheric attenuation at these higher frequencies? We note that Battelle has suggested an EIRP of 70 dBW in their rulemaking petition, which would be 31.25 dBW/MHz if spread evenly across the 102-109.5 GHz band, claiming that the 70/80/90 GHz bands suffers from limited range and operating availability during severe weather and that there will be additional atmospheric attenuation in the 102-109.5 GHz band.<sup>104</sup> Should we segment any of the proposed bands as the Commission did for the 90 GHz band?<sup>105</sup> What segmentation would be appropriate? Would a specific channel plan be appropriate in any of the bands?<sup>106</sup> Do the rules provide a workable framework for protecting radio astronomy facilities and federal operations in the band? Are there any modifications to the proposed rules that would be necessary to address any of the characteristics of the proposed fixed bands?

36. Do the antenna gain requirements for the 70/80/90 GHz bands strike an appropriate

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<sup>100</sup> The transmit power limit for the 31-31.3 GHz band is 30 dBW/MHz. 47 CFR § 101.113(a).

<sup>101</sup> 47 CFR § 30.202(a); *Above 24 GHz R&O*, 31 FCC Rcd at 8110 para. 277.

<sup>102</sup> Allocations and Service Rules for the 71-76 GHz, 81-86 GHz and 92-95 GHz Bands, *Order*, 19 FCC Rcd 20524 (WTB, BD 2004); Key Bridge Global LLC Proposal to be Designated as a Database Manager for the 70/80/90 GHz Link Registration System. *Order and Notice to Database Managers for the 70/80/90 GHz Link Registration System Under Subpart Q of Part 101*, 31 FCC Rcd 9564 (2016). Although designated, Key Bridge is not operating as a 70/80/90 GHz database manager, to date.

<sup>103</sup> We clarify that the scope of the instant proceeding does not include the rules for the 70/80/90 GHz bands. Nonetheless, in seeking comment on whether to extend the 70/80/90 GHz rules to certain bands above 95 GHz, we are aware of several proposals pending in our Wireless Backhaul proceeding (WT Docket No. 10-153) to modify the existing rules for the 70/80/90 GHz bands. *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, Second Report and Order, Second Further Notice of Proposed Rulemaking, Order on Reconsideration, and Memorandum Opinion and Order, GN Docket No. 14-177, FCC 17-152, para. 201 (rel. Nov. 22, 2017). Commenters in response to the instant NPRM are invited to discuss those proposals, or other revisions, in the context of rules for certain bands above 95 GHz.

<sup>104</sup> Battelle Petition at 12.

<sup>105</sup> 47 CFR § 101.1505(b).

<sup>106</sup> The Fixed Wireless Communications Coalition has requested that the Commission adopt a specific channel plan for the 70/80 GHz bands. Fixed Wireless Communications Coalition Comments, WT Docket No. 10-153, at 5-6 (filed Oct. 5, 2012) at 6-7.

(continued....)

balance between facilitating sharing of the spectrum and providing flexibility? We note that the Fixed Wireless Communications Coalition has requested that the Commission relax the antenna gain standards for the 70/80 GHz band to enable the use of small planar antennas.<sup>107</sup> We further note that phased array antennas have been used in microwave frequency devices to provide directionality while keeping the size of the antennas small. Do the proposed rules need to be modified to allow for the use of small planar or phased array antennas?

37. Should we make provisions in the rules for fixed point-to-multipoint systems in addition to point-to-point links? For example, could we allow licensees to register operations in an area around a fixed location instead of requiring registration of individual links as required by the 70/80/90 GHz rules? This would enable a licensee to establish an access point/base station that serves a number of fixed customer locations in the surrounding area. The access point/base station would be permitted to operate with multiple beams where each beam must abide by the power limits we are adopting, but the sum of the power of all the beams could be higher. What are the advantages or disadvantages of such a proposal? We envision that the area served by an access/point base station would be small. What size area could an access point/base station serve given the propagation properties of these bands? Would allowing such point-to-multipoint systems require a higher degree of coordination with other licensees or Federal operations to prevent harmful interference from occurring? Should the area that is reserved around a particular access point/base station depend on the technical parameters of the access point such its transmit power and antenna height and characteristics of the surrounding environment such as terrain and structures? Because the access point/base station may use dynamically steerable antenna arrays to point at particular customer locations as needed, would it make sense to allow licensees to specify their coverage areas as a probability density function that describes the relative likelihood of pointing in a particular direction?<sup>108</sup> By specifying coverage areas in terms of probably density functions, the coverage areas of different licensees could overlap to allow a means of sharing the spectrum on a statistical basis. Do commenters agree with this assessment?

38. While we did not include the above 95 GHz bands that are allocated for the FSS or MSS in the above discussion, we note that satellite services successfully share spectrum with terrestrial services in many bands. For example, in the 10.7-11.7 GHz and 12.7-13.25 GHz bands, fixed point-to-point links share spectrum with the FSS; while fixed and mobile stations operating under the new rules in the 27.5-28.35 GHz and 37.5-50 GHz bands share spectrum with the FSS.<sup>109</sup> The fact that satellite and terrestrial services have shared spectrum in lower frequency bands provides some evidence that this could also be possible in the bands above 95 GHz. Therefore, we seek comment on extending our above proposal based on the 70/80/90 GHz rules to permit fixed operations in one or more of the following additional bands that are allocated for either the FSS or the MSS in addition to the fixed and mobile services: 158.5-164 GHz, 167-174.5 GHz, 191.8-200 GHz, 209-226 GHz, 232-235 GHz, 238-240 GHz, and 252-275 GHz. What changes, if any, to our proposed rules would be necessary to permit fixed operations in these bands?

39. Alternatively, should we instead adopt the licensing and prior coordination requirement used in many bands subject to our Part 101 rules. Under such an approach, links would be individually

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<sup>107</sup> *Id.* at 5-6.

<sup>108</sup> Google has suggested that the 70/80 GHz rules be updated to allow for point-to-multipoint systems with coverage specified either as a static polygon or on a statistical basis using probably density functions. Google Comments, GN Docket 14-177, at 4-5 (filed Sept. 30, 2016).

<sup>109</sup> Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range, First Report and Order and Further Notice of Proposed Rulemaking, 16 FCC Rcd 4096, 4101-02, 4121, paras. 5, 6, 51 (2000); 47 CFR §§ 25.136, 25.203.

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licensed and we would require that the links be coordinated with the licensee of other potentially affected links prior to application for a license?<sup>110</sup> Are there any other models for licensing that we should consider for these bands?

40. *Mobile Services:* As noted above, the atmospheric attenuation of radio signals with distance suggests that the deployment of mobile services may be possible in spectrum above 95 GHz. We seek comment generally on the deployment of mobile services in this spectrum. Would there be significant interest in implementing mobile services here? Given the propagation characteristics of these bands, what type of systems could feasibly be deployed? What type of licensing and technical rules should we consider adopting for mobile services in this spectrum?

41. *Sharing Considerations:* With the exception of passive services (EESS, RAS, and SRS) that collectively have exclusive primary allocations in some of the bands between 95 GHz and 275 GHz, all other services in the 95-275 GHz bands have shared allocations. Thus, all the candidate bands for which we have proposed rules or on which we have sought comment have allocations for other services in addition to the fixed and mobile services. As noted above, we do not intend to foreclose future federal and non-federal primary use and access opportunities. Moreover, our proposals in this NPRM, if adopted, would not establish any priority of access for non-federal users or impair future federal access. Sometimes, without specific guidance, such allocations convey a perception that when two or more primary services are listed in the U.S. Table, later-licensed or authorized federal or non-federal operations would be expected to protect the earlier-licensed or authorized operations. However, to avoid any mistaken perceptions and in light of the unique physical characteristics in these bands, we seek comment below on adopting a new US footnote in the table of allocations that would clarify that, among co-primary federal and non-federal services, first-in-time does not necessarily mean priority relative to other current or future licensed or unlicensed uses. For example, the 105-109.5 GHz, 111.8-114.25 GHz and 217-226 GHz bands have shared allocations with the SRS with use limited to space-based radio astronomy. With the exception of 158.5-164 GHz, 167-174.8 GHz, 191.8-200 GHz, 231.5-235 GHz and 238-241 GHz, all the candidate bands have shared allocations with the RAS. The 130-134 GHz band has a shared allocation with the active EESS. In addition, most of the candidate bands are adjacent to EESS and SRS services. Furthermore, there are number of bands in the Terahertz (THz) frequency range from 300 to 3000 GHz that are of interest both to RAS and to the remote sensing community.<sup>111</sup> Because of the importance of the passive services, any rules adopted by the Commission must ensure their continued protection from harmful interference, including that from adjacent bands.

42. *Sharing with the RAS.* RAS operations in this region of the spectrum are limited to certain locations. For this reason, the Commission believes that excluding fixed and mobile stations from these localities would provide adequate protection for incumbent operations. US footnote 161 includes a list of RAS locations operating in the bands 81-86 GHz, 92-94 GHz, and 94.1-95 GHz that are protected from fixed stations by the use of coordination distances.<sup>112</sup> We seek comment as to whether a similar approach would adequately protect RAS operations in the bands above 95 GHz. Does this list reflect RAS operations that currently exist or are anticipated above 95 GHz, or should we modify it to add or eliminate certain locations? Given that the propagation losses in the bands above 95 GHz are higher than

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<sup>110</sup> 47 CFR §§ 101.103(d)(1).

<sup>111</sup> Sebastian Priebe, et al., "Interference Investigations of Active Communications and Passive Earth Exploration Services in the THz Frequency Range", IEEE Trans. on THz Sci. and Tech., Vol. 2, No. 5, Sept. 2012, Pg. 1. The EESS and SRS remote sensors perform air and space-borne measurements of the molecular absorption lines for meteorology, climatology and atmospheric chemistry, while ground-based RAS remote sensors perform studies of electromagnetic radiation from molecular gas clouds, remote stars, and galaxies.

<sup>112</sup> 47 CFR § 2.106 footnote US161.

(continued...)

the bands identified in US161, should the coordination distances be adjusted accordingly?

43. We note that footnote US246 prohibits all transmissions in a number of bands above 95 GHz to protect passive services such as the RAS and EESS (passive).<sup>113</sup> Footnote US74 specifies that radio astronomy observatories operating in most of the frequency bands listed in US246 will be protected from unwanted emissions from other stations only to the extent the emissions exceed what would be permitted under the technical standards or criteria applicable to the service in which the station operates.<sup>114</sup> However, US74 omits the 182-185 GHz and 226-231.5 GHz bands even though they are included in US246 and have RAS allocations. We seek comment on whether these two bands should be added to US74.

44. *Sharing services with the EESS and SRS.* We seek comments on the appropriate methodology for modelling potential interference to the EESS and SRS. We are aware that interference may occur to the EESS and SRS under worst case conditions.<sup>115</sup> We seek to balance protecting these services from harmful interference with the ability to provide for expanded uses of spectrum above 95 GHz. Limitations on power or the number and locations of devices may be appropriate mitigation techniques that would not necessarily restrict the transmission ranges of services such as terahertz WLANs or fixed backhaul links to the point they are unworkable. Are there specific environmental propagation models the Commission should consider when contemplating allowing shared services with EESS and SRS? Should additional environmental characteristics, for example via building or other forms of clutter model, be considered? The Commission seeks comment on the harmful interference criteria for satellite passive remote sensing, as well as any published studies or recommendations<sup>116</sup> that may be relevant in assessing sharing with satellite passive remote sensors. Are there methodologies the Commission should adopt into its rules that could mitigate interference to EESS and SRS services caused by new users of above 95 GHz spectrum? What is the best way of predicting atmospheric attenuation (including losses from rain, etc.), particularly in the bands beyond the 1 THz limit of the ITU recommendation on attenuation by atmospheric gases, ITU-R P676-11?<sup>117</sup> Are there other assumptions that must be considered in ensuring interference protected operation for passive sensors in the EESS and SRS?

45. *Sharing with the FSS, MSS, and ISS.* The 158.5-164 GHz, 167-174.5 GHz, 209-226 GHz, 232-235 GHz, 238-240 GHz, and 265-275 GHz bands have shared allocations with the FSS. We expect that sharing between the MS service and the FSS service would be similar to the lower frequency bands under the new Part 30 rules. In the 27.5-28.35 GHz band shared between UMFUS and earth-to-space FSS, a limited number of FSS earth stations are permitted to operate without protecting UMFUS receivers.<sup>118</sup> The 37.5-40 GHz band, which shared between UMFUS and space-to-earth FSS, has a stricter PFD limit for the FSS than other FSS bands to protect UMFUS operations: a limited number of FSS earth stations in that band are also provided with interference protection from UMFUS.<sup>119</sup> We seek comment on how the UMFUS rules could be used to facilitate sharing between the MS and FSS in the above 95 GHz bands. How can interference be avoided between mobile stations and satellite operations?

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<sup>113</sup> 47 CFR § 2.106 footnote US246.

<sup>114</sup> 47 CFR § 2.106 footnote US74.

<sup>115</sup> See Thomas Kurner et al., “Towards THz Communications - Status in Research, Standardization and Regulation”, *Journal of Infrared, Millimeter, and Terahertz Waves*, August 2013, at 7.

<sup>116</sup> For example, ITU-R RS.1861 and ITU-R RS.2017

<sup>117</sup> See n. 66, *supra*.

<sup>118</sup> 47 CFR § 25.136(a).

<sup>119</sup> 47 CFR §§ 25.136(b),(c), 25.208(q),(r).

(continued....)

Could exclusion zones or coordination be used to prevent interference? Would designating portions of the shared spectrum where satellite or terrestrial services have priority be an appropriate means for sharing the spectrum?

46. We also seek comment on how sharing could be accomplished between the FS and FSS in the bands under discussion. We note that the 70 GHz and 80 GHz bands have allocations for the FSS, but no satellites currently operate in these bands and the Commission has not adopted any specific coordination provisions to protect the FSS. Would the use of a narrow-beam antenna requirement in our proposed rules for FS operations avoid harmful interference to the FSS? Sharing between the FS and the FSS in the lower frequency bands under our Part 101 of our rules uses first-in-time coordination.<sup>120</sup> Would this be an appropriate method for sharing between the FS and FSS? Could the registration of fixed links with the database manager required under our proposed rules be extended to also apply to satellite earth stations?

47. The 158.5-164 GHz, 191.8-200 GHz, 232-235 GHz, and 252-265 GHz bands have shared allocations with the MSS. Given the highly directional nature of antennas in the bands above 95 GHz and the wide angular separations between terrestrial stations and satellite stations, we believe sharing between FS and MSS is technically feasible, and we seek comment on possible sharing mechanisms between these services. In the bands below 95 GHz sharing between the MS service and the MSS service is challenging because of the potential interference from the terrestrial base stations to MSS user equipment. However, given the more limited propagation characteristics of the higher frequencies we believe that sharing is likely feasible. We seek comment on possible sharing mechanisms between the MS and MSS services. Would geographical partitioning between services, for example between urban/rural markets, serve as a possible sharing mechanism? If so, how should such markets be defined? Could dual MS/MSS user equipment, if available, resolve possible interference conditions by switching to terrestrial service when a terrestrial network is detected? Could requiring operators of terrestrial MS networks to adopt a method of registration and tracking of MSS user equipment reduce the possibility of interference by limiting emissions in the direction of MSS user equipment?

48. The 122.25-123 GHz, 130-134 GHz, 167-174.8 GHz, and 191.8-200 GHz bands have a shared allocation with the inter-satellite service (ISS). The ISS is used for communication links between satellites. Given the propagation properties of these bands and the angular and spatial separation between terrestrial FS and MS stations and satellites, is there a need to make provisions in our rules to prevent harmful interference to and from the ISS? Should there be specific antenna performance requirements for FS and MS stations to limit potential interference to the ISS? If so, should there be separate requirements for each of the shared bands? Commenters who support antenna performance requirements for FS and MS stations should provide specific technical information and proposals showing the need for such requirements. Similarly, should there be specific antenna performance requirements for aeronautical use of MS stations or should such use be prohibited entirely to protect the ISS? We note that international footnote 5.562C limits the ISS in 116-122.25 GHz for GSO satellites only. We seek comment whether NGSO satellites can be accommodated in this band.

49. *Other shared services.* The 95-100 GHz, 141-148.5 GHz, 151.5-155.5 GHz, 191-200 GHz, 238-241 GHz, and 252-265 GHz bands have shared allocations for radar use (radionavigation service or radiolocation service). The 95-100 GHz, 238-240 GHz, and 252-265 GHz bands are also allocated for the radio navigation satellite service. Given the limited current uses of the spectrum above 95 GHz and given the elevated free space propagation and atmospheric losses in these bands, how likely is it that these allocations will be used in the future by non-federal users? We seek comment generally on how stations in the fixed and/or mobile service could share the bands with the radar allocated services. Can the sharing mechanism be based on geographical separation? Could a database of locations where

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<sup>120</sup> 47 CFR §§ 101.103(d)(1), 25.203 (c).



radar operations occur or the locations of transmitters or receivers of other licensed services be used to facilitate sharing in these bands? Such a database could be a relatively simple record of the locations of fixed facilities or the geographic areas where mobile operations may occur or it could be more sophisticated.<sup>121</sup> Could the use of sensing technologies to determine when radars are in operation be used to share the bands between radars and other licensed services? For example, Unlicensed National Information Infrastructure (UNII) devices operating in the 5.25-5.35 GHz and 5.47-5.725 GHz bands are required to implement a radar detection mechanism to avoid co-channel operation with radar systems,<sup>122</sup> and our rules for the 3550-3700 GHz band allow for data from sensors to be used by a spectrum access system.<sup>123</sup>

50. *Federal/non-federal sharing:* As we noted above, the 95-275 GHz spectrum is allocated on a co-primary basis for federal and non-federal use. In developing rules for this spectrum, we will work closely with the NTIA with the objective of developing a framework that both encourages private sector investment in new technologies and services and preserves the ability of federal users to research, develop, test, and deploy new technologies and services to meet their needs. This is particularly challenging given that we cannot predict what those technologies and services may be and where they may be deployed. It is not our intention to do anything that would diminish the existing rights of federal users to research, develop, test, and deploy systems that operate in this spectrum. While this notice considers the possibility of granting nationwide licenses, access to the band by both federal and non-federal users would be on a shared basis where access by users would not preclude federal and non-federal users from deploying systems where no authorized facilities have been registered or deployed. Moreover, consistent with our tried and true spectrum management principles, any incumbent service would have an obligation to act in good faith to coordinate to enable the deployment of new entrant federal and non-federal systems. Specific sharing and coordination terms to ensure federal and non-federal co-primary access will be addressed through a future framework to be jointly developed by NTIA and FCC as part of follow-on proceedings. We believe that such an approach is viable because the propagation characteristics in this spectrum should make it possible for multiple systems to operate in the same spectrum. We seek comment on adding the following footnote to the Table of Frequency Allocations that reflects this approach:

USxxx: Federal and non-federal users shall have equal rights to access the spectrum in the 95 – 275 GHz band. Use of the band by non-federal users on a licensed or unlicensed basis shall not preclude or impair co-primary use of the bands by federal users and shall not establish non-federal priority in bands allocated for shared federal and non-federal use.

We also recognize that as new services and technologies are developed by both federal and non-federal users, any rules we adopt through this proceeding may need to be revisited in the future as we learn more.

## **B. Unlicensed operations under Parts 15**

51. Part 15 of the Commission's rules permits the operation of RF devices without issuing individual licenses to operators of these devices. Typically, unlicensed devices operate at relatively low power and transmit short distances. The primary operating conditions for unlicensed devices are that a

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<sup>121</sup> Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, GN Docket No. 12-354, *Report and Order and Second Further Notice of Proposed Rulemaking*, 30 FCC Rcd 3959, 4048-69, paras. 301-378 (2015); *Order on Reconsideration and Second Report and Order*, 31 FCC Rcd 5011 (2016); 47 CFR pt. 96 subpart F.

<sup>122</sup> 47 CFR § 15.407(h)(2).

<sup>123</sup> 47 CFR § 96.67.

(continued....)

device may not cause harmful interference to authorized services, and that the operator must accept whatever interference is received. The Commission's Part 15 rules are designed to ensure that there is a low probability that these devices will cause harmful interference to authorized users of the same or nearby spectrum. Should harmful interference occur, the operator is required to immediately correct the interference problem or cease operation.<sup>124</sup>

52. Apart from a few specified frequency bands, spectrum above 38.6 GHz is designated as "restricted" in Section 15.205 of the rules.<sup>125</sup> Unless expressly permitted by rule or waiver, unlicensed devices are not allowed to intentionally radiate energy into a restricted band; this restriction is primarily intended to protect sensitive radio services from harmful interference.<sup>126</sup> The Commission designated the entire frequency range above 38.6 GHz as a restricted band in 1989 at a time when manufacturers were not producing equipment that transmitted in that frequency range and when there were no requirements in our rules to make measurements of RF emissions above 40 GHz because of limitations in measurement technology.<sup>127</sup> Designating the entire frequency range above 38.6 GHz as restricted, rather than restricting designated segments, was simply a matter of administrative convenience and had no impact on manufacturers. However, due to advancements in technology, the Commission in 1996 began requiring measurements above 40 GHz for certain devices.<sup>128</sup> Additionally, it subsequently permitted unlicensed operation within specific frequency bands above 38.6 GHz, e.g., 57-71 GHz, and 92-95 GHz, after determining that such operation would not cause harmful interference to authorized services in these bands.<sup>129</sup> In doing so, the Commission provided exemptions to the restricted band rules in the specific frequency bands above 38.6 GHz where it permitted unlicensed operation.<sup>130</sup> We are proposing similar actions below, i.e., to allow unlicensed operation in additional frequency bands where we believe it will not cause harmful interference to authorized services, and to remove those specific bands from the list of restricted bands.

53. We seek comment on whether to make 15.2 gigahertz of spectrum above 95 GHz available for unlicensed use in four frequency bands. First, we seek comment on allowing unlicensed operation in the 122-123 GHz and the 244-246 GHz bands, which are already designated ISM bands.<sup>131</sup> ISM devices are not subject to emissions limits in these bands, although they must comply with emission limits outside of the bands and are subject to the provisions of footnote 5.138.<sup>132</sup> As part of our proposal to allow unlicensed operation in the 122-123 GHz and 244-246 GHz bands, we would remove these bands from the list of restricted bands in Section 15.205. We seek comment on these proposals.

54. We also seek comment on whether to allow unlicensed operation in two frequency bands

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<sup>124</sup> 47 CFR §§ 15.5(b), (c).

<sup>125</sup> 47 CFR § 15.205(a).

<sup>126</sup> *Revision of the Rules Regarding Operation of Radio Frequency Devices Without and Individual License*, First Report and Order, GEN Docket 87-389, 4 FCC Rcd 3493 (1989) and 47 CFR § 15.205.

<sup>127</sup> *Id.*

<sup>128</sup> *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*, First Report and Order and Second Notice of Proposed Rule Making, 11 FCC Rcd 4481 (1996) and 47 CFR § 15.33(a).

<sup>129</sup> 47 CFR §§ 15.253, 15.255 and 15.257. The 57-71 GHz band is open to most types of unlicensed operations except equipment used on satellites; operation in the 92-95 GHz band is limited to indoor applications.

<sup>130</sup> 47 CFR § 15.205(d).

<sup>131</sup> 47 CFR § 18.301.

<sup>132</sup> 47 CFR §§ 18.301 and 18.305(a). Also, as discussed in para. 5 *supra*, footnote 5.138 is applicable to these bands.

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near 183 GHz. As discussed above, there is a sharp peak in the atmospheric attenuation curve at this frequency. We believe that the frequency bands located around this peak may be appropriate for unlicensed use because the severe signal attenuation will minimize the likelihood of interference occurring to authorized users of the spectrum. However, no transmissions are permitted in the frequency band at the peak due to Allocations Table footnote US246 stating that no station shall be authorized to transmit in a number of bands including the 182-185 GHz band.<sup>133</sup> We would leave the footnote US246 restriction in place and make spectrum available for unlicensed use on both sides of the attenuation peak in the two closest frequency bands that are not subject to this restriction, specifically, the 174.8-182 GHz and 185-190 GHz bands.<sup>134</sup> These two bands, despite not being at the highest portion of the attenuation curve peak, still have significant atmospheric attenuation which we believe will minimize the potential for interference to authorized services. Thus, we would remove these bands from the list of restricted bands in Section 15.205. We seek comment on this approach.

55. We also seek comment on what technical rules should apply to unlicensed operation within the 122-123 GHz, 174.8-182 GHz, 185-190 GHz and 244-246 GHz frequency bands. In particular, we seek comment on whether the requirements that apply to the operation of unlicensed devices in the 57-71 GHz band under Section 15.255 of the rules are appropriate in these bands.<sup>135</sup> A proposed rule section based on these requirements is provided in Appendix A.<sup>136</sup> Would the power levels provided in that rule section be high enough for unlicensed equipment to function as intended in the bands under consideration here? If not, what would be a reasonable power level that provides for a practical operational range that would also provide adequate protection to authorized services in the same and nearby spectrum? Could we permit higher power levels in the 174.8-182 GHz and 185-190 GHz bands since they are close to a peak in atmospheric attenuation that is greater than the peak at 60 GHz? We recognize that the primary allocations for the 174.8-182 GHz and 185-190 GHz bands are for the ISS and for the EESS and the SRS (passive) and that footnote 5.562H limits ISS emissions to levels below the EESS (passive) protection criteria.<sup>137</sup> We also note that the rules applying to unlicensed use of the 57-71 GHz band do not allow the use of devices on satellites or allow for the use of field disturbance sensors unless the sensors are part of fixed equipment. In addition, these rules permit the use of devices on aircraft only under certain specific circumstances.<sup>138</sup> Therefore, we seek comment on whether any of

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<sup>133</sup> 47 CFR § 2.106 footnote US246. Footnote US246 is similar to international footnote 5.340 which lists a number of frequency bands in which no station may be authorized to transmit. Even low levels of interference received by passive sensors may have a degrading impact on the sensor/receiver performance and thus on passive service bands usage. In most cases the sensors/receivers are not able to discriminate between natural radiation and man-made radiation. Therefore, the passive bands cannot tolerate any man-made interference and, in this respect, footnote US246 enables the passive services to deploy and operate their systems with the highest possible level of reliability. Emissions in passive-only bands could seriously interfere with radio astronomy observations of Carbon Monoxide (CO) spectral emission in these bands. *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, Notice of Proposed Rulemaking, 30 Rcd 11878, 11966, para. 305 (2015).

<sup>134</sup> The proposed rules are in Appendix A.

<sup>135</sup> 47 CFR § 15.255.

<sup>136</sup> Proposed rule section 15.258 for unlicensed operation in the bands 122-123 GHz, 174.8-182 GHz, 185-190 GHz and 244-246 GHz is based on the current rules that apply to operation in the band 57-71 GHz. For simplicity, it does not show the restriction on the use of non-fixed field disturbance sensors that is in current section 15.255, but as noted below in this paragraph we are seeking comment on whether such a restriction is necessary.

<sup>137</sup> 47 CFR § 2.106 footnote 5.562H.

<sup>138</sup> Operation of unlicensed devices in the 57-71 GHz band on aircraft is permitted only when the aircraft is on the ground, and while airborne in closed exclusive on-board communication networks within the aircraft. Operation is not permitted in wireless avionics intra-communication applications where external structural sensors or external

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these restrictions should apply to unlicensed devices in any or all of the four proposed bands to protect the existing authorized services in these bands, and if so, why? Is there a need to prohibit all operation of devices on aircraft in any of the proposed bands? Would any other modifications to the requirements of Section 15.255 be needed to permit unlicensed operation in these bands?

We further seek comment on whether there are any other bands above 95 GHz that would be suitable for unlicensed use in addition to the 15.2 gigahertz of spectrum identified above. In particular, we seek comment on allowing unlicensed use of the 116-122 GHz band, which is immediately adjacent to the 122-123 GHz ISM band for which we are proposing to allow unlicensed use, potentially making a contiguous seven gigahertz band of spectrum available for unlicensed use. The 116-122.25 GHz band is allocated to passive services such as the EESS and SRS (passive) as well as the ISS which is used for communications between satellites with footnote 5.562C limiting ISS emission levels below the EESS (passive) protection criteria.<sup>139</sup> The passive services would likely be compatible only with low density deployments and low power unlicensed uses because of the high sensitivity of these types of passive receivers. Because devices operating under our Part 15 rules are limited to transmission at low power levels, and given the increased propagation attenuation from high atmospheric absorption, we believe that Part 15 devices may be able to share spectrum with these passive services without causing interference. However, we note that while this band is close to a peak in the atmospheric attenuation curve, this peak is smaller than the peaks at 60 GHz and 183 GHz. Also, we note that RAS observations at 115.27 GHz may necessitate geographic restrictions to protect RAS facilities. Accordingly, we seek comment on whether unlicensed operation should be permitted in the 116-122 GHz band. If so, what technical and other requirements should apply to prevent interference to authorized services in the band? We also seek comment on any other bands above 95 GHz that may be suitable for unlicensed use and the technical requirements that would be necessary to allow operation in them while protecting authorized services. In particular, we seek comment on how such use would relate to the current and planned passive services outlined in Appendix B.

56. The bands discussed above for possible unlicensed operation are allocated for both federal and non-federal uses for services such as EESS and SRS (passive) as well as the ISS. Potential future applications in these bands includes ultra-high definition video, and high-speed data transmission, such as temporary fiber optic line replacement, chip-to-chip communication within computer equipment, and replacement of computer data cables in data centers with wireless links. Would the rules proposed above for unlicensed devices allow for applications such as these? With respect to non-federal users, we seek comment on whether the unlicensed spectrum access model is most appropriate for the types of devices that could be operated in the proposed frequency bands, or whether some other spectrum access model would be more appropriate, e.g., licensed or licensed by rule.

57. As mentioned above, James Whedbee has filed a rulemaking petition requesting that we adopt rules to permit unlicensed device operation in the 95-1000 GHz range.<sup>140</sup> Whedbee advocates that we apply the same technical rules to these unlicensed operations as currently apply in the 57-71 GHz band with a few differences. While the 57-71 GHz rules do not specify a maximum occupied bandwidth, Whedbee proposes unlicensed devices in 95-1000 GHz be limited to a bandwidth of 500 megahertz. Whedbee also specifies that unlicensed operations be limited to indoors only and that transmitters not be

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cameras are mounted on the outside of the aircraft structure, or on aircraft where there is little attenuation of RF signals by the body/fuselage of the aircraft, such as toy/model aircraft, unmanned aircraft, and crop-spraying aircraft. 47 CFR § 15.255(b), as modified by the *Spectrum Frontiers Report and Order. Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, Second Report and Order, Second Further Notice of Proposed Rulemaking, Order on Reconsideration, and Memorandum Opinion and Order, FCC 17-152, paras. 80-87 (2017).

<sup>139</sup> 47 CFR § 2.106 footnote 5.562C.

<sup>140</sup> See para. 17, *infra*.

deliberately pointed at windows in a number of bands used by the RAS, EESS (passive), and SRS (passive). According to Whedbee, licensing of transmissions over the range 95-1000 GHz may hinder the technological developments that his proposed rule would permit without licensing. We are reluctant to open such a wide swath of spectrum for unlicensed use because we believe it represents inefficient use of the spectrum, provides no focus for development of technologies in specific bands and our proposals would already provide considerable opportunities for unlicensed devices. Nevertheless, in seeking comment on making 15.2 gigahertz of spectrum above 95 GHz available for unlicensed use we grant his petition in part. We also seek comment broadly on Whedbee's rulemaking petition to the extent his proposal goes beyond what we have sought comment on and on any costs or benefits that could arise from making the 95-1000 GHz band available for unlicensed use in accordance with his proposal.<sup>141</sup>

58. The Commission also seeks comment on what rules might be most appropriate for ISM operations in the above 95 GHz band. Part 18 of the rules contains the regulations for ISM equipment. ISM equipment is defined as equipment or appliances designed to generate and use locally RF energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunication. Typical ISM applications are the production of physical, biological, or chemical effects such as heating, ionization of gases, mechanical vibrations, hair removal and acceleration of charged particles.<sup>142</sup> ISM equipment operated within certain designated frequency bands is not subject to emissions limits within those bands.<sup>143</sup> However, emissions from ISM equipment that fall outside of these bands must comply with limits designed to prevent harmful interference to authorized radio services.<sup>144</sup>

59. The Commission has historically treated RF devices that transmit a radio signal for purposes such as measuring the level of a fluid in a container or for measuring some quantifiable property of a material as Part 15 devices.<sup>145</sup> Due to the modulated transmission of information, the Commission decided that they were best treated as Part 15 low power transmission devices as opposed to Part 18 equipment where RF energy is generated to perform work, such as in an industrial heater or microwave oven.<sup>146</sup> With some applications the distinctions are not as distinct, which has resulted in a case-by-case analysis. For example, magnetic resonance imaging systems subject to Part 18 that use RF energy to stimulate molecules to produce a detectable RF field used to form images of the body have been determined to be subject to Part 18 of the rules.<sup>147</sup> We are aware of interest in using the spectrum above 95 GHz for devices that use terahertz spectroscopy to analyze material properties and for imaging applications, which could possibly be considered ISM applications.<sup>148</sup> While the Office of Engineering and Technology currently evaluates applications for devices that use the frequencies above 95 GHz on a case-by-case basis, we note that it has found that some equipment used to detect the presence of powders, solids and liquids inside sealed parcels and envelopes to be ISM equipment subject to Part 18 of the

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<sup>141</sup> Comments regarding Whedbee's rulemaking petition should be filed in both this docket (ET Docket No. 18-21) and rulemaking RM-11795.

<sup>142</sup> 47 CFR § 18.107(c).

<sup>143</sup> 47 CFR § 18.305(a).

<sup>144</sup> 47 CFR § 18.305(b).

<sup>145</sup> *Amending Part 15 Subpart E – To Provide for RF Operated Measuring Devices*, Docket No. 18260, Report and Order, 20 FCC 2d 158 (1969).

<sup>146</sup> *Id.*

<sup>147</sup> 47 CFR §§ 18.107(c) and 18.121.

<sup>148</sup> Terahertz spectroscopy is a technique in which the properties of a material are probed with short pulses of terahertz radiation.

rules.<sup>149</sup> We seek comment on whether we should establish a more certain regulatory approach for devices that use the frequencies above 95 GHz. Are the lack of provisions under Part 15 for equipment that operates in these higher frequency bands hampering the ability of these new technologies to be approved and, if so should we modify the Part 15 rules to allow them? Or would it be more appropriate to routinely treat these terahertz applications as Part 18 ISM equipment for which there are already power and field strength limits specified in the rules?

60. We recognize that the radiated emission limits in Part 18 were originally developed for devices operating at significantly lower frequencies than we are considering here, and seek comment on how that should affect our analysis. Accordingly, we seek comment on whether changes to these limits are necessary for operation above 95 GHz. Are the limits in Section 18.305 appropriate for these devices? If not, what are the appropriate limits, and in what terms should they be expressed, e.g., field strength, power density, EIRP or some other power-related terms? In addition, we note that the rules currently specify that radiated emissions from most ISM equipment must be measured at a distance of 300 meters from the equipment. Due to the rapid attenuation of signals and the limitations in measurement devices at frequencies above 95 GHz, measurements at this distance are likely not practical. We therefore seek comment on the appropriate measurement distance and procedures for determining compliance with the rules. We also seek comment on whether any other changes to the rules may be required to prevent harmful interference to authorized services. For example, should we restrict operation in certain frequency bands to indoor locations only, and if so, in which frequency bands should such a restriction apply and how could it be enforced?

### C. Experimental Radio Service

61. In this section, we seek comment on whether to create a new subpart of our Part 5 Experimental Radio Service (ERS) rules to better encourage experiments in the spectrum range between 95 GHz and 3 THz. We find this to be desirable both because of the potential for technological breakthroughs in this spectrum range, and the current lack of experimentation there. While our existing ERS rules have been very beneficial in encouraging experimentation below 95 GHz, we believe that they may be overly restrictive for the largely uncharted spectrum range above 95 GHz. Accordingly, we would seek ways to liberalize the rules in that range by permitting a longer license term and increased ability to market experimental equipment and use available frequencies over broad geographic areas. We emphasize, however, that any experimentation above 95 GHz would continue to be on a non-exclusive, non-harmful interference basis to authorized spectrum users in that range in accordance with Section 5.84 of the Commission's rules and subject to coordination with federal users through NTIA.

62. Our Part 5 ERS rules prescribe the requirements for authorizing a variety of entities to experiment with new radio technologies, equipment designs, characteristics of radio wave propagation, or service concepts related to the use of the radio spectrum.<sup>150</sup> To encourage innovation, the Part 5 rules provide the flexibility for an applicant for an experimental license to propose the frequency range, power, and emissions limits of their choosing.<sup>151</sup> In exchange for this flexibility, and as noted above, experimental operations are not entitled to exclusive use protected from harmful interference from allocated services, and ERS licensees must not cause harmful interference to stations of authorized services, including secondary services.<sup>152</sup>

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<sup>149</sup> See Knowledge Database (KDB) Publication 227764.

<sup>150</sup> 47 CFR Part 5.

<sup>151</sup> 47 CFR §§ 5.77 and 5.85.

<sup>152</sup> 47 CFR §§ 5.84, 5.85(b). "If harmful interference to an established radio service occurs, upon becoming aware of such harmful interference the Experimental Radio Service licensee shall immediately cease transmissions.

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63. The Commission authorizes different types of experimental licenses, several of which cover very specific circumstances that do not appear to be generally useful in conjunction with research and development of new technologies that can use the spectrum above 95 GHz. For example, the compliance testing experimental radio license authorizes testing laboratories recognized by the FCC to perform testing of RF devices for compliance under our Part 2 equipment authorization program.<sup>153</sup> The broadcast experimental license is issued for the development and advancement of new broadcast technology, equipment, systems or services. Such licenses are limited to stations intended for reception and use by the general public.<sup>154</sup> At this time, it does not appear that broadcasting applications over wide service areas are practical on the spectrum above 95 GHz. The medical testing experimental radio license is also narrowly focused on permitting clinical trials of medical devices that use RF wireless technology for diagnosis, treatment, or patient monitoring for the purposes of, but not limited to, assessing patient compatibility and usage issues, as well as operational, interference, and RF immunity issues.<sup>155</sup>

64. The experimental authorization with the least restrictive eligibility requirements is the conventional ERS license, which is available to any persons who we deem qualified to conduct a variety of communications-related experimentation and research.<sup>156</sup> This type of license is issued for a specific research or experimentation project (or a series of closely-related research or experimentation projects) and may cover product development or market trials. However, widely divergent and unrelated experiments require separate licenses.<sup>157</sup> Broader long-term authority for a variety of related experiments may be obtained via the program experimental radio license. Eligible entities for a program license include colleges, universities, research laboratories, manufacturers of RF equipment, manufacturers that integrate RF equipment into their end products, and medical research institutions.<sup>158</sup> However, product development or market trials may not be conducted in conjunction with program experimental radio licenses under current rules.<sup>159</sup>

### 1. Challenges for experimental use of spectrum above 95 GHz

65. As we have discussed herein, the technology for practical RF communications above 95 GHz is at a very nascent stage. Our experimental licensing rules and procedures, which are premised on encouraging the development of new technologies and equipment, would seem to be logically suited for a scenario where there are few service rules and virtually no equipment widely available for “routine” use. However, at this time, only 13 experimental radio licenses are currently active for spectrum above 95 GHz.<sup>160</sup> While we have established several experimental radio licenses that are tailored to a variety of

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Furthermore, the licensee shall not resume transmissions until the licensee establishes to the satisfaction of the Commission that further harmful interference will not be caused to any established radio service.” *Id.* at § 5.84.

<sup>153</sup> 47 CFR § 5.54(e).

<sup>154</sup> 47 CFR § 5.54(b).

<sup>155</sup> The testing is further limited to equipment designed to comply with the rules in part 15, Radio Frequency Devices; part 18, Industrial, Scientific, and Medical Equipment; part 95, Personal Radio Services, subpart H—Wireless Medical Telemetry Service; or part 95, subpart I—Medical Device Radiocommunication Service. See 47 CFR § 5.402(b). Additionally, eligibility for this type of license is issued only to qualified hospitals and health care institutions. See 47 CFR §§ 5.54(d) & 5.402(a).

<sup>156</sup> 47 CFR §§ 5.3, 5.51(a) & 5.54(a)(1).

<sup>157</sup> 47 CFR § 5.54(a)(1). Experiments lasting no more than six months may be conducted under special temporary authorization. 47 CFR § 5.54(a)(2).

<sup>158</sup> 47 CFR § 5.54(c).

<sup>159</sup> 47 CFR § 5.305(d).

<sup>160</sup> Those 13 experiments are being conducted by the following licensees under the listed call signs.

(continued....)

users under different research program scenarios, which further the interests expressed in the petition filed by IEEE-USA,<sup>161</sup> we believe that we can further encourage innovation above 95 GHz by creating a new experimental license available to technologies or services that propose to employ spectrum only in that range.<sup>162</sup>

66. Conventional experimental licenses require separate authorizations for multiple ongoing projects,<sup>163</sup> repeated filings when parameters are changed,<sup>164</sup> and are routinely limited to a two-year term.<sup>165</sup> RF technology above 95 GHz is at a formative stage where uncertainty about expected outcomes is likely to require dynamic experimentation under a variety of parameters and usage scenarios for extended periods. The conventional experimental licensing requirements could place an undue filing burden on licensees, while not providing adequate certainty that an authorization will be valid for a sufficient time period to complete long-term research.

67. Program licenses provide licensees with the ability to be authorized for a wider research program<sup>166</sup> with the certainty of a longer license term.<sup>167</sup> However, the existing program license eligibility requirements preclude individual applicants or new entrants in the RF communications field, as eligibility is restricted to a college or university with a graduate research program in engineering that is accredited by the Accreditation Board for Engineering and Technology; a research laboratory; a hospital or health care institution; a manufacturer of radio frequency equipment; or a manufacturer that integrates radio frequency equipment into its end product.<sup>168</sup> Additionally, operation under a program license must

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(1) Brown University (WI2XVS) – Propagation measurements, including passive bands at approximately 100, 200, 300, and 400 GHz. (2) Lockheed Martin Corporation (WG2XJE) – Radar cross-section measurements in various bands, including 95-100 GHz. (3) Northrop Grumman Systems Corporation (WJ2XEM) – Testing of frequency hopping systems in two bands, including the 92-96 GHz band. (4) NYU Tandon School of Engineering (WI2XSY) – Propagation testing, including 5G, in various bands, including 140-160 GHz. (5) Raytheon IDS (KI2XGC) – Development of antenna test ranges in various bands, including 92-100 GHz. (6) Raytheon Missile Systems (WB2XGB) – Testing, development, and demonstration of radars in three bands, including 92-100 and 102-105 GHz. (7) Raytheon Missile Systems (WI2XWW) – Testing of carbon-loaded Teflon equipment for US Army in the 92-96 GHz band. (8) Raytheon Missile Systems (WG2XHU) – Testing of RF deterrent system in the 94-96 GHz band. (9) Raytheon Missile Systems (WM9XAM) – Testing antenna patterns in the 90-102 GHz frequency range. (10) S2 Corporation (WH2XUK) – Development of a broadband spatial/spectrum receiver in support of developing a broadband staring receiver in various bands, including 26.5-100 GHz. (11) Sierra Nevada Corporation (WE2XCP) – Testing helicopter autonomous landing system in the 92.5-95.5 GHz band. (12) The Boeing Company (KB2XEU) – Testing of company’s antennas in various bands, including 148.5-151.5 and 185-190 GHz. (13) University of Buffalo (WM9XGE) – Propagation measurements in the 1 THz region. Database query of January 30, 2018.

<sup>161</sup> See para. 17, *supra*.

<sup>162</sup> As explained in n.171, *supra*, we find it appropriate to permit experimentation not just between 95-275 GHz, but up to 3 THz.

<sup>163</sup> 47 CFR § 5.54(a)(1).

<sup>164</sup> 47 CFR § 5.77.

<sup>165</sup> 47 CFR § 5.71(a). An experimental license may be renewed for an additional term not to exceed five years, upon an adequate showing of need to complete the experiment.

<sup>166</sup> 47 CFR § 5.54(c).

<sup>167</sup> 47 CFR § 5.71(b).

<sup>168</sup> 47 C.F.R. § 5.302.

(continued....)



be confined to a specific geographic area.<sup>169</sup> Other limitations on program licenses—such as the prohibition on product development and market trials, and the unavailability of non-disclosure protection of the experimental licensee’s proprietary information—may not be conducive to the process for developing equipment that could operate above 95 GHz.<sup>170</sup> We believe it important that innovation licensee be guaranteed non-disclosure of proprietary information in the largely uncharted spectrum range above 95 GHz – otherwise, they would likely be much less inclined to experiment. We seek comment on this approach.

## 2. Proposal for “Spectrum Horizons Experimental Radio Licenses”

68. Because of the potential for innovation above 95 GHz, and the unique nature of this spectrum (e.g., limited propagation and virtually no existing operations), we believe that certain experimental requirements can be relaxed or modified without creating an unacceptable risk of interference or undermining our longstanding general policies related to the marketing and authorization of equipment. Additionally, we observe that our Office of Engineering and Technology (OET) has received a number of informal inquiries requesting guidance as to the rules applicable to technologies and services that operate above 95 GHz. These inquiries pertain to both licensed and unlicensed services, and some involve the use of frequencies far above what has traditionally been defined as the radio spectrum.<sup>171</sup> We believe that establishing a new ERS license focused solely on this largely uncharted area of the spectrum can provide us assistance in establishing the most appropriate rules for use of that spectrum in the long term. Accordingly, we seek comments on a proposal to create an experimental radio license for authorizing operation on frequencies from 95 GHz to 3 THz. In keeping with the current structure of Part 5, we propose to add a new subpart I that would provide specific requirements for “Spectrum Horizons Experimental Radio Licenses” and amend subparts A, B, and C, which are generally applicable to all Part 5 ERS licenses, as necessary. Since these Spectrum Horizons licensees would be subject to unique requirements that, in many cases, reflect existing or modified versions of the requirements associated with other ERS licensees, we believe this would be the best option for providing prospective licensees with clear requirements, while at the same time maintaining existing rules for the various other forms of ERS authorization. We seek comment on the assumptions made above and whether a unique subpart of the ERS rules is warranted.

69. As discussed above, we believe that Spectrum Horizons licenses should have a number of characteristics that differ from existing ERS authorizations, although they would also have a number of characteristics in common. Specifically, we seek comment on the following proposed rules for these Spectrum Horizon licenses.

70. *Marketing.* We recognize that the hallmark of the ERS is to demonstrate the technical viability of new spectrum-using technologies and services. An important component of this is our product developments trials, which permit ERS licensees to evaluate product performance in the conceptual, developmental, and design stages.<sup>172</sup> However, marketing of experimental devices or

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<sup>169</sup> 47 CFR § 5.302(a).

<sup>170</sup> 47 C.F.R. §§ 5.305(c) and (d).

<sup>171</sup> The radio spectrum has traditionally been defined to be 3 kHz to 300 GHz, but in recent years the 300-3000 GHz band has been added by spectrum management authorities, as new technology makes applications of this band possible; see 47 CFR § 2.101. These decimillimetric waves encompass the terahertz range, which begins at 1,000 GHz (1 THz). One promising application of this range is detection and identification of explosives using terahertz pulsed spectroscopic imaging; see <http://pcwww.liv.ac.uk/~ycshen/publications/2005-APL-6-RDX.pdf>.

<sup>172</sup> 47 C.F.R § 5.601.

provision of services for hire under product development trial is currently prohibited.<sup>173</sup> While our rules permit market trials under certain circumstances, ERS licensees may sell equipment only to each other under such trials, rather than to market trial participants, and must also ensure that the number of marketed devices is the minimum necessary to conduct the market trial.<sup>174</sup>

71. In the spectrum range above 95 GHz, we believe that marketing of innovative devices at a relatively early stage of experimentation may be particularly important to permit entrepreneurs to gauge consumer acceptance and to determine whether to proceed to the next stage of the experiment. As operations extend further into the spectrum above 95 GHz, the unique technical issues associated with such operations make capable devices more expensive to produce. Further, these same issues also make it less likely that such devices could be easily adapted for use in the lower spectrum. Thus, entrepreneurs will be reluctant to proceed without a clear signal from consumers that they are interested in purchasing such devices.

72. To encourage wider deployment of new innovative devices, we believe it is appropriate to seek comment on whether and how to loosen our marketing requirements for Spectrum Horizons experiments to permit the sale of equipment to market trial participants and to permit license applicants to specify the number of devices that may be sold. For example, our existing rules for market trials permit the sale of devices only between two licensed parties,<sup>175</sup> which is intended to reduce the risk of interference from uncertified devices that remain with consumers after the trial ends.<sup>176</sup> We believe that the characteristics of the spectrum above 95 GHz (such as the limited propagation capabilities and lack of existing services) warrant a less burdensome regulatory approach. We propose to allow experimental devices used in market trials in these bands to be sold directly to participants to encourage experimentation, as well as to help innovators share device manufacturing costs with potential early adopters who are willing to bear the risks associated with experimental licensing in this range. As a safeguard against such devices causing harmful interference, we will maintain a requirement that the Spectrum Horizons licensee must adhere to the conditions specified in Section 5.602(e) of our rules, which states that “trial devices are either rendered inoperable or retrieved . . . at the conclusion of the trial.”<sup>177</sup> We also propose that the Spectrum Horizons licensee must provide market trial participants with a written disclosure clearly stating that the equipment being purchased is part of an experiment that may be terminated at any time by the licensee or the Commission. Thus, only those individuals who are willing to accept the risk that their devices could be rendered unusable on short notice would be candidates for participating in such market trials. We seek comment on these proposals.

73. In this connection, we propose to require that Spectrum Horizons licensees who choose to market equipment must label any such equipment as “Experimental – Not Authorized for Permanent Use” and carry with it an equipment ID number registered as part of the experimental license process. We note that a Spectrum Horizons license should have no expectation that an experiment will always lead to the establishment of a permanent service. Thus, a Spectrum Horizons licensee who chooses to market a substantial – rather than a limited – amount of equipment would be increasing its financial risk. We seek comment on these marketing proposals, and on any alternatives to them.<sup>178</sup>

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<sup>173</sup> 47 C.F.R. § 5.601(c).

<sup>174</sup> 47 C.F.R. § 5.602(d)(1-3).

<sup>175</sup> 47 CFR 5.601(d). Users are permitted to lease devices operated under an experimental license.

<sup>176</sup> See *Experimental Streamlining Order* at 806-808, paras. 130-136.

<sup>177</sup> 47 C.F.R. § 5.602(e).

<sup>178</sup> Our part 2 equipment authorization rules prohibit the marketing of devices that have not been authorized under the appropriate procedure except under specified exceptions. See 47 CFR § 2.803. Our current rules have an

(continued....)

74. *Eligibility and filing requirements.* We seek comment on whether Spectrum Horizons licenses should be broadly available to qualified persons as generally defined under existing ERS rules.<sup>179</sup> Thus, such licenses would be comparable to conventional licenses, but different from program licenses, in that respect. We believe that permitting broad eligibility is appropriate for Spectrum Horizons licenses, as there may be entrepreneurs not eligible for program licenses who have expertise in above 95 GHz frequencies. However, to obtain a Spectrum Horizons license, we propose that a qualified applicant be required to include a narrative statement that sufficiently explains the proposed new technology/potential new service and that incorporates an interference analysis that explains why the proposed experiment would not cause harmful interference to any other spectrum user. This statement would be similar to the one required of program licensees.<sup>180</sup> The statement should include technical details, including the requested frequency band(s), maximum power, emission designators, area(s) of operation, type(s) of device(s) to be used, and the maximum number of each type of device to be used. We seek comment on these and any other issues that we should require a Spectrum Horizons service applicant to address in its narrative statement.

75. *Available frequencies.* Because all ERS licenses are authorized on a non-interfering basis,<sup>181</sup> and such applications must be coordinated with federal users via NTIA,<sup>182</sup> we propose that subpart I specify that Spectrum Horizons licenses be permitted on any frequency in the range of 95 GHz-3 THz, provided there are no objections raised in the coordination process. Applicants would be expected to address any allocation footnotes and any known use(s) of the requested frequency or frequencies in the spectrum analysis that they would be required to provide in their narrative statements discussed above.<sup>183</sup> Additionally, applicants must ensure that the significant number of passive services that use spectrum above 95 GHz are protected from harmful interference and, if proposing to use spectrum that is exclusive allocated for passive use(s), they must explain why nearby bands that have non-passive allocations are not adequate for the experiment.<sup>184</sup> We seek comment on this proposal. Commenters who propose limitations on available frequencies should identify specific bands where they believe that Spectrum Horizons experiments should be prohibited or restricted, including references to pertinent footnotes listed in the Table of Frequency Allocations. We propose to list in subpart I all bands that we conclude should be prohibited or restricted for Spectrum Horizons experimental use.

76. *Scope of license grant.* Because our goal is to encourage experimentation in a spectrum range that is today very lightly used, we propose to provide Spectrum Horizons licensees with substantial flexibility to conduct long-term experiments over a wide geographic area and frequency range, market equipment if necessary, and adapt their program of experimentation as needed. In making these proposals, we emphasize the overriding considerations that Spectrum Horizons licensees – like all ERS licensees – would have to accept to operate: (1) licensees would be prohibited from causing harmful interference to any established radio service, and would be solely responsible for promptly remedying any such interference; (2) licenses would be non-exclusive; and (3) there would be no assurance that experimentation would lead to the establishment of an authorized service. Otherwise, we ask for

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exception for devices operating pursuant to a part 5 market trial authorization. The proposed rules in Appendix A include an amendment to this section that would expand this exception to include devices operating under a Spectrum Horizons experimental radio license.

<sup>179</sup> 47 CFR §§ 5.3 and 5.51.

<sup>180</sup> 47 CFR § 5.309(a)(1).

<sup>181</sup> 47 C.F.R § 5.84.

<sup>182</sup> See para 28, *supra*.

<sup>183</sup> See para. 74, *supra*.

<sup>184</sup> 47 CFR § 5.85.

comment on what specific technical rules in Subpart C should or should not be applicable to Spectrum Horizons stations.

77. *License term and interim reporting requirement.* We seek comment on whether to extend the experimental license term for Spectrum Horizons licenses and, if so, for how long. Given the many uncertainties that exist with respect to spectrum use above 95 GHz, we believe that a longer license term than the renewable 2-year and 5-year license terms that are currently available to other ERS licenses is necessary to encourage investment in the development of path-breaking new technologies and services in that spectrum region. Would a longer license term, such as 10 years, encourage entrepreneurs to make investments in this portion of the spectrum where there has been relatively minimal experimentation and, thus, limited “real world” experiences to guide the experimental planning process? If we provide longer license terms, we propose to require an interim report be submitted to the Commission at the half-way point of the license term to provide the public with information about the progress of the experiment. We believe that such information could potentially encourage other innovative experimental uses of the above 95 GHz range,<sup>185</sup> and seek comment on this proposal. We also seek comment on whether a longer Spectrum Horizons license would be eligible for renewal. In general, we believe that a license period longer than the current 2- or 5-year term would be useful to help determine whether a proposed new technology or service should be considered in developing new or modified service rules in the future and anticipate that successful, longer-term experiments would yield more useful information and data in support of subsequent petitions or waiver requests to the Commission.<sup>186</sup>

78. *Other aspects.* We wish to provide Spectrum Horizons licensees with maximum flexibility, consistent with ensuring that each experiment operates on a non-harmful interference basis. Accordingly, we seek comment on how best to handle geographic, frequency, or technical limits on experiments, and limits on the number of devices or their type, including whether these limits should be decided on a case-by-case basis. We also seek comment on how applicants should be required to justify their proposed parameters in their narrative statements. In order to avoid the filing of subsequent requests to modify those parameters during the license term, we propose that applicants request the maximum parameters that they may ultimately use, even if their initial plans do not require those maximums. For example, an applicant who intends to experiment on a local or regional basis initially, but who foresees expanding the experiment to a nationwide deployment, should apply for a nationwide license, if that is supportable and can be done on a non-harmful interference bases. We acknowledge that circumstances may change however and would still consider granting applications to modify Spectrum Horizons licenses.

79. To better ensure that Spectrum Horizons experiments do not cause harmful interference, we propose to adopt rules for such experiments similar to our existing “station identification,” “responsible party,” and “stop buzzer” rules.<sup>187</sup> These rules are designed to ensure overall compliance and prompt resolution of any harmful interference. However, consistent with our rules for conventional experimental licenses,<sup>188</sup> we propose to permit Spectrum Horizons licenses to be transferred, if the

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<sup>185</sup> Licensees may request that all or portions of the interim progress report be withheld from public inspection under routine Commission procedures, which, among other things provide for the protection of trade secrets. *See* 47 CFR 0.459.

<sup>186</sup> We have drafted the proposed rules to reflect a 10-year license term and a 5-year interim progress report requirement, using those proposed durations as placeholders. The Commission will update the final rules to reflect its ultimate determination of the appropriate time periods.

<sup>187</sup> These rules are intended to ensure that if an experiment causes harmful interference, the entity experiencing such interference can immediately contact the experimenter; *see* 47 C.F.R §§ 5.115, 5.307, 5.308.

<sup>188</sup> 47 C.F.R § 5.79(a).

Commission finds that to be in the public interest and gives its consent in writing. While we do not permit the transfer of program, medical testing, or compliance testing licenses,<sup>189</sup> we believe that permitting Spectrum Horizons licenses to be transferred could encourage entrepreneurs to initiate high risk/high reward experiments that they would otherwise not undertake because of the potential to reap significant financial gains by transferring an Spectrum Horizons license to a large company. Comments are requested on each of these proposals.

#### **D. RF Exposure Limits**

80. RF devices must comply with the Commission's RF exposure limits.<sup>190</sup> These limits are currently specified up to 100 GHz, while the radio spectrum is managed up to 3,000 GHz (3 THz). The power density limits specified for general population and occupational exposure at 100 GHz are 1 mW/cm<sup>2</sup> and 5 mW/cm<sup>2</sup> respectively for whole-body continuous exposure.<sup>191</sup> We note that these limits could in principle be applied up to infrared wavelengths, although we do not suggest that there should be any particular changes to our rules at this time. We also note that the issues of averaging area and averaging time for localized and time varying exposure are the subject of ongoing consideration at lower frequencies in the context of developing laboratory test procedures for specific devices.<sup>192</sup> However, the Commission has an open proceeding in which it is broadly examining its RF exposure rules and policies, which could potentially influence how such devices are authorized in the future.<sup>193</sup> In the *RF Inquiry* of that separate open proceeding, the Commission specifically asks whether it should expand the frequency scope of its exposure rules above the present maximum of 100 GHz.<sup>194</sup> We propose that the Commission make no changes to its present rules limiting human exposure to RF energy until it considers the broader issues brought forth in its *RF Inquiry*.<sup>195</sup>

#### **E. Equipment Authorization Matters**

81. As we have noted previously in the Spectrum Frontiers proceeding, there are unique technical challenges specific to demonstrating compliance with our rules for the purpose of equipment authorization of millimeter-wave devices.<sup>196</sup> As we push the boundaries of traditional spectrum use, we likewise brush against the outermost technical limits of readily available measurement equipment, and

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<sup>189</sup> 47 C.F.R. § 5.79(b).

<sup>190</sup> See 47 C.F.R. § 1.1310. See also 47 C.F.R. §§ 1.1307(b) (for fixed), 2.1091 (for mobile), and 2.1093 (for portable).

<sup>191</sup> 47 CFR § 1.1310.

<sup>192</sup> *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd 8014, 8139-43, paras. 356-363 (2016).

<sup>193</sup> 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, ET Docket Nos. 13-84, 03-137, *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).

<sup>194</sup> See *RF Inquiry* at para 229 "... we request comment on whether, in addition to the limits already established for RF fields between 100 kHz and 100 GHz, we should also explore actions to control exposure outside of this frequency range (e.g., in the range between 0 and 100 kHz and/or 100 and 300 GHz) due to sources authorized by the Commission. We note that some wireless inductive chargers operate at frequencies below our current frequency scope, and all terahertz (THz) sources operate at frequencies above our current frequency scope." 28 FCC Rcd 3580 (2013).

<sup>195</sup> See generally *RF Inquiry*, 28 FCC Rcd at 3570 ¶ 205. Thus, comments regarding RF exposure in the above 95 GHz bands should be filed in the *RF Inquiry* proceeding.

<sup>196</sup> R&O at 8139, paras. 354-355 and NPRM at 11971-72, paras. 319-320.

(continued...)

have little experience as to what measurement guidelines and standards are best suited for these frequencies.<sup>197</sup> As technology evolves to address the technical challenges related to perform compliance measurements above 95 GHz (with respect to propagation, interference protection, modulation techniques, transmission security, etc.), we expect that OET, in its capacity as the technical administrator of the Commission's Part 2, 5, 15 and 18 rules, will provide guidance on appropriate measurement techniques through its knowledge database publications as products are developed, seeking notice and comment as appropriate.<sup>198</sup> To inform this guidance, we generally request information on relevant research as we address measurement techniques to verify that devices meet the electromagnetic compatibility (EMC) technical rules; we discuss specific concerns in more detail below.

82. *EMC measurements.* In this Notice, we have sought comment on what technical rules (including, e.g., RF power (radiated and conducted), antenna standards, bandwidth limits and out-of-band emission limits) should apply to operation in spectrum above 95 GHz. At this time, the FCC laboratory has offered generally limited guidance related to the technical procedures that could be used to demonstrate the compliance of millimeter-wave devices with such rules. We recognize that radiated field strength measurements at frequencies above 1 GHz present challenges due to the relatively high values of cable loss and antenna factor.<sup>199</sup> Similarly, a conducted method of measurement would only be effective if the device and other mixer waveguides are both accessible. We seek information on fundamental aspects of measurements of radiated and conducted emissions at these frequencies. What are ways to demonstrate compliance with procedures which are practical, repeatable, and do not have large margins of error? Specifically, Sections 15.255 and 15.257 of our rules apply to the use of an RF detector that has been specified to make millimeter-wave measurements. Is the use of an RF detector an appropriate method for measuring the frequencies above 95 GHz? Are there industry measurement standards available for RF devices operating above 95 GHz?<sup>200</sup> We seek further comment on whether and how present procedures can be adapted or modified to appropriately address the specific technical challenges presented by millimeter-wave devices.

83. *Out-of-band and spurious emissions measurement.* Conventionally, out-of-band and spurious emissions are verified by direct measurement of conducted power at an output port, which avoids the additional losses and uncertainties associated with field measurements.<sup>201</sup> However, devices that operate above 95 GHz may not have an output port, primarily due to the manner in which the antennas in the array will be fed. At the present time, the FCC laboratory guidance does offer a procedure

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<sup>197</sup> See Mark Terrien, "Millimeter-wave Emissions Measurement Challenges for FCC Intentional Radiator compliance," 2016 IEEE International Symposium on Electromagnetic Compatibility (EMC), July 2016. See also, draft Harmonised European Standard ETSI EN 305 550 v2.1.0 (2017-10) entitled "Short Range Devices (SRD); Radio equipment to be used in the 40 GHz to 246 GHz frequency range; Harmonised Standard for access to radio spectrum," at 26-27, discussing measurement uncertainties at higher frequencies, noting that "'Standard' measurement equipment is only available up to a frequency range of around 110 GHz."

<sup>198</sup> For example, if standard bodies subsequently adopt measurement guidelines that are specific to these frequencies, we expect that the Commission will take appropriate rulemaking action to evaluate whether the public interest would be served by incorporating such guidelines into applicable rules.

<sup>199</sup> See annex E of ANSI C63.10-2013.

<sup>200</sup> See KDB Publication 200443. Procedures for testing millimeter-wave systems are provided in clause 9 ANSI C63.10-2013. ASC C63-EMC has initiated a project to update ANSI C63.26 to include millimeter wave measurement procedures. [http://www.c63.org/documents/misc/matrix/c63\\_standards.htm](http://www.c63.org/documents/misc/matrix/c63_standards.htm)

<sup>201</sup> For licensed devices, measurement procedures are described in 47 CFR §§ 2.1051 and 2.1053. For unlicensed devices, measurement procedures are described in 47 CFR § 15.31.

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to measure the out-of-band and spurious emissions from devices with multiple antennas.<sup>202</sup> The measurement challenges discussed above are often accentuated in the case of out-of-band and spurious emissions due to the low levels of these emissions relative to the fundamental emissions.<sup>203</sup> We seek comment on what other measurement procedures, such as those in ANSI C63.10-2013, may be used and whether we need to provide additional guidance (e.g., appropriate measurement bandwidth, cut-off frequency, etc.) to determine compliance with the out-of-band and spurious emission limits for millimeter-wave devices considering the technical challenges of such measurements.

84. *Equipment authorization procedures.* We have proposed to use parallel existing 70/80/90 service rules for the bands we are proposing for fixed services<sup>204</sup> and similarly adapt our UMFUS rules for the bands we are proposing for mobile services.<sup>205</sup> Transmitters used for operation in accordance with our Part 101 Fixed Microwave Services rules are generally authorized via our Suppliers Declaration of Conformity (SDoC) procedure.<sup>206</sup> Transmitters used for Part 30 UMFUS mobile operations are required to be authorized via the certification procedure.<sup>207</sup> We seek comment on which equipment authorization procedure would be most appropriate for any fixed or mobile service adopted under the proposals set forth herein, or whether some other authorization procedure would be more appropriate.

#### **F. Rulemaking and Waiver Petitions**

85. *Battelle Petition.* Battelle Memorial Institute, Inc. (Battelle) filed a petition for rulemaking in February 2014 asking the Commission to commence a rulemaking to propose service rules for fixed use of the 102-109.5 GHz band.<sup>208</sup> Battelle's proposed rules draw extensively from the 70/80/90 GHz rules.<sup>209</sup> The rules we are proposing for the 102-109.5 GHz band and other bands above 95 GHz differ only slightly from what Battelle has proposed. For example, Battelle has suggested a transmitted EIRP limit of 70 dBW and a loading requirement of 1 bps/Hz while we are proposing an EIRP density of 75 dBm/MHz and a loading requirement of 0.125 bps/Hz.<sup>210</sup> Because the rules we are proposing for the 102-109.5 GHz band are similar to what Battelle has proposed, we consider their rulemaking petition granted in part. Battelle and other interested parties are able to participate in this rulemaking and will have ample opportunity to comment on the rules we have proposed and therefore we dismiss Battelle's petition from further consideration.

86. *ZenFi Waiver.* ZenFi Networks, Inc. (ZenFi), which holds a nationwide, non-exclusive license under call sign WQUN758 in the 71-76 GHz, 81-86 GHz, and 92-95 GHz bands,<sup>211</sup> seeks a waiver of the applicable Part 1 and Subpart Q of Part 101 rules to permit use of the 102-109.5 GHz band under

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<sup>202</sup> See KDB Publication 662911 D01 at 4.

<sup>203</sup> The challenges in measuring out-of-band and spurious emissions from millimeter wave devices are the result of the sensitivity of the measurement instrumentation resulting from the harmonic mixer conversion losses, small effective aperture of the measurement antennas at millimeter-wave frequencies and the system noise levels of the measurement receiver (e.g., spectrum analyzer).

<sup>204</sup> Paras. 28-40, *supra*.

<sup>205</sup> Paras 41-42, *supra*.

<sup>206</sup> 47 CFR § 101.39.

<sup>207</sup> 47 CFR 30.201(a).

<sup>208</sup> Petition of Battelle Memorial Institute, Inc. for Rulemaking, RM-11713 (Feb. 6, 2014) (*Battelle Petition*).

<sup>209</sup> *Battelle Petition* at 5.

<sup>210</sup> *Battelle Petition* at 11-12.

<sup>211</sup> Call Sign WQUN758.

its existing license and to register individual point-to-point links at locations within the New York City, Chicago, Washington, DC, and San Francisco metropolitan markets using the regulatory framework established for registering links in the 70/80/90 GHz bands.<sup>212</sup> ZenFi seeks to use the 102-109.5 GHz band to provide high-speed, low latency point-to-point data streams with high reliability to users that demand a wireless solution with the high bandwidth of fiber, including for local area networks and broadband Internet access.<sup>213</sup> ZenFi also argues that its wireless links can be used to provide diverse and resilient backhaul solutions for customers located in each of the New York City, Chicago, DC, and San Francisco metropolitan areas.<sup>214</sup> ZenFi argues that grant of its waiver request will make the newly developed technology available for commercial use in the near term in the four identified metropolitan markets while the Commission considers amending the rules in accordance with Battelle's rulemaking petition.<sup>215</sup> ZenFi states that it understands that grant of its waiver request will serve as a pre-requisite for coordinating and registering individual point-to-point links in the 102-109.5 GHz band in the four identified markets and that its use of the 102-109.5 GHz band would continue pending resolution of the Battelle rulemaking proceeding.<sup>216</sup>

87. ZenFi notes that fixed use of the 102-109.5 GHz band is allocated on a co-primary basis with the RAS and fixed use of the 105-109.5 GHz segment of the band is allocated on a co-primary basis with space research (passive).<sup>217</sup> ZenFi believes that use of the band for these services is limited, thus allowing a fixed terrestrial service such as ZenFi's to be introduced without adverse impact.<sup>218</sup> ZenFi does not expect any future RAS observatories to be located in close proximity to the four metropolitan areas identified in its waiver request such that RAS observations in the 102-109.5 GHz band would be affected.<sup>219</sup> ZenFi offers to protect the operations of the radio astronomers, noting that under the proposed coordination and link registration approach described in its waiver request, its use of the 102-109.5 GHz band, which will be limited to the four identified metropolitan areas, will not interfere with the current and planned observations by RAS.<sup>220</sup>

88. ZenFi asserts that its requests meets our waiver standard under Section 1.3 and under the first prong of Section 1.925.<sup>221</sup> First, ZenFi contends that grant of the requested waiver would not frustrate the underlying purpose of the relevant part of Subpart Q of Part 101 of the Commission rules.<sup>222</sup> According to ZenFi, Subpart Q of Part 101 was adopted to establish service rules to promote non-Federal development and use of the "millimeter wave" spectrum on a shared basis with Federal Government operations and the rules were likewise adopted to implement a flexible and innovative regulatory framework for the 71-95 GHz bands to streamline the administrative process for non-Federal Government

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<sup>212</sup> Request for Waiver, ZenFi Networks, Inc., WT Docket 15-245(filed July 22, 2015).

<sup>213</sup> ZenFi Waiver Request at 5.

<sup>214</sup> ZenFi Waiver Request at 5.

<sup>215</sup> ZenFi Waiver Request at 3.

<sup>216</sup> ZenFi Waiver Request at 3. ZenFi understands the current system used to register links in the 70/80/90 GHz band is fully automated and that grant of this waiver will not result in the current system being modified to include within the fully automated process the 102-109.5 GHz band. ZenFi Waiver Request at 9.

<sup>217</sup> ZenFi Waiver Request at 2.

<sup>218</sup> ZenFi Waiver Request at 2.

<sup>219</sup> ZenFi Waiver Request at 3.

<sup>220</sup> ZenFi Waiver Request at 3.

<sup>221</sup> ZenFi Waiver Request at 11.

<sup>222</sup> ZenFi Waiver Request at 11.

(continued....)



users in the band.<sup>223</sup> ZenFi argues that grant of its waiver “will continue to serve the underlying purpose of this rule and extend its reach to the four identified markets in the 102-109.5 GHz band, a band that is largely fallow, already allocated for fixed use on a co-primary basis, and has the 7.5 GHz of contiguous bandwidth necessary to support 10GE service.”<sup>224</sup> Second, ZenFi states that grant of its waiver is in the public interest because it will address the growing demand for reliable, interference-free wireless links capable of delivering 10GE.<sup>225</sup> ZenFi notes that the cost to deploy fiber optic cable is highly variable and that, in urban areas, the cumulative cost of rights of ways, permits, construction, and installation are often prohibitive for new or smaller user sites.<sup>226</sup>

89. On October 13, 2015, the Commission’s Wireless Telecommunications Bureau released a public notice seeking comment on the ZenFi Waiver Request.<sup>227</sup> Battelle and SMG Holdings, LLC (SMG) support grant of the ZenFi Waiver Request,<sup>228</sup> and SMG asks that the Commission extend to it any relief granted to ZenFi.<sup>229</sup> Battelle argues that “[p]ermitting use of the 102-109.5 GHz band by ZenFi and McKay during the pendency of the . . . [rulemaking] will begin to address the growing commercial demand for wireless links capable of delivering 10 gigabit/second Ethernet service, particularly in areas where fiber is not available or deployment is not economically feasible.”<sup>230</sup> SMG states that the 100 GHz band could provide much needed additional spectrum for 70/80/90 GHz licensees to expand their network coverage and capacity through the registration of new 100 GHz band links along point-to-point routes that currently are congested in the 70/80/90 GHz band and that this would enable licensees to provide their customers with greater capacity along the paths facing the most customer demand.<sup>231</sup> CORF also does not oppose waivers for fixed terrestrial use of the 102-109.5 GHz band in the specific geographic areas named in the waiver requests, as long as the waivers are conditioned on protecting RAS observations from interference, as proposed in the waiver requests.<sup>232</sup> DRW Trading Group (DRW) supports authorization of service in the 102-109.5 GHz band, but suggests that a rulemaking proceeding would be

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<sup>223</sup> ZenFi Waiver Request at 11-12.

<sup>224</sup> ZenFi Waiver Request at 12.

<sup>225</sup> ZenFi Waiver Request at 12.

<sup>226</sup> ZenFi Waiver Request at 12.

<sup>227</sup> Wireless Telecommunications Bureau Seeks Comment on Requests of ZenFi Networks, Inc. and Geneva Communications, LLC for Waiver to Authorize Service in the 102.109.5 GHz Band, WT Docket No. 15-245, *Public Notice*, 30 FCC Rcd 10965 (WTB 2015).

<sup>228</sup> Comments of Battelle Memorial Institute, Inc., WT Docket No. 15-245 (filed Nov. 12, 2015) (Battelle Comments); Comments of SMG Holdings, LLC, WT Docket No. 15-245 (filed Nov. 12, 2015) (SMG Comments); *see also* Reply Comment of ZenFi Networks, Inc., WT Docket No. 15-245 (filed Nov. 30, 2015) (ZenFi Reply Comments).

<sup>229</sup> SMG Comments at 3 (also noting that grant of all three waiver requests will maintain competitive parity between the applicants with respect to access to spectrum resources). Because we deny the ZenFi Waiver Request, we need not consider granting waiver relief to SMG.

<sup>230</sup> Battelle Comments at 4. Battelle believes that “[i]f a user’s needs change, wireless links can be moved or repurposed relatively quickly and at a cost that is significantly less than for moving or changing fiber infrastructure (assuming that such fiber even can be moved or changed). It will also provide useful information about how this technology works in practice to the Commission as it considers rule changes for the band.” *Id.*

<sup>231</sup> SMG Comments at 3.

<sup>232</sup> Comments of the National Academy of Sciences, Committee on Radio Frequencies, WT Docket No. 15-245 (filed Nov. 30, 2015) (CORF Waiver Comments).

(continued....)

the most appropriate vehicle for authorizing service in the band.<sup>233</sup>

90. Generally, the Commission may waive any rule for good cause shown.<sup>234</sup> Waiver is appropriate where the particular facts make strict compliance inconsistent with the public interest.<sup>235</sup> In making this determination, we may take into account considerations of hardship, equity, or more effective implementation of overall policy on an individual basis.<sup>236</sup> Waiver is therefore appropriate if special circumstances warrant a deviation from the general rule, such deviation will serve the public interest, and the waiver does not undermine validity of the general rule.<sup>237</sup> We deny the ZenFi Waiver Request and SMG's informal request seeking waiver to use the 102-109.5 GHz band because ZenFi and SMG have not met the standard for a waiver and grant of a waiver would improperly judge the outcome of the rulemaking proceeding we have begun with this NPRM. First, ZenFi has failed to justify a waiver based on special circumstances because there is nothing unique or unusual about its situation. It is no different than any other operator who has potential interest in using the above 95 GHz bands, and has not demonstrated a need to use this band that cannot be met by deployment in another band. Second, ZenFi has not shown that a deviation from the general rule would be in the public interest. Although ZenFi generally discusses its intent to address the growing demand for wireless links capable of delivering 10GE, it fails to reference a specific proposed deployment that would require a waiver, or discuss the extent to which its proposed deployments could not be reasonably achieved on other spectrum. ZenFi has also failed to distinguish itself from any other party who would potentially be interested in using the 102-109.5 GHz band.<sup>238</sup> ZenFi also fails to satisfy the third prong, because a waiver grant here would essentially replace the current rulemaking process, undermining the validity of that final rule.<sup>239</sup> This is particularly true in this band where we lack any actual service, licensing, or technical rules. What ZenFi is requesting is not a waiver of the existing rules, but the authority to operate absent any established rules governing the operations. As noted above, there are a series of issues that we must decide before we authorize service in the 102-109.5 GHz band and develop service rules for that band, including whether to adopt the existing 70/80/90 GHz licensing regime for this band. We do not believe that it would be a prudent policy to subject licensees and their customers to this potential disruption, particularly in the absence of any specific, demonstrated need for interim operation in the band. While we may ultimately adopt rules similar to what Battelle has proposed, ZenFi (and SMG) have not justified the need for a waiver prior to our developing a full record on the proposed changes.

91. *McKay Brothers Waiver.* McKay Brothers has requested that if the Commission were not to issue a notice of proposed rulemaking regarding Battelle's petition, we should consider granting a

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<sup>233</sup> See Letter from Cory Feign, DRW Trading Group, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 15-245 (filed Dec. 4, 2015).

<sup>234</sup> 47 CFR § 1.3.

<sup>235</sup> *Northeast Cellular Tel. Co. v. FCC*, 897 F.2d 1164, 1166 (D.C. Cir. 1990).

<sup>236</sup> *WAIT Radio v. FCC*, 418 F.2d 1153, 1159 (D.C. Cir. 1969), *cert. denied*, 409 U.S. 1027 (1972); *Northeast Cellular*, 897 F.2d at 1166.

<sup>237</sup> *NetworkIP, LLC v. FCC*, 548 F.3d 116, 125-28 (D.C. Cir. 2008); *Northeast Cellular*, 897 F.2d at 1166; *WAIT Radio*, 418 F.2d at 1158.

<sup>238</sup> Indeed, SMG requested that, in order to maintain competitive parity among 70/80/90 GHz licensees, the Commission grant SMG similar relief to the extent it granted the ZenFi Waiver Request. See SMG Comments at 3.

<sup>239</sup> See *WAIT Radio*, 418 F.2d at 1159 (an agency's obligation to give meaningful consideration to requests for waiver of its rules does not contemplate that the agency must or should tolerate evisceration of a rule by waivers).

(continued....)

waiver of the Commission's rules to permit operations similar to ZenFi's waiver request.<sup>240</sup> Because we have deemed Battelle's rulemaking petition granted-in-part, we shall likewise consider McKay Brothers request granted-in-part and dismiss it from further considerations.

#### IV. PROCEDURAL MATTERS

##### A. *Ex Parte* Rules – Permit-but-disclose

92. Pursuant to Section 1.1200(a) of the Commission's rules,<sup>241</sup> this NPRM shall be treated as a "permit-but-disclose" proceeding in accordance with the Commission's *ex parte* rules.<sup>242</sup> 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

93. 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).

- 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 12<sup>th</sup> St., SW, Room TW-A325, Washington, DC 20554. The filing hours are 8:00 a.m. to 7:00 p.m. All hand deliveries

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<sup>240</sup> McKay Brothers, LLC, *Ex Parte* Support of Petition for Rulemaking or, In the Alternative, Request for Waiver (filed Aug. 10, 2015).

<sup>241</sup> 47 CFR § 1.1200(a).

<sup>242</sup> 47 CFR §§ 1.1200 *et seq.*

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 9050 Junction Drive, Annapolis Junction, MD 20701.
- U.S. Postal Service first-class, Express, and Priority mail must be addressed to 445 12<sup>th</sup> Street, SW, Washington DC 20554.

94. 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](mailto:fcc504@fcc.gov) or call the Consumer & Governmental Affairs Bureau at 202-418-0530 (voice), 202-418-0432 (tty).

95. Availability of Documents. Comments, reply comments, and *ex parte* submissions will be publicly available online via ECFS.<sup>243</sup> These documents will also be available for public inspection during regular business hours in the FCC Reference Center, Federal Communications Commission, 445 12<sup>th</sup> Street, SW, CY-A257, Washington, DC, 20554. The Reference Information Center is open to the public Monday through Thursday from 8:00 a.m. to 4:30 p.m. and Friday from 8:00 a.m. to 11:30 a.m.

### C. Initial Regulatory Flexibility Analysis

96. As required by the Regulatory Flexibility Act of 1980 (RFA),<sup>244</sup> as amended, the Commission has prepared an Initial Regulatory Flexibility Analysis (IRFA) regarding the possible significant economic impact on small entities of the policies and rules adopted in the *Notice of Proposed Rulemaking*, which is found in Appendix C. 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 *NRPM* and must have a separate and distinct heading designating them as responses to the IRFA. The Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, will send a copy of the *Notice*, including the IRFA, to the Chief Counsel for Advocacy of the Small Business Administration.<sup>245</sup>

### D. Paperwork Reduction Analysis

97. This document contains proposed new 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 (OMB) 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.

### E. Further information

98. For further information, contact Michael Ha of the Office of Engineering and Technology, Policy and Rules Division, at 202-418-2099 or [Michael.Ha@fcc.gov](mailto:Michael.Ha@fcc.gov).

## V. ORDERING CLAUSES

99. IT IS ORDERED, pursuant to the authority found in Sections 1, 2, 4, 7, 201, 301, 302a, 303, 307, 310, and 332 of the Communications Act of 1934, 47 U.S.C. §§ 151, 152, 154, 157, 201, 301, 302a, 303, 307, 310, 332, Section 706 of the Telecommunications Act of 1996, as amended, 47 U.S.C.

<sup>243</sup> Documents will generally be available electronically in ASCII, Microsoft Word, and/or Adobe Acrobat.

<sup>244</sup> *See* 5 U.S.C. § 603.

<sup>245</sup> *See* 5 U.S.C. § 603(a). In addition, the *Notice* and IRFA (or summaries thereof) will be published in the federal Register.

§ 1302, and Section 1.411 of the Commission's Rules, 47 CFR § 1.411, that this *Notice of Proposed Rulemaking and Order* IS HEREBY ADOPTED.

100. IT IS FURTHER ORDERED, pursuant to Section 4(i) of the Communications Act of 1934, 47 U.S.C. § 154(i), and Section 1.925 of the Commission's Rules, that the Requests for Waivers filed by ZenFi Networks, Inc. on July 22, 2015, McKay Brothers, LLC on August 10, 2015, and SMG Holdings, LLC on November 12, 2015 ARE DENIED.

101. IT IS FURTHER ORDERED, pursuant to Section 4(i) of the Communications Act of 1934, 47 U.S.C. § 154(i), and Section 1.407 of the Commission's Rules, that the Petition for Rulemaking of Battelle Memorial Institute, Inc. filed on February 6, 2014 is GRANTED-IN-PART as described herein and IS OTHERWISE DENIED.

102. IT IS FURTHER ORDERED, pursuant to Section 4(i) of the Communications Act of 1934, 47 U.S.C. § 154(i), and Section 1.407 of the Commission's Rules, that the Petition for Rulemaking of James Edwin Whedbee filed on November 5, 2013 is GRANTED-IN-PART as described herein.

103. IT IS FURTHER ORDERED that the Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, SHALL SEND a copy of this *Notice of Proposed Rulemaking*, including the Initial Regulatory Flexibility Analysis, to the Chief Counsel for Advocacy of the Small Business Administration.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch  
Secretary

**APPENDIX A**

**Proposed Rules**

The Federal Communications Commission proposes to amend title 47 of the Code of Federal Regulations, parts 1, 2, 5, 15, and 101, as follows:

**PART 1 – PRACTICE AND PROCEDURE**

1. The authority citation for Part 1 continues to read as follows:

**Authority:** 47 U.S.C. 151, 154(i), 154(j), 155, 225, 303(r), 309 and 325(e).

2. Section 1.1307(b)(1) is amended by revising the last entry of Table 1 as follows:

**§ 1.1307 Actions that may have a significant environmental effect, for which Environmental Assessments (EAs) must be prepared.**

(a) \* \* \* \* \*

(b) (1) \* \* \* \* \*

Service (title 47 CFR rule part)	Evaluation required if:
*	*****
70/80/90 GHz and above 95 GHz Bands (subpart Q of part 101)	Non-building-mounted antennas: height above ground level to lowest point of antenna < 10 m and power > 1640 W EIRP  Building-mounted antennas: power > 1640 W EIRP, licensees are required to attach a label to transceiver antennas that  (1) provides adequate notice regarding potential radiofrequency safety hazards, e. g., information regarding the safe minimum separation distance required between users and transceiver antennas; and  (2) references the applicable FCC-adopted limits for radio-frequency exposure specified in §1.1310.

**PART 2 – FREQUENCY ALLOCATIONS AND RADIO TREATY MATTERS; GENERAL RULES AND REGULATIONS**

3. The authority citation for part 2 continues to read as follows:

**Authority:** 47 U.S.C. 154, 302a, 303, and 336, unless otherwise noted.

4. Section 2.803 is amended by revising paragraph (c)(1) to read as follows:

**§2.803 Marketing of radio frequency devices prior to equipment authorization.**

\* \* \* \* \*

(c) \* \* \*

(1) Activities conducted under market trials pursuant to subpart H of part 5 or in accordance with a Spectrum Horizons experimental radio license issued pursuant to subpart I of part 5.

## **PART 5 – EXPERIMENTAL RADIO SERVICE**

5. The authority citation for Part 5 continues to read as follows:

**Authority:** Secs. 4, 302, 303, 307, 336 48 Stat. 1066, 1082, as amended; 47 U.S.C. 154, 302, 303, 307, 336. Interpret or apply sec. 301, 48 Stat. 1081, as amended; 47 U.S.C. 301.

6. The Table of Contents of Section 5 is amended by adding Subpart I to the end as follows:

Subpart I—Spectrum Horizons Experimental Radio Licenses

§5.701 Applicable rules.

§5.702 Licensing requirement - necessary showing

§5.703 Responsible party

§5.704 Marketing of devices under Spectrum Horizons experimental radio licenses.

§5.705 Supplemental report

7. Section 5.1 is amended by revising paragraph (b) to read as follows:

### **§5.1 Basis and purpose**

\* \* \* \* \*

(b) *Purpose.* The rules in this part provide the conditions by which portions of the radio frequency spectrum may be used for the purposes of experimentation and innovation, product development, and market trials.

\* \* \* \* \*

8. Section 5.3 is amended by revising paragraph (l) and adding paragraph (m) to read as follows:

### **§5.3 Scope of service.**

\* \* \* \* \*

(l) Experimentation in innovative new devices and services that operate on frequencies above 95 GHz

(m) Types of experiments that are not specifically covered under paragraphs (a) through (l) of this section will be considered upon demonstration of need for such additional types of experiments.

9. Section 5.54 is amended by renaming paragraph (f) as paragraph (g) and adding a new paragraph (f) to read as follows:

### **§5.54 Types of authorizations available.**

\* \* \* \* \*

(f) *Spectrum Horizons experimental radio license*. This type of license is issued for the purpose of testing potentially innovative devices and services on frequencies above 95 GHz, where there are no existing service rules.

\* \* \* \* \*

10. Section 5.55 is amended by revising paragraphs (c) and (d) to read as follows:

**§5.55 Filing of applications.**

\* \* \* \* \*

(c) Each application for station authorization shall be specific and complete with regard to the information required by the application form and this part.

(1) Conventional and Spectrum Horizons license and STA applications shall be specific as to station location, proposed equipment, power, antenna height, and operating frequencies.

(2) Broadcast license applicants shall comply with the requirements in subpart D of this part; Program license applicants shall comply with the requirements in subpart E of this part; Medical Testing license applicants shall comply with the requirements in subpart F of this part; Compliance Testing license applicants shall comply with the requirements in subpart G of this part; and Spectrum Horizons license applicants shall comply with the requirements in subpart I of this part

(d) Filing conventional, program, medical, compliance testing, and Spectrum Horizons experimental radio license applications:

(1) Applications for radio station authorization shall be submitted electronically through the Office of Engineering and Technology Web site <http://www.fcc.gov/els>.

(2) Applications for special temporary authorization shall be filed in accordance with the procedures of §5.61.

(3) Any correspondence relating thereto that cannot be submitted electronically shall instead be submitted to the Commission's Office of Engineering and Technology, Washington, DC 20554.

\* \* \* \* \*

11. Section 5.59 is amended by revising paragraph (a) to read as follows:

**§5.59 Forms to be used.**

(a) *Application for conventional, program, medical, compliance testing, and Spectrum Horizons experimental radio licenses.* (1) *Application for new authorization or modification of existing authorization.* Entities must submit FCC Form 442.

\* \* \* \* \*

12. Section 5.71 is amended by adding paragraph (d) to read as follows:

**§5.71 License period.**

\* \* \* \* \*

(d) *Spectrum Horizons experimental radio license.* Licenses are issued for a term of 10 years.

Section 5.79 is amended by revising section title and adding paragraph (c) as follows



**§ 5.79 Transfer and assignment of station authorization for conventional, program, medical testing, Spectrum Horizons, and compliance testing experimental radio licenses.**

\* \* \* \* \*

(c) A station authorization for a Spectrum Horizons experimental radio license, the frequencies authorized to be used by the grantee of such authorization, and the rights therein granted by such authorization shall be transferred, assigned, or in any manner either voluntarily or involuntarily disposed of, if the Commission decides that such a transfer is in the public interest and gives its consent in writing.

13. Section 5.107 is amended by adding paragraph (f) to read as follows:

**§5.107 Transmitter control requirements.**

\* \* \* \* \*

(f) *Spectrum Horizons experimental radio licenses.* The licensee shall ensure that transmissions are in conformance with the requirements in subpart I of this part and that the station is operated only by persons duly authorized by the licensee.

14. Section 5.115 is amended by adding paragraph (d) to read as follows:

**§5.115 Station identification.**

\* \* \* \* \*

(d) *Spectrum Horizons experimental radio licenses.* Spectrum Horizons experimental radio licenses shall transmit identifying information sufficient to identify the license holder and the geographic coordinates of the station. This information shall be transmitted at the end of each complete transmission except that: this information is not required at the end of each transmission for projects requiring continuous, frequent, or extended use of the transmitting apparatus, if, during such periods and in connection with such use, the information is transmitted at least once every thirty minutes. The station identification shall be transmitted in clear voice or Morse code. All digital encoding and digital modulation shall be disabled during station identification.

15. Section 5.121 is amended by revising paragraph (a) to read as follows:

**§5.121 Station record requirements.**

(a) For conventional, program, medical testing, compliance testing, and Spectrum Horizons experimental radio stations, the current original authorization or a clearly legible photocopy for each station shall be retained as a permanent part of the station records, but need not be posted. Station records are required to be kept for a period of at least one year after license expiration.

\* \* \* \* \*

16. Subpart I is added to Part 5 as follows:

**Subpart I—Spectrum Horizons Experimental Radio Licenses**

17. A new Section 5.701 is added as follows:

**§5.701 Applicable rules.**

In addition to the rules in this subpart, Spectrum Horizons experimental radio station applicants and licensees shall follow the rules in subparts B and C of this part. In case of any conflict between the rules set forth in this subpart and the rules set forth in subparts B and C of this part, the rules in this subpart shall govern.

18. A new Section 5.702 is added as follows:

**§5.702 Licensing requirement – necessary showing**

Each application must include a narrative statement describing in detail how its experiment could lead to the development of innovative devices and/or services on frequencies above 95 GHz. This statement must sufficiently explain the proposed new technology/potential new service and incorporate an interference analysis that explains why the proposed experiment would not cause harmful interference to any other spectrum user. The statement should include technical details, including the requested frequency band(s), maximum power, emission designators, area(s) of operation, type(s) of device(s) to be used, and the maximum number of each type of device to be used.

19. A new Section 5.703 is added as follows:

**§5.703 Responsible party.**

- (a) Each program experimental radio applicant must identify a single point of contact responsible for all experiments conducted under the license and ensuring compliance with all applicable FCC rules.
- (b) The responsible individual will serve as the initial point of contact for all matters involving interference resolution and must have the authority to discontinue any and all experiments being conducted under the license, if necessary.
- (c) The license application must include the name of the responsible individual and contact information at which the person can be reached at any time of the day; this information will be listed on the license. Licensees are required to keep this information current.

20. A new Section 5.704 is added as follows:

**§5.704 Marketing of devices under Spectrum Horizons experimental radio licenses.**

Unless otherwise stated in the instrument of authorization, devices operating in accordance with a Spectrum Horizons experimental radio license may be marketed subject to the following conditions:

- (a) Marketing of devices (as defined in §2.803 of this chapter) and provision of services for hire is permitted before the radio frequency device has been authorized by the Commission, provided that the number of devices to be marketed shall be the minimum quantity of devices necessary to conduct the experiment as approved by the Commission.
- (b) Licensees are required to ensure that trial devices are either rendered inoperable or retrieved by them from trial participants at the conclusion of the trial. Licensees are required to notify trial participants in advance that operation of the trial device is subject to this condition.
- (c) The size and scope of the experiment are subject to limitations as the Commission shall establish on a case-by-case basis. If the Commission subsequently determines that the experiment is not so limited, authorization shall be immediately terminated.

21. A new Section 5.705 is added as follows:

**§5.705 Interim report.**

Licensee must submit to the Commission an interim progress report 5 years after grant of its license.

**PART 15 – RADIO FREQUENCY DEVICES**

22. 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.

23. Section 15.205 is amended by revising paragraph (d)(4) to read as follows:

**§ Section 15.205 Restricted bands of operation.**

\* \* \* \* \*

(d) \* \* \*

(4) Any equipment operated under the provisions of §15.253, 15.255, 15.256 in the frequency band 75-85 GHz, §15.257, or §15.258 of this part.

\* \* \* \* \*

24. A new section 15.258 will be added as follows:

**§ 15.258 Operation in the bands 122-123 GHz, 174.8-182 GHz, 185-190 GHz and 244-246 GHz.**

(a) (1) Operation under the provisions of this section is not permitted for equipment used on satellites.

(2) Operation on aircraft is permitted under the following conditions:

(i) when the aircraft is on the ground.

(ii) while airborne, only in closed exclusive on-board communication networks within the aircraft, with the following exceptions:

(A) Equipment shall not be used in wireless avionics intra-communication (WAIC) applications where external structural sensors or external cameras are mounted on the outside of the aircraft structure.

(B) Equipment shall not be used on aircraft where there is little attenuation of RF signals by the body/fuselage of the aircraft. These aircraft include, but are not limited to, toy/model aircraft, unmanned aircraft, crop-spraying aircraft, aerostats, etc.

(b) Emission levels within the 122-123 GHz, 174.8-182 GHz, 185-190 GHz and 244-246 GHz bands shall not exceed the following equivalent isotropically radiated power (EIRP) as measured during the transmit interval:

(1) The average power of any emission shall not exceed 40 dBm and the peak power of any emission shall not exceed 43 dBm; or

(2) 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.

(i) 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) of this section.

(ii) 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) The peak power shall be measured with an RF detector that has a detection bandwidth that encompasses the band of operation, e.g., 122-123 GHz, 174.8-182 GHz, 185-190 GHz or 244-246 GHz, and that 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) Limits on spurious emissions:

(1) The power density of any emissions outside the band of operation, e.g., 122-123 GHz, 174.8-182 GHz, 185-190 GHz or 244-246 GHz, shall consist solely of spurious emissions.

(2) Radiated emissions below 40 GHz shall not exceed the general limits in §15.209.

(3) Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm<sup>2</sup> at a distance of 3 meters.

(4) The levels of the spurious emissions shall not exceed the level of the fundamental emission.

(d) Except as specified paragraph (d)(1) of this section, the peak transmitter conducted output power shall not exceed 500 mW. Depending on the gain of the antenna, it may be necessary to operate the intentional radiator using a lower peak transmitter output power in order to comply with the EIRP limits specified in paragraph (b) of this section.

(1) Transmitters with an emission bandwidth of less than 100 MHz must limit their peak transmitter conducted output power to the product of 500 mW times their emission bandwidth divided by 100 MHz. For the purposes of this paragraph, emission bandwidth is defined as the instantaneous frequency range occupied by a steady state radiated signal with modulation, outside which the radiated power spectral density never exceeds 6 dB below the maximum radiated power spectral density in the band, as measured with a 100 kHz resolution bandwidth spectrum analyzer. The center frequency must be stationary during the measurement interval, even if not stationary during normal operation (e.g., for frequency hopping devices).

(2) Peak transmitter conducted output power shall be measured with an RF detector that has a detection bandwidth that encompasses the band of operation, e.g., 122-123 GHz, 174.8-182 GHz, 185-190 GHz or 244-246 GHz, and that has a video bandwidth of at least 10 MHz.

(3) For purposes of demonstrating compliance with this paragraph, corrections to the transmitter conducted output power may be made due to the antenna and circuit loss.

(e) *Frequency stability.* Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the temperature

range -20 to + 50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

(f) Regardless of the power density levels permitted under this section, devices operating under the provisions of this section are subject to the radiofrequency radiation exposure requirements specified in §§1.1307(b), 2.1091 and 2.1093 of this chapter, as appropriate. Applications for equipment authorization of devices operating under this section must contain a statement confirming compliance with these requirements for both fundamental emissions and unwanted emissions. Technical information showing the basis for this statement must be submitted to the Commission upon request.

(g) Any transmitter that has received the necessary FCC equipment authorization under the rules of this chapter may be mounted in a group installation for simultaneous operation with one or more other transmitter(s) that have received the necessary FCC equipment authorization, without any additional equipment authorization. However, no transmitter operating under the provisions of this section may be equipped with external phase-locking inputs that permit beam-forming arrays to be realized.

(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 101 – FIXED MICROWAVE SERVICES**

25. The authority citation for Part 101 continues to read as follows:

**Authority: 47 U.S.C. 154 and 303.**

26. Section 101.63 is amended by revising paragraph (b) to read as follows:

**§ 101.63 Period of construction; certification of completion of construction.**

\* \* \* \* \*

(b) For the 71-76 GHz, 81-86 GHz, 92-95 GHz, 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz bands, the 12-month construction period will commence on the date of each registration of each individual link; adding links will not change the overall renewal period of the license.

\* \* \* \* \*

27. Section 101.101 is amended by adding ten new entries in numerical order to read as follows:

**§ 101.101 Frequency Availability.**

Frequency band (MHz)	Radio Service				
	Common carrier (Part 101)	Private radio (Part 101)	Broadcast auxiliary (Part 74)	Other (Parts 15, 21, 22, 24, 25, 74, 78 & 100)	Notes
*	*	*	*	*	**
95,000-100,000	CC.....	OFS.....	.....	25	F/M/TF

Frequency band (MHz)	Radio Service				
	Common carrier (Part 101)	Private radio (Part 101)	Broadcast auxiliary (Part 74)	Other (Parts 15, 21, 22, 24, 25, 74, 78 & 100)	Notes
102,000-109,500	CC.....	OFS.....	.....	25	F/M/TF
111,800-114,250	CC.....	OFS.....	.....	25	F/M/TF
122,250-123,000	CC.....	OFS.....	.....	25	F/M/TF
130,000-134,000	CC.....	OFS.....	.....	25	F/M/TF
141,000-148,500	CC.....	OFS.....	.....	25	F/M/TF
151,500-158500	CC.....	OFS.....	.....	25	F/M/TF
174,500-174,800	CC.....	OFS.....	.....	25	F/M/TF
231,500-232,000	CC.....	OFS.....	.....	25	F/M/TF
240,00-241,000	CC.....	OFS.....	.....	25	F/M/TF

\* \* \* \* \*

28. Section 101.105(a)(5), (c)(2) is amended as follows:

**§ 101.105 Interference protection criteria.**

(a) \* \* \*

\* \* \* \* \*

(5) 71,000–76,000 MHz; 81,000–86,000 MHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz bands. In these bands the following interference criteria shall apply:

\* \* \* \* \*

(c) \* \* \*

\* \* \* \* \*

(2) \* \* \*

(i) *Co-Channel Interference.* Both side band and carrier-beat, applicable to all bands; the existing or previously authorized system must be afforded a carrier to interfering signal protection ratio of at least 90 dB, except in the 952-960 MHz band where it must be 75dB, and in the 71-76 GHz, 81-86 GHz, 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz bands where the criteria in paragraph (a)(5) of this section applies, and in the 92,000-94,000 MHz and 94,100-95,000 MHz bands, where the criteria in paragraph (a)(6) of this section applies; or

(ii) *Adjacent Channel Interference.* Applicable to all bands; the existing or previously authorized system must be afforded a carrier to interfering signal protection ratio of at least 56 dB, except in the 71-76 GHz, 81-86 GHz, 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz bands where the criteria in paragraph (a)(5) of this section applies, and in the 92-94 GHz and 94-95 GHz bands, where the criteria in paragraph (a)(6) of this section applies.

\* \* \* \* \*

29. Section 101.107(a) is amended by adding ten new entries in numerical order and modifying footnote 8 to the table in paragraph (a) to read as follows:

**§ 101.107 Frequency tolerance.**

(a) \* \* \*

Frequency (MHz)	Frequency tolerance (percent)
*	*
95,000-100,000 <sup>8</sup>	
102,000 to 109,500 <sup>8</sup>	
111,800-114,250 <sup>8</sup>	
122,250-123,000 <sup>8</sup>	
130,000-134,000 <sup>8</sup>	
141,000-148,500 <sup>8</sup>	
151,500-158,500 <sup>8</sup>	
174,500-174,800 <sup>8</sup>	
231,500-232,000 <sup>8</sup>	
240,00-241,000 <sup>8</sup>	

\* \* \*

<sup>8</sup> Equipment authorized to be operated in the 71-76 GHz, 81-86 GHz, 92-95 GHz, 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz bands is exempt from the frequency tolerance requirement noted in the table of paragraph (a) of this section.

\* \* \* \* \*

30. Section 101.109(c) is amended by adding ten new entries in numerical order to read as follows:

**§ 101.109 Bandwidth.**

(a) \* \* \*

\* \* \* \* \*

(c) \* \* \*

Frequency Band (MHz)	Maximum Authorized bandwidth
*	*
95,000 to 100,000	5 GHz
102,000 to 109,500	7.5 GHz
111,800 to 114,250	2.45 GHz
122,250 to 123,000	750 MHz
130,000 to 134,000	4 GHz
141,000 to 148,500	7.5 GHz
151,500 to 158,500	7.5 GHz
174,500 to 174,800	300 MHz
231,500 to 232,000	500 MHz
240,000 to 241,000	1 GHz

\* \* \* \* \*

31. Section 101.111(a)(2) is amended by revising paragraph (v) to read as follows:

**§ 101.111 Emission limitations.**

(a) \* \* \*

\* \* \* \* \*

(2) \* \* \*



\*\*\*\*\*

(v) The emission mask for the 71-76 GHz, 81-86 GHz, 92-95 GHz, 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz bands used in the equation in paragraph (a)(2)(ii) of this section applies only to the edge of each channel, but not to sub-channels established by licensees. The value of P in the equation is for the percentage removed from the carrier frequency and assumes that the carrier frequency is the center of the actual bandwidth used. The value of B will always be 500 MHz. In the case where a narrower sub-channel is used within the assigned bandwidth, such sub-carrier will be located sufficiently far from the channel edges to satisfy the emission levels of the mask. The mean output power used in the calculation is the sum of the output power of a fully populated channel.

\*\*\*\*\*

32. Section 101.113(a) is amended by adding ten entries in numerical order to the table in paragraph (a) to read as follows:

**§ 101.113 Transmitter power limitations.**

(a) \*\*\*\*\*

Frequency band (MHz)	Maximum Allowable EIRP <sup>1 2</sup>	
	Fixed <sup>1 2</sup> (dBW)	Mobile (dBW)
*	*	*
95,000-100,000.....	25 dBW/MHz	25 dBW/MHz
102,000-109,500.....	25 dBW/MHz	25 dBW/MHz
111,800-114,250.....	25 dBW/MHz	25 dBW/MHz
122,250-123,000.....	25 dBW/MHz	25 dBW/MHz
130,000-134,000.....	25 dBW/MHz	25 dBW/MHz
141,000-148,500.....	25 dBW/MHz	25 dBW/MHz
151,500-158,500.....	25 dBW/MHz	25 dBW/MHz
174,500-174,800.....	25 dBW/MHz	25 dBW/MHz
231,500-232,000.....	25 dBW/MHz	25 dBW/MHz
240,000-241,000.....	25 dBW/MHz	25 dBW/MHz

\*\*\*\*\*

33. Section 101.139(h) is amended to read as follows:

**§ 101.139 Authorization of transmitters.**

\*\*\*\*\*

(h) 71-76 GHz; 81-86 GHz, 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz. For equipment employing digital modulation techniques, the minimum bit rate requirement is 0.125 bit per second per Hz.

\*\*\*\*\*

34. Section 101.115 is amended by adding twenty new entries in numerical order to the table in paragraph (b) to read as follows:

**§ 101.115 Directional Antennas.**

(b) \* \* \* \* \*

Frequency (MHz)	Category	Maximum beam width to 3 dB points <sup>1</sup> (included angle in degrees)	Minimum antenna gain (dBi)	Minimum radiation suppression to angle in degrees from centerline of main beam in decibels						
				5° to 10°	10° to 15°	15° to 20°	20° to 30°	30° to 100°	100° to 140°	140° to 180°
*	*	*	*	*	*	*	*	*	*	*
95,000 to 100,000 (co-polar) <sup>15</sup> .	N/A	1.2	43	35	40	45	50	50	55	55
95,000 to 100,000 (cross-polar) <sup>15</sup> .	N/A	1.2	43	45	50	50	55	55	55	55
102,000 to 109,500 (co-polar) <sup>15</sup> .	N/A	1.2	43	35	40	45	50	50	55	55
102,000 to 109,500 (cross-polar) <sup>15</sup> .	N/A	1.2	43	45	50	50	55	55	55	55
111,800 to 114,250 (co-polar) <sup>15</sup> .	N/A	1.2	43	35	40	45	50	50	55	55
111,800 to 114,250 (cross-polar) <sup>15</sup> .	N/A	1.2	43	45	50	50	55	55	55	55
122,250 to 123,000 (co-polar) <sup>15</sup> .	N/A	1.2	43	35	40	45	50	50	55	55
122,250 to 123,000 (cross-polar) <sup>15</sup> .	N/A	1.2	43	45	50	50	55	55	55	55
130,000 to 134,000 (co-polar) <sup>15</sup> .	N/A	1.2	43	35	40	45	50	50	55	55
130,000 to 134,000 (cross-polar) <sup>15</sup> .	N/A	1.2	43	45	50	50	55	55	55	55
141,000 to 148,500 (co-polar) <sup>15</sup> .	N/A	1.2	43	35	40	45	50	50	55	55
141,000 to 148,500 (cross-polar) <sup>15</sup> .	N/A	1.2	43	45	50	50	55	55	55	55
151,500 to 158,500 (co-polar) <sup>15</sup> .	N/A	1.2	43	35	40	45	50	50	55	55
151,500 to 158,500 (cross-polar) <sup>15</sup> .	N/A	1.2	43	45	50	50	55	55	55	55
174,500 to 174,800 (co-polar) <sup>15</sup> .	N/A	1.2	43	35	40	45	50	50	55	55
174,500 to 174,800 (cross-polar) <sup>15</sup> .	N/A	1.2	43	45	50	50	55	55	55	55

231,500 to 232,000 (co-polar) <sup>15</sup> .	N/A	1.2	43	35	40	45	50	50	55	55
231,500 to 232,000 (cross-polar) <sup>15</sup> .	N/A	1.2	43	45	50	50	55	55	55	55
240,000 to 241,000 (co-polar) <sup>15</sup> .	N/A	1.2	43	35	40	45	50	50	55	55
240,000 to 241,000 (cross-polar) <sup>15</sup> .	N/A	1.2	43	45	50	50	55	55	55	55

\* \* \* \* \*

<sup>15</sup> Antenna gain less than 50 dBi (but greater than or equal to 43 dBi) is permitted only with a proportional reduction in maximum authorized EIRP in a ratio of 2 dB of power per 1 dB of gain, so that the maximum allowable EIRP (in dBW/MHz) for antennas of less than 50 dBi gain becomes  $25 - 2(50-G)$ , where G is the antenna gain in dBi. In addition, antennas in these bands must meet two additional standards for minimum radiation suppression: At angles between 1.2 and 5 degrees from the centerline of the main beam, co-polar discrimination must be  $G-28$ , where G is the antenna gain in dBi; and at angles of less than 5 degrees from the centerline of main beam, cross-polar discrimination must be at least 25 dB.

\* \* \* \* \*

35. Section 101.147 is amended by adding ten new entries in numerical order in 101.147(a) and revising paragraph (z) and (z)(2) to read as follows:

**§ 101.147 Frequency assignments.**

(a) \* \* \*

\* \* \* \* \*

- 95,000,100,000 MHz
- 102,000-109,500 MHz
- 111,800-114,250 MHz
- 122,250-123,000 MHz
- 130,000-134,000 MHz
- 141,000-148,500 MHz
- 151,500-158,500 MHz
- 174,500-174,800 MHz
- 231,500-232,000 MHz
- 240,000-241,000 MHz

\* \* \* \* \*

(z) 71-76 GHz, 81-86 GHz, 92-94 GHz, 94.1-95 GHz, 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz. \* \* \*

2) Prior links shall be protected using the interference protection criteria set forth in section 101.105. For transmitters employing digital modulation techniques and operating in the 71-76 GHz, 81-86 GHz, 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz bands, the licensee must construct a system that meets a minimum bit rate of 0.125 bits per second per Hertz of bandwidth. For transmitters that operate in the 92,000-94,000 MHz or 94,100-95,000 MHz bands, licensees must construct a system that meets a minimum bit rate of 1.0 bit per second per Hertz of bandwidth. If it is determined that a licensee has not met these loading requirements, then the database will be modified to limit coordination rights to the spectrum that is loaded and the licensee will lose protection rights on spectrum that has not been loaded.

36. The title of Subpart Q is amended to read as follows:

**SUBPART Q – SERVICE AND TECHNICAL RULES FOR THE 70/80/90 GHZ AND ABOVE 95 GHZ BANDS**

37. Section 101.1501 is amended to read as follows:

**§ 101.1501 Service areas.**

The 71-76 GHz, 81-86 GHz, 92-95 GHz, 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz bands are licensed on the basis of non-exclusive nationwide licenses. There is no limit to the number of non-exclusive nationwide licenses that may be granted for these bands, and these licenses will serve as a prerequisite for registering individual links.

38. Section 101.1505 is amended by adding paragraph (c) as follows:

**§ 101.1505 Segmentation plan.**

\* \* \* \* \*

(c) An entity may request any portion of the 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz bands.

39. Section 101.1507 is amended by revising as follows:

**§ 101.1507 Permissible operations.**

Licensees may use the 71-76 GHz, 81-86 GHz, 92-95 GHz, 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz bands for any point-to-point, non-broadcast service. The segments may be unpaired or paired, but pairing will be permitted only in a standardized manner (*e.g.*, 71-72.25 GHz may be paired only with 81-82.25 GHz, and so on). The segments may be aggregated without limit.

40. Section 101.1523 is amended by revising paragraph (a) as follows:

**§ 101.1523 Sharing and coordination among non-Government licensees and between non-Government and Government services.**

(a) Registration of each link in the 71-76 GHz, 81-86 GHz, 92-95 GHz, 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz,

231.5-232 GHz, and 240-241 GHz bands will be in the Universal Licensing System until the Wireless Telecommunications Bureau announces by public notice the implementation of a third-party database.

\* \* \* \* \*

41. Section 101.1525 is amended by revising as follows:

**§ 101.1525 RF safety.**

Licenses in the 71-76 GHz, 81-86 GHz, 92-95 GHz, 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz bands are subject to the exposure requirements found in §§1.1307(b), 2.1091 and 2.1093 of this chapter, and will use the parameters found therein.

42. Section 101.1527 is amended by revising as follows:

**§ 101.1527 Canadian and Mexican coordination.**

(a) A licensee of bands 71-76 GHz, 81-86 GHz, 92-95 GHz, 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz must comply with §1.928(f) of this chapter, which pertains to coordination with Canada.

(b) A licensee of bands 71-76 GHz, 81-86 GHz, 92-95 GHz, 95-100 GHz, 102-109.5 GHz, 111.8-114.25 GHz, 122.25-123 GHz, 130-134 GHz, 141-148.5 GHz, 151.5-158.5 GHz, 174.5-174.8 GHz, 231.5-232 GHz, and 240-241 GHz must coordinate with Mexico in the following situations:

\* \* \* \* \*

## APPENDIX B

## Passive Satellite Operations Above 95 GHz

The following list of current and proposed passive satellite operations above 95 GHz was provided by the National Aeronautics and Space Administration. The list specifies the mission, agency, instrument, frequency allocation, and actual or scheduled launch dates.

Instrument	Mission	Agency				Allocation	PASSIVE	PASSIVE (FN 5.340)	PASSIVE	PASSIVE (FN 5.340)
			T	Launch	N	Low GHz	116	148.5	155.5	164
						High GHz	122.25	151.5	158.5	167
MHS	NOAA-15, 18, 19	NOAA	p	1998	n				MHS	
SMR	ODIN	SNSB+	p	2001	o		SMR			
MLS	AURA	NASA	p	2004	n		MLS			
MHS	MetOp Series	EUMETSAT	p	2006	o				MHS	
ATMS	SNPP	NOAA	p	2011	n					ATMS
MADRAS	Megha-Trop.	ISRO/CNES	p	2011	o				MADRAS	
SAPHIR	Mega-Trop.	CNES/ISRO	p	2011	o					
GMI	GPM	NASA/JAXA	p	2014	n					GMI
ATMS*	JPSS*	NOAA	p	2018	nf					ATMS*
ICI*	METOP-SG-B*	EUMETSAT	p	2021	of					
MWI*	METOP-SG-A*	EUMETSAT	p	2022	of		MWI*(4)			MWI*
MWS*	METOP-SG-A*	ESA	p	2022	of					MWS*
SSMIS	DMSP	USA	p	2003	n			SSMIS		
AMSU-B	POES Series	NOAA	p	1998	n			AMSU-B(2)		
MWHS	FY-3	CMA	p	2008	o			MWHS(2)		
MTVZA-GY	METEOR-M1	RFSA	p	2009	o					
MTVZA-GY	METEOR-M2	RFSA	p	2014	o					
MTVZA-GY- MP*	METEOR-MP*	RFSA	p	2021	of					

Instrument	Mission	Agency				Allocation	PASSIVE	PASSIVE (FN 5.340)	PASSIVE	PASSIVE (FN 5.340)
			T	Launch	N	Low GHz	174	182	185	190
						High GHz	182	185	190	191
MHS	NOAA-15, 18, 19	NOAA	p	1998	n			MHS(2)		MHS
SMR	ODIN	SNSB+	p	2001	o					
MLS	AURA	NASA	p	2004	n					MLS
MHS	MetOp Series	EUMETSAT	p	2006	o			MHS(2)		MHS
ATMS	SNPP	NOAA	p	2011	n			ATMS(5)		
MADRAS	Megha-Trop.	ISRO/CNES	p	2011	o					
SAPHIR	Mega-Trop.	CNES/ISRO	p	2011	o			SAPHIR(6)		
GMI	GPM	NASA/JAXA	p	2014	n			GMI(2)		
ATMS*	JPSS*	NOAA	p	2018	nf			ATMS*(5)		
ICI*	METOP-SG-B*	EUMETSAT	p	2021	of			ICI*(3)		
MWI*	METOP-SG-A*	EUMETSAT	p	2022	of			MWI*(5)		
MWS*	METOP-SG-A*	ESA	p	2022	of			MWS*(5)		
SSMIS	DMSP	USA	p	2003	n			SSMIS(3)		
AMSU-B	POES Series	NOAA	p	1998	n			AMSU-B(6)		
MWHS	FY-3	CMA	p	2008	o			MWHS(3)		
MTVZA-GY	METEOR-M1	RFSA	p	2009	o			MTVZA-GY(3)		
MTVZA-GY	METEOR-M2	RFSA	p	2014	o			MTVZA-GY(3)		
MTVZA-GY-MP*	METEOR-MP*	RFSA	p	2021	of			MTVZA-GY*(3)		

Instrument	Mission	Agency				Allocation	PASSIVE (FN 5.340)	None	PASSIVE (FN 5.565)	None
			T	Launch	N	Low GHz	226.000	240.000	316.000	448.000
						High GHz	231.500	240.000	334.000	448.000
MHS	NOAA-15, 18, 19	NOAA	p	1998	n					
SMR	ODIN	SNSB+	p	2001	o					
MLS	AURA	NASA	p	2004	n			MLS		
MHS	MetOp Series	EUMETSAT	p	2006	o					
ATMS	SNPP	NOAA	p	2011	n					
MADRAS	Megha-Trop.	ISRO/CNES	p	2011	o					
SAPHIR	Mega-Trop.	CNES/ISRO	p	2011	o					
GMI	GPM	NASA/JAXA	p	2014	n					
ATMS*	JPSS*	NOAA	p	2018	nf					
ICI*	METOP-SG-B*	EUMETSAT	p	2021	of			ICI*	ICI*(3)	ICI*(3)
MWI*	METOP-SG-A*	EUMETSAT	p	2022	of					
MWS*	METOP-SG-A*	ESA	p	2022	of		MWS*			
SSMIS	DMSP	USA	p	2003	n					
AMSU-B	POES Series	NOAA	p	1998	n					
MWHS	FY-3	CMA	p	2008	o					
MTVZA-GY	METEOR-M1	RFSA	p	2009	o					
MTVZA-GY	METEOR-M2	RFSA	p	2014	o					
MTVZA-GY-	METEOR-MP*	RFSA	p	2021	of					

MP\*

Instrument	Mission	Agency				Allocation	PASSIVE (FN 5.565)	PASSIVE (FN 5.565)	None	PASSIVE (FN 5.565)
			T	Launch	N	Low GHz	496	546	568	634
						High GHz	506	568	580	654
MHS	NOAA-15, 18, 19	NOAA	p	1998	n					
SMR	ODIN	SNSB+	p	2001	o		SMR	SMR	SMR(2)	
MLS	AURA	NASA	p	2004	n					MLS
MHS	MetOp Series	EUMETSAT	p	2006	o					
ATMS	SNPP	NOAA	p	2011	n					
MADRAS	Megha-Trop.	ISRO/CNES	p	2011	o					
SAPHIR	Mega-Trop.	CNES/ISRO	p	2011	o					
GMI	GPM	NASA/JAXA	p	2014	n					
ATMS*	JPSS*	NOAA	p	2018	nf					
ICI*	METOP-SG-B*	EUMETSAT	p	2021	of					
MWI*	METOP-SG-A*	EUMETSAT	p	2022	of					
MWS*	METOP-SG-A*	ESA	p	2022	of					
SSMIS	DMSP	USA	p	2003	n					
AMSU-B	POES Series	NOAA	p	1998	n					
MWHS	FY-3	CMA	p	2008	o					
MTVZA-GY	METEOR-M1	RFSA	p	2009	o					
MTVZA-GY	METEOR-M2	RFSA	p	2014	o					
MTVZA-GY-MP*	METEOR-MP*	RFSA	p	2021	of					

Instrument	Mission	Agency				Allocation	None	None
			T	Launch	N	Low GHz	664	2500
						High GHz	664	2500
MHS	NOAA-15, 18, 19	NOAA	p	1998	n			
SMR	ODIN	SNSB+	p	2001	o			
MLS	AURA	NASA	p	2004	n			MLS
MHS	MetOp Series	EUMETSAT	p	2006	o			
ATMS	SNPP	NOAA	p	2011	n			
MADRAS	Megha-Trop.	ISRO/CNES	p	2011	o			
SAPHIR	Mega-Trop.	CNES/ISRO	p	2011	o			
GMI	GPM	NASA/JAXA	p	2014	n			
ATMS*	JPSS*	NOAA	p	2018	nf			
ICI*	METOP-SG-B*	EUMETSAT	p	2021	of		ICI*	
MWI*	METOP-SG-A*	EUMETSAT	p	2022	of			
MWS*	METOP-SG-A*	ESA	p	2022	of			
SSMIS	DMSP	USA	p	2003	n			
AMSU-B	POES Series	NOAA	p	1998	n			
MWHS	FY-3	CMA	p	2008	o			
MTVZA-GY	METEOR-M1	RFSA	p	2009	o			
MTVZA-GY	METEOR-M2	RFSA	p	2014	o			



MTVZA-GY-MP*	METEOR-MP*	RFSA	p	2021	of			
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#### Table Legend

T = Type of instrument: a = active or p = passive

Launch = Launch date (the first, if a series), actual (past) or scheduled (future, next year if not launched yet this year)

Allocation: Upper Case = Primary, A = active, P = passive

Lower Case = Secondary

An asterisk following an instrument or mission acronym indicates an instrument for a future flight

#### Table Acronyms

AMSU-B	Advanced Microwave Sounding Unit-B
ATMS	Advanced Technology Microwave Sounder
CMA	China Meteorological Administration
DMSP	Defense Meteorological Satellite Program
GMI	GPM Microwave Imager
GPM	Global Precipitation Measurement
ICI	Ice Cloud Imaging
JPSS	Joint Polar Satellite System
MADRAS	Microwave Analysis and Detection of Rain and Atmospheric Systems
Megha-Trop	Megha-Tropiques
MetOp	Meteorological Operational
MetOp-SG	MetOp Second Generation
MHS	Microwave Humidity Sounder
MLS	Microwave Limb Sounder
MWHS	Micro-Wave Humidity Sounder
MWI	Microwave Imager
MWS	Microwave Sounder
POES	Polar Operational Environmental Satellites
SAPHIR	Sounder for Probing Vertical Profiles of Humidity
SMR	Submillimeterwave Radiometer
SNPP	Suomi-National Polar-Orbiting Partnership
SSMIS	Special Sensor Microwave Imager/Sounder

## APPENDIX C

## Initial Regulatory Flexibility Analysis

1. As required by the Regulatory Flexibility Act of 1980, as amended (RFA),<sup>247</sup> 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 this *Notice of Proposed Rule Making (NPRM)*. Written public comments are requested on this IRFA. Comments must be identified as responses to the IRFA and must be filed by the deadlines for comments on the *NPRM* provided in the item. The Commission will send a copy of the *NPRM*, including this IRFA, to the Chief Counsel for Advocacy of the Small Business Administration (SBA).<sup>248</sup> In addition, the *NPRM* and IRFA (or summaries thereof) will be published in the Federal Register.<sup>249</sup>

**A. Need for, and Objectives of, the Proposed Rules**

2. The purpose of this Notice of Proposed Rulemaking (Notice) is to implement the rules that will make the spectrum above 95 GHz more readily accessible for new innovative services and technologies. The frequencies above 95 GHz have long been considered to represent the outer edges of the usable radio spectrum for FCC-authorized communications purposes, but advances in research and technology development have stirred interest in commercial use of these bands. Updating our rules will encourage investment in technologies that will make better use of the bands above 95 GHz. Specifically, adopting rules in Part 101 to permit licensed operations in several bands, adopting rules in Part 15 to provide for unlicensed operations in several bands, and expanding our Part 5 experimental licensing program will increase the opportunities for entities to develop new services and technologies in the bands above 95 GHz.

3. This Notice addresses licensed and unlicensed spectrum use opportunities in the 95 GHz to 275 GHz range, with additional provisions for experimental licensing up to 3000 GHz. The frequencies in the 95 GHz to 275 GHz range are, with minor exceptions, allocated on a co-primary basis for federal government and non-federal government use, while the frequencies above 275 GHz are not allocated. Because we presently have no rules in these bands to permit licensed or unlicensed telecommunications use other than for experimental and amateur radio operations, there is limited Commission-authorized use above 95 GHz. Our proposed approach is intended to provide incentives and opportunities for investment in the development of innovative new FCC-authorized technologies and services. Doing so serves the public interest; not only can it lead to new and novel communications opportunities in an uncrowded frequency range, it could also pay dividends by reducing spectrum-use pressures in lower parts of the spectrum.

**B. Legal Basis**

4. The proposed action is taken pursuant to Sections 1, 2, 4, 7, 201, 301, 302a, 303, 307, 310, and 332 of the Communications Act of 1934, 47 U.S.C. §§ 151, 152, 154, 157, 201, 301, 302a, 303, 307, 310, 332, 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.

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<sup>247</sup> 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).

<sup>248</sup> See 5 U.S.C. § 603(a).

<sup>249</sup> See 5 U.S.C. § 603(a).

(continued....)

### C. Description and Estimate of the Number of Small Entities to Which the Proposed Rules Will Apply

5. 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, if adopted.<sup>4</sup> The RFA generally defines the term “small entity” as having the same meaning as the terms “small business,” “small organization,” and “small governmental jurisdiction.”<sup>5</sup> In addition, the term “small business” has the same meaning as the term “small business concern” under the Small Business Act.<sup>250</sup> 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 Small Business Administration (SBA).<sup>251</sup>

6. The Commission has not developed a definition of small entities applicable to Radio Frequency Equipment Manufacturers (RF Manufacturers). The most analogous definition of small entity is that which is contained in the rules applicable to manufacturers of “Fixed Microwave Services, Other Communications Equipment Manufacturing, Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing.” This notice also addresses the repair of devices that are subject to the Commission’s equipment authorization rules. For this reason, we also include small entities associated with an additional category, “Communication Equipment Repair and Maintenance,” in our analysis.

7. *Fixed Microwave Services.* Microwave services include common carrier,<sup>252</sup> private-operational fixed,<sup>253</sup> and broadcast auxiliary radio services.<sup>254</sup> They also include the Local Multipoint Distribution Service (LMDS),<sup>255</sup> the Digital Electronic Message Service (DEMS),<sup>256</sup> and the 24 GHz Service,<sup>257</sup> where licensees can choose between common carrier and non-common carrier status.<sup>258</sup> At present, there are approximately 36,708 common carrier fixed licensees and 59,291 private operational-fixed licensees and broadcast auxiliary radio licensees in the microwave services. There are approximately 135 LMDS licensees, three DEMS licensees, and three 24 GHz licensees. The Commission has not yet defined a small business with respect to microwave services. The closest applicable SBA category is Wireless Telecommunications Carriers (except Satellite) and the appropriate

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<sup>4</sup> See 5 U.S.C. § 603(b)(3).

<sup>5</sup> 5 U.S.C. § 601(6).

<sup>250</sup> 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.”

<sup>251</sup> 15 U.S.C. § 632.

<sup>252</sup> See 47 CFR Part 101, Subparts C and I.

<sup>253</sup> See 47 CFR Part 101, Subparts C and H.

<sup>254</sup> Auxiliary Microwave Service is governed by Part 74 of Title 47 of the Commission’s Rules. See 47 CFR Part 74. Available to licensees of broadcast stations and to broadcast and cable network entities, broadcast 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 mobile TV pickups, which relay signals from a remote location back to the studio.

<sup>255</sup> See 47 CFR Part 101, Subpart L.

<sup>256</sup> See 47 CFR Part 101, Subpart G.

<sup>257</sup> See *id.*

<sup>258</sup> See 47 CFR §§ 101.533, 101.1017.

size standard for this category under SBA rules is that such a business is small if it has 1,500 or fewer employees.<sup>259</sup> For this industry, U.S. Census data for 2012 show that there were 967 firms that operated for the entire year.<sup>260</sup> Of this total, 955 firms had employment of 999 or fewer employees and 12 had employment of 1000 employees or more.<sup>261</sup> Thus under this SBA category and the associated size standard, the Commission estimates that a majority of fixed microwave service licensees can be considered small.

8. The Commission does not have data specifying the number of these licensees that have more than 1,500 employees, and thus is unable at this time to estimate with greater precision the number of fixed microwave service licensees that would qualify as small business concerns under the SBA's small business size standard. Consequently, the Commission estimates that there are up to 36,708 common carrier fixed licensees and up to 59,291 private operational-fixed licensees and broadcast auxiliary radio licensees in the microwave services that may be small and may be affected by the rules and policies adopted herein. We note, however, that the common carrier microwave fixed licensee category does include some large entities.

9. *Other Communications Equipment Manufacturing.* This industry comprises establishments primarily engaged in manufacturing communications equipment (except telephone apparatus, and radio and television broadcast, and wireless communications equipment).<sup>262</sup> Examples of such manufacturing include fire detection and alarm systems manufacturing, Intercom systems and equipment manufacturing, and signals (e.g., highway, pedestrian, railway, traffic) manufacturing.<sup>263</sup> The SBA has established a size standard for this industry as all such firms having 750 or fewer employees.<sup>264</sup> U.S. Census Bureau data for 2012 show that 383 establishments operated in that year.<sup>265</sup> Of that number, 379 operated with fewer than 500 employees and 4 had 500 to 999 employees.<sup>266</sup> Based on this data, we conclude that the majority of Other Communications Equipment Manufacturers are small.

10. *Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing.* This industry comprises establishments primarily engaged in manufacturing radio and television broadcast and wireless communications equipment.<sup>267</sup> 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

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<sup>259</sup> See 13 CFR § 121.201, NAICS code 517210.

<sup>260</sup> U.S. Census Bureau, *2012 Economic Census of the United States*, Table EC1251SSSZ5, Information: Subject Series, "Estab and Firm Size: Employment Size of Firms for the U.S.: 2012 NAICS Code 517210" (rel. Jan. 8, 2016). [https://factfinder.census.gov/bkmk/table/1.0/en/ECN/2012\\_US/51SSSZ5//naics~517210](https://factfinder.census.gov/bkmk/table/1.0/en/ECN/2012_US/51SSSZ5//naics~517210).

<sup>261</sup> *Id.* Available census data do not provide a more precise estimate of the number of firms that have employment of 1,500 or fewer employees; the largest category provided is for firms with "1000 employees or more."

<sup>262</sup> See U.S. Census Bureau, 2017 NAICS Definitions, NAICS Code "334290 Other Communications Equipment Manufacturing", <https://www.census.gov/cgi-bin/sssd/naics/naicsrch?input=334290&search=2017+NAICS+Search&search=2017>.

<sup>263</sup> *Id.*

<sup>264</sup> See 13 CFR 121.201, NAICS Code 334290.

<sup>265</sup> U.S. Census Bureau, *2012 Economic Census of the United States*, Table EC1231SG2, Manufacturing: Summary Series: General Summary: Industry Statistics for Subsectors and Industries by Employment Size: 2012, NAICS Code 334290, [https://factfinder.census.gov/bkmk/table/1.0/en/ECN/2012\\_US/31SG2//naics~334290](https://factfinder.census.gov/bkmk/table/1.0/en/ECN/2012_US/31SG2//naics~334290).

<sup>266</sup> *Id.*

<sup>267</sup> The NAICS Code for this service is 334220. 13 C.F.R 121.201. See also U.S. Census Bureau, 2012 NAICS Definitions, "334220 Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing" <https://factfinder.census.gov/faces/affhelp/jsf/pages/metadata.xhtml?lang=en&type=ib&id=ib.en./ECN.NAICS2012.334220#>.

broadcasting equipment.<sup>268</sup> The SBA has established a small business size standard for this industry of 1,250 employees or less.<sup>269</sup> U.S. Census Bureau data for 2012 show that 841 establishments operated in this industry in that year.<sup>270</sup> Of that number, 828 establishments operated with fewer than 1,000 employees, 7 establishments operated with between 1,000 and 2,499 employees and 6 establishments operated with 2,500 or more employees.<sup>271</sup> Based on this data, we conclude that a majority of manufacturers in this industry are small.

11. *Communication Equipment Repair and Maintenance.* This U.S. industry comprises establishments primarily *engaged* in repairing and maintaining communications equipment without retailing new communication equipment, such as telephones, fax machines, communications transmission equipment, and two-way radios.<sup>272</sup> The SBA has developed a size standard for this industry which is that any firm whose annual receipts are \$11 million or less is defined as a small business.<sup>273</sup> Census Bureau data for 2012 indicate that in this industry, 1,185 firms operated for the entire year. Of these firms, 1,148 operated with annual receipts of less than \$10 million dollars. Based on this data, the Commission concludes that the majority of firms operating in this industry are small.<sup>274</sup>

#### **D. Description of Projected Reporting, Recordkeeping, and Other Compliance Requirements for Small Entities**

12. The NPRM seeks comment on, and proposes a number of, rule changes that would affect reporting, recordkeeping and other compliance requirements in spectrum above 95 GHz. Many of the proposed rule changes are *identical* to existing rules for the 70/80/90 GHz band contained in Part 101 of the Commission's rules. We are proposing to require entities applying for licensed use above 95 GHz will be required to submit an application for an individual station license and to register links associated with their licensed operation. Applying for a license would: (1) require submission of an Environmental Assessment of the facilities under Section 1.1307 of the Commission's Rules;<sup>275</sup> (2) require (in certain geographical locations) international coordination of the application;<sup>276</sup> and (3) require coordination with NTIA's Frequency Assignment Subcommittee of the Interdepartment Radio Advisory Committee. While these requirements are new with respect to potential licensees in the spectrum above 95 GHz, they would be modeled after existing requirements that we have applied in other bands.

13. The NPRM also seeks comment on whether to make 15.2 gigahertz of spectrum above 95 GHz available for unlicensed use in four frequency bands, as well seeking comment on whether there are any other bands in that frequency range that might additionally be suitable for unlicensed use. Equipment designed for unlicensed use would be subject to the existing requirements of Subpart J of Part 2 of the Commission's rules, which governs equipment authorization procedures.<sup>277</sup>

<sup>268</sup> *Id.*

<sup>269</sup> 13 CFR § 121.201, NAICS Code 334220.

<sup>270</sup> U.S. Census Bureau, *2012 Economic Census of the United States*, Table EC1231SG2, Manufacturing: Summary Series: General Summary: Industry Statistics for Subsectors and Industries by Employment Size: 2012, NAICS Code 334220, [https://factfinder.census.gov/bkmk/table/1.0/en/ECN/2012\\_US/31SG2//naics~334220](https://factfinder.census.gov/bkmk/table/1.0/en/ECN/2012_US/31SG2//naics~334220).

<sup>271</sup> *Id.*

<sup>272</sup> <https://www.census.gov/cgi-bin/sssd/naics/naicsrch?input=811213&search=2012+NAICS+Search&search=2012>

<sup>273</sup> 13 C.F.R. 121.201, NAICS Code 811213

<sup>274</sup> [https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN\\_2012\\_US\\_81SSSZ4&prodType=table](https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2012_US_81SSSZ4&prodType=table)

<sup>275</sup> 47 CFR § 1.1307.

<sup>276</sup> *See e.g.* 47 CFR § 1.928 (regarding frequency coordination arrangements between the U.S. and Canada).

<sup>277</sup> 47 CFR § 1.913(a)(1).

(continued...)

14. Finally, the NPRM seeks comment on whether to create a new subpart of the Commission's Part 5 Experimental Radio Service rules to better encourage experiments in the spectrum range between 95 and 3000 GHz. These proposed rules, which would permit new ERS Spectrum Horizons licensees substantial flexibility to conduct long-term experiments over a wide geographic area and frequency range, would set forth an application requirement that includes an analysis explaining why the experiment would not result in harmful interference to other spectrum users. Licensees would also have to maintain station records and file an interim report halfway through their license term. Under our proposed marketing rules, licensees would have to disclose information to users of equipment operated under the experimental license authority.

**E. Steps Taken to Minimize the Significant Economic Impact on Small Entities, and Significant Alternatives Considered**

15. The RFA requires an agency to describe any significant alternatives that it has considered in reaching its proposed 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.<sup>278</sup>

16. The rules proposed in the NPRM provide for potential users of the spectrum above 95 GHz easier access to that spectrum to provide innovative new services and technologies. We believe that we have streamlined these rules appropriately to afford small entities new opportunities to access that spectrum in a cost-effective manner. For example, we believe that by creating a new ERS license and by looking to existing licensing models to govern this spectrum range, we will minimize the reporting, recordkeeping and other compliance requirements to require only those that are narrowly tailored to meet our responsibilities to effectively manage the different shared Federal and non-Federal uses of the band. With respect to our proposal to establish a new type of ERS license, we are proposing to grant a longer license term than is currently available under our conventional experimental license. This longer-term license will reduce the burdens associated with license renewals and subsequent applications. Nevertheless, conventional ERS licenses will still be available for that spectrum to the extent that a potential experimental user of the spectrum above 95 GHz finds that such a license is more appropriate for its needs.

17. The regulatory burdens we have proposed, such as filing applications on appropriate forms, are necessary in order to ensure that the public receives the benefits of innovative services and technologies in a prompt and efficient manner and apply equally to large and small entities, thus without differential impact. We will continue to examine alternatives in the future with the objectives of eliminating unnecessary regulations and minimizing any significant impact on small entities.

18. We encourage comment regarding the possible alternatives to the approaches proposed, including any cost estimates. Comments with proposed alternatives will assist in reaching the best outcomes.

**F. Federal Rules that May Duplicate, Overlap, or Conflict with the Proposed Rules**

19. None.

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<sup>278</sup> 5 U.S.C. § 603(c)(1) – (c)(4).