September 28, 2023

FCC FACT SHEET*

Unlicensed Use of the 6 GHz Band

Second Report and Order, Second Further Notice of Proposed Rulemaking, and Memorandum Opinion and Order
ET Docket No. 18-295; GN Docket No. 17-183

Background: The Report and Order will expand unlicensed use of the 6 GHz band by permitting very low power devices in the 5.925-6.425 GHz and 6.525-6.875 GHz sub-bands while ensuring that the licensed services operating in the spectrum continue to thrive. The Further Notice proposes to expand very low power device operations to the remainder of the band. It also proposes to permit very low power devices to operate at increased power with the use of a geofencing system. The Memorandum Opinion and Order addresses a remand from a court challenge of the 6 GHz low-power indoor rules stemming from assertions of interference in the 2.4 GHz band from unlicensed devices.

What the Report and Order Would Do:

- Permits very low power unlicensed devices to operate in the U-NII-5 (5.925-6.425 GHz) and U-NII-7 (6.525-6.875 GHz) portions of the 6 GHz band.
- The very low power devices will be permitted to operate anywhere, indoors and outdoors, without being under the control of a frequency coordination system.
- The very low power devices will operate at power levels that permit them to coexist with incumbent operations in the band: 14 dBm EIRP and a power spectral density of -5 dBm/MHz EIRP.
- The VLP devices would be required to employ transmit power control, would not be permitted to operate as part of a fixed outdoor infrastructure, and would be required to prioritize operations above 6105 MHz prior to operating between 5925 MHz and 6105 MHz.

What the Further Notice of Proposed Rulemaking Would Do:

- Proposes to permit very low power devices to also operate in the U-NII-6 (6.425-6.525 GHz) and U-NII-8 (6.875-7.125 GHz) portions of the 6 GHz band.
- Proposes to permit very low power devices to operate across the 6 GHz band at higher power levels while under the control of a geofencing system. The geofencing system would utilize commission databases to establish exclusion zones to protect incumbent licensed services
- Seeks comment on permitting clients to 6 GHz unlicensed low-power indoor access points to directly communicate with each other. Currently the 6 GHz unlicensed rules prohibit direct communication between client devices.

What the Memorandum Opinion and Order Would Do:

- The United States Court of Appeals for the District of Columbia Circuit directed the Commission to consider whether a portion of the 6 GHz band should be reserved for the mobile broadcast auxiliary service (BAS) based on broadcasters' assertion that BAS has experienced interference from unlicensed devices in the 2.4 GHz band.
- Concludes that broadcasters' unsubstantiated claims of interference in the 2.4 GHz band do not warrant any modification of our 6 GHz rules

* 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. 18-295, 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	)	
	)	
Unlicensed Use of the 6 GHz Band	)	ET Docket No. 18-295
	)	
Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz	)	GN Docket No. 17-183
	)	
	)	

SECOND REPORT AND ORDER, SECOND FURTHER NOTICE OF PROPOSED RULEMAKING, AND MEMORANDUM OPINION AND ORDER ON REMAND*

Adopted: [ ] **Released: [ ]**

Comment Date: 30 days after Federal Register publication
Reply Comment Date: 60 days after Federal Register publication

By the Commission:

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* This document has been circulated for tentative consideration by the Commission at its October 2023 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.

I. INTRODUCTION

1. Unlicensed devices employing Wi-Fi and other unlicensed standards are found in countless products that Americans use every day. Whether it is sending information between a watch and a

smartphone, connecting a laptop computer or smartphone to the internet, or remotely controlling a thermostat or other household items, these devices have become an important part of everyday life. In 2020, the Commission took a crucial step to ensure that the United States will meet increasing demand for wireless connectivity by adopting rules that expanded access for unlicensed devices across 1200 megahertz of spectrum in the 5.925-7.125 GHz (6 GHz) band. Those rules have been instrumental in bringing the next generation of Wi-Fi devices with even greater connection speeds to the American public. As those rules limit connectivity to communications between client devices, such as smartphones, and either low-power indoor (LPI) or standard power access points, we recognize the need to permit even more flexibility to enable another class of devices—that is, those that operate at very low power (VLP) across short distances to provide very high connection speeds for some of the most advanced applications.

2. Today, we build on the 6 GHz band unlicensed rules to foster unlicensed innovation and continue developing an ecosystem for new VLP unlicensed devices by permitting their use in two portions of the 6 GHz band. These devices will be instrumental in supporting cutting-edge applications, such as augmented and virtual reality, that will help businesses, enhance learning opportunities, advance healthcare opportunities, and bring new entertainment experiences. As we discuss below, we will limit these VLP devices to very low power levels and subject them to other technical and operational requirements that will permit these devices to operate across the United States while protecting incumbent licensed services that operate in the 6 GHz band from harmful interference. We expect that these VLP devices will quickly become invaluable for people as they go about their everyday lives.

3. Our actions today are intended to provide for near-term VLP deployment while also exploring a framework to provide additional flexibility to spur even more innovation, all while taking care to ensure that incumbent users are protected from harmful interference. In this connection, we provide rules in a Second Report and Order that will allow VLP devices to operate in the U-NII-5 (5.925-6.425 MHz) and U-NII-7 (6.525-6.875 MHz) portions of the 6 GHz band in any location. In a Second Further Notice of Proposed Rulemaking, we explore additional steps we could take and rules we could modify to provide more utility for VLP devices. Specifically, we seek comment on permitting higher power VLP devices under a two-tiered system where those higher powered devices would be permitted to operate only in locations where the potential for causing harmful interference to incumbent operations remains insignificant. Our decision provides a balance between accommodating these new and novel devices to deliver innovative applications to the American public now and taking a judicious approach toward modifying the rules to provide even more robust use at most locations. We also seek comment on VLP device requirements and limits for operation in the U-NII-6 and U-NII-8 bands. In sum, we believe that this may be a first step rather than the culmination of the rulemaking process regarding VLP use in the 6 GHz band.

4. Finally, we take action today in a Memorandum Opinion and Order on Remand to address a remand from the United States Court of Appeals for the District of Columbia Circuit concerning an issue raised by television broadcasters. Namely, the court directed the Commission to consider whether, in light of broadcasters' assertions that they have experienced interference from unlicensed devices in the 2.4 GHz band, a portion of the 6 GHz band should be reserved for mobile broadcast operations. We find, upon further analysis, that broadcasters' unsubstantiated claims of interference in the 2.4 GHz band do not warrant any changes to the 6 GHz rules.

II. BACKGROUND

5. The demand for wireless broadband continues to grow at a phenomenal pace, as American citizens and businesses increasingly rely on Internet connectivity. To meet this demand, the Commission continues to examine ways to increase spectrum options for unlicensed operations in the 6 GHz band.

6. *Incumbent services.* The 6 GHz band is comprised of allocations for Fixed Services, Mobile Services, and Fixed Satellite Services (FSS) across four sub-bands.[1] These four sub-bands—which we refer to as U-NII-5, U-NII-6, U-NII-7, and U-NII-8, respectively—are derived based on the prevalence and characteristics of incumbent licensed services that operate in each sub-band as denoted in Table 1.[2] Fixed microwave service licensees, specifically those operating point-to-point microwave links that support a variety of critical services provided by utilities, commercial and private entities, and public safety agencies, are the largest user group in the 6 GHz band.[3] These fixed microwave service licensees make significant use of the U-NII-5 and U-NII-7 bands, and also operate in relatively smaller numbers in the U-NII-8 band.[4] The band is used to provide backhaul for commercial wireless providers (such as traffic between commercial wireless base stations and wireline networks), and links used to coordinate railroad train movements, control natural gas and oil pipelines, manage electric grids, as well as long-distance telephone service.[5]

Table 1: Predominant Licensed Uses of the 6 Gigahertz Band

Sub-band	Frequency Range (GHz)	Primary Allocation	Predominant Licensed Services
U-NII-5	5.925-6.425	Fixed FSS	Fixed Microwave FSS (uplinks)
U-NII-6	6.425-6.525	Mobile FSS	Broadcast Auxiliary Service Cable Television Relay Service FSS (uplinks)
U-NII-7	6.525-6.875	Fixed FSS	Fixed Microwave FSS (uplinks/downlinks)
U-NII-8	6.875-7.125	Fixed Mobile FSS	Fixed Microwave Broadcast Auxiliary Service Cable Television Relay Service FSS (uplinks/downlinks) (6.875-7.075 GHz only)

[1] *Unlicensed Use of the 6 GHz Band; Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, Notice of Proposed Rulemaking, 33 FCC Rcd 10496, 10499-501, paras. 8-13 (2018) (*Notice*); *Unlicensed Use of the 6 GHz Band; Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, Report and Order and Further Notice of Proposed Rulemaking, 35 FCC Rcd 3852, 3855, para. 7 (2020) (*6 GHz Order*), *reversed in part, aff'd in part and remanded*, *AT&T Servs. Inc., v. FCC*, 21 F.4th 841, 853-54 (D.C. Cir. 2020) (affirming *6 GHz Order* and reversing and remanding to address issue of whether to "reserve a sliver of the 6 GHz band for licensed mobile operation").

[2] *Notice*, 35 FCC Rcd at 10499-501, 10503-04, paras. 8-12, 20.

[3] *Notice*, 35 FCC Rcd at 10499, para. 8, Figure 1.

[4] As of August 21, 2023, the FCC databases indicate that there were 32,276 call signs for fixed microwave links in U-NII-5, 13 in U-NII-6, 16,443 in U-NII-7, and 4,878 in U-NII-8. The predominant usage in the U-NII-5 and U-NII-7 bands is common carrier, industrial/business pool, and public safety pool fixed point-to-point links. The U-NII-6 band is dominated by mobile industrial/business pool and public safety pool microwave and TV Pickup operations; of the 363 unique call signs in the band, only 13 have fixed or temporary fixed operations. The predominant usage in the U-NII-8 band is TV intercity relay stations and TV studio-to-translator links. There are also 329 mobile stations (323 TV mobile pickup and 6 Broadcast Auxiliary Service low power stations) in the U-NII-8 band.

[5] *6 GHz Order*, 35 FCC Rcd at 3855, para. 7 (citing Fixed Wireless Communications Coalition Comments at 3 (filed Oct. 2, 2017)).

7. The Broadcast Auxiliary Service (BAS) and Cable Television Relay Service (CARS) operate in the U-NII-6 band on a mobile basis, and in the U-NII-8 band on both a fixed and mobile basis.[6] Licensees use BAS and CARS pick-up stations to transmit programming material from special events or remote locations, including electronic news gathering, back to the studio or other central receive locations.[7] Television broadcast related microwave links, such as television studio transmitter links, television inter-city relay links, and television translator relay links, operate primarily one-way point-to-point systems in the U-NII-8 band.[8] Additionally, Low Power Auxiliary Stations (i.e., wireless microphones), which operate on an itinerant basis, are authorized to operate in the U-NII-8 band on a secondary basis for uses such as portable cameras, wireless microphones, cues, and backstage communications.[9]

8. The Fixed Satellite Service (FSS) Earth-to-space is allocated in all four sub-bands, except for the 7.075-7.125 GHz portion of the U-NII-8 band.[10] FSS operations are heaviest in the U-NII-5 band, which is paired with the 3.7-4.2 GHz space-to-Earth frequency band to comprise the "conventional C-band."[11] In the *C-Band Order*, the Commission adopted rules to make 280 megahertz of mid-band spectrum available for flexible use (plus a 20 megahertz guard band) throughout the contiguous United States by transitioning existing satellite services out of the lower portion of the 3.7–4.2 GHz band and into the upper 200 megahertz of the band (i.e., 4.0–4.2 GHz).[12] Specifically, the *C-Band Order* established a December 5, 2025 deadline, by which incumbent space station operators were to complete transitioning their operations to the upper 200 megahertz of the band, but it also provided an opportunity for accelerated band clearing by allowing eligible space station operators to voluntarily commit to relocate on a two-phased accelerated schedule, with a Phase I deadline of December 5, 2021, and a Phase II deadline of December 5, 2023.[13] All five eligible space station operators elected accelerated

[6] 47 CFR §§ 74.602(a), (i), 78.18(a)(5), 78.18(a)(7). We also note that, although less prevalent, the rules permit mobile private operational, common carrier, and local television transmission service operations in these bands. *See id.* §§ 101.101, 101.147, 101.801, 101.803.

[7] 47 CFR §§ 74.631, 78.11(e).

[8] Most systems are comprised of a single point-to-point link without a corresponding return link. 47 CFR § 74.631 and review of ULS licensing records for TV Studio Transmitter (TS), TV Intercity Relay (TI), and TV Translator Relay (TT) licenses.

[9] 47 CFR §§ 74.802(a)(1), 74.803(c). Wireless microphone users may operate on a licensed basis under part 74 in the 6.875-6.9 GHz and 7.1-7.125 GHz bands. *See Promoting Spectrum Access for Wireless Microphone Operations; Expanding the Economic and Innovation Opportunities of Spectrum through Incentive Auctions*, Report and Order, 30 FCC Rcd 8739, 8789-90, paras. 131-32 (2015).

[10] 47 CFR § 2.106.

[11] 47 CFR § 25.103; *see Expanding Flexible Use of the 3.7 to 4.2 GHz Band*, Report and Order and Order of Proposed Modification, 35 FCC Rcd 2343, 2406, paras. 147-48 (2020) (*C-Band Order*).

[12] *C-Band Order*, 35 FCC Rcd at 2345, para. 4.

[13] *C-Band Order*, 35 FCC Rcd at 2408, para. 155; *see* 47 CFR § 27.1412(b)(1)–(2). By the Phase I deadline of December 5, 2021, eligible space station operators were required to repack any existing services and relocate associated incumbent earth stations throughout the contiguous United States into the upper 380 megahertz of the C-band (3820–4200 MHz), and the operators must provide passband filters to block signals from the 3700–3820 MHz band to associated incumbent earth stations in 46 of the top 50 PEAs. *C-Band Order*, 35 FCC Rcd at 2414, para. 171; *accord* 47 CFR § 27.1412(b)(1). By the Phase II deadline of December 5, 2023, eligible space station operators must repack any existing service and relocate associated incumbent earth stations throughout the contiguous United States into the upper 200 megahertz of the C-band (4.0–4.2 GHz), and the operators must provide passband filters to block signals from the 3700–4000 MHz band to all associated incumbent earth stations in the contiguous United States. *C-Band Order*, 35 FCC Rcd at 2414, para. 171; *accord* 47 CFR § 27.1412(b)(2).

relocation[14] and completed both phases of the relocation process. Predominant FSS uses of these frequencies include content distribution to television and radio broadcasters, including transportable antennas to cover live news and sports events, cable television and small master antenna systems, and backhaul of telephone and data traffic.[15] The 7.025-7.075 GHz portion of the U-NII-8 band also hosts feeder uplinks to Satellite Digital Audio Radio Service space stations.[16] Additionally, portions of the U-NII-7 and U-NII-8 bands are allocated for FSS space-to-Earth operations for Mobile-Satellite Service feeder links between 6.700 GHz and 7.075 GHz.[17] However, there are currently no licensed FSS space-to-Earth stations in U-NII-7, and the 7.025-7.075 GHz allocation is limited to two grandfathered satellite systems with three grandfathered locations.[18]

9. In addition to these licensed incumbent services, an international footnote in the table of allocations urges that we take "all practicable steps" to protect radio astronomy service observations in 6.650-6.6752 GHz.[19] Finally, low-power unlicensed ultra-wideband (UWB) and wideband systems operate in the 6 GHz band under our part 15 rules.[20] Like all other part 15 devices, UWB and wideband devices operate on a non-interference basis and are not permitted to cause harmful interference.[21]

10. *The Report and Order and Further Notice of Proposed Rulemaking*. The April 2020 Report and Order (*6 GHz Order*) adopted rules to permit expanded unlicensed use throughout the 6 GHz band by authorizing two new types of unlicensed operations.[22] First, unlicensed standard power access points in the U-NII-5 and U-NII-7 bands can access spectrum through use of an Automated Frequency Coordination (AFC) system.[23] The AFC systems permit the standard power access points to only operate on frequencies and at power levels that will protect co-channel incumbent fixed microwave operations from harmful interference.[24] These standard power access points can operate at the same power levels already permitted in the 5 GHz UNII-1 and U-NII-3 bands (5.150-5.250 GHz and 5.725-5.850 GHz

[14] *Wireless Telecommunications Bureau Announces Accelerated Clearing in the 3.7–4.2 GHz Band*, GN Docket No. 18-122, Public Notice, 35 FCC Rcd 5517 (WTB 2020).

[15] *Notice*, 33 FCC Rcd at 10501, para. 12.

[16] 47 CFR § 25.214(c)(5).

[17] 47 CFR § 25.214(c)(5).

[18] 47 CFR § 2.106(b)(458)(ii), (d)(172) (international footnote 5.458B and non-governmental footnote NG172). The space-to-Earth allocation is limited to non-geostationary Mobile-Satellite Service feeder links and earth stations receiving in this band are limited to locations within 300 meters of coordinates in Brewster, WA, Clifton, TX, and Finca Pascual, PR. *Id.* § 2.106(d)(172).

[19] 47 CFR § 2.106(b)(458)(i) (international footnote 5.458A).

[20] 47 CFR § 15.250; *id.* pt. 15, subpt. F. Unlicensed UWB operations are permitted in many different frequency bands. *See id.* pt. 15, subpt. F. Wideband operations are mostly limited to the 6 GHz band. 47 CFR § 15.250 (limiting wideband operations to the 5.925-7.250 GHz band). For both the wideband and ultra-wideband systems permitted under the Part 15 rules, the maximum EIRP allowed is –41.3 dBm/MHz except for certain vehicular radar systems which are restricted to –61.3 dBm/MHz EIRP. *See id.* § 15.250(d)(1), subpt. F.

[21] 47 CFR § 15.5(b).

[22] *6 GHz Order,* 35 FCC Rcd at 3860, paras. 17-18. There are three pending petitions for reconsideration of the *6 GHz Order* filed by Verizon, CTIA, and the Fixed Wireless Communications Coalition (FWCC). Verizon Petition for Reconsideration, ET Docket 18-295 (filed June 25, 2020); CTIA Petition for Partial Reconsideration, ET Docket 18-295 (filed June 25, 2020); Fixed Wireless Communications Coalition Petition for Reconsideration, ET Docket 18-295 (filed June 25, 2020).

[23] *6 GHz Order,* 35 FCC Rcd at 3860, para. 17.

[24] *6 GHz Order,* 35 FCC Rcd at 3862, para. 22.

bands, respectively), enabling synergistic use of both the 5 GHz and 6 GHz bands for promoting unlicensed broadband deployment.[25]

11. Second, unlicensed LPI access points can operate without an AFC system over the entire 6 GHz band.[26] In authorizing use of the entire 6 GHz band for this type of use, the Commission provided opportunities for unlicensed operations to transmit using up to 320-megahertz wide channels to expand capacity and performance capabilities.[27] This forward-looking action anticipates the next generation of unlicensed devices and advances the U.S.'s role as an innovator and global spectrum policy leader.[28] The Commission also permitted operation by client devices at varying power levels based on the type of access point it is connected to—either standard power or LPI.[29]

12. In the Further Notice of Proposed Rulemaking (*Further Notice*), the Commission proposed to permit an additional class of unlicensed devices—VLP devices. VLP devices were proposed for operations across the entire 6 GHz band, with no requirement that the devices be kept indoors or be under the control of an AFC system.[30] The Commission envisioned that body-worn devices would make-up most VLP device use cases and that these devices would provide large quantities of data in real-time.[31] Entities that support the Commission permitting VLP device operation expect that these devices will support portable use cases, such as wearable peripherals (e.g., smartphones, glasses, watches, and earphones), including augmented reality/virtual reality and other personal-area-network applications, as well as in-vehicle applications (e.g., dashboard displays).[32] The *Further Notice* sought comment on the appropriate power levels as well as other rules for VLP devices to ensure that the potential for causing harmful interference to incumbent operations is minimized.[33] To this end, the *Further Notice* sought comment on several topics, such as: Whether VLP devices should be required to employ a contention-based protocol that requires the devices to listen to the spectrum prior to transmission;[34] how should the interference potential of these devices be evaluated when operating outdoors;[35] how should clutter losses from the presence of buildings and other objects be accounted for when evaluating interference potential;[36] what value should be assumed for body loss and transmit power control;[37] whether a proximity sensor could be used to adjust power based on how much body loss is expected;[38] how would transmit

[25] *6 GHz Order,* 35 FCC Rcd at 3860, para. 17.

[26] *6 GHz Order,* 35 FCC Rcd at 3860, para. 18.

[27] *6 GHz Order,* 35 FCC Rcd at 3860, para. 18.

[28] *See* D. Lopez-Perez, A. Garcia-Rodriguez, L. Galati-Giordano, M. Kasslin and K. Doppler, "IEEE 802.11be Extremely High Throughput: The Next Generation of Wi-Fi Technology Beyond 802.11ax," in IEEE Communications Magazine, vol. 57, no. 9, pp. 113-119, Sept. 2019 (stating that 320-megahertz bandwidth is a leading candidate for inclusion in the 802.11be standard), available at https://ieeexplore.ieee.org/document/8847238.

[29] *6 GHz Order,* 35 FCC Rcd at 3860, para. 18.

[30] *6 GHz Further Notice,* 35 FCC Rcd at 3939-40, para. 235.

[31] *6 GHz Further Notice,* 35 FCC Rcd at 3939-40, paras. 235-36.

[32] *See* Apple, Broadcom et al. July 2, 2019 *Ex Parte* at 5,7; Apple, Broadcom et al. Dec 9, 2019 *Ex Parte* at 8.

[33] *6 GHz Further Notice,* 35 FCC Rcd at 3940-42, paras. 236-43.

[34] *6 GHz Further Notice,* 35 FCC Rcd at 3940, para. 237.

[35] *6 GHz Further Notice,* 35 FCC Rcd at 3940-41, para. 238.

[36] *6 GHz Further Notice,* 35 FCC Rcd at 3940-41, para. 238.

[37] *6 GHz Further Notice,* 35 FCC Rcd at 3941, para. 239.

[38] *6 GHz Further Notice,* 35 FCC Rcd at 3941, para. 240

power control be implemented to protect incumbent licensees;[39] what technology measures can be incorporated into VLP devices to support the operations at the power limits requested by proponents and mitigate the potential for harmful interference to incumbent services;[40] and what technical or operational rules should the Commission consider to maximize the utility of the 6 GHz band and protect incumbent licensees?[41]

13. In the *Further Notice*, the Commission also sought comment on several modifications to the 6 GHz band unlicensed rules. The *Further Notice* sought comment on increasing the permitted power spectral density of LPI access points from 5 dBm/MHz to 8 dBm/MHz and the maximum transit power from 30 dBm to 33 dBm EIRP.[42] The *Further Notice* also sought comment on permitting standard power access points to operate under the control of an AFC system while in motion.[43] Lastly, the *Further Notice* sought comment on permitting standard power access points that are used for point-to-point links to operate at power levels greater than the 36 dBm EIRP level currently permitted.[44] Of the topics raised in the *Further Notice*, in this Second Report and Order we are only addressing the proposal to permit VLP devices. We intend to address the remaining issues raised in the Further Notice at a later time.

14. Several parties filed petitions for review of the *6 GHz Order* in the D.C. Circuit[45] asserting that the Commission erred when adopting rules for the 6 GHz band. The petitioners claimed that the rules the Commission put in place to protect incumbent operations from harmful interference were not adequate to ensure that such interference would not occur.[46] The Court largely denied the petitions for review and held that, for the most part, petitioners did not provide a basis for questioning the Commission's conclusions regarding the interference protection the rules would afford to incumbent users.[47] However, the Court did remand a single issue finding that the Commission failed to adequately address NAB's concern that its experience with contention-based protocols in the 2.4 GHz band should have led the Commission to grant NAB's request to reserve a portion of the 6 GHz band for licensed mobile broadcast operations.[48]

15. After the Commission adopted the *6 GHz Order* and *Further Notice*, the Office of Engineering and Technology (OET) sought comment on whether the Commission should permit direct communications between client devices.[49] The rules adopted in the *6 GHz Order* prohibited unlicensed client devices from acting as "mobile hotspots" because "[p]ermitting a client device operating under the control of an access point to authorize the operation of additional client devices could potentially increase

[39] *6 GHz Further Notice,* 35 FCC Rcd at 3941, para. 241.

[40] *6 GHz Further Notice,* 35 FCC Rcd at 3942, para. 242.

[41] *6 GHz Further Notice,* 35 FCC Rcd at 3942, para. 243.

[42] *6 GHz Further Notice,* 35 FCC Rcd at 3942-43, paras. 244-45.

[43] *6 GHz Further Notice,* 35 FCC Rcd at 3943-44, paras. 246-51.

[44] *6 GHz Further Notice,* 35 FCC Rcd at 3944-45, paras. 252-55.

[45] Parties seeking review of the rules were the National Association of Broadcasters, AT&T Services, Inc., Lumen Technologies, Inc., APCO International, Edison Electric Institute, the Utilities Technology Council, the National Rural Electric Cooperative Association, and the American Public Power Association.

[46] *See* Joint Brief of Petitioners, *AT&T Servs., Inc. v. FCC*, D.C. Cir. No. 20-1190 (and consolidated cases) (Petitioners' Brief).

[47] *AT&T Servs. Inc., v. FCC*, 21 F.4th 841, 843 (D.C. Cir. 2020).

[48] *Id.* at 853-54.

[49] *See The Office of Engineering & Technology Seeks Additional Information Regarding Client-To-Client Device Communications in the 6 GHz Band*, ET Docket No. 18-295, GN Docket No. 17-183, Public Notice, 36 FCC Rcd 36, 36 (OET 2021) (*6 GHz Public Notice*).

the distance between these additional client devices and the access point and increase the potential for harmful interference to fixed service receivers or electronic news gathering operations."[50] Recognizing that such operations could be useful and permit additional use cases, OET "invite[d] interested parties to supplement the record, for the Commission's consideration, on whether and under what circumstances client devices could be permitted to directly communicate with each other in a limited manner consistent with the rationale underlying the Commission's decisions in the *6 GHz Order* that were targeted at protecting incumbent licensed services."[51] OET specifically sought comment on "whether the Commission should permit 6 GHz U-NII client devices to directly communicate when they are under the control of or have received an enabling signal from a[n] [LPI] access point."[52]

16. *The record.* The Commission received comments from numerous parties in favor of permitting unlicensed VLP operations in the 6 GHz band as well as parties representing the interests of incumbent licensees raising concerns about potential harmful interference from the proposed unlicensed VLP operations. In response to the *Further Notice*, proponents of unlicensed operations in the 6 GHz band—including Apple, Broadcom et al.,[53] the Wi-Fi Alliance, the Dynamic Spectrum Alliance (DSA), the Consumer Technology Association, and the Public Interest Spectrum Coalition[54]—support the Commission's proposal for authorizing VLP unlicensed device operations across the 6 GHz band. They emphasize that such operations will support a host of immersive, real-time applications in areas such as healthcare, high accuracy location, advanced connectivity, innovative game experiences, and augmented-reality/virtual-reality devices,[55] among other uses.[56] These commenters assert that technical rules can be established that protect incumbents from harmful interference.[57] Apple, Broadcom, et al. submitted several technical studies to support their contention that harmful interference will not occur to licensed incumbents from VLP devices.[58]

[50] *6 GHz Order*, 35 FCC Rcd at 3927, para. 202.

[51] *6 GHz Public Notice*, 36 FCC Rcd at 37.

[52] *Id.*

[53] *See* Apple, Broadcom et al. Comments (filed June 29, 2020) (a group of companies that includes Apple, Broadcom, Cisco Systems, Facebook, Google, Hewlett Packard Enterprise, Intel, Microsoft, NXP Semiconductors, Qualcomm, and Ruckus Networks). This group submitted several joint filings in this proceeding. Several of these companies also submitted individual filings on behalf of their companies. We also note that, at times, joint filings made by Apple, Broadcom, and other companies include variations in the composition of the group, depending on the particular filing(s).

[54] The Public Interest Spectrum Coalition consists of: New America's Open Technology Institute, Public Knowledge, American Library Association, Schools, Health & Libraries Broadband (SHLB) Coalition, Benton Institute For Broadband And Society, COSN – Consortium for School Networking, National Hispanic Media Coalition, Tribal Digital Village Network, Institute for Local Self-Reliance, Next Century Cities, Common Cause, Access Humboldt, and X-Lab.

[55] *Augmented Reality* (AR) is the digital creation of a fabricated set of objects that can be interspersed with real world elements, usually through a headset that overlays the objects on the lens, as the users also view their real surroundings. *Virtual Reality* (VR) is the digital creation of a fabricated immersive world, typically via a headset technology, that generates all the photons that the eye sees.

[56] *See, e.g.*, Apple, Broadcom et al. Comments at 2 (filed June 29, 2020); Wi-Fi Alliance Comments at 4-8 (filed June 29, 2020).

[57] *See, e.g.*, Apple, Broadcom et al. Comments at 25, 27-29 (filed June 29, 2020); Wi-Fi Alliance Comments at 9-12 (filed June 29, 2020), Consumer Technology Association Comments at 1-3 (filed June 29, 2020); Open Technology Institute et al. Comments at 5-13 (filed June 29, 2020).

[58] Apple, Broadcom et al. Comments Attachs. A, B, C (filed June 29, 2020).

17. Commenters representing incumbents express various concerns about the potential for harmful interference to their operations from standard power, LPI, and VLP unlicensed operations. Commenting parties include the Fixed Wireless Communications Coalition (FWCC), AT&T, the Utilities Technology Council (UTC) et al., and the National Public Safety Telecommunications Council on behalf of fixed microwave incumbents,[59] Sirius XM Radio representing satellite service incumbents,[60] the National Association of Broadcasters (NAB) on behalf of local radio and television stations and broadcast networks,[61] and the National Academy of Sciences' Committee on Radio Frequencies regarding radio astronomy observatories.[62] Several of these commenters also submitted technical studies to support their positions.[63] The Ultra-Wide Band Alliance and Zebra advocate for lower power levels or placing antenna gain requirements on very low power devices.[64] Finally, several parties advocate for protection of the adjacent 5.9 GHz band.[65]

III. SECOND REPORT AND ORDER

18. We adopt rules to permit VLP devices to operate with up to -5 dBm/MHz EIRP power spectral density (PSD) and 14 dBm EIRP across the U-NII-5 and U-NII-7 portions of the 6 GHz band. VLP devices will enable new innovative uses and will provide opportunities to enhance nascent applications, such as augmented reality/virtual reality, in-car connectivity, wearable on-body devices, healthcare monitoring, short-range mobile hotspots, high accuracy location and navigation, and automation.[66] The rules we are adopting are designed to support innovation to bring exciting new applications to market while protecting the important licensed services that operate in the 6 GHz band from harmful interference. At this time, we are limiting VLP devices to the U-NII-5 and U-NII-7 bands because the technical record has mainly focused on the potential for interference to fixed microwave links which are the predominate uses of these portions of the 6 GHz band. In the Second Further Notice of Proposed Rulemaking, we propose to expand VLP device operation to the U-NII-6 and U-NII-8 portions of the band which supports mobile operations.

A. VLP Power Levels and Protection of the Fixed Microwave Services

19. Apple, Broadcom et al. and the Wi-Fi Alliance claim that VLP devices will require 14 dBm EIRP and 1 dBm/MHz EIRP PSD[67] to meet expected consumer use cases, overcome on-body loss, and

[59] *See, e.g.*, Fixed Wireless Communications Coalition Comments at 3-4 (filed July 8, 2020); AT&T Comments at 7-11 (filed June 29, 2020); Utilities Technology Council, et al. (a group of commenters including the Utilities Technology Council, the American Public Power Association, the National Rural Electric Cooperative, the American Gas Association, and the American Water Works Association) Comments at 5-9 (filed June 29, 2020); NPSTC Comments at 3-5 (filed June 29, 2020).

[60] Sirius XM Radio Comments at 12-15 (filed June 29, 2020).

[61] NAB Comments at 6-8 (filed June 29, 2020).

[62] National Academy of Sciences Committee on Radio Frequencies Comments at 3-6 (filed June 29, 2020).

[63] Nokia Comments Attach. (filed June 29, 2020); Southern Company Comments Attach. A (filed June 29, 2020); CTIA Reply Attach. (filed July 27, 2020).

[64] *See, e.g.*, Ultra-Wide Band Alliance Comments at 10 (filed June 29, 2020); Zebra Technologies Reply at 1-2 (filed July 27, 2020).

[65] *See, e.g.*, 5GAA Comments at 4-7 (filed June 29, 2020); Alliance for Automotive Innovation Comments at 5-7 (filed June 29, 2020).

[66] Apple, Broadcom et al. Comments at 4-5 (filed June 29, 2020); Wi-Fi Alliance Comments at 4-8 (filed June 29, 2020).

[67] Because total power increases with increasing bandwidth, 1 dB/MHz EIRP PSD would permit 14 dBm EIRP across 20, 40, 80, 160 and 320 megahertz channel bandwidths.

meet minimum throughput, latency, and power efficiency requirements.[68] Otherwise, they claim, performance will suffer due to lower data rates, increased latency, and higher duty cycles.[69] Apple, Broadcom et al. state that "[b]ecause power consumption increases with duty cycle, these higher duty cycles undermine the ability to achieve low power consumption, which is critical for small-form factor battery-power-limited devices," such as VLP devices.[70] Ensuring that latency is minimized is also essential for many expected VLP applications, such as augmented reality/virtual reality, screen mirroring, and gaming.[71] Apple, Broadcom et al. claim that their companies, which include leading product experts and engineers, "agree that a minimum of 14 dBm EIRP is critical to balance the tradeoffs between latency, data rate, power consumption, and other essential factors required to enable useful consumer products and cutting-edge innovative applications."[72] They explain that "[t]he range of potential on-body loss scenarios is a central factor driving the required power for [VLP] devices" and point to measurements by the Wireless Research Center of North Carolina showing that the path loss between body worn devices is highly variable.[73] They claim that manufacturers must design VLP devices to function in worst-case operating scenarios.[74]

20. In addition, Apple, Broadcom et al. ask the Commission to adopt the 1 dBm/MHz EIRP PSD limit to avoid unnecessarily constraining power in narrower channel sizes.[75] They claim that limiting the PSD to lower levels, such as -8 dBm/MHz EIRP, would negatively affect the ability of VLP devices to achieve the required throughput.[76] They also state that using a smaller bandwidth may be necessary to maximize channel use in high user densities or high path loss environments.[77]

21. Other commenters also support the need for permitting VLP devices to operate at the 14 dBm EIRP and 1 dBm/MHz EIRP PSD power levels. The Consumer Technology Association states that authorizing VLP devices at less than 14 dBm would prohibit important use cases from emerging where body losses are a key factor.[78] The DSA claims that a 14 dBm EIRP and 1 dBm/MHz EIRP PSD is necessary for anticipated use cases, such as new immersive, real-time applications and personal area network, wearable, and in-vehicle portable devices.[79] Facebook points to the report from the Wireless Research Center of North Carolina illustrating the challenges that arise due to body loss.[80] According to Facebook, this study demonstrates that VLP devices need to overcome significant variability in body loss

[68] Apple, Broadcom et al. Comments at 10 (filed June 29, 2020); Wi-Fi Alliance Comments at 9 (filed June 29, 2020).

[69] Apple, Broadcom et al. Comments at 10.

[70] *Id*.

[71] *Id*. at 10-11.

[72] *Id*. at 12.

[73] *Id*. at 12-13.

[74] *Id*. at 13.

[75] *Id*. at 14.

[76] *Id*. -8 dBm/MHz EIRP/PSD would permit 5 dBm EIRP for a 20 megahertz channel bandwidth, 8 dBm EIRP for a 40 megahertz channel bandwidth, 11 dBm EIRP for an 80 megahertz channel bandwidth, and 14 dBm EIRP for 160 megahertz and 320 megahertz channel bandwidths.

[77] *Id*. at 14-15.

[78] Consumer Technology Association Comments at 7 (filed June 29, 2020).

[79] Dynamic Spectrum Alliance Comments at 4-5 (filed June 29, 2020).

[80] Facebook Comments at 5 (filed June 29, 2020).

to provide the expected reliability and the best means to do this is to permit the requested 14 dBm EIRP.[81] Microsoft states that VLP device designers will need the 14 dBm EIRP power level to create innovative new product categories, configurations, and form factors.[82] It explains that if VLP devices are authorized with a lower power, the economic benefits will be tempered as 14 dBm EIRP is the threshold at which VLP device throughput would be high enough and latency low enough for personal area network users to have a reliable highly interactive mixed-reality experience.[83]

22. In making this decision to enable this new class of unlicensed devices to operate in the 6 GHz band while protecting licensed incumbent operations from harmful interference, we note that this policy represents a careful balancing between enabling new services and protecting existing services. In response to comments reflecting incumbents' concerns regarding the potential for harmful interference as well as analysis in the record, we are taking reasonable actions to minimize such potential. However, we also take this opportunity to reiterate several core Commission spectrum management principles that directly affect our decision-making in this proceeding. The Commission recently stated in its *Policy Statement*,[84] which provides guidance on how the Commission intends to manage spectrum efficiently and effectively going forward, that:

- "The electromagnetic environment is highly variable, and zero risk of occasional service degradation or interruption cannot be guaranteed";[85]
- "Services should plan for the spectrum environment in which they intend to operate, the service they intend to provide, and the characteristics of spectrally and spatially proximate operations. Planning should be ongoing and account for changes in spectrum operating environments";[86]
- "Radio transmitter and receiver system operators and equipment manufacturers should plan for and design error tolerant systems, using good engineering practices, to mitigate degradation from interference";[87] and
- "Quantitative analyses of interactions between services that are fact- and evidence-based, sufficiently robust, transparent, and reproducible are needed to better inform spectrum management decision-making."[88]

23. We emphasize the core principle from the Policy Statement that expresses the notion that data-driven approaches are necessary to promote co-existence.[89] In adopting rules to enable VLP devices to share the 6 GHz band, we have followed this approach in anchoring our decision on an extensive technical record. We recognize the highly variable nature of the electromagnetic environment and rely on analyses that use a probabilistic approach to evaluating interference risk rather than basing our decision on worst-case examples.

[81] *Id*. at 5-6.

[82] Microsoft Comments at 8 (filed June 29, 2020).

[83] *Id*. at 8.

[84] *Principles for Promoting Efficient Use of Spectrum and Opportunities for New Services; Promoting Efficient Use of Spectrum through Improved Receiver Interference Immunity Performance*, ET Docket Nos. 23-122 and 22-137, Policy Statement, FCC 23-27 (Apr. 21, 2023) (*Policy Statement*).

[85] *Id*. at 2, para. 5 (emphasis omitted); *accord id.* at 6-7, paras. 15-17.

[86] *Id*. at 2, para. 5 (emphasis omitted); *accord id.* at 7, paras. 18-19.

[87] *Id*. at 3, para. 5 (emphasis omitted); *accord id.* at 10-11, paras. 33-35.

[88] *Id*. at 3, para. 5 (emphasis omitted); *accord id.* at 12-13, paras. 41-44.

[89] *See id*. at 11-13, paras. 36-47.

24. In considering the maximum power level for VLP devices, our goal is to balance competing factors. We aim to permit as much power as possible for these devices so that the maximum benefit can be derived from their operation while minimizing the potential risk of harmful interference to licensed incumbent operations. As described below, the record is replete with many analyses and tests that come to widely different conclusions. These analyses and tests provide a basis for our understanding of the potential for VLP devices to cause harmful interference under a variety of conditions. As described in detail, we believe based on the technical record that we can permit at this time VLP devices to operate at up to -5 dBm/MHz power spectral density (PSD) and 14 dBm EIRP without presenting a significant risk of harmful interference to the licensed microwave incumbents that share the 6 GHz band.[90]

1. Computer Simulations/Monte Carlo Analysis

25. In considering the technical record, we find that two computer simulations based on Monte Carlo analysis submitted by Apple, Broadcom et al. and by Apple provide sufficient support for permitting VLP operation at up to -5 dBm/MHz EIRP power spectral density (PSD) and 14 dBm EIRP across the U-NII-5 and U-NII-7 portions of the 6 GHz band.[91] Relying on computer simulations is in harmony with our *Policy Statement*'s directive to follow a data-driven approach to spectrum management rather than placing dispositive weight on worst-case examples that may be rare or never occur in practice.[92] In relying on these computer simulations, we follow the path of the Commission's previous decision in adopting rules for unlicensed 6 GHz LPI devices. For the LPI rules, the Commission characterized a computer simulation submitted by CableLabs as "the best evidence in the record of the impact that unlicensed low-power indoor devices will have on incumbent operations."[93]

26. A well-designed computer simulation can simultaneously model many probabilistic factors that determine whether harmful interference may occur. These factors include VLP device location variability in relation to the microwave receiver, height of the VLP device, whether the VLP device is operating co-channel, the VLP power level, and the radio propagation environment. In examining the potential for harmful interference to occur to microwave links from VLP devices, the characteristics of the microwave links must also be considered. Microwave links use highly directional antennas typically located on tall towers or building rooftops to transmit over distances up to 30 kilometers. Because of the heights of these antennas and their directional nature, VLP devices only present a harmful interference risk if they are located within the main beam of the antenna and are close enough to the microwave receiver that a strong signal can be received.[94] One important factor to consider when modeling interference to 6 GHz microwave receivers is atmospheric multipath fading. Atmospheric multipath fading is caused when stable air masses, such as warm and humid air, lead to stratification of the atmosphere.[95] Atmospheric multipath fades can be very deep—30 dB or more. However, deep fades are

[90] -5 dBm/MHz EIRP/PSD would permit 8 dBm EIRP for a 20 megahertz channel bandwidth, 11 dBm EIRP for a 40 megahertz channel bandwidth, and 14 dBm EIRP for 80 megahertz, 160 megahertz, and 320 megahertz channel bandwidths.

[91] *See* Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* to OET*;* Apple Feb. 13, 2023 *Ex Parte* to OET. A Monte Carlo simulation uses random sampling and statistical modeling to estimate mathematical functions and mimic the operations of complex systems. Harrison RL., *Introduction To Monte Carlo Simulation*, AIP Conf Proc. 2010;1204:17–21. doi:10.1063/1.3295638.

[92] *See Policy Statement* at 11-13, paras. 36-47.

[93] *6 GHz Order,* 35 FCC Rcd at 3896, para. 120.

[94] FWCC Oct. 31, 2019 *Ex Parte* at 7 (agreeing that an unlicensed device will cause harmful interference to a microwave receiver if it is in or near the receiver's main beam, there is little attenuation between the device and receiver, the device is close enough to the receiver, and the microwave link is in a fade (not always necessary)); Apple, Broadcom, Google, Meta, Aug. 2, 2023 *Ex Parte* at 1-2.

[95] *See* George Kizer, Digital Microwave Communication, 321-324 (2013).

rare while more mild fades occur more frequently. For a typical link, fades greater than 30 dB occur, on average, 15 seconds a month while fades greater than 10 dB occur, on average, 37 minutes a month.[96] Because of this fading phenomenon, 6 GHz microwave links are designed with large "fade margins" that are typically 25-40 dB.[97] This fade margin provides transmitted power beyond what is needed to maintain the link when no fading is occurring. Thus, the typical microwave link can operate with 5-nines availability (99.999%) despite the presence of fading. Because the links are designed with these large fade margins, even when a VLP device is located directly within the main beam of a microwave antenna at a close enough distance where it might be possible for it to cause harmful interference, the microwave link's operation will not be degraded unless a deep enough fade occurs so that the combination of received signal from the VLP device and fade depth is greater than the link's fade margin. Hence, an examination of the interference potential of VLP devices to microwave links must consider not only the position and transmit power of the VLP devices and the technical characteristics of the microwave links, but also include the effects of fading.

27. A computer simulation submitted by Apple, Broadcom et al. modeled the effect of VLP devices on two hundred forty-seven (247) fixed microwave links in the San Francisco area.[98] Data from the Commission's licensing database was used to model each microwave link.[99] For each iteration during this simulation, 1,146 VLP devices were randomly placed in the San Fransisco area where the distribution of devices was determined by the population data—i.e., it was more likely that the devices were placed in areas with higher population density.[100] This 1,146 number was based on an estimate of how many VLP devices were likely to be operating outdoors in the region at any given time based on the population and assumptions on how many people are outdoors, the percentage of those people with a VLP device, the percentage of unlicensed devices operating in the 6 GHz band as compared to other bands, and the VLP devices' activity factor.[101] One million iterations of the simulation were run for VLP PSD levels of 10 dBm/MHz, 1 dBm/MHz, -5 dBm/MHz, -8 dBm/MHz, and -18 dBM/MHz.[102] The characteristics of each VLP device were determined based on several probability distributions. The bandwidth that the devices used ranged from 20, 40, 80, 160, to 320 megahertz, with 160 megahertz being the most common.[103] The simulations assumed that 90% of the VLP devices were 1.5 meters above ground level and that the remaining devices were randomly distributed using a distribution based on LIDAR data of building heights for that location, if the LIDAR data on building heights was available, or an exponential

[96] Apple, Broadcom et al. Oct. 7, 2019 *Ex Parte* at slide 12.

[97] FWCC Comments at 16 (filed Feb. 15, 2019); FWCC Oct 31, 2019 *Ex Parte* at 12-13.

[98] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* to OET at 8.

[99] *Id*. at 5. Apple, Broadcom et al. state that "San Francisco was selected to model one of the most challenging cities in the nation—a region with significant height disparities between FS transmitters and receivers, including many FS links on hills above the city—resulting in an analysis of many worst-case receiver heights and elevation angles. Other cities can be expected to have fewer such scenarios." They add that "[t]he San Francisco region is also useful to simulate because it includes both extremely dense urban cores as well as suburban and rural areas, allowing all three environments to be captured in one simulation."

[100] *Id*. at 9.

[101] *Id*. at 9. This 1,146 number is obtained by multiplying the total area population by all of the factors listed on the slide.

[102] *Id*. at 5, 8.

[103] *Id*. at 8. The bandwidth distribution ranged from 5% of devices operating with 40 megahertz channel bandwidth to 35% of devices operating with 160 megahertz channel bandwidth. *Id.*

distribution if LIDAR data was not available.[104] While each simulation iteration assumed a uniform peak 14 dBm EIRP power level, the VLP devices were assumed to use transmit power control, which reduces the transmit power for individual devices based on a truncated gaussian distribution ranging from 0 to 6 dB with a 3 dB mean and 3 dB standard deviation.[105] An antenna pattern based on a model of consumer Wi-Fi devices developed by the European Conference of Postal and Telecommunications Administrators (CEPT) SE45 working group was assumed for all VLP devices.[106] The simulation also assumed a distribution for body loss with a 4 dB mean and 4 dB standard deviation truncated above and below one standard deviation.[107] The simulation used a free space path-loss propagation model for distances less than 30 m, the WINNER II-Combined model for distances between 30 m and 1 km and heights less than 15 m, the WINNER-II line-of-sight model for distances between 30 m and 1 km and heights greater than 15 m, and the ITM model for distances greater than 1 km.[108]

28. The Apple Broadcom et al. computer simulation indicates that for VLP devices transmitting at -5 dBm/MHz EIRP PSD the probability of the interference to noise power (I/N) ratio exceeding the -6 dB evaluation metric[109] was 0.003% and the probability of the I/N exceeding 0 dB was 0.001% over the one million simulation iterations.[110] The simulation specifies that the same probability of exceeding the -6 dB I/N evaluation metric results when the VLP PSD is 1 dBm/MHz EIRP, but is correspondingly lower for -8 dBm/MHz and -18 dBm/MHz EIRP PSD levels and higher for the simulations that used 10 dBm/MHz EIRP.[111] In addition to providing statistics on the I/N ratio, the simulation also evaluated the

[104] *Id*. Light Detection and Ranging (LIDAR) is a technology similar to RADAR that can be used to create high-resolution digital elevation models (DEMs) with vertical accuracy as good as 10 cm. LiDAR data includes terrain and clutter information for the geographic area studied. *See* U.S. Geological Survey at www.usgs.gov.

[105] *Id.* at 8.

[106] Apple, Broadcom et al. claim that this antenna pattern is less protective than most masks used in the real world. *Id.* at 8, 11-12.

[107] Apple, Broadcom et al. claim that this represents less loss than expected under real world operating conditions. *Id.* at 8.

[108] *Id*.; Apple, Broadcom, Google, Meta Aug. 31, 2023 *Ex Parte* at 1.

[109] In the *6 GHz Order*, the Commission established -6 dB I/N as an evaluation metric for AFC systems when determining spectrum availability for standard power devices. *6 GHz Order*, 35 FCC Rcd at 3878, para. 71. For this evaluation metric, "I (interference) is the co-channel signal from the standard power access point or fixed client device at the fixed microwave service receiver, and N (noise) is background noise level at the fixed microwave service receiver." *See* 47 CFR § 15.407(l)(2)(i). In making this determination, the Commission also stated that it was not making a determination that any signal received with an I/N greater than -6 dB would constitute "harmful interference." *Id.*

[110] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* to OET at 8, 19.

[111] *Id*. at 19. The results for each PSD are summarized below:

PSD (dBm/MHz)	Average Probability of exceeding I/N > -6 dB	Percentage Difference from -5 dB PSD	Average Probability of exceeding I/N > 0 dB	Percentage Difference from -5 dB PSD
-5	0.003%	-	0.001%	-
1	0.003%	0	0.001%	0
-8	0.002%	33% decrease	0.001%	0
-18	0.0003%	90% decrease	0.0001%	90% decrease
10	0.075%	2500% increase	0.020%	2000% increase

likelihood that the microwave link's fade margin will be exceeded by the combination of the interference power received from the VLP devices and the atmospheric multipath fading. For each of the 247 microwave links in the San Francisco area, the simulation calculated the fade margin by calculating the actual carrier-to-noise (C/N) ratio for the microwave link based on the link's technical parameters—i.e., the transmitted power, propagation distance, antenna gain, receiver feeder loss, and receiver noise figure—and subtracting the C/N ratio needed for the link to operate at the highest data rate listed in the Commission's database for that link.[112] The simulation then determined the probability distribution for the atmospheric multipath fading for each link using the ITU-R P.530-17 model.[113] This model takes into account factors such as the local climate, the transmitter and receiver heights for the microwave link, and the average terrain elevation to create a fading distribution.[114] The simulation then calculated a distribution of the noise floor increase for each link based on the I/N statistics and convolved that with the multipath fading distribution. For VLP devices operating at powers up to 1 dBm/MHz EIRP, the results indicate that the probability of the fade margin being exceeded by the combination of the interference power received from VLP devices plus the multipath fading is not materially different than the probability of the link margin being exceeded solely from multipath fading.[115] According to the simulation results, of the 247 links assessed in the study, the presence of VLP devices transmitting at 1 dBm/MHz EIRP at the "worst-case" location for a microwave link would change the probability that the worst-case link will be degraded by 0.3%.[116]

29. The computer simulation submitted by Apple has many similarities to the Apple, Broadcom et al. simulation. Apple's simulation modeled VLP to microwave receiver interactions in the Houston, Texas area by modeling a single microwave link while varying the VLP parameters for each simulation run based on the characteristics of microwave links that area.[117] Two hundred twenty-four (224) VLP devices operating at 14 dBm EIRP within bandwidths varying from 20 megahertz to 320 megahertz were randomly placed within 23.49 kilometers of the microwave link on each of 10 million iterations.[118] Separate simulations were conducted for VLP PSD levels of 1 dBm/MHz, -5 dBm/MHz, -8 dBm/MHz, and -18 dBm/MHz, with the total power in each case set at 14 dBm EIRP.[119] The simulation assumed a body loss that is gaussian distributed with a 4 dB mean and a 4 dB standard deviation, truncated to one standard deviation.[120] 90% of the VLP devices were assumed to be at a height of 1.5 meters above ground level, and the remaining devices' heights were randomly chosen using a distribution based on actual Houston area building heights.[121] It assumed that transmit power control was used with a gaussian distribution in seven discrete steps from 0-6 dB.[122] The simulation assumed a 1.3 dB feeder loss and a 5 dB noise figure for the microwave receivers.[123] It also assumed that the microwave antenna had a 44 dBi

[112] *Id*. at 24.

[113] *Id*. at 25.

[114] *Id*. at 25.

[115] *Id*. at 17.

[116] *Id*. at 15.

[117] Apple Feb. 13, 2023 *Ex Parte* at 4, 9-13.

[118] The distribution of channel bandwidths varied from 5% at 320 megahertz to 45% at 80 megahertz. *Id.* at 1, 10. Apple Sept. 14, 2023 *Ex Parte* at 3.

[119] *Id*. at 10.

[120] *Id.* at 10.

[121] *Id*. at 11.

[122] *Id*. at 11.

[123] *Id*. at 11.

gain, was at a 35 meter height above ground level, and had an elevation angle (downtilt/uptilt) that was randomly chosen between plus and minus 2 degrees.[124] The simulation used the propagation models specified in the Commission's rules for the AFC systems that control spectrum access for 6 GHz band standard power unlicensed devices to calculate the I/N at the microwave receiver on each iteration. The simulation used a free space path-loss propagation model for distances less than 30 m, the WINNER-II statistical model for distances between 30 m and 1 km, and the ITM model for distances greater than 1 km.[125]

30. The Apple simulation found that for VLP devices operating at -5 dBm/MHz EIRP PSD, the -6 dB I/N level was exceeded approximately 0.06% of the time and 0 dB I/N was exceeded approximately 0.01% of the time.[126] For VLP devices operating at 1 dBm/MHz EIRP PSD, the -6 dB I/N level was exceeded approximately 0.085% of the time and 0 dB I/N was exceeded approximately 0.02% of the time.[127] Similar to the San Francisco simulation, the Houston simulation also examined the likelihood that the microwave link's fade margin will be exceeded by the combination of the interference power received from the VLP devices and the atmospheric multipath fading.[128] These results, which were derived for various microwave transmitter heights, show that the presence of VLP devices have no noticeable impact on microwave link reliability compared to atmospheric multipath fading alone.[129] The simulation for the Houston area also indicated that the chance of exceeding -6 dB I/N increased from 0.07% to 0.135% when both VLP and LPI devices were included as compared to just having LPI present.[130] Finally, this simulation also examined the sensitivity of various inputs to the overall result. Apple claims that the results are sensitive to fixed service receiver antenna height, where higher microwave receiver antenna height above ground level results in a lower potential for impact to the microwave link and that the 35 meter antenna height assumed for the simulation represents a conservative value because such a height is significantly lower than the typical microwave receiver height in the Houston area.[131] Likewise, Apple asserts that the assumed 44 dBi microwave receiver antenna gain and assumed ITU-R F.1245 antenna pattern do not represent typical antenna gains or antenna gain patterns and that more realistic inputs would result in the results showing a lower potential for exceeding the -6 dB I/N evaluation metric.[132]

31. AT&T argues that the approximate 0.1% chance that the Apple simulation indicates for the I/N to exceed -6 dB for a VLP device operating at 1 dBm/MHz EIRP PSD implies that 1,300 device

[124] *Id*. at 11. These parameters were chosen to be representative of fixed links in the Houston area. *Id*. at 12-13.

[125] Apple's filing indicates that a free space propagation model is used for distances greater than or equal to 30 meters and that WINNER II is used for distances greater than 30 meters and less than 1 kilometer. We believe this is an error and that the free space model was used for distances less than or equal to 30 meters. Apple Feb. 13, 2023 *Ex Parte* at 10.

[126] *Id*. at 20.

[127] *Id*. at 20. AT&T complains that the computer simulations focus on the 1 dBm/MHz EIRP PSD power level claiming this is 9 dB higher than what was proposed in the *Further Notice*. AT&T Aug. 29, 2023 *Ex Parte* at 9. While the *Further Notice* did note that Apple, Broadcom et al. argued that -8 dBm/MHz PSD EIRP was necessary for VLP devices, the Commission did not propose a particular power level for VLP devices; it sought comment on what would be an appropriate power level while proposing requirements for VLP devices to provide commenters a foundation on which to base their preferred power level. *6 GHz Further Notice,* 35 FCC Rcd at 3940, 3942, paras. 236, 243.

[128] Apple Feb. 13, 2023 *Ex Parte* at 16-17.

[129] *Id*. at 15

[130] *Id.* at 19.

[131] *Id.* at 22.

[132] *Id.* at 23-24.

deployments in the Houston area would impair the fade margin of a microwave link by more than 1 dB (i.e., produce an I/N greater than -6 dB) at any given moment.[133] AT&T apparently reaches this number by multiplying 0.1% times 1.285 million, which is listed as the number of VLP capable devices in Houston.[134] AT&T argues that this demonstrates a significant risk to microwave links.[135] This contention is based on several misunderstandings of the Apple Monte Carlo simulation. In this simulation, only 224 VLP devices are simultaneously transmitting in each iteration.[136] Ten million iterations of the simulation were conducted.[137] The approximately 0.1% chance of the I/N being greater than -6 dB means that on 10,000 of these 10 million iterations, the calculated I/N at the microwave receiver from all 224 VLP devices was greater than -6 dB; the I/N contribution from any individual VLP device would be much less. As to AT&T's contention that this demonstrates a significant risk to the microwave links, this represents the likelihood that the aggregate signal from all 224 transmitting VLP devices causes the microwave link to receive a signal at greater than -6 dB I/N, which represents a 1 dB reduction in the fade margin of the link.[138] We reiterate that in the *6 GHz Order* the Commission stated that it was not making a determination that a signal received at greater than -6 dB I/N would constitute "harmful interference."[139]

32. These simulations examined the statistical relationship that the combination of the interference power received from VLP devices and atmospheric multipath fading could have on microwave receivers. Both the San Francisco analysis and the Houston analysis considered the summation of microwave receiver noise floor from VLP device transmissions and the occurrence of atmospheric multipath fading.[140] Because atmospheric multipath fading and the signal levels received from the VLP devices are independent phenomenon, in accordance with a well-known statistical theorem the probability distribution of the combination of these two processes is the convolution of the probability distribution of each of the individual processes.[141] The computer simulations used this mathematical convolution process to examine the combination of these two processes[142] and illustrate that the presence of VLP devices does not result in a significant increase in the likelihood that the fade margin of the links will be exceeded by the combination of both atmospheric multipath fading and signals received from the VLP devices.[143] Because the functioning of a microwave link is only interrupted when the combination of multipath fading and received VLP signals exceeds the fade margin, these results show that the presence of VLP devices will not significantly increase the potential for harmful interference to a microwave link over effects due to atmospheric fading alone.

33. AT&T claims the data on fade margin exceedance from the combination of atmospheric multipath fading and VLP devices that the Apple, Broadcom et al. Monte Carlo simulation presents is

[133] AT&T Aug. 29, 2023 *Ex Parte* at 9.

[134] Apple indicates that there are 1, 285,376 6 GHz capable VLP devices assuming a 50% adoption factor. Apple Feb. 13, 2023 *Ex Parte* at 10. Apple does not provide a source for this number.

[135] *Id*.

[136] Apple Feb. 13, 2023 *Ex Parte* at 1.

[137] *Id*. at 10; Apple Sept. 14, 2023 *Ex Parte* at 7.

[138] Apple Sept. 14, 2023 *Ex Parte* at 4.

[139] *6 GHz Order*, 35 FCC Rcd at 3878, para. 71.

[140] Apple Feb. 13, 2023 *Ex Parte* at 18; Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 15.

[141] *See e.g.* Athanasios Papoulis, Probability, Random Variables, and Stochastic Processes 136 (3d ed. 1991); George Casella & Roger L Berger, Statical Inference 215 (2d ed. 2002).

[142] The convolution integral of two functions x(t) and h(t) is defined as: $y(t) = \int x(\gamma)\, h(t-\gamma)\, d\gamma$. Rodger Ziemer, William Tranter, & D. Ronald Fannin, Signals and Systems: Continuous and Discrete 44 (1983).

[143] Apple Feb. 13, 2023 *Ex Parte* at 26; Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 22.

suspect.[144] According to AT&T, Apple, Broadcom et al. have not explained how they calculate these results.[145] AT&T claims that for the data without VLP devices present (the "fading only" data), the presence of links with availabilities below 99.95% and above 99.99999999% seem improbable and that the most obvious conclusion for this is that Apple, Broadcom et al. may have omitted some parameter in its calculations.[146] In response, Apple, Broadcom, and Meta explain that the vast majority of links have reliability in the five-nines to eight-nines range; the links with higher reliability tend to be short links, operating at higher EIRPs, with high gain antennas, narrower bandwidths resulting in high signal-to-noise ratios; the links with lower reliability tend to be much longer, transmit at lower power, use lower gain antennas, and operate with higher bandwidths resulting in lower signal-to-noise ratio at the receiver.[147] We believe that Apple, Broadcom et al. have sufficiently explained how they calculate this data. As they explain, for each link, the available C/N ratio was calculated based on the link's transmitted power, propagation distance, receiver antenna gain, receiver feeder loss, and receiver noise figure and the required C/N ratio was calculated based on the highest order modulation for the link as indicated in the Commission's licensing data.[148] The fade margin is simply the difference between these two C/N ratios.[149] The probability that the fade margin for a link will be exceeded by an atmospheric multipath fade was obtained from ITU-R P.530-17.[150] As to whether some of the link availabilities are excessively low or high, as AT&T claims, we do not find the range of link availabilities indicated by Apple, Broadcom et al. to be unrealistic. As Apple, Broadcom, and Meta indicate, there are many factors that impact the calculated availability of the microwave links. While most of the 247 microwave links are in the five-nines to six-nines range to which microwave links are typically designed, it is reasonable to expect that there will be link availabilities outside this range. This could be the result of atypical situations such as very short or long links or because they are being used for applications that either do not require high reliability or require extremely high reliability. It may also be possible that for some of the links the information in the Commission's ULS database upon which these calculations are based is inaccurate. AT&T also suggests that it would be useful for Apple, Broadcom et al. to have listed the links that appear to be more susceptible to VLP interference to help understand what they have in common.[151] Because none of the links appear to have an increased potential for the fade margin being exceeded by the combination of multipath fading and VLP devices operating at the -5 dBm/MHz power level, the information is not necessary to reach a conclusion regarding the potential for harmful interference occurring.

34. For the Commission to have confidence in the results of computer simulations, the assumptions and models that are used must be appropriate. We find that for both the Apple, Broadcom et al. and Apple simulations, the assumptions are not only appropriate, but also represent reasonably conservative estimates of the potential impact on microwave receivers and that using more realistic input assumptions would produce results showing even less potential impact. Nevertheless, the Monte Carlo analyses results are important as they represent an upper bound on what could be expected under real-world conditions with the actual impact likely to be much lower. To reiterate this point, we discuss these assumptions.

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[144] AT&T Aug. 29, 2023 *Ex Parte* at 12. While AT&T's filing refers to "Apple" when making this claim, this contention is in the *San Franciso Study* section and cites the Apple, Broadcom et al. filing.

[145] *Id*. at 11-12.

[146] *Id.* at 12.

[147] Apple, Broadcom, and Meta Sept. 14, 2023 *Ex Parte* 11.

[148] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 24.

[149] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 24.

[150] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 25.

[151] AT&T Aug. 29. 2023 *Ex Parte* at 11.

35. Each of the simulations randomly distributed a number of VLP devices over the study area for each iteration. Consequently, one of the most important simulation parameters is how many VLP devices are placed during each iteration. This number must represent a realistic estimate of the likely number of VLP devices that could be operating at each instant in time so that the simulations accurately model the potential interference environment. Because VLP devices do not yet exist, there are no actual use statistics and the number of simulated devices is, by necessity, based on set of assumptions. We find that the number of devices placed within the study area for each simulation iteration appears to be based on realistic assumptions. Both simulations assume that all simulated VLP devices will operate outdoors because indoor VLP devices are assumed to not present an interference risk to microwave links.[152] We agree; such an assumption is consistent with the Commission's finding in the *6 GHz Order*, which adopted rules permitting LPI devices to operate with 5 dBm/MHz PSD EIRP and up to 30 dBm EIRP;[153] at least 10 dB more than we are permitting for VLP devices. The Apple, Broadcom et al. simulation, assumes that for the population within the study area, 6% of people will be outdoors, and that 25% of those people will be using VLP devices.[154] Apple, Broadcom et al. indicate that 6% is a realistic assumption because EPA and Department of Transportation statistics show that the average American spends 90% of the time indoors and, of the remaining 10%, 4% of the time is spent in vehicles, which leaves 6% with no attenuation of the signal from buildings or vehicles.[155] As this assumption is based on Department of Transportation and Environmental Protection Agency statistics, we find that it is reasonable.[156] We believe that assuming 25% of people outdoors at any given time will be using a VLP device is a conservative assumption as even if 25% of the people are simultaneously using devices, many are apt to be operating using licensed spectrum and of the devices operating on an unlicensed basis, they are likely to be spread across the various bands that support unlicensed devices (e.g., U-NII bands 1-5). Apple, Broadcom et al. acknowledge this by further stating that they assume that 90% of the devices will operate on an unlicensed basis (rather than using licensed spectrum), that 50% of unlicensed devices will be capable of using the 6 GHz band, and that of these devices capable of using the 6 GHz band, 65% will actually be using the 6 GHz band.[157] These appear to be reasonable assumptions. In addition, they assume that VLP devices will actively transmit 2% of the time.[158] While this assumption may not necessarily reflect the real-world operation of future VLP devices, we find that it is reasonable for analytical purposes because it is (1) consistent with the assumptions in studies by the European Conference of Postal and Telecommunications Administrations (CEPT);[159] and (2) several times higher than the 0.4% activity factor the Commission assumed for LPI devices in the *6 GHz Order*.[160] Thus, as the number of VLP devices placed in each iteration for the Apple, Broadcom et al. simulation appears to

[152] *See* Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 5, 9; Apple Feb. 13, 2023 *Ex Parte* at 12.

[153] *6 GHz Order*, 35 FCC Rcd at 3860, 3892, paras. 18 tbl. 3, 110.

[154] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 9.

[155] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 9.

[156] How much time do Americans Spend Behind the Wheel?, U.S. Department of Transportation (Dec. 11, 2017) https://www.volpe.dot.gov/news/how-much-time-do-americans-spend-behind-wheel (indicating that American's on average spend just under an hour driving every day); U.S. Environmental Protection Agency. 1989. Report to Congress on indoor air quality: Volume 2. EPA/400/1-89/001C. Washington, DC.

[157] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 9.

[158] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 9.

[159] *Sharing and Compatibility Studies Related to Wireless Access Systems include Radio Local Area Networks (WAS/RLAN) in the Frequency Band 5925-6425 MHz*, ECC Report 302 at 23, May 29, 2019.

[160] *6 GHz Order*, 35 FCC Rcd at 3893, para. 101.

be based on reasonable assumptions, we conclude that placing 1,146 devices per iteration was appropriate to model the interference potential of VLP devices.[161]

36. Apple placed 224 VLP devices during each iteration for its Houston area analysis.[162] This number was based on a set of assumptions about VLP device use: 50 percent of the Houston residents would have 6 GHz band capable devices, 62.7% of the people with such devices would be using them during the busy hour, 90% of the devices would operate on an unlicensed basis rather than using licensed spectrum, 64% of the devices operating on an unlicensed basis would operate in the 6 GHz band, 12.54% of the devices operating the 6 GHz band would be co-channel with the microwave links, and the devices would transmit with a duty cycle of 1.5%.[163] These assumptions appear to be reasonable. Because the analysis places all 224 VLP devices around a single microwave receiver[164] rather than the 247 microwave receivers simulated in the Apple, Broadcom et al. simulation, the average number of VLP devices per microwave receiver is much higher for the Houston analysis and likely overestimates the VLP device density that would occur under real-world conditions. Given the higher VLP device density used for the Houston analysis as compared to the San Franscisco analysis, we find that the fact that the Houston results show a 20 times increase in the potential for a VLP device to exceed the -6 dB I/N evaluation metric is not cause for concern regarding an increase in the potential for actual harmful interference. First, the analysis assumed that every VLP device was operating co-channel with the microwave receiver.[165] This situation is unlikely to occur under actual operating conditions as 802.11 unlicensed devices employ a carrier-sense multiple access with collision avoidance protocol to ensure that devices only operate when other devices are not transmitting, which is a feature that tends to ensure that devices spread out across the available spectrum.[166] Second, the propagation models estimate clutter losses based on the mean for various statistical categories and are likely to underestimate these losses, especially in cities where tall buildings and urban canyons are likely to block signals from microwave receivers.[167] Third, from a purely mathematical standpoint, it stands to reason that the more devices that are randomly placed around a microwave receiver, the greater the likelihood that the signal level received at the microwave receiver may exceed the evaluation metric. However, as we believe that the number of VLP devices used in each simulation run for Houston was higher than what would be reasonably expected

[161] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 9. The number of devices was derived using the aforementioned assumptions and a population of 13,066,000 based on Census Bureau data. *Id.* AT&T claims that the number of VLP devices in the simulation is not clear, but we disagree. AT&T Aug. 29, 2023 *Ex Parte* at 11. The number of devices is obtained by multiplying the area population of 13,066,000 by the all of the assumed percentages.

[162] Apple Feb. 13, 2023 *Ex Parte* at 1. AT&T raises the possibility that the Apple simulation is implicitly using a low 0.017% activity factor for VLP devices based on the 224 simultaneously transmitting devices and a claimed universe of 1,285,376 VLP capable devices. AT&T Aug. 29 *Ex Parte* at 10. Apple subsequently explained that the number of devices they placed per iteration is consistent with assuming a 1.5% duty cycle. Apple Sept. 14, 2023 *Ex Parte* at 7.

[163] Apple Sept. 14, 2023 *Ex Parte* at 7.

[164] This methodology is consistent with the methodology used by CEPT when it analyzed the potential for VLP devices to cause harmful interference to microwave receivers. *Sharing and Compatibility Studies Related to Wireless Access Systems include Radio Local Area Networks (WAS/RLAN) in the Frequency Band 5925-6425 MHz*, ECC Report 302 at 62-63, May 29, 2019.

[165] Apple Feb. 13, 2023 *Ex Parte* at 1.

[166] The 802.11 protocol uses a carrier sense multiple access (CSMA) method in which the wireless stations (STA) first sense the channel and attempt to avoid collisions by transmitting only when they sense the channel to be idle. National Instruments, Introduction to 802.11ax High-Efficiency Wireless (Apr. 19, 2023) http://www.ni.com/en-us/innovations/white-papers/16/introduction-to-802-11ax-high-efficiencywireless.html#section-1277099502.

[167] *See* ITU Recommendation ITU-R P.2108-1 (09/2021), "Prediction of Clutter Loss", available at: https://www.itu.int/dms_pubrec/itu-r/rec/p/R-REC-P.2108-1-202109-I!!PDF-E.pdf.

under actual operating conditions, we believe that the results similarly overestimate the actual number of devices that would exceed the -6 dB I/N evaluation metric. And even if the results from the San Francisco and the Houston analyses represent lower and upper bounds, these percentages are sufficiently low as to pose an insignificant risk of harmful interference to microwave links. And fourth, as noted in the *6 GHz Order* and herein, the -6 dB I/N is an evaluation metric and exceeding that metric does not in and of itself represent harmful interference as microwave links are designed with significant fade margin. Lastly, many microwave links rely on multiple receive antennas that are physically separated from one another to provide spatial diversity as a method to mitigate multipath fading. This will make the receivers even more resistant to multipath fading meaning that the likelihood that the fade margin will be exceeded by the combination of fading and VLP interference is even lower than is indicated by the simulation.

37. AT&T points out that for many VLP device use cases there will be at least two and maybe more VLP transmitters exchanging data at the same location.[168] According to AT&T, the simulations should therefore account for both devices' effective radiated power and antenna patterns.[169] Apple, Broadcom, and Meta claims that it is improper to treat multiple devices as simultaneously transmitting because when one device is transmitting the other will not be transmitting so it can receive the signal.[170] We agree with AT&T that many VLP device use cases, such as body worn devices and mobile hotspots, involve communication between multiple VLP devices. However, only one of these devices will be transmitting at a time. Furthermore , such usage will usually involve devices located in close proximity, in many cases on the same person's body, sharing the same channel through intermittent transmissions. Thus, these multiple devices can appropriately be considered a single device within the simulation. Moreover, if multiple proximate devices communicate over different channels, then only one of the simulated devices would be co-channel with a given microwave receiver, negating it from consideration within the simulation. Therefore, we do not agree with AT&T that it is necessary for multiple proximate VLP devices communicating with each other to be specifically modeled by the simulations as such use is implicitly accounted for.

38. One of the key parameters in computer simulations is the propagation model used to calculate the signal level received by the microwave receivers from the VLP devices. The Apple simulation uses the exact propagation models that the Commission specified for the AFC systems that manage access to 6 GHz band spectrum by standard power access points,[171] while the Apple, Broadcom et al. simulation departs slightly from this framework.[172] Our rules require AFC systems to use a free space path-loss propagation model for a separation distance of up to 30 meters, the WINNER II model for a separation distance of more than 30 meters and up to and including one kilometer, and the Irregular Terrain Model for a separation distance of greater than one kilometer.[173] As the Commission concluded that these models are appropriate in preventing harmful interference from standard power devices in this band, we agree that these models are appropriate for a computer simulation for VLP devices. The Apple, Broadcom, et al. simulation departs from our AFC rules by using the WINNER-II combined version when the VLP device is below 15 meters in height and the WINNER-II line-of-sight (LOS) version when the VLP device is 15 meters or more in height.[174] The combined version of WINNER-II is required by our AFC rules when site-specific information on buildings and terrain is not available to determine

[168] AT&T Aug. 29, 2023 *Ex Parte* at 5.

[169] AT&T Aug. 29, 2023 *Ex Parte* at 5.

[170] Apple, Broadcom, and Meta Sept. 14, 2023 *Ex Parte* at 7.

[171] Apple Feb. 13, 2023 *Ex Parte* at 10. As stated in footnote 125 *supra*, there is apparently a mistake in Apple's description of when the free space propagation model is used.

[172] Apple, Broadcom, Google, Meta Aug. 31, 2023 *Ex Parte* at 1.

[173] 47 CFR § 15.407(l)(1); *6 GHz Order,* 35 FCC Rcd at 3875-77, paras. 64-66.

[174] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 8.

whether there is LOS between the VLP device and microwave tower.[175] Using the WINNER-II (LOS) version always results in less propagation loss than the WINNER-II combined version. Hence, employing the WINNER-II (LOS) version when the VLP device is 15 meters or more in height is a more conservative assumption than the AFC rules. As the difference in the propagation models used in the Apple, Broadcom et al. simulation and our AFC rules produces a more conservative result—i.e. overpredict the possibility of interference—they are not only appropriate for evaluating the potential for exceeding the -6 dB I/N evaluation metric, but also act to overprotect microwave receivers beyond the limits we deem appropriate in our rules.

39. Another input modeled within the simulations was attenuation to account for "body loss" due to scattering and absorption from a VLP device operating on or near a body or other object (e.g., a VLP device placed on a table).[176] As VLP devices are envisioned to generally be small form factor body worn type devices or devices used in close proximity to people, this is an appropriate input for analysis. Commenters suggest different attenuation levels that should be used for body loss. Southern Company suggests that it would be reasonable to assume 4.5 dB for body loss since a VLP device is as likely to be in full view of the fixed microwave receiver as it is to be obstructed and that this value seems to be industry practice.[177] AT&T cites a CEPT Electronic Communications Committee (ECC) report that assumes a 4 dB body loss for VLP devices.[178] The Wi-Fi Alliance points to an ITU report to support a 4 dB body loss value when suggesting parameter values.[179] Nokia also used a 4 dB body loss in its technical analysis of VLP interference potential.[180] Apple, Broadcom et al. submitted a measurement study by the Wireless Research Center of North Carolina that includes measured data on the effect of the human body on transmissions from VLP devices with respect to receivers in the far field for six test subjects and six positions and finds that the median body loss was 8 dB.[181] Meta also submitted a study

[175] 47 CFR § 15.407(l)(ii). The "combined" WINNER-II propagation model is what the rule refers to as using "a probabilistic model combining the line-of-sight path and non-line-of-sight path into a single path-loss."

[176] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 8; Apple Feb. 13, 2023 *Ex Parte* at 10.

[177] Southern Company Comments at 9 (filed June 29, 2020).

[178] AT&T Comments at 9 (referencing *European Conference of Postal and Telecommunications Administrations Electronic Communications Committee, Sharing studies assessing short-term interference from Wireless Access Systems including Radio Local Area Networks (WAS/RLAN) into Fixed Service in the frequency band 5925-6425 MHz*, ECC Report 316 at 11; *see* ECC 316 Report at 7 ("A fixed body loss of 4 dB is applied to VLP devices when performing sharing studies."); *id.* ("Very Low Power portable battery-operated device category is expected to enable a hand-held or wearable client device class. VLP devices will provide connectivity to client devices when located outside of locations that contain low power indoor access points. Example outdoor use cases include short range personal area networks for Automotive, such as improved vehicle to driver interface, and Augmented and Virtual Reality (AR/VR) applications in education, medicine, training, defense, remote presence, gaming, and more generally, next generation human – computer interaction.")) (filed June 29, 2020).

[179] Wi-Fi Alliance Comments at 11 (filed June 29, 2020) (citing *Characteristics of terrestrial IMT-Advanced systems for frequency sharing interference analysis*, International Telecommunication Union, ITU-R M.2292-0 (Dec. 2013)).

[180] Nokia Comments Technical App. at 5 (filed June 29, 2020).

[181] Apple, Broadcom et al. Comments Attachs. B at 9, Figure 26 (filed June 29, 2020). The median value in this Figure is 14 dB but it includes 6 dB of antenna mismatch. *See* Apple, Broadcom et al. Nov. 3, 2020 *Ex Parte* at 2. AT&T claims this study is not relevant for the potential harm of VLP devices to microwave links. AT&T Oct. 13, 2020 *Ex Parte* at 11. This appears to be based on only looking at the data in the study for relative loss between two body worn devices. However, the study also contains data showing the energy received in the far-field from body worn devices, which is what Apple, Broadcom et al. are relying on here. Apple, Broadcom et al. Comments Attachs. B at 8-11.

with measurement data indicating that the attenuation from the body was 3-5 dB for handheld devices, around 3 dB for an eyeglass device, and 8-16 dB for a device in a pocket.[182]

40. Body loss is a random variable and subject to variation due to a multitude of factors, such as whether a device is body-worn or not, what part of the body it is worn on, body type, and whether it is in a pocket. Thus, a body loss value for analytic purposes must reflect not just the body loss itself, but also the wide range of values possible, the varying behavior of VLP device users, and the variety of uses for which VLP devices may be employed. For non-body-worn devices, such losses will occur due to absorption and reflections from a table or other surface the device is sitting on or, for in-vehicle use, from the vehicle's cabin.[183] The body loss reduces the signal level that reaches a potential victim receiver from a VLP device. Considering the data placed on the record reflecting widely varying levels of body loss under different conditions, as well as the general consensus among studies relied on by other regulators, we find that the computer simulations' assumptions that there would be a mean attenuation of 4 dB for body and/or clutter loss and that this would follow a gaussian distribution is appropriate. We believe that this is a reasonable approach as it is in the range specified by many commenters, is consistent with the measurements made by Meta, and is consistent with what was used by the ITU and ECC for interference analysis. While many commenters put data on the record purporting to show losses greater than 4 dB, we note that this data also shows, in some instances, losses less than this value.[184] Because VLP devices are anticipated to be worn across a wide range of positions on the body or placed on a wide range of surfaces, we believe that use of a gaussian distribution with a 4 dB mean as used by the computer simulations captures the wide range of use cases described by VLP proponents and is appropriate for analytical purposes. Gaussian distributions are commonly used to represent random processes that vary over a range such as far-field body loss. As body loss is used to represent attenuation from a range of objects near the VLP device such as a human body or the surface of table, using such a distribution is appropriate. Considering that the body loss measurements submitted by Apple, Broadcom et al. and Meta have a mean higher than 4 dB and some measured attenuations were much greater than the then 8 dB maximum of the truncated distributions used in the simulations, use of these distribution appears to be a conservative assumption.[185] We do not find merit in AT&T's criticism of the body loss distribution used by the simulations as not being justified or being "abnormally" truncated to plus/minus one standard deviation.[186] While AT&T implies the distribution must be "justified," it does not provide any information on what

[182] Meta Platforms April 12, 2023 *Ex Parte* slides at 10. Meta is the new name for Facebook, effective Dec. 1, 2021. Facebook submitted comments in this proceeding under the name Facebook Inc. up to and including the year 2021. All Facebook subsequent comments were submitted under the new name Meta Platforms Inc.

[183] The Commission previously assumed 3 dB for absorption and reflection loss for a 600 MHz band device when placed on a surface. *Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37*, Report and Order, 30 FCC Rcd 9551, 9600, para. 125 (2015). Given the reduced signal propagation in the 6 GHz band compared to 600 MHz band, a loss of at least 4 dB is reasonable for 6 GHz band devices.

[184] Meta Platforms April 12, 2023 *Ex Parte* slides at 12; Apple, Broadcom et al. Comments Attachs. B at 6-9, (filed June 29, 2020).

[185] Apple, Broadcom et al. Comments Attachs. B at 9, Figure 26 (filed June 29, 2020); Meta Platforms April 12, 2023 *Ex Parte* slides at 10.

[186] AT&T Aug. 29, 2023 *Ex Parte* at 5. AT&T also points out "that there is no demonstrated correlation between body loss and orientation of the VLP device relative to the FS receiver." *Id*. This statement appears to be confusing two different types of body loss: 1) the propagation loss of transmissions between two body worn devices and 2) the signal attenuation due to the presence of the body when a body worn device transmits to a distant transmitter. AT&T with this statement appears to be referring to the first type of body loss. However, the Monte Carlo simulations are modeling the second type of body loss in determining the signal received by microwave receivers from VLP devices. As mentioned in footnote 181, data on both of these types of losses was included in the study submitted by Apple, Broadcom et al.

such a justification may entail or how body loss should otherwise be modeled. Use of a truncated distribution is reasonable as this prevents the distribution from unrealistically including a body loss less than 0 dB while maintaining the 4 dB mean.[187]

41. Both computer simulations assumed that 90% of VLP devices would operate at a 1.5 meter height above ground level.[188] Device height is an important variable in these simulations as devices located at greater height are more likely to present an interference risk due to a higher likelihood for being within the main beam of a microwave antenna and because the propagation models will include less clutter loss to represent the fact the devices at greater heights will be above clutter from buildings, trees, etc. As the simulations are only modeling outdoor VLP devices, the VLP devices that are at greater heights will represent use on building balconies and rooftops. We agree with Apple, Broadcom et al. that, assuming that 10% are at heights greater than 1.5 meters appears to be a conservative assumption.[189] For those 10% of VLP devices that are assumed to be above 1.5 meters, both simulations base the height of the device on data for building heights in the cities they are modeling.[190] We conclude that this is a reasonable approach to modeling the VLP device heights. Moreover, for devices that may be operated on a balcony or a rooftop, it is likely that there will be other buildings in the vicinity which create clutter that reduce the signal level received by the microwave receiver.

42. Both simulations used the ITU-R F.1245 antenna pattern to model microwave receiver antennas.[191] This ITU recommendation provides an average antenna pattern to be used in interference assessments.[192] AT&T criticizes the simulations for not using actual antenna patterns for the antennas specified in the Commission's licensing database.[193] AT&T claims that the ITU-R F.1245 pattern has "better side lobe performance than many fixed antennas in use today" and suggests that if the actual antenna patterns are not used that "a better choice would have been to base the antenna pattern on F.699 and the FCC antenna mask in Part 101.115 as has been agreed within the WinnForum" for the AFC specification.[194] When not using the actual antenna patterns, for the primary antenna the WinnForum AFC specification uses the ITU-R F.699 mask for angles within 5 degrees of the boresight of the main beam and a mask based on the part 101.115 rules, which differs by category of antenna, for larger angles (i.e. for the side lobes).[195] Apple, Broadcom, and Meta assert that ITU-R- F.1245 is the appropriate choice because the documentation indicates it should be used when there are multiple sources of interference and that use of ITU-R F.699 may lead to inaccurate results in this type of study.[196]

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[187] Apple Sept. 14, 2023 *Ex Parte* at 6.

[188] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 8; Apple Feb. 23, 2023 *Ex Parte* at 11.

[189] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 7.

[190] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 8; Apple Feb. 23, 2023 *Ex Parte* at 11.

[191] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 8; Apple Feb. 23, 2023 *Ex Parte* at 24.

[192] *Mathematical model of average and related radiation patterns for point-to-point fixed wireless system antennas for use in interference assessment in the frequency range from 1 GHz to 86 GHz*, ITU-R F.1245-3, Jan. 2019, available at https://www.itu.int/rec/R-REC-F.1245-3-201901-I/en

[193] AT&T Aug. 29, 2023 *Ex Parte* at 10.

[194] AT&T Aug. 29, 2023 *Ex Parte* at 10.

[195] Wireless Innovation Forum, *Functional Requirements for the U.S. 6 GHz Band under the Control of an AFC System*, WINNF-TS-1014 Version V1.3.0 at 30-32 (Mar. 9, 2023), https://winnf.memberclicks.net/assets/work_products/Specifications/WINNF-TS-1014.pdf.

[196] Apple, Broadcom, and Meta Sept. 14, 2023 Ex Parte at 7 (citing *Mathematical model of average and related radiation patterns for point-to-point fixed wireless system antennas for use in interference assessment in the frequency range from 1 GHz to 86 GHz*, Recommendation ITU-R F.1245-3 at 4 (Jan. 2019)).

43. Given that the actual antenna model is not specified for many of the microwave link licensing records in the Commission's ULS database and the added complexity of obtaining and integrating into the simulation antenna patterns for microwave links where the antenna pattern is known, we appreciate why the simulations did not use actual antenna patterns. In addition, as the Apple simulation did not model specific microwave links, using a particular actual antenna pattern would have been completely arbitrary. We do not believe the Monte Carlo simulations using a different antenna pattern than the WinnForum AFC specification detracts from the simulation's accuracy for two reasons. First, because ITU-R F.699 is based on the peak envelope for the side lobes it will overestimate the level of interference from signals received in the side lobes because most actual antennas will have lower side lobe gain.[197] ITU-R F.1245, which is based on the average side lobe levels for microwave antennas, appears to be a more appropriate choice given that the purpose of a Monte Carlo simulation is to determine the typical level of interference experienced by microwave receivers and that the simulations are summing the signals received at the microwave antenna at different arrival angles from multiple VLP devices. Second, the WinnForum AFC specification appears to use a mask based on our Part 101.115 rules for the side lobes because this permits use of different levels of attenuation for different categories of microwave antennas for angles of arrival outside the main beam of the antenna. Because the goal of the AFC systems is to protect specific fixed microwave receivers from harmful interference from standard power unlicensed devices, trying to more closely match the characteristics of particular classes of antennas is important for this purpose. In a Monte Carlo simulation the goal is to obtain overall statistics on the likelihood of occurrence of harmful interference to all the microwave links rather than determining exclusion zones around specific microwave receivers. Hence, trying to match the characteristics of individual antennas is of less importance. For this purpose, we believe that use of the ITU-R F.1245 pattern, which represents an "average" antenna pattern, is a reasonable alternative to using the actual antenna patterns or to following the approach used in the WinnForum AFC specification. As this pattern represents an average antenna, there will be some actual antennas with worse side lobe performance as AT&T points out. However, there will also be many antennas with better performance. Across the many simulation iterations, the average antenna performance of the ITU-R F.1245 pattern should provide a reasonable estimate of the interference performance of the microwave links. Therefore we believe that using the ITU-R F.1245 pattern was appropriate for use in these simulations.

44. AT&T also criticizes the Apple simulation for not using the actual microwave link data available in the Commission's ULS licensing database and instead using different antenna heights and either a 44 dBi antenna gain or antenna gains selected from a distribution whose source was unspecified.[198] AT&T suggests that these parameters should have been tied to real-world data or the distributions validated against real world data.[199] In response, Apple points out that the simulation used real-world data from the Commission's ULS database to set characteristics of its analysis.[200] According to Apple, its simulation used actual building heights, microwave receiver heights, and microwave antenna patterns for Houston to establish conservative characteristics for the simulation.[201] Apple claims that this method allowed it to conduct an enormous number of iterations to achieve a high degree of accuracy and to provide a sensitivity analysis on microwave antenna height, antenna gain, and antenna pattern.[202] Monte Carlo simulations are designed to assess the potential of various outcomes (e.g., probability of I/N

[197] *Mathematical model of average and related radiation patterns for point-to-point fixed wireless system antennas for use in interference assessment in the frequency range from 1 GHz to 86 GHz*, Recommendation ITU-R F.1245-3 at 4 (Jan. 2019).

[198] AT&T Aug. 29, 2023 *Ex Parte* at 10.

[199] AT&T Aug. 29, 2023 *Ex Parte* at 10.

[200] Apple Sept. 14, 2023 *Ex Parte* at 8.

[201] *Id*.

[202] *Id*. at 9.

> -6 dB) based on the range of potential inputs.[203] While Apple, Broadcom et al.'s simulation used the data from the ULS for each individual link,[204] Apple took a different, yet also valid, approach in which it simulated both the range of microwave receiver characteristics (antenna gain, antenna height, etc.) and VLP parameters over 10 million iterations to determine the probability of exceeding the -6 dB I/N evaluation metric for any potential VLP to microwave receiver configuration.[205] Contrary to AT&T's assertion, the parameters Apple used are based on distributions taken from the Commission's ULS licensing database for the Houston market and are based on real-world data representative of the Houston area.[206] By choosing a microwave antenna height at the 10-percentile and a microwave antenna gain at the 90-percentile for the Houston market, the Apple simulation represents a conservative estimate of the potential for harmful interference to occur to microwave links from VLP devices in the Houston area.[207] While we believe the more complex approach taken by Apple, Broadcom et al. for the San Francisco simulation does have some advantages over the approach taken in the Apple simulation, the Apple simulation is a reasonable approach for assessing VLP device operation in the Houston market.[208]

45. The Apple Broadcom et al. simulation used an antenna pattern for all VLP devices that is based on a model of consumer Wi-Fi devices developed by the European Conference of Postal and Telecommunications Administrators (CEPT) SE45 working group.[209] The Apple simulation used an antenna pattern for client devices from the ECC 302 report, which examined the interference potential of unlicensed 6 GHz devices.[210] AT&T states that it has "previously shown that assumptions made in simulations by [proponents of VLP devices] rely on inaccurate antenna patterns and illogical assumptions regarding [device] positioning."[211] In making this broad statement, AT&T refers to its previous discussion of a Monte Carlo simulation for LPI devices conducted by CableLabs.[212] That discussion finds fault with CableLabs using a distribution of EIRP transmitted by LPI devices from the ECC 302 report, which is based on a combination of antenna patterns for different indoor devices, such as a consumer access point or gaming router.[213] AT&T claims that this EIRP distribution has several flaws. First, AT&T claims that the EIRP distribution assumes that all elevation angles are equally likely, even though

[203] A Monte Carlo simulation uses random sampling and statistical modeling to estimate mathematical functions and mimic the operations of complex systems. Harrison RL., *Introduction To Monte Carlo Simulation*, AIP Conf Proc. 2010;1204:17–21. doi:10.1063/1.3295638.

[204] Apple, Broadcom, et al. Feb. 28, 2023 *Ex Parte* at 5..

[205] Apple Feb. 13, 2023 *Ex Parte* at 9.

[206] Apple Feb. 13, 2023 *Ex Parte* at 13.

[207] *Id*.

[208] To emphasize the validity of Apple's simulation approach for the Houston market, we note that this is the same approach used by CEPT in their Monte Carlo analyses assessing the harmful interference risk to microwave receivers from LPI and VLP devices. In those analyses, CEPT relied on both a site-general and a site-specific Monte Carlo analysis akin to the Houston and San Francisco simulations, respectively. *See Sharing and Compatibility Studies Related to Wireless Access Systems include Radio Local Area Networks (WAS/RLAN) in the Frequency Band 5925-6425 MHz*, ECC Report 302, May 29, 2019; *Sharing studies assessing short-term interference from Wireless Access Systems including Radio Local Area Networks (WAS/RLAN) into Fixed Service in the frequency band 5925-6425 MHz*, ECC Report 316, May 21, 2020.

[209] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 8.

[210] Apple Feb. 13, 2023 *Ex Parte* at 11 (referring to *Sharing and Compatibility Studies Related to Wireless Access Systems include Radio Local Area Networks (WAS/RLAN) in the Frequency Band 5925-6425 MHz*, ECC Report 302 at 150, May 29, 2019).

[211] AT&T Aug. 29, 2023 *Ex Parte* at 6.

[212] AT&T Aug. 29, 2023 *Ex Parte* at footnote 23 (citing AT&T Sept 9, 2022 *Ex Parte* at A14-19).

[213] AT&T Sept 9, 2022 *Ex Parte* at A14.

this is not the case for the antenna patterns of the different classes of devices it is based on and only relatively low elevation angles are likely to occur for LPI devices in practice.[214] Second, AT&T claims that the patterns are not typical for devices sold in the United States, giving one example of a pattern for a Wi-Fi device sold by Cisco.[215] Third, AT&T claims that even consumer Wi-Fi devices use multiple antennas, which improves performance.[216] And lastly, AT&T claims that there is no suggestion that the ECC 302 used a non-zero beamwidth in its EIRP distribution, which would understate the power in many cases.[217] While there might be some validity to some of these concerns regarding CableLabs' simulation, we do not believe that they have validity for the two simulations under consideration here. Neither of these simulations use the ECC 302 EIRP distribution for VLP transmit powers that is the subject of AT&T's detailed discussion. Rather than using the ECC 302 EIRP distribution, the Apple simulation uses an antenna pattern for client devices from that report.[218] The antenna patterns that each of the simulations used is more uniform than that ECC 302 EIRP distribution and, consequently, AT&T's concerns regarding elevation angle do not apply. These two patterns also do not appear to be that different from the Cisco antenna pattern that AT&T uses as an example of a pattern for a "typical" United States device. As for AT&T's third concern, this also does not apply to VLP devices as small battery-powered devices, such as VLP devices, are not likely to have numerous antennas to improve performance. Regarding AT&T's final concern, AT&T's description of this non-zero beamwidth issue is not detailed enough for us to determine if this is a valid concern.

46. Transmit power control is another important parameter that VLP devices will use and was appropriately included in the analyses.[219] In their filings, Apple, Broadcom et al. and the Wi-Fi Alliance suggest that the permitted power level for VLP devices be adjusted to reflect that the devices will employ transmit power control.[220] According to Apple, Broadcom et al., we should allow a 3 dB reduction in the link budget[221] to account for transmit power control for body worn devices and an 8 dB reduction for off-body use.[222] They justify the 3 dB transmit power control reduction for body-worn devices by pointing to an ITU resolution and ECC regulations for the U-NII-2A (5.250-5.350 MHz) and U-NII-2C (5.470-5.725 GHz) band requiring that mobile devices employ transmit power control with an average mitigation factor of at least 3 dB in order to operate at higher power.[223] For the off-body devices, they justify the 8 dB reduction based on a computer simulation showing the power reduction between a laptop computer and a smartphone placed on a table.[224] The Wi-Fi Alliance supports a minimum 3 dB reduction for transmit power control based on the ITU resolution and a proposal the Commission previously made to require U-

[214] AT&T Sept 9, 2022 *Ex Parte* at A14-A17.

[215] AT&T Sept 9, 2022 *Ex Parte* at A18.

[216] AT&T Sept 9, 2022 *Ex Parte* at A18.

[217] AT&T Sept 9, 2022 *Ex Parte* at A19.

[218] Apple Feb. 13, 2023 *Ex Parte* at 11; Apple Sept. 14, 2023 Ex Parte at 6.

[219] Apple Feb. 13, 2023 *Ex Parte* at 3; Apple, Broadcom, et al. Feb. 28, 2023 *Ex Parte* at 8.

[220] Wi-Fi Alliance Comments at 9; Apple, Broadcom, et al. Reply at 9.

[221] A link budget accounts for all of the gains and losses in power that a signal experiences in a telecommunication system.

[222] Apple, Broadcom et al. Nov. 3, 2020 *Ex Parte* at 2-3.

[223] Apple, Broadcom et al. Nov. 3, 2020 *Ex Parte* at 3 (citing ITU-R Res. 229 (WRC-19) r*esolves* 8); *see On the harmonized use of the 5 GHz frequency bands for Wireless Access Systems including Radio Local Area Networks (WAS/RLAN)*, ECC (04)08, July 1, 2022 available at: https://docdb.cept.org/download/4053.

[224] *Id.*; Broadcom, Intel, Microsoft Oct. 22, 2020 Ex Parte Attach. at 6-11.

NII devices to employ transmit power control with a 6 dB back-off.[225] Southern Company claims that based on the body loss measurements submitted by Apple, Broadcom et al., VLP devices will be using little or no transmit power control most of the time and, consequently, transmit power control should not be considered in analyzing possible interference.[226] Broadcom, Microsoft, and Intel, proponents of VLP operations at the 14 dBm power level, in a joint filing state that transmit power control will "reduce transmit power for 17-30% of operations."[227] For transmit power control the Apple, Broadcom et al. simulation used a gaussian distribution with a mean and standard deviation of 3 dB that is truncated at 0 and 6 dB.[228] The Apple simulation used a gaussian distribution with 7 discrete steps from 0 to 6 dB for transmit power control.[229]

47. We believe that transmit power control is likely to be implemented for most VLP devices, such as body worn devices, to save battery power. The actual amount of power reduction from transmit power control will depend on how often that reduction may occur and under what circumstances. Consequently, modeling the transmit power control as a random variable in the computer simulations is appropriate. As VLP devices do not yet exist, there are no actual statistics on how often and to what extent transmit power control will reduce the transmit power of VLP devices. However, the body loss measurements submitted by Apple, Broadcom et al. show that the signal attenuation between two body-worn devices can be over 90 dB.[230] To overcome such severe attenuation, the VLP devices will need to operate at full power which illustrates that transmit power control may only be active under certain VLP device operating conditions. While we do believe that some statistical modeling for transmit power control in a computer simulation is useful and appropriate, we do not have a strong foundation on which to base a distribution. However, given that the form factors proposed for VLP devices will necessitate that the vast majority are battery powered and to maximize customer satisfaction, designers strive to ensure that batteries last as long as possible and devices almost always employ some form of transmit power control. Given the ITU resolution and ECC regulation requiring an average power reduction of 3 dB from transmit power control for U-NII-2A and U-NII-2C devices and that the Commission previously required that U-NII-2A and U-NII-2C devices have the capability for at least 6 dB transmit power control,[231] we believe that the distributions used in the San Francisco and Houston simulations are reasonable approximations for the amount of transmit power control VLP devices are likely to employ for VLP devices.

[225] Wi-Fi Alliance Nov. 11, 2020 *Ex Parte* at 1, 2, 6, 8. Although the rules require certain U-NII-2A and U-NII-2C devices to incorporate a transmit power control mechanism with capability to operate at least 6 dB below the mean EIRP level, reduced power operation only occurs when the device is capable of closing the link at reduced power; reduced power operation does not occur 100% of the time. *See* 47 CFR § 15.407(h)(1).

[226] Southern Company Reply at 11-12 (filed July 27, 2020); Southern Company Sept. 11, 2020 *Ex Parte* at 2; *see also* UTC Reply at 6 (filed July 27, 2020).

[227] Broadcom, Microsoft, Intel Oct. 22, 2020 *Ex Parte* at 2.

[228] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 8.

[229] Apple Feb. 13, 2023 *Ex Parte* at 11.

[230] Apple, Broadcom et al. Comments Attachs. B at 6-7, Figures 16, 19-22 (filed June 29, 2020).

[231] *Use of the frequency bands 5.150-5.250 MHz, 5.250-5.350 MHz and 5.470-5.725 MHz by the mobile service for the implementation of wireless access systems including radio local area networks*, World Radio Conference 2019 (WRC-19), Resolution 229, r*esolves* 8 (2019); *On the harmonized use of the 5 GHz frequency bands for Wireless Access Systems including Radio Local Area Networks (WAS/RLAN)*, ECC (04)08, July 1, 2022 available at: https://docdb.cept.org/download/4053; Although the Commission's rules require certain U-NII-2A and U-NII-2C devices to incorporate a transmit power control mechanism with capability to operate at least 6 dB below the mean EIRP level, reduced power operation only occurs when the device is capable of closing the link at reduced power; reduced power operation does not occur 100% of the time. *See* 47 CFR § 15.407(h)(1).

48. The Apple simulation used a noise figure of 5 dB and a feeder loss of 1.3 dB for the microwave receivers.[232] AT&T claims that the 5 dB noise figure is "larger than typical" and suggests that using 4 dB for U-NII-5 and 4.5 dB for U-NII-7 microwave receivers, as in WinnForum's functional requirements document for AFC systems, would be a better choice.[233] AT&T also claims that a 1.3 dB feeder loss may not be appropriate for all cases as many microwave radios are mounted directly to the antenna and have no feeder loss.[234] AT&T notes that the Apple, Broadcom et al. study states it uses data from the Commission's ULS licensing database, "but the exact radio parameters such as noise figure, waveguide feeder loss, and antenna pattern are not always available in ULS," and the parameters the simulation used were not disclosed.[235] The Apple, Broadcom et al. initial simulation filing stated that the simulation used the microwave antenna pattern from ITU-R F.1245 and Apple, Broadcom, and Meta subsequently indicated that the simulation used 2 dB for waveguide feeder loss and 5 dB for the noise figure.[236] According to Apple, Broadcom, and Meta, the 2 dB waveguide feeder loss was used in the *6 GHz Order* and the 5 dB noise figure is supported by an ITU recommendation. While we agree that the noise figure numbers from the WinnForum AFC specification would have been a better choice than the 5 dB that both simulations used, this up to 1 decibel difference is not significant enough to make an appreciable difference in the simulation results. For feeder loss, when no feeder loss is available in the Commission's ULS database and the type of microwave radio is known, WinnForum's AFC specification document indicates that a value of 3 dB be used for radios that are identified as indoor units—i.e., radios that are not mounted directly to the antenna—while no feeder loss should be used for outdoor units.[237] Hence, according to WinnForum's AFC specification, a 1.3 dB or 2 dB feeder loss would be too large for an outdoor radio and too small for indoor radio.[238] As these simulations are designed to model the potential for harmful interference to occur to microwave links in general rather than explore the interference risk of a particular microwave receiver, we believe that employing such an "in-between" value for feeder loss is a reasonable approach for a Monte Carlo simulation.[239]

49. In sum, our review of Apple, Broadcom et al's Monte Carlo simulation examining the potential for VLP device interaction with microwave links and the similar Apple simulation for Houston provide a solid basis for concluding that VLP devices can coexist with incumbent services in the 6 GHz band with an insignificant potential for causing harmful interference. In fact, as noted, we believe that the assumptions and thus, the results, err on the side of caution, are conservative, and overestimate the potential for any given VLP device to exceed the -6 dB I/N evaluation metric. The worst case operating scenario occurs when the VLP device is in the main beam of a microwave receiver, at close distance,

[232] Apple Feb. 13, 2023 *Ex Parte* at 11.

[233] AT&T Aug. 29, 2023 *Ex Parte* at 10-11.

[234] *Id*. at 11.

[235] AT&T Aug. 29, 2023 *Ex Parte* at 11.

[236] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 8; Apple, Broadcom, and Meta Sept. 14, 2023 *Ex Parte* at 11.

[237] Wireless Innovation Forum, *Functional Requirements for the U.S. 6 GHz Band under the Control of an AFC System*, WINNF-TS-1014 Version V1.3.0 at 41 (Mar. 9, 2023), https://winnf.memberclicks.net/assets/work_products/Specifications/WINNF-TS-1014.pdf.

[238] Because the Apple simulation is not modeling a particular fixed microwave link it would not have been possible for Apple to use a feeder loss that varies based on whether the microwave receiver uses an indoor or outdoor radio as WinnForum's AFC specification suggests.

[239] Because Apple, Broadcom et al. modeled actual microwave links they could have used values for feeder loss and noise figure based on ULS data regarding the radio employed by the microwave link, if this information was in ULS for a particular link. However, obtaining this information for the different radios and integrating it into the simulation would have been complex. We do not believe the approach taken detracted from the accuracy of the simulation results given that they have used reasonable values for noise figure and feeder loss.

operating co-channel to the microwave receiver, and not significantly attenuated by terrain, body loss, or blocked by buildings, which is an event that the simulations show will be a rare occurrence.

2. Power Level for VLP Devices

50. The computer simulations show virtually no impact on the microwave links even for VLP devices operating at 1 dBm/MHz EIRP PSD—the Houston and San Francisco simulations indicate that a -6 dB I/N event occurs only at either 0.06% or 0.003% of the time, respectively. The San Francisco results show an identical outcome for VLP devices transmitting at -5 dBm/MHz PSD and for the Houston simulations, a slight decrease in occurrences that the -6 dB I/N evaluation metric may be exceeded. Thus, as a conservative initial approach for permitting VLP devices to operate in the U-NII-5 and U-NII-7 portions of the 6 GHz band, we will limit them to a maximum of -5 dBm/MHz PSD EIRP and 14 dBm EIRP at this time. We believe the conservative nature of the analyses resulting in extremely low probabilities for exceeding the -6 dB I/N evaluation metric justify this approach which balances the need to provide enough power for VLP devices to ensure manufacturers can provide useful devices with the requirement to protect licensed incumbent operations from harmful interference. This approach recognizes, as pointed out by licensed incumbents, that there are locations where VLP devices operating at these power levels could result in a signal with I/N ratios that indicate there is a possibility that harmful interference may occur.[240] Therefore, we believe that it is appropriate to be conservative at this time and permit the VLP devices to operate at no more than -5 dBm/MHz EIRP PSD. We also limit total EIRP to no more than 14 dBm consistent with Apple, Broadcom, et al. and other VLP proponents' comments.[241] We examine in the Second Further Notice of Proposed Rulemaking additional steps that we could take to provide additional power or operating flexibility to VLP devices. However, given that no VLP devices have yet to be deployed, we believe limiting operation to no more than -5 dBm/MHz EIRP PSD is appropriate at this time.

51. Southern Company cautions that to the extent the Commission is relying on computer simulations to inform its decisions for the 6 GHz band, it should require the underlying algorithms used by the simulation to be disclosed to all stakeholders consistent with the Commission's *Policy Statement* on spectrum management.[242] The Utilities Telecom Council (UTC) et al. express similar views, arguing that 6 GHz band unlicensed use proponents relied on simulation information that is not reproducible by any party and that others have not been given the opportunity to review or fully understand the data and simulation methodology.[243] In addition to echoing these views, AT&T suggests that the Commission should require the simulation code to be released consistent with the Commission's *Policy Statement* and the practices of NTIA, which released similar software for evaluation of 3.1 GHz network deployments.[244] AT&T claims that requiring the simulation authors to produce their source code would allow the public to reproduce the simulation results and investigate other scenarios to ensure that interference is correctly modeled and explore variations that inform the Commission of relevant risk.[245]

52. While Apple Broadcom et al. and Apple have not made their simulation code or the resulting raw data produced by the simulations publicly available, we believe that they have provided sufficient information for knowledgeable engineers to understand the algorithms and models used in the

[240] AT&T Aug. 29, 2023 *Ex Parte* at 9; Southern Company July 28, 2023 *Ex Parte* at 2..

[241] Apple, Broadcom, et al. Aug. 26, 2022 *Ex Parte* at 1; Public Interest Spectrum Coalition Aug. 6, 2023 *Ex Parte* at 3; Wi-Fi Alliance May 18, 2023 *Ex Parte* at 19. -5 dBm/MHz PSD equates to 8 dBm maximum total power in a 20 megahertz bandwidth channel, 11 dBm in a 40 megahertz bandwidth channel, and 14 dBm in 80 megahertz or greater bandwidth channels.

[242] Southern Company Aug. 24, 2023 *Ex Parte* at 1.

[243] Utilities Telecom Council (UTC) et al. April 13, 2023 *Ex Parte* at 2.

[244] AT&T Aug. 29, 2023 *Ex Parte* at 7-8.

[245] *Id*. at 8.

simulations.[246] Both Apple, Broadcom et al. for the San Francisco simulation and Apple for the Houston simulation provided filings detailing the significant simulation assumptions.[247] Apple has indicated that its simulation was prepared using the widely available and well understood SEAMCAT Monte Carlo simulation tool,[248] while Apple, Broadcom et al. indicated that its simulation used was implemented using the C++ programming language using well-established Monte Carlo simulation techniques.[249] Through these filings to the record, we believe that Apple Broadcom et al. and Apple have provided enough technical details that engineers experienced in radio propagation modeling and coexistence analysis would be able to conduct identical simulations and obtain consistent results.[250] Furthermore, we observe that it is noteworthy that no opponents of VLP deployment have conducted their own simulations to confirm or refute the results. We therefore conclude that the results presented in the filings are adequate to inform our decision. We note that parties opposing our LPI rules raised a similar concern in a challenge to our *6 GHz Order* in the United States Court of Appeals for the District of Columbia Circuit regarding a computer simulation conducted by CableLabs on which the Commission relied.[251] The court rejected that challenge noting that "requiring agencies to obtain and publicize the data underlying all studies on which they rely would be impractical and unnecessary."[252] In accordance with this established precedent, we find that Apple Broadcom et al. and Apple provided ample information on the record such that any interested party could undertake similar analyses and that opponents' challenge on this point is meritless.

53. *Fade margin infringement*. FWCC expresses a strong opinion that unlicensed devices should not be permitted to infringe on the fade margin of microwave links. According to FWCC, the microwave systems "are entitled to enjoy the benefits of the fade margin which is built into their system designs at considerable cost to enhance reliability by maintaining communications through atmospheric fades."[253] FWCC claims that it has "shown that interference from unlicensed (RLAN) operations will cut into the fade margin and leave FS systems vulnerable to data loss and outages."[254] FWCC believes it would be "bad policy" for the Commission to permit even occasional failures caused by unlicensed devices to high

[246] AT&T seems to be advocating that we mandate that all parties providing simulations be required to provide their source code based on one instance of another government agency, NTIA, providing the public with code that it developed. The Commission would need to develop a more robust record before adopting such a policy.

[247] Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 8-9; Apple February 13, 2023 *Ex Parte* at 9-13.

[248] Apple February 13, 2023 *Ex Parte* at 8. SEAMCAT – Spectrum Engineering Advanced Monte Carlo Analysis Tool allows statistical modelling of different radio interference scenarios for performing coexistence studies between wireless systems operating in overlapping or adjacent frequency bands. The software is maintained by the European Communications Office (ECO) and is distributed free of charge at https://www.cept.org/eco/eco-tools-and-services/seamcat-spectrum-engineering-advanced-monte-carlo-analysis-tool.

[249] Apple, Broadcom et al. Feb. 28, 2023, *Ex Parte* at 4-5; Apple, Broadcom, and Meta Sept. 14, 2023 *Ex Parte* at 10.

[250] As AT&T points out, the initial simulation filings did not include a few parameters that would need to be disclosed to reproduce the simulations, such as the area in which the VLP devices were deployed in the Apple simulation and the noise figure and feeder loss used for microwave links when this information was not available in the Commission's database for the Apple, Broadcom et al. simulation. AT&T Aug. 29, 2023 *Ex Parte* at 10-11. Apple and Apple, Broadcom, and Meta subsequently provided this information. Apple Sept. 14, 2023 *Ex Parte* at 3; Apple, Broadcom, and Meta Sept. 14, 2023 *Ex Parte* at 11. Apple Sept. 14, 2023 *Ex Parte* at 3; Apple, Broadcom, and Meta Sept. 14, 2023 *Ex Parte* at 11.

[251] *AT&T Servs., Inc. v. FCC*, 21 F.4th 841 at 847 (D.C. Cir. 2021).

[252] *Id*. at 848 (quoting *Am. Trucking Ass'ns v. EPA*, 283 F.3d 355, 372 (D.C. Cir. 2002)).

[253] FWCC April 13, 2020 *Ex Parte* at 2; *see also* AT&T Aug. 29, 2023 *Ex Parte* at 6-7.

[254] FWCC April 13, 2020 *Ex Parte* at 2.

reliability microwave links, many of which carry safety-critical services.[255] FWCC claims that because adding fade margin is expensive, system designers build only the necessary minimum, with a small safety margin, and that any unlicensed interference that encroaches into a microwave link's fade margin will reduce the link reliability.[256]

54. As the Commission stated in the *6 GHz Order*, it "is not required to refrain from authorizing services or unlicensed operations whenever there is any possibility of harmful interference."[257] Instead, "the Commission may authorize operations in a manner that reduces the possibility of harmful interference to the minimum that the public interest requires, and it will then authorize the service or unlicensed use to the extent that such authorization is otherwise in the public interest."[258] There is no prohibition in either previous Commission decisions or legal precedents on the Commission adopting rules that permit VLP devices to occasionally infringe upon the fade margins of microwave links.[259] Instead, the Commission's responsibility is to ensure that the operation of the VLP devices might only impose an insignificant risk of harmful interference occurring to the microwave links to the minimum that the public interest requires.[260] We believe based on the computer simulations, which take into account both the technical characteristics of actual microwave links and reasonable technical assumptions for VLP devices, that our decision is within the bounds of this principle. Finally, we reiterate that in its recent Policy Statement, the Commission noted that "zero risk of occasional service degradation or interruption cannot be guaranteed" whether from natural events or other spectrum users.[261]

3. Fixed Infrastructure Prohibition

55. As suggested by Apple, Broadcom, Google, and Meta, we are prohibiting VLP devices from operating as part of a fixed outdoor infrastructure.[262] We note that no commenters have opposed us adopting this prohibition. This measure is being adopted as an additional means of protecting incumbent operations to ensure that all VLP devices are subject to body and/or clutter loss, to add additional assurance that the simulation assumption that most outdoor devices will operate at 1.5 m above ground

[255] FWCC Oct. 31, 2019 *Ex Parte* at 3.

[256] *Id*. at 3, 14.

[257] *6 GHz Order,* 35 FCC Rcd at 3907, para. 146.

[258] *Id*.

[259] *See, e.g.*, *Am. Radio Relay League, Inc. v. FCC*, 524 F.3d 227, 234 (D.C. Cir. 2008) (recognizing longstanding Commission interpretation of section 301 "to allow the unlicensed operation of a device that emits radio frequency energy as long as it does not 'transmit[ ] enough energy to have a significant potential for causing harmful interference' to licensed radio operators") (quoting Revision of Part 15 of the Commission's Rules Regarding Ultra–Wideband Transmission Systems*,* 19 FCC Rcd 24558, 24589 & n.179 (2004)); *Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37 et al*., Report and Order, 30 FCC Rcd 9551, 9562-64, paras. 28-31 (2015) (authorizing expanded unlicensed operations of fixed white space devices where potential of causing harmful interference to TV reception would be minimized, while still providing increased opportunities for the provision of unlicensed service); *Amendment of Part 15 Regarding New Requirements and Measurement Guidelines for Access Broadband over Power Line Systems; Carrier Current Systems, Including Broadband over Power Line Systems*, Second Report and Order, 26 FCC Rcd 15712, 15719-20, paras. (2011) (establishing "a regime of rules for Access BPL systems that will provide a robust environment for the development and deployment of this important new technology option for delivery of broadband internet/data services while at the same time minimizing the potential for interference to licensed services caused by leakage from power lines of the RF energy used by BPL transmissions," despite "some potential for increased harmful interference from BPL operations").

[260] *Id*.

[261] *Policy Statement* at 2, para. 5 (emphasis omitted); *accord id.* at 6-7, paras. 15-17.

[262] Apple, Broadcom, Google, and Meta July 25, 2023 *Ex Parte* at 2.

level is correct, and to force all devices to be itinerant consistent with the VLP devices simulated in the Monte Carlo analyses. Thus, VLP devices will be prohibited from attaching to outdoor infrastructure, such as poles or buildings, that would make any instances of potential interference more than fleeting. In addition, device mobility results in devices, even if remaining in a general location, constantly changing their orientation due to even subtle body movements. Such movements can result in widely varying VLP signal levels in any given direction. Thus, the maximum VLP signal level, which is likely to be less than the maximum our rules permit for a device in the worst-case location and operating co-channel to a microwave system, may only be oriented toward a microwave receiver for a short period of time, which also serves to keep the potential for causing harmful interference to a minimum.

4. Transmit Power Control Requirement

56. We are adopting a requirement that VLP devices employ a transmit power control mechanism that has the capability to operate at least 6 dB below the -5 dBm/MHz EIRP PSD level permitted for VLP devices. Both computer simulations, which we have concluded are the best evidence that the potential for VLP devices to cause harmful interference is insignificant, assume that VLP devices would operate with a transmit power control mechanism with a range up to 6 dB and a mean power reduction of 3 dB.[263] To ensure that actual VLP devices operate consistent with the simulations on which we are relying, we adopt this provision to provide confidence that such devices do indeed operate using transmit power control. We are not placing any specific requirements in our rules as to how the VLP device transmit power control algorithm will function, but proof of such functionality must be provided with a device's application for equipment certification. We do not expect that placing this transmit power control requirement will present an undue burden on device manufacturers as such functionality is routinely included in battery-powered device design to conserve battery power. In this connection, Broadcom states that transmit power control is enabled in 100% of its portable products.[264] In addition, Apple, Broadcom, Google, and Meta jointly suggested that the Commission adopt a VLP device transmit power control requirement that would require such devices to reduce their PSD by 3 dB on average.[265] No commenters have opposed us mandating that VLP devices employ a transmit power control mechanism. While AT&T advocates that any limitation on VLP device use that was assumed in the computer simulations, such as average power due to transmit power control, should be subject to a specific rule, we do not believe it is necessary to put in place such a rule at this time, given that there are no actual statistics on how often and to what extent transmit power control will reduce the power of VLP devices in practice.[266]

5. Cumulative Effect of Different Classes of Unlicensed Devices

57. AT&T contends that 6 GHz unlicensed devices have been modeled under the erroneous presumption that each type of device — standard power, LPI, and VLP — can interfere with microwave links up to a threshold of -6 dB I/N, but as there is only one -6 dB I/N margin, the modeling must account for consumption of that margin by all three types of devices.[267] AT&T points out that no computer simulation models the combined impact of all these different types of unlicensed devices.[268] According to AT&T, standard power devices operating under the control of the AFC systems can consume any headroom up to the -6 dB I/N interference threshold specified in the rules and that LPI devices were

[263] Apple, Broadcom et al. Feb. 2, 2023 *Ex Parte* at 8; Apple Feb. 23, 2023 *Ex Parte* at 11.

[264] Broadcom July 6, 2022 *Ex Parte* at 4.

[265] Apple, Broadcom, Google, Meta July 25, 2023 *Ex Parte* at 1.

[266] AT&T Aug. 29 2023 *Ex Parte* at 6.

[267] AT&T Aug. 29, 2023 *Ex Parte* 8-9; AT&T March 31, 2022 *Ex Parte* at 3-4.

[268] AT&T Aug. 29, 2023 *Ex Parte* 8.

justified under this same basis.[269] AT&T claims that proponents of VLP devices are justifying these devices on an identical basis of being able to generate interference up to the same threshold.[270] AT&T points to the CEPT computer simulation that addressed 6 GHz devices that did not include standard power devices, simulated LPI devices at a lower power level than our rules permit, and only assumed 1% of devices located outdoors as illustrating the error in the VLP proponents reasoning.[271]

58. As we stated above, typical microwave link architecture results in 6 GHz band unlicensed devices only presenting a potential interference risk if they are in the microwave antenna's main beam at a close enough distance that a signal of sufficient strength will be received. The AFC systems that control standard power access points' spectrum access will prevent those devices from operating at locations where they present a risk of causing harmful interference. Therefore, we do not believe that it is necessary for unlicensed proponents to provide a study that jointly considers the potential for harmful interference from the cumulative effect of standard power devices and other types of unlicensed 6 GHz devices. Regarding VLP and LPI devices, we again point out that Apple's Monte Carlo analysis for devices operating in the Houston areas included results for the additive effect of LPI and VLP devices and concluded that the likelihood that there was no material effect on potential microwave degradation due to the presence of both the LPI and VLP devices.[272]

6. Request for Higher Power

59. While supporting comments advocating for a 14 dBm EIRP power level, a subset of VLP device advocates point out that allowing even higher power would enable VLP devices to communicate with higher order modulation, which would enable higher throughputs and lower latencies and request that the Commission authorize up to 21 dBm EIRP.[273] They claim that the 14 dBm EIRP power level would be insufficient for untethered augmented reality/virtual reality, remote surgery, data center wireless flyways, educational applications requiring transmitting high resolution materials, and other demanding applications.[274] They point to the computer simulation conducted by RKF to claim that operation at this power level would not cause harmful interference to licensed stations.[275]

60. As these commenters also support the more modest 14 dBm EIRP power level and the applications cited are more speculative than those generally cited as other use cases for VLP devices, we decline to permit additional power for VLP devices at this time. We also observe that devices delivering many of the cited applications, such as remote surgery, necessitate indoor operation and can be conducted under the LPI device rules that already permit more power than we are permitting for VLP devices. Much of our decision is based on the computer simulations that are based on a maximum 14 dBm EIRP power level. Due to the undeveloped record on operations with up to aa 21 dBm EIRP, we decline to permit VLP devices to operate at greater than 14 dBm EIRP. We do seek comment, however, in the Second Further Notice of Proposed Rulemaking on whether we can, under certain circumstances, increase the VLP power level without increasing the harmful interference risk to incumbent operations.

7. Request for Lower Power

61. The Ultra Wide Band (UWB) Alliance expresses concern that VLP devices will radiate power uniformly in all directions even though they likely only need the maximum power in a specific

[269] AT&T Reply Comments at 4 (filed July 27, 2020).

[270] *Id*. at 5.

[271] *Id*. at 5-6.

[272] Apple Feb. 13, 2023 *Ex Parte* at 17.

[273] Apple, Broadcom, Google, Microsoft Comments at 5 (filed June 29, 2020) at 5.

[274] *Id*. at 5-6.

[275] *Id*. at 7-8.

direction and that this will result in unnecessary interference to other receivers, including other VLP devices.[276] To address this issue, it suggests that VLP devices meet one of two alternate power limits: (1) a -32 dBm power spectral density with a peak power of 0 dBm;[277] or (2) a -8 dBm power spectral density that is reduced by 2 dB for every dB that the antenna gain is less than 12 dBi as well as a peak power of 14 dBm that is reduced by 2 dB for every dB that the antenna gain is less than 7 dB.[278] According to the UWB Alliance, the use of directional antennas by VLP devices can improve link performance and reduce interference.[279] The UWB Alliance notes that many VLP device use cases advocates assert require 14 dBm are currently being served by wideband and ultra-wideband devices at 50 dB less power.[280] The UWB Alliance also suggests that dynamic transmit power control be required for VLP devices as the power needed for on-body locations can vary from nearly free space to over 70 dB.[281] Other commenters suggest that we only permit VLP if we limit such devices to much lower power than what we proposed. Nokia suggests that a -18 dBm/MHz PSD EIRP would minimize the potential for co-channel interference to microwave receivers.[282] The National Association of Broadcasters (NAB) states that VLP devices should operate at no more than -15.5 dBm/MHz to be consistent with the Commission's previous finding for unlicensed 6 GHz low-power indoor devices.[283] NAB arrives at this number by subtracting the 20.5 dB building entry loss assumed in the Commission's low-power indoor analysis in the *6 GHz Order* from the adopted 5 dBm/MHz PSD level for low-power indoor access points.[284] AT&T points out that because VLP devices are mobile, they are analogous to LPI client devices that operate at -1 dBm/MHz indoors, which means VLP devices are operating at an outdoor power level that is effectively hundreds of times greater when adjusted for the assumed 20.5 dB building entry loss.[285]

62. While several commenters request that we only permit VLP devices to operate at lower power, for the reasons already articulated we decline to do so. First, we conclude based on the computer simulations that VLP device operation at -5 dBm/MHz PSD will only pose an insignificant risk of harmful interference to incumbent operations. Additionally, we appreciate the UWB Alliance's concern for improving spectrum efficiency and reducing the potential for interference by proposing rules that would incentivize the use of directional antennas. However, we agree with Apple, Broadcom et al. that directional antennas are likely infeasible for small form factor portable devices, particularly when the device's orientation is constantly changing.[286] We do not believe that it would be appropriate to adopt rules that would likely make it impractical to manufacture devices for many of the proposed VLP use cases, such as small portable body-worn devices. As for the UWB Alliance's suggestion to require dynamic transmit power control, as explained above, we are adopting such a requirement on VLP devices. Second, we do not believe that tying the power level for VLP devices to the power levels for low-power indoor devices, as NAB and AT&T suggests, is appropriate, given the fundamental differences between these device classes. VLP devices will inherently be mobile rather than stationary like LPI access points,

[276] Ultra Wide Band (UWB) Alliance Comments at 9-10 (filed June 29, 2020).

[277] Although not explicitly stated, we believe the intended reference bandwidth for the power spectral density is 1 megahertz.

[278] Ultra Wide Band (UWB) Alliance Comments at 10 (filed June 29, 2020).

[279] Ultra Wide Band (UWB) Alliance Reply at 7-8 (filed July 27, 2020).

[280] Ultra Wide Band (UWB) Alliance Reply at 10 (filed July 27, 2020).

[281] Ultra Wide Band (UWB) Alliance Comments at 12 (filed June 29, 2020).

[282] Nokia Comments at 3 (filed June 29, 2020).

[283] NAB Oct. 30, 2020 *Ex Parte* at 3.

[284] NAB March 4, 2021 *Ex Parte* at 2.

[285] AT&T Aug. 29, 2023 *Ex Parte* at 6.

[286] Apple, Broadcom et al. Reply at 29 (filed July 27, 2020).

have smaller form factors, less efficient antennas due to the small form factors, and operate at low power levels to conserve battery. Consequently, we believe that the -5 dBm/MHz PSD EIRP and maximum 14 dBm EIRP are appropriate and will result in widespread coexistence within the 6 GHz band among the various devices that operate there. Thus, we are not persuaded to reduce VLP device utility by artificially restricting their power levels to even lower levels.

8. VLP Devices and the AFC

63. Many microwave incumbents advocate that VLP devices should be required to use an AFC system to control spectrum access based on their potential to cause harmful interference to microwave receivers.[287] AT&T claims that the only rationale for not requiring VLP devices to operate under AFC control is that either they cannot be located or they will not be connected to a network that can establish a connection to an AFC system.[288] AT&T points out that the suggested use cases for VLP devices require network connections and that filings in the record have indicated that accurate geolocation for indoor devices is both possible and effective.[289] According to AT&T,VLP devices should be limited to ultra-wideband device power levels unless AFC control is also required.[290] Cisco et al. respond that there are significant costs to develop, deploy, and update AFC-controlled devices, including geolocation requirements, additional installation requirements, support for the AFC-to-device protocol, changes to the radio resource management algorithm, and updates to the user interface.[291] AT&T casts doubt on these claims, asserting that there is no increased cost to implement those features, that the AFC systems are already developed for standard power devices, that the suggested use cases for VLP devices involve geolocation capabilities, and that there are no examples of changes needed to user interface, installation cost, or device operational management requirements.[292] AT&T also suggests that VLP advocates have failed to even roughly quantify the costs and balance them against the benefit of protecting incumbents through a proper cost/benefit analysis.[293] Apple, Broadcom, and Meta claim that communications with an AFC system, device location reporting, and the hardware and software needed to support these functions would needlessly consume a VLP device's power and system resources and points out that existing standard-power device rules do not allow portable operations.[294]

64. As we conclude that the risk of harmful interference from VLP devices operating at -5 dBm/MHz is insignificant, the use of AFC systems to control spectrum access by VLP devices is unnecessary. Thus, we see no reason to impose such a requirement on VLP devices. While there is dispute on the record as to how much it would cost to impose AFC control on VLP devices, there clearly is some cost to imposing such a requirement without a requisite benefit. Furthermore, there will likely be some VLP devices, such as laptop computers that do not have geolocation capabilities and requiring such devices to operate under AFC control would limit the utility of the VLP rules.[295] In addition, neither the standard power or LPI rules support the highly mobile applications envisioned for VLP devices as LPI

[287] *E.g.*, AT&T Comments at 11 (filed June 29, 2020); UTC et al. Comments at 6-7 (filed June 29, 2020); Edison Electric Institute Comments at 10 (filed June 29, 2020); Century Link Comments at 4 (filed June 29, 2020).

[288] AT&T Sept. 9, 2022 *Ex Parte* at 2.

[289] *Id*. (citing *Ex Parte* filings by HP Enterprise on July 28, 2022 and Apple on Aug. 17. 2022 and Apple Comments filed on June 29, 2020).

[290] AT&T Comments at 11 (filed June 29, 2020).

[291] Cisco Systems, Extreme Networks, HP Enterprise, Juniper Networks Oct. 13, 2022 *Ex Parte* at 2.

[292] AT&T Dec. 19, 2022 *Ex Parte* at 11.

[293] *Id*.

[294] Apple, Broadcom, and Meta Sept. 14, 2023 *Ex Parte* at 3.

[295] AT&T Dec. 19, 2022 *Ex Parte* at 3 ("VLP versions of other internet devices that are not body-worn can and will be developed . . . .").

devices are limited to indoor locations utilizing access points that are supplied power by a wired connection while standard power access points may not be mobile.[296]

65. We also note that AT&T clearly mischaracterizes the Apple, Broadcom, Google and Meta filing regarding exclusion zones for AFC devices.[297] In this filing, Apple, Broadcom, Google, and Meta make no statement regarding the burden of adding an AFC or exclusion zone capability to VLP devices. Instead, the parties, in response to questions from OET, explain how the Commission could ensure the VLP exclusion zones would be no larger than an AFC system would have calculated for the same device power level and that the Commission should avoid prescriptive rules requiring specific geolocation accuracy or re-check periods for devices in motion.[298]

9. Link Budget Analysis

66. As discussed in more detail below, a number of commenters submitted link budget analyses that they claim show that harmful interference will result from VLP device operation. According to CTIA, an earlier simulation presented by Apple, Broadcom et al. demonstrates that a single device-emitter scenario is the primary interference event for VLP operation.[299] CTIA claims that a link budget is a better analytic tool for analyzing interference from a single device than a computer simulation in order to deterministically access whether the device is causing interference.[300] Southern Company also claims that the appropriate way to model the potential interaction between VLP devices and microwave incumbents is through a link budget analysis.[301] Southern Company states that as VLP device deployment reaches millions of devices or higher, an analysis that uses duty cycle or computer simulations becomes irrelevant due to the high probability that enough units will be transmitting at the same time co-channel with a microwave receiver.[302]

67. We disagree with CTIA, Southern, and others regarding the utility of link budget analysis in driving our decision regarding VLP devices. In determining whether to permit VLP devices to operate in the 6 GHz band, the controlling factor is the potential risk that VLP devices could cause harmful interference to microwave links. This is a function not just of the received power level from a VLP device at a "worst-case" location, but also of the likelihood that a device will be at the location at the same time that a severe enough atmospheric multipath fade occurs to overcome the microwave link's fade margin. This question is not one that a link budget analysis alone can answer. A link budget provides a calculation of the power received at a receiver at one instant of time based on deterministic quantities for quantities such as transmitted power level, propagation loss, antenna gain, polarization loss, feeder loss, etc. Such an analysis does not take into account probabilistic quantities such as multipath fading or the likelihood of a transmitting device being in a particular location or transmitting co-channel with a microwave links. One important factor that a link budget analysis cannot consider is the fact that, because we are prohibiting VLP device use for fixed infrastructure purposes, the VLP devices will be mobile and will not remain in potentially problematic locations for significant periods of time. A computer simulation that takes into account the transient nature of VLP use is a better model for determining VLP device interference potential as compared to a link budget analysis. We also disagree with Southern Company's contention regarding the utility of computer simulations as the number of VLP devices reach the millions. In fact, that is exactly what Monte Carlo simulations are designed to analyze,

[296] 47 CFR § 15.403; *6 GHz Order*, 35 FCC Rcd at 3929 para. 207.

[297] AT&T Aug. 29, 2023 Ex Parte at 2-3.

[298] Apple, Broadcom, Google, Meta July 26, 2023 *Ex Parte* at 1-2.

[299] CTIA Reply at 11 (filed July 27, 2020).

[300] *Id*.

[301] Southern Company Comments at 15 (filed June 29, 2020).

[302] *Id* at 10.

especially when each device is subject to multiple probabilistic operating conditions. The assumptions used in the Apple, Broadcom et al. simulation to determine the number of simultaneously transmitting devices in the San Fransisco area assumed millions of VLP devices present in that area, but that did not mean that all these devices were transmitting simultaneously co-channel. As discussed above, that simulation starts with the 13,066,000 people in the San Francisco area and calculates how many VLP devices will be simultaneously transmitting outdoors in the area based on assumptions as to how many people are outdoors, how many of these people use VLP devices, how many VLP devices are capable of using the 6 GHz band, how many VLP devices actually use the 6 GHz band, and how many VLP devices are actively transmitting at a given moment.[303] While the link budget analyses submitted by VLP opponents do not convince us to change our decision allowing VLP devices in the 6 GHz band, for completeness we shall briefly discuss them.

68. Southern Company and the Edison Electric Institute (EEI) submitted identical link budget analyses for assumed VLP devices operating at five locations near an actual microwave link in Georgia.[304] These analyses assume that VLP devices operate with a -5 dBm/MHz EIRP PSD.[305] In the *6 GHz Order*, the Commission applied a 5 dB adjustment to the link budget analysis of six real-world examples submitted by AT&T to account for the assumed loss for the antenna pattern mismatch between the unlicensed LPI device and the microwave antenna.[306] As LPI devices and VLP devices will have similar antennas, we believe it is appropriate to also adjust the I/N numbers of this link budget analysis by the same amount. When this is done, the resulting I/N at the microwave receiver from a single device at the five locations ranged from -12.9 dB to -20.3 dB. Southern and EEI also present their assessment of the aggregation impact that 10 and 100 VLP devices operating at the same locations and transmitting simultaneously would have on the I/N evaluation metric.[307] Their analysis shows that for 10 VLP devices, the I/N levels adjusted for 5 dB antenna pattern mismatch ranged from -2.9 dB to -10.3 dB and for 100 devices the adjusted I/N levels ranged from 7.1 dB to -0.3 dB.[308] While these results indicate it may be theoretically possible for the aggregate emissions from multiple VLP devices to cause harmful interference to a microwave link, a link budget analysis gives no indication of the likelihood of such as occurrence. For such interference to actually occur all of these VLP devices would have to be located within the main beam of the microwave distance at a close enough distance and actually transmitting co-channel with the microwave link at the same instant. Furthermore, this would have to occur at the same time that a sufficiently deep atmospheric multipath fade is occurring. As the Monte Carlo simulations show, the probability that one device could be in the position to result in an I/N over -6 dB is extremely low. The likelihood that multiple devices would be in such a position at the same time is even lower. Hence, we believe that using a Monte Carlo simulation is more appropriate for examining aggregate interference than using a link budge approach.

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[303] See *supra* para. 33 (citing Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 9.).

[304] Southern Company Comments at 23-26 (filed June 29, 2020); Edison Electric Institute Comments at 22-24 (filed June 29, 2020).

[305] Southern Company Comments at 23 (filed June 29, 2020); Edison Electric Institute Comments at 22 (filed June 29, 2020) . The analyses used 14 dBm EIRP total power in an 80 megahertz channel, which results in a -5 dBm/MHz EIRP PSD. *E.g.*, Southern Company Comments at 26 (filed June 29, 2020).

[306] *6 GHz Order*, 35 FCC Rcd at 3900, para. 128.

[307] Southern Company Comments at 23-26 (filed June 29, 2020); Edison Electric Institute Comments at 22-24 (filed June 29, 2020).

[308] Southern Company Comments . at 26. While Southern Co. and EEI's analysis includes 4.5 dB of body loss, Edison Electric Institute Comments at 22; Southern Company Comments at 26, the Apple, Broadcom et al. and Apple computer simulations used a body loss distribution with a mean of 4 dB. Apple, Broadcom et al. Feb. 28, 2023 *Ex Parte* at 8; Apple Feb. 13, 2023 *Ex Parte* at 10 .

69. Nokia submitted a VLP link budget analysis for devices operating in buildings directly beneath a microwave receiver and at street level within line-of-sight to a 6 GHz microwave receiver.[309] Based on this analysis, Nokia concludes that a power limit for VLP devices "on the lower side of the power range considered by the Commission, e.g. 4 dBm EIRP (-18 dBm/MHz PSD EIRP), would minimize the potential for co-channel interference" to a microwave receiver based on maintaining a -6 dB I/N ratio.[310] However, we note that the Nokia analysis does not include two factors that the Commission included in its LPI device analysis. Specifically, Nokia does not include a 5 dB loss to account for RLAN/FS antenna pattern mismatch between unlicensed devices and microwave receivers nor a 2 dB microwave receiver feeder line loss.[311] When accounting for these additional 7 dB of losses, Nokia's suggested -18 dBm/MHz EIRP PSD rises to -11 dBm/MHz EIRP PSD. While Nokia concludes that the I/N ratio may exceed -6 dB, which in itself is not an indication that harmful interference will occur, as detailed below, we continue to believe that Monte Carlo analysis rather than a static link budget analysis provides a more realistic indication of the potential for devices to cause harmful interference.

70. CTIA submitted a link budget analysis showing the interference potential that VLP devices could have on five "real-world" microwave links.[312] This analysis makes a number of assumptions which we do not find appropriate. Most significantly, CTIA's analysis assumes free space propagation rather than using one of the propagation models the Commission used in its analysis when adopting the LPI rules.[313] As the Commission explained in the *6 GHz Order*, while the free space path loss may be appropriate for short distances it drastically underpredicts path loss for longer distances because, as a practical matter, there is almost always interaction with the environment that reduces the signal level below the free space level.[314] For this reason the Commission in the 6 GHz Order relied on either the WINNER II or ITM models rather than using free space when conducting link budget analysis.[315] CTIA's analysis uses a cumulative distribution function from the body loss measurement study that Apple, Broadcom et al. submitted that has a mean body loss of 8 dB rather than a mean of 4 dB that we believe is more appropriate.[316] It also assumes that VLP devices transmit at -8 dBm/MHz.[317] CTIA's analysis reached a conclusion that the I/N for the five links ranged from 9-16.1 dB.[318]

71. As already noted, we believe that Monte Carlo analysis is the most appropriate method for evaluating the potential for VLP devices to exceed the -6 dB I/N evaluation metric. Although these link budget analyses provided by commenters concluded that in some instances the I/N caused by a VLP device could exceed that evaluation metric, as previously noted, just the mere possibility that under certain circumstances and in certain locations an I/N may rise to a level greater than -6 dB I/N does not translate to any certainty that harmful interference will occur; several other independent factors must also

[309] Nokia Comments Technical App. (filed June 29, 2020).

[310] Nokia Comments at 3, Technical App. at 1, 3, 6 (filed June 29, 2020).

[311] *6 GHz Order*, 35 FCC Rcd at 3900, para. 128, tbl. 5; Nokia Comments Technical Appendix at 2-6 (filed June 29, 2020). Because the Nokia analysis is a link budget analysis of the same type of microwave antennas the Commission examined in its LPI analysis and the VLP antennas are likely to have similar antenna patterns, these same assumptions are appropriate for use in adjusting Nokia's results.

[312] CTIA Reply Attach: 6 GHz VLP Interference (filed July 27, 2020).

[313] *Id*. at 4; *see 6 GHz Order*, 35 FCC Rcd at 3900, tbl. 5.

[314] *6 GHz Order*, 35 FCC Rcd at 3877, para. 67.

[315] *6 GHz Order*, 35 FCC Rcd at 3899-00, Tables 4, 5.

[316] CTIA Reply Attach: 6 GHz VLP Interference at 2-3.

[317] CTIA assumes a 14 dBm EIRP power level in a 160 megahertz signal bandwidth, which results in a PSD of -8 dBm/MHz. *Id*. at 6.

[318] CTIA Reply Attach: 6 GHz VLP Interference at 6 (filed July 27, 2020).

simultaneously occur and the probability of those events occurring is sufficiently low to lead us to our conclusion that based on the analyses in the record, VLP devices can coexist with incumbent operations in the 6 GHz band with an insignificant risk of causing harmful interference.

10. Interference Studies

72. Several utilities filed field test measurement reports directed at quantifying LPI device interference potential on actual microwave receivers. While the focus of those studies is on LPI devices that are located indoors, some of the results do have implications for understanding the potential for VLP devices to cause harmful interference. CTIA and Southern Company jointly conducted field measurements using a signal generator to emulate both LPI and VLP devices.[319] They took outdoor measurements at three locations directly in front of a microwave antenna using an emulated VLP device operating with 11 dBm EIRP in a 80 megahertz wide channel, which corresponds to -8 dBm/MHz EIRP PSD.[320] They made measurements when the device was operating with a 30% activity factor and a 100% activity factor.[321] They claim that the emulated VLP device reduced the microwave link fade margin between 5.2 dB and 10.9 dB.[322]

73. For its test, Evergy used a commercially purchased LPI access point located within a school classroom, which was located directly in the main beam of a microwave receiver 1.3 miles away.[323] When the access point was placed in the classroom window, the microwave receiver I/N ratio was 24.5 dB for a high data rate transmission.[324] Because this test used an LPI device, it could have been transmitting at 5 dBm/MHz rather than the -5 dBm/MHz we are permitting for VLP devices. When the I/N ratio is adjusted to account for the transmit power difference, this still indicates that the I/N could be 14.5 dB for a VLP device at that location. Other electric utilities also conducted field test measurements: First Energy reports I/N ratios as high as 9.1 dB and Southern Company reports I/N ratios at high as 25.7 dB.[325]

74. Apple, Broadcom et al. criticize these field tests for using an indirect methodology to measure the reduction in link fade margin and estimating the I/N ratio.[326] Apple, Broadcom et al. claim the field test methodology is unreliable and produces inconsistent results.[327] They also claim that the test chose worst-case locations and set the LPI access point parameters to reflect only extreme worst-case

[319] Letter from Jennifer L. Oberhausen, Director of Regulatory Affairs; Doug Hyslop, VP of Technology and Spectrum Planning, CTIA , to Marlene H.- Dortch, Secretary, FCC at 4 (Nov. 13, 2020) (on file in ET Docket No. 18-295) (*6 GHz Field Test Report*).

[320] *6 GHz Field Test Report* at 4.

[321] *Id*.

[322] *Id.* at 12.

[323] *Wi-Fi 6E and 6 GHz Microwave Testing*, Evergy at 2-9, 3-1(filed December 8, 2022).

[324] *Id*. at 4-10.

[325] *First Energy 6 GHz Additive Interference Study*, EPRI at 3-4, 3-5, 3-11, 3-12 (filed by First Energy Oct. 12, 2022); *First Energy 6 GHz Additive Interference Study: Phase 2-Winter*, EPRI at 3-4 (filed by First Energy May 9, 2023); *Test Report on the Effects of 6 GHz Unlicensed RLAN Units on Fortson to Columbus Microwave Link*, Southern Company at 55 (filed June 23, 2021); *see also Reliable Operation of 6 GHz Microwave Links*, EPRI (filed by Ameren Dec. 14, 2021); *Impact of Unlicensed use of the 6 GHz Band Summary Report for FCC Filing*, Pacific Gas and Electric (filed Apr. 25, 2023).

[326] Apple, Broadcom et al. Oct 21, 2021 *Ex Parte* at 7-13; Apple, Broadcom et al. Feb. 22, 2023 *Ex Parte* at 8-10, 23-24; Apple, Broadcom et al. March 9, 2021 *Ex Parte* at 3-5.

[327] *Id*.

scenarios with unrealistic data rates.[328] NCTA expresses many of the same concerns with the Southern Company field test regarding its testing methodology, testing locations, and device activity rates.[329] In addition, NCTA suggests that the field test should use a metric based on the microwave link's signal to interference-plus-noise ratio S/(I+N) rather than using an I/N ratio or a reduction in fade margin as an interference metric as the S/(I+N) ratio would take into account the characteristics of the microwave link.[330]

75. We believe Apple, Broadcom et al. and NCTA express valid points about the field test results, especially regarding the testing methodology. However, as our focus here is on the potential for VLP devices to cause harmful interference and the field tests were mainly directed to LPI devices, we refrain from opining on how representative the tests are of LPI device use. As for their connection to assessing VLP interference potential, we observe that they suffer from the same flaw as the link budget analyses. They purport to measure the I/N ratio at a worst-case location directly in the main beam of a microwave receiver. As these tests do not take into the account the fade margin designed into the microwave link and the occurrence of atmospheric multipath fading they are of limited utility in determining the likelihood that the microwave links will actually experience harmful interference from a mobile VLP device, which by nature is unlikely to remain at any specific location or in a fixed orientation for a significant interval of time.[331] Thus, these analyses are not informative with respect to the impact that VLP devices could have on microwave link reliability.

11. Chain of Coincidences Rationale

76. AT&T claims that the VLP device proponents make a flawed argument in claiming that "a chain of improbable coincidences" is necessary for interference to occur to microwave links and "citing indoor use, device positioning, channel overlap, body loss, RLAN antenna gain, transmit power control, fade margin and itinerant use."[332] We agree with AT&T to the extent that it intimates that merely mentioning each of these factors, claiming each is unlikely, and thus deducing that harmful interference is unlikely to occur is of little utility.[333] Consequently, while these assertions may have some merit, we did not rely on them in reaching our conclusions here. Instead, our conclusions rely heavily on Apple, Broadcom et al.'s and Apple's Monte Carlo simulations, which considered the respective likelihood for different factors that could impact interference potential to quantify the overall risk of harmful interference occurring to 6 GHz microwave links. Based on these analyses, we conclude that the risk is insignificant.

[328] Apple, Broadcom et al. Oct 21, 2021 *Ex Parte* at 13, 30-35; Apple, Broadcom et al. Feb. 22, 2023 *Ex Parte* at 4-8, 19-20.

[329] NCTA Feb. 23, 2022 *Ex Parte* at 7, 10-12.

[330] *Id*. at 4-5.

[331] AT&T points to the results of these test as demonstrating that VLP devices in ordinary locations will cause interference to microwave links. AT&T Aug. 29, 2023 *Ex Parte* at 3-4. We disagree with AT&T's contention as exceedance of a -6 dB I/N ratio in and of itself is not indicative of harmful interference.

[332] AT&T Aug. 29, 2023 *Ex Parte* at 2; *see id.* at 2-7.

[333] AT&T appears to make the opposite mistake in asserting that "the threat of interference should evaluate the probability of [VLP] devices being within the main beam [of a microwave receiver] based on real-world deployments—with the probability of some [VLP] devices being in that zone at any given time being nearly 100%"—given the level of VLP device deployment suggested. AT&T Aug. 29, 2023 *Ex Parte* at 4. This ignores all the other factors that must occur for harmful interference to occur besides the location of the VLP device.

B. Fixed Satellite Services

77. The entire 6 GHz band is allocated for the FSS in the Earth-to-space direction.[334] Additionally, portions of the U-NII-7 and U-NII-8 bands are allocated for FSS space-to-Earth (downlink) operations.[335] However, there are no licensed downlink earth stations in the U-NII-7 band. Sirius XM and Globalstar were the only FSS operators to file comments in response to the *Further Notice*, but these comments were limited to their operations in the U-NII-8 band.[336]

78. In *6 GHz Order*, the Commission concluded that FSS receivers in space would not receive harmful interference from either 6 GHz standard power or LPI devices.[337] Considering that the satellites receiving in the 6 GHz band are limited to geostationary orbits, approximately 35,800 kilometers above the equator, the Commission found that it is unlikely the relatively low power unlicensed devices would cause harmful interference to the space station receivers.[338] The only restriction that the Commission adopted to protect the satellite receivers was to require that outdoor standard-power access points limit their maximum EIRP above a 30 degree elevation angle to 21 dBm.[339] Because VLP devices are limited to no more than 14 dBm EIRP, for the same reasons, we conclude that no restrictions on VLP devices are necessary to protect FSS Earth-to-space operations.

C. Radio Astronomy Services

79. Incumbent operations in the U-NII-7 band include several radio astronomy observatories, located in remote areas, that observe methanol spectral lines between 6.65-6.6752 GHz.[340] To protect these radio observatories, the National Academy of Sciences' Committee on Radio Frequencies (CORF) requests that we implement exclusion zones for this band, as listed in Allocation Table footnote US385, if VLP devices are able to determine their locations.[341] If the devices are not able to determine their locations, CORF claims that the radio observatories must be protected by notching out the VLP device's transmissions within this band.[342] CORF claims that an individual VLP device operating at -8 dBm/MHz could cause a threshold exceedance for spectral line observations in an ITU recommendation at a distance of several hundred kilometers.[343]

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[334] 47 CFR § 2.106 footnotes NG172 and 5.458B. The space-to-Earth allocation is limited to use by non-geostationary mobile-satellite service feeder links and earth stations receiving in this band are limited to locations within 300 m of coordinates in Brewster, WA, Clifton, TX, and Finca Pascual, PR. Globalstar also operates earth station receive sites at Wasilla, AK and Seabring, FL. These last two locations are authorized to operate on a coprimary basis for feeder downlinks for FSS, except for 7.025-7.055 GHz band, where they are authorized only on an unprotected basis .

[335] 47 CFR § 25.214(c)(5).

[336] Sirius XM Comments (filed June 29, 2020); Globalstar Reply (filed July 27, 2020).

[337] *6 GHz Order,* 35 FCC Rcd at 3886-87, 3916-17, paras. 91-92, 171-72.

[338] *6 GHz Order,* 35 FCC Rcd at 3886, para. 91.

[339] *6 GHz Order,* 35 FCC Rcd at 3886, para. 92; *see* 47 CFR § 15.407(a)(4).

[340] 47 CFR § 2.106 5.458A . Observation of methanol spectral lines is a significant contributor to research of star formation. *See* Nicolas Clarisse; Anuj P. Sarma, Methanol Masers in Star-Forming Regions (2019), https://via.library.depaul.edu/cgi/viewcontent.cgi?article=1148&context=depaul-disc. The observatories where such research is conducted are Arecibo Observatory, the Green Bank Observatory, the Very Large Array, the 10 Stations of the Very Long Baseline Array, the Owens Valley Radio Observatory, and Allen Telescope Array. National Academy of Sciences Committee on Radio Frequencies Comments at 6.

[341] National Academy of Sciences' Committee on Radio Frequencies Comments at 5 (filed May 28, 2020).

[342] *Id*.

[343] *Id*. at 4.

80. When we adopted the rules for 6 GHz LPI devices, we did not implement exclusion zones or require the LPI devices to notch out the 6.65-6.6752 GHz band. Because VLP devices will operate at an even lower power than LPI devices, we do not expect them to create an interference problem for the radio observatories. We recognize the importance of these observations to the scientific community but, as VLP devices will not operate under the control of an AFC system and will not be required to have a geolocation capability, we are not able to adopt exclusion zones around these radio observatories.[344] The radio observatories that receive in the 6 GHz band are in remote locations, and it is unlikely that unlicensed VLP devices will be operating nearby. Furthermore, these observatories can restrict such devices from being used at their facilities. Consequently, we conclude that radio astronomy operations will not be subject to harmful interference from unlicensed VLP devices. Given this conclusion, we cannot justify requiring VLP devices to notch out this band as requested as this would increase device complexity and result in less efficient spectrum use.

D. Emission Mask and Out-of-Band Emission Limit

1. Limits for Very Low Power Devices in the U-NII-5 and U-NII-7 Bands

81. In the *Further Notice*, the Commission sought comment on appropriate power levels and other technical parameters that VLP unlicensed devices in the 6 GHz band should have to meet.[345] We note that there were no comments regarding the in-band emission mask for 6 GHz VLP devices. The Commission's previous decision in the *6 GHz Order*[346] found that the emission mask originally proposed by RKF engineering, with certain modifications, was necessary to protect incumbent microwave links and other services operating in the adjacent channel to unlicensed devices within the U-NII-5 through U-NII-8 bands. Because 6 GHz VLP devices will operate in two of these same bands and on the same channels as LPI and standard power 6 GHz devices and need to protect the same incumbent operations, we find that using the same emission mask for VLP devices as we adopted for LPI and standard power devices is appropriate. As the incumbent operations' protection requirements have not changed since our previous decision for this band, using the same mask ensures that those operations are fully protected from unlicensed adjacent channel operations. Moreover, by adopting the same emission requirements, we anticipate that device manufacturers will be able to take advantage of economies of scale regarding filters necessary to meet these requirements which should help to reduce costs. Finally, we take this opportunity to again point out that the emission specification we are adopting represents the minimum requirement. We encourage device manufacturers, consistent with the recent Commission *Policy Statement*, to design their devices to minimize energy transmitted into adjacent channels.[347]

82. Accordingly, we are requiring emissions from VLP devices in the U-NII-5 and U-NII-7 bands to comply with the transmission emission mask adopted in the *6 GHz Order*.[348] That is, we are requiring the power spectral density to be suppressed by 20 dB at one megahertz outside of an unlicensed device's channel edge, suppressed by 28 dB at one channel bandwidth from an unlicensed device's channel center, and suppressed by 40 dB at one and one-half times the channel bandwidth away from an unlicensed device's channel center.[349] At frequencies between one megahertz outside an unlicensed device's channel edge and one channel bandwidth from the center of the channel, the limits must be

[344] We note that there is no radio astronomy allocation for these observations requiring that they be protected from interference; the radio astronomy allocation table footnote merely provides that "all practicable steps shall be taken to protect the radio astronomy service" in this band from harmful interference. 47 CFR § 2.106(c)(142) (U.S. footnote 342).

[345] *6 GHz Order,* 35 Rcd at 3940–42, paras. 236-43.

[346] *6 GHz Order,* 35 Rcd at 3924–25, para. 196.

[347] *See Policy Statement* at 2, 8-9, paras. 5, 23-25.

[348] *6 GHz Order,* 35 Rcd at 3924-25, para. 196.

[349] *6 GHz Order,* 35 Rcd at 3925, para. 196.

linearly interpolated between the 20 dB and 28 dB suppression levels.[350] At frequencies between one and one and one-half times an unlicensed device's channel bandwidth from the center of the channel, the limits must be linearly interpolated between the 28 dB and 40 dB suppression levels.[351] Emissions removed from the channel center by more than one and one-half times the channel bandwidth, but within the U-NII-5 and U-NII-7 bands, must be suppressed by at least 40 dB.[352]

2. Emission Limits Outside the U-NII-5 and U-NII-7 Bands

83. We are adopting emissions limits at the edge of the U-NII-5 and U-NII-8 bands for VLP devices that are identical to the emissions limits that we adopted in the *6 GHz Order*.[353] Specifically, we are adopting a -27 dBm/MHz EIRP limit for 6 GHz VLP devices at frequencies below the bottom of the U-NII-5 band (5.925 GHz) and above the upper edge of the U-NII-8 band (7.125 GHz), but will not require it between the sub-bands, i.e., between the U-NII-5 and U-NII-6, the U-NII-6 and U-NII-7, and the U-NII-7 and U-NII-8 bands; those emissions are subject to the emission mask and OOBE limits discussed above.[354] These limits are intended to protect cellular vehicle-to-everything (C-V2X) operations below the 6 GHz band and federal operations above the band. The Commission previously determined that the -27 dBm/MHz limit will sufficiently protect C-V2X operations from harmful interference from U-NII devices operating in other bands.[355]

84. We note here that the Commission adopted rules that require Intelligent Transportation System (ITS) licensees to cease use of the 5.850-5.895 GHz band and operate only in the 5.895 – 5.925 GHz band.[356] In the 5.9 GHz Order, the Commission also required that DSRC-based technology operating in the ITS radio service transition to C-V2X-based technology.[357] The Further Notice of Proposed Rulemaking in that proceeding addressed transitioning all ITS operations in the revised ITS band at 5.895-5.925 GHz to C-V2X-based technology, including the appropriate timeline for the implementation and codification of C-V2X technical parameters for operation in the 5.895-5.925 GHz band.[358] Since then, the C-V2X proponents requested and the Commission has begun granting waivers to allow immediate C-V2X deployment in the ITS bands prior to the initiation of final rules for CV2X operations.[359]

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[350] *Id*.

[351] *Id*.

[352] *Id*.

[353] 47 CFR § 15.407(b)(6); *6 GHz Order,* 35 Rcd at 3925, para. 197.

[354] *See supra* para. 82.

[355] *6 GHz Order*, 35 FCC Rcd at 3925-26, paras. 197-98 (recognizing that -27 dBm/MHz is the appropriate out-of-band emission limit and that using a root-mean-square (RMS) measurement is sufficient to protect incumbent services from unlicensed 6 GHz devices.); *see Use of the 5.850-5.925 GHz Band*, ET Docket No. 19-138, First Report and Order, Further Notice of Proposed Rulemaking, and Order of Proposed Modification, 35 FCC Rcd 13440, 13474-76, paras. 80-83 (2020) (*5.9 GHz Order*); *see also Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band,* First Report and Order, 29 FCC Rcd 4127, 4158-60, paras. 114-20 (2014) (*5 GHz Order*); 47 CFR § 15.407(b)(6).

[356] *5.9 GHz Order*, 35 FCC Rcd at 13446, para. 14.

[357] *5.9 GHz Order*, 35 FCC Rcd at 13483-84, para. 107-110.

[358] *5.9 GHz Order*, 35 FCC Rcd at 13500-07, para. 146-168.

[359] *See* Request for Waiver of 5.9 GHz Band to Permit Initial Deployment of Cellular Vehicle-to-Everything Technology, Order, ET Docket No. 19-138, DA 23-343 (PSHSB/OET/WTB rel. Apr. 24, 2023) (*Joint Waiver Order*); *Request for Waiver of 5.9 GHz Band Rules to Permit Initial Deployments of Cellular Vehicle-to-Everything Technology, Ford Motor Company, et al.*, ET Docket No. 19-138, at 1 (filed Dec. 13, 2021) (*C-V2X Joint Waiver Request*).

85. Several parties support the -27 dBm/MHz EIRP emission limit,[360] while other parties make alternative proposals. For example, The Alliance for Automotive Innovation (AAI) offers two alternative out-of-band emission proposals: adopt an emission mask that requires VLP devices to suppress out-of-band emissions to -60 dBm/MHz below 5.9 GHz or alternatively require VLP devices operating in the lowermost channel to utilize a low 1-2% duty cycle averaged over a range in the tens of milliseconds.[361] Panasonic suggests that the Commission require unlicensed U-NII-5 devices to include sensing technology that would enable the device to detect adjacent C-V2X signals and cease operating in the lowest U-NII-5 channel, similar to the environmental sensing capability employed by the spectrum access systems in the Citizens Broadband Radio Service.[362] A group of VLP proponents jointly propose a compromise out-of-band emission limit that would apply at the bottom of the U-NII-5 band.[363] Specifically, they propose that VLP devices comply with a -37 dBm/MHz out-of-band emission limit at 5925 MHz measured by root mean square (RMS) to ensure coexistence when 6 GHz devices are operating in the lowermost channels.[364]

86. We are not convinced that a more stringent out-of-band emission limit nor operational restrictions suggested by C-V2X proponents are necessary to protect in-vehicle C-V2X devices from harmful interference. The Commission already determined that standard power and LPI 6 GHz devices must comply with this same -27 dBm/MHz out--of-band emission limit and that emissions at or under that limit will protect adjacent band users from harmful interference.[365] C-V2X devices must be designed to successfully operate in an interference-limited environment as they are subjected to cochannel and adjacent channel signals between each other that are higher than the -27 dBm/MHz -outof--band emission limit we are adopting here for 6 GHz unlicensed VLP devices.[366] C-V2X devices have to coexist with

[360] *See, e.g.*, Wi-Fi Alliance Reply at 13 (filed July 27, 2020) (stating that protection of ITS operations is necessary but that "there is no reason to require VLP devices to protect ITS to a different out-of-band emission ('OOBE') level than currently required from other licensed and unlicensed services"); Dynamic Spectrum Alliance Reply at 10, 13 (filed July 27, 2020) (stating that the Commission should maintain -27 dBm/MHz as the out-of-band emission limit from all 6 GHz unlicensed devices at frequencies below the lowest frequency available in the U-NII-5 band and above the highest frequency available in U-NII-8 and that "[n]one of the comments submitted to the Further Notice provide sufficient justification for the Commission to change its 6 GHz [out-of-band emission limit] rules"); Facebook, Inc. Reply at 5 (filed July 27, 2020) (stating that very low power devices "will not cause harmful interference to adjacent C-V2X operations").

[361] Alliance For Automotive Innovation Reply at 7-8.

[362] Panasonic Comments at 3 (filed June 29, 2020); *see also* 47 CFR §§ 96.3, 96.15, 96.67. The Citizens Broadband Radio Service (CBRS) operates in the 3550-3700 MHz band and utilizes a three-tiered access and authorization framework to accommodate shared federal and non-federal use of the band. 47 CFR §§ 96.1, 96.11. Access and operations are managed by an automated frequency coordinator, known as a Spectrum Access System (SAS). *Id.* § 96.3. While coordinating spectrum access, SASs may incorporate information from an Environmental Sensing Capability (ESC). *Id.* § 96.15. The ESC is a system that detects and communicates the presence of a signal from an incumbent user to an SAS to facilitate shared spectrum access. *Id.* § 96.3.

[363] Broadcom, Cisco, Facebook, Intel, Qualcomm Mar. 1, 2021 *Ex Parte* at 1.

[364] *Id*.

[365] 47 CFR § 15.407(b)(6); *6 GHz Order*, 35 FCC Rcd at 3925, para. 197; *5.9 GHz Order*, 35 FCC Rcd at 13474-75, paras. 80-83.

[366] *5 GHz Order,* 29 FCC Rcd at 4127, para. 114; *see also Wireless Telecommunications Bureau and Public Safety and Homeland Security Bureau Seek Comment on a Request for Nationwide Waiver of Intelligent Transportation System Rules to Use C-V2X Technology in the 5.895-5.925 GHz Band*, ET Docket No. 19-138, Public Notice, DA 22-611, at 3 (WTB/PSHSB June 7, 2022) (Table on page 3 shows the out-of-band emission limits for C-2VX proposed by parties seeking waiver. The limits for zero frequency offset are higher than the out-of-bound emission limit for 6 GHz devices.); *C-V2X Joint Waiver Request* . More recently, additional information on the request was submitted to the Commission. *See Letter from the C-V2X Joint Waiver Parties to Marlene H. Dortch, Secretary*,

(continued….)

other C-V2X devices that operate in close proximity to each other, e.g., other on-board units (within vehicles) and roadside units. Finally, to the extent that commenters may be worried about harmful interference from aggregate VLP device emissions, we note that the number of such devices present in any given vehicle is anticipated to be low and because transmissions between VLP devices would occur over very short distances, the transmit power levels and their associated out-of-band emissions are expected to be well below the maximum permitted. Thus, even if multiple out-of-band emissions were aggregated, the total out-of-band emissions in the local area would still be expected to be below C-V2X device's own signal levels.

87. We decline to adopt the -37 dBm/MHz out-of-band emissions limit suggested by some parties. Likewise we find the -60 dBm/MHz out-of-band emission limit suggested by AAI for application at the U-NII-5 band edge to be too restrictive. In addition, we find AAI's suggestion to require VLP devices to operate with a 1-2% duty cycle that is averaged over a range of tens of milliseconds is not reasonable. While duty cycle is an important parameter for system operation, we typically do not make rules requiring adherence to specific duty cycle requirements as they may artificially restrict design choices and limit the applications that can be used by the American public. Similarly, we decline to adopt a requirement advocated by Panasonic that VLP devices include sensing technology as we do not believe that such a complex solution is necessary to achieve the protection requirements needed for all users in the band. Moreover, any new sensing technology often requires long development cycles along with extended testing to ensure proper operation, which would only delay the benefits that VLP devices can provide.

88. As discussed above, we remain convinced that the -27 dBm/MHz out-of-band emission level at the lower edge of U-NII-5 will protect C-V2X operations below 5925 MHz and adopt that level for VLP devices. This will create a consistent out-of-band limit for all 6 GHz unlicensed devices throughout the 6 GHz band.

3. Prioritization of Operations on Channels above 6105 MHz

89. We are mindful of the concerns from the auto industry regarding the potential for harmful interference to automotive safety systems operating below the U-NII-5 band. For example, the proponents of the compromise proposal propose that VLP devices prioritize unlicensed operation in channels above 6105 MHz (i.e., the top edge of the first 160 megahertz wide channel in the IEEE band plan) before operating below 6105 MHz and that manufacturers submit with their equipment authorization application a declaration that the equipment complies with this prioritization rule.[367] The proponents of the compromise proposal claim that prioritizing channels above 6105 MHz will reduce the likelihood of VLP device traffic adjacent to the 5.9 GHz band when VLP devices are used in vehicles.[368] Additionally, the 5G Automotive Association and others believe that when operating at that proposed emission limit, unlicensed VLP devices transmitting at 14 dB EIRP inside vehicles in the lowermost U-NII-5 channel could cause interference to C-V2X devices that operate in the ITS band from 5.895-5.925 GHz and propose that the Commission prohibit VLP devices from operating on the lowermost channel in the 6 GHz band.[369] The 5G Automotive Association offers a technical study in which it claims that C-

FCC, ET Docket No. 19-138 (filed Apr. 20, 2022) (*C-V2X Joint Waiver Request Supplement*). According to the joint waiver request, C-V2X proponents anticipate operating with a 33 dBm on-board unit EIRP limit within 20 MHz channels. *C-V2X Joint Waiver Request Supplement* at 3.

[367] Broadcom, Cisco, Facebook, Intel, Qualcomm Mar. 1, 2021 *Ex Parte* at 1.

[368] *See supra* footnote 363.

[369] 5G Automotive Association Dec. 9, 2019 *Ex-Parte* at 2; *see also* Alliance for Automotive Innovation Reply at 6-7 (filed July 27, 2020) (contending that the Commission should prohibit very low power and mobile standard power access points in the lowermost U-NII-5 channels and generally offers support for the analysis provided by 5G Automotive Association); American Trucking Association Reply at 1-2 (filed July 27, 2020) (offering general (continued….)

V2X performance will be degraded and its range reduced by up to 50% when operating in the presence of in-vehicle VLP devices.[370] NAB expresses concern regarding the aforementioned compromise proposal contending that the compromise proposal could effectively concentrate unlicensed operations in portions of the band used by broadcasters for ENG operations because U-NII-6 and U-NII-8, where broadcasters operate, are above 6105 MHz.[371] NAB also claims that this proposal would be inconsistent with the Commission's previous decision to not adopt NAB's proposal to forbid unlicensed operation in an 80 megahertz swath of the 6 GHz spectrum where the Commission stated that providing reduced spectrum for unlicensed devices would increase the likelihood of harmful interference because unlicensed operations would be concentrated into fewer channels.[372]

90. To ensure that safety of life services below the U-NII-5 band are protected from harmful interference, we adopt the suggestion from the compromise proposal to require VLP devices to prioritize spectrum above 6105 MHz. We disagree with NAB that this is inconsistent with our previous decision not to exclude VLP devices from a portion of the 6 GHz band to protect ENG operations as this requirement does not prohibit operation below 6105 MHz; it merely requires that devices seek to operate in the spectrum above that frequency first before operating below it. Although under this approach, there may be fewer VLP devices operating on the spectrum below 6105 MHz, many devices will still operate on that spectrum and we do not expect abnormal concentrations of VLP devices in U-NII-6 and U-NII-8 where ENG operates as devices would still naturally spread across the available spectrum.

E. Other Matters

1. Restrictions on Very Low Power Device Use on Aircraft, Boats, and Oil Platforms

91. In the *6 GHz Order*, the Commission did not permit mobile (i.e., in cars, trains, boats, or aircraft 10,000 feet and under) unlicensed standard power and LPI access points to operate in the 6 GHz band due to the potential for increasing interference to incumbent licensees.[373] Similarly, in the *6 GHz Order*, the Commission prohibited standard power and LPI access points from operating on oil platforms.[374] The restrictions on boats and oil platforms were put in place to protect incumbent licensees and protect Earth-Exploration Satellite Service (EESS) sensing operations.[375]

support for Automotive Innovative Alliance, 5G Automotive Association, Panasonic and Qualcomm positions regarding adjacent band interference into the C-V2X band); Qualcomm Comments at 9 (filed June 29, 2020) (supporting generally the 5G Automotive Association request asking the Commission to prohibit very low power and mobile standard power access point operations in the lowermost channels of the 6 GHz band to protect the adjacent ITS band); Panasonic Comments at 2-3 (filed June 29, 2020) (stating that "[t]he proposed . . . out of band emissions from [VLP] and mobile standard-power access point unlicensed operations would cause harmful interference to C-V2X Direct receivers if permitted to operate in adjacent channels of the U-NII-5 band in close proximity to C-V2X on-board units ("OBUs") installed in vehicles" and that VLP devices "should not be permitted to be installed or operated in motor vehicles due to their proximity to the OBU receiver and antenna").

[370] 5G Automotive Association Nov. 16, 2020 *Ex-Parte* at 9, 90-96. (The 5G Automotive Association submitted a technical study in association with the Crash Avoidance Metrics Partners (CAMP) consortium, which asserts that out-of-band emissions into 5895-5925 MHz from U-NII-5 very low power devices will be slightly more interfering than from U-NII-4 devices.)

[371] National Association of Broadcasters Mar. 4, 2021 *Ex Parte* at 1.

[372] *Id*. at 2 (citing *6 GHz Order*, 35 FCC Rcd at 3852, paras. 103, 117, n.297).

[373] *6 GHz Order*, 35 FCC Rcd at 3929, para. 207; *see* 47 CFR § 15.407(d)(1), (4).

[374] *6 GHz Order*, 35 FCC Rcd at 3931, para. 212; *see* 47 CFR § 15.407(d)(1), (4).

[375] *6 GHz Order*, 35 FCC Rcd at 3931, para. 212.

92. Because VLP access points can operate in motion, unlike standard power and LPI devices that the rules limit to stationary operation, we will permit VLP devices to operate in terrestrial land-based vehicles, including cars, buses, trains, etc. We will also not prohibit VLP device use on boats in contrast to our decision to prohibit standard power and LPI devices from operating on boats.[376] That decision stemmed from a request from the National Academy of Sciences' Committee on Radio Frequencies (CORF) seeking protection for EESS remote sensing operations over oceans.[377] Given that VLP devices will operate at much lower power levels than LPI and standard power devices, and many boaters, particularly recreational boaters operate either on inland lakes and waterways or in close proximity to the coastline, we do not believe that they will present an interference threat to EESS sensing over the oceans. However, we are seeking comment in the Second Further Notice of Proposed Rulemaking on whether any restrictions should be put in place for VLP operation on boats. We will continue to prohibit 6 GHz devices, including VLP devices, from operating on oil platforms because EESS operations in this band mainly include oceanic sensing, and operation of VLP devices on oil platforms could potentially interfere with passive and active sensing operations over the oceans and coastal where these oil rigs tend to be concentrated. We also note that ocean based oil platforms, are located anywhere from a few hundred meters to a few hundred miles off of the coast where EESS operations are monitoring critical data oceanographic and weather phenomenon.[378] However, we are seeking comment on whether this restriction should be eliminated in the Second Further Notice of Proposed Rulemaking.

93. Consistent with our decision in the *6 GHz Order* to prohibit standard power and LPI devices from operating in low flying aircraft and unmanned aircraft systems (UAS) (i.e., drones), we similarly prohibit such operation for VLP devices. Use on such platforms presents novel propagation paths and introduces the potential for causing harmful interference to fixed microwave receivers, which are typically located on towers and rooftops. Unlike operation that may occur outside on a balcony above ground level, operation on a low flying aircraft or UAS may not have buildings or other structures nearby to attenuate signals and thus will have a higher probability of having a line-of-sight path to an incumbent receiver location resulting in a higher potential for causing harmful interference. Hence, we will apply the same aircraft restriction to VLP devices as we adopted for LPI and standard power devices. VLP devices will not be permitted on aircraft, except in large aircraft while flying above 10,000 feet.[379] Consistent with our decision in the *6 GHz Order*, we believe that operating at those altitudes along with attenuation provided by an aircraft's fuselage will keep signal levels to such a low level at incumbents' receivers as to pose an insignificant harmful interference risk. We will permit VLP devices operating on aircraft above 10,000 feet to operate across the 5.925-6.425 GHz band. This is consistent with the *6 GHz Order*, which restricted LPI operation on large aircraft flying above 10,000 feet to the U-NII-5 band to prevent harmful interference to radio astronomy and EESS operations in the U-NII-6, U-NII-7, and U-NII-8 bands.[380] VLP devices will also not be permitted to be used for control of or communications with unmanned aircraft systems.[381]

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[376] *6 GHz Order*, 35 FCC Rcd at 3929, para. 207; *see* 47 CFR § 15.407(d)(1), (4).

[377] *Id.* at 3931, para. 212 (citing The National Academy of Sciences Committee on Radio Frequencies Comments, ET Docket No. 18-295 at 8-9 (filed Jan. 29, 2019)).

[378] *See* Thomas Kuegler, *7 Interesting Facts About Offshore Oil Rigs* (Dec. 23, 2016), https://www.billypugh.com/newsroom/7-interesting-facts-offshore-oil-rigs/#:~:text=Offshore%20platforms%20are%20located%20anywhere,2%20kilometers%20beneath%20the%20surface.; Energy Information Administration, *Oil and petroleum products explained* (Oct. 4, 2022), https://www.eia.gov/energyexplained/oil-and-petroleum-products/offshore-oil-and-gas-in-depth.php.

[379] *See* 47 CFR § 15.407(d)(1), (4); *6 GHz Order*, 35 FCC Rcd at 3931-32, paras. 214-15.

[380] *See 6 GHz Order*, 35 FCC Rcd at 3929, 3932, paras. 207, 215; *see also* 47 CFR § 15.407(d)(1), (4).

[381] *See 6 GHz Order*, 35 FCC Rcd at 3931, para. 213.

2. 57-71 GHz Band

94. CTIA opposes expanding AFC-free VLP unlicensed operations in the 6 GHz band and instead proposes that unlicensed proponents consider the 57-71 GHz band for VLP operations.[382] It claims that the band is "ideal for short-range, very low-power use cases" as there are no incumbent operations that require protection from harmful interference.[383] In response, Apple, Broadcom et al. assert that the 57-71 GHz band is not compatible with VLP use because short range, high-data applications at those frequencies require line-of-sight propagation to function effectively on battery power and that line of sight will not be achievable for most wearable devices and personal area network applications.[384] We decline to prohibit VLP device operations in the U-NII-5 and U-NII-7 portions of the of the 6 GHz band in favor of the 57-71 GHz band. The Commission's policy has been to provide as much flexibility for spectrum users – both licensed and unlicensed - to use spectrum bands that best meet their needs based on their business case and expected use cases.[385] VLP operations are no different and, as explained in this Second Report and Order, we believe that permitting VLP operations in the 6 GHz band meets that goal. The rules we are adopting provide flexibility for VLP operations while still protecting authorized services from harmful interference. Furthermore, we note that the 57-71 GHz band has flexible rules for unlicensed operations[386] and that manufacturers could develop similar devices to 6 GHz VLP devices under those rules should they determine that it is both feasible and would meet consumer demand.

95. *LPI and standard power devices as substitute for VLP.* AT&T points to claims by VLP device proponents that 90% of these devices will operate indoors to argue that VLP devices are not necessary to address the use cases purportedly supported by the VLP rules.[387] According to AT&T, the small residual percentage of applications that are outdoors can be addressed by standard power device regulations requiring devices operate under the control of a AFC system.[388] AT&T also claims that VLP device proponents essentially concede that the burden of adding AFC capability to VLP devices would be minimal, pointing to a filing by Apple, Broadcom, Google, and Meta that discusses implementing exclusion zones for VLP devices.[389] According to Apple, Broadcom, and Meta, LPI is not a substitute for VLP because the Commission's rules prohibit direct communications by LPI client devices.[390] This would result in applications like virtual reality and augmented reality experiencing increased latency and decreased spectrum efficiency. Apple, Broadcom, and Meta also claim that VLP is essential for supporting mobility which would be inconsistent with the indoor-only requirement of LPI.[391]

96. We do not agree with AT&T's rationale that if 90% of VLP use is assumed to be indoors, there is no utility in enabling outdoor VLP device operation. VLP proponents describe portable battery-

[382] CTIA Comments at 2 (filed June 29, 2020).

[383] *Id*.

[384] Apple, Broadcom et al. Reply at 31 (filed July 27, 2020).

[385] *See 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 (2015); *Unlicensed White Space Device Operations in the Television Bands*, ET Docket No. 20-36, Report and Order and Further Notice of Proposed Rulemaking, 35 FCC Rcd 12603 (2020).

[386] 47 CFR § 15.255.

[387] AT&T Aug. 29, 2023 Ex Parte 2-3.

[388] *Id*. at 2.

[389] *Id*. at 2-3 (citing Apple, Broadcom, Google, Meta July 26, 2023 *Ex Parte*).

[390] Apple, Broadcom, and Meta Sept. 14, 2023 *Ex Parte* at 2.

[391] *Id*.

powered consumer products as a primary use case for these devices,[392] and apportioning significant battery resources to the overhead necessary to operate pursuant to an AFC could reduce utility of these devices to the point that they would be infeasible. In addition, as discussed above, we disagree with AT&T's assertion that there is no cost to implement an AFC capability in VLP devices.[393] Adding AFC capability to these small battery-powered portable device would likely increase their complexity and, correspondingly, their cost. We also agree with Apple, Broadcom, and Meta that VLP devices will be suitable for applications that require direct communications between client devices and to support mobility that may require devices to transition between indoor and outdoor use. Therefore, we find AT&T's contention to be without merit.

3. Rule Corrections

97. We are making two minor changes to section 15.407 to correct cross-references that were inadvertently not updated when the Commission previously renumbered paragraphs in this section.[394] Specifically, we correct the cross-reference in the introductory text of section 15.407(b) to reference paragraph (b)(10) rather than (b)(7), and we correct the cross-reference in section 15.407(l)(2)(ii) to reference paragraph (b)(7) rather than (b)(6).

F. Benefits and Cost

98. As discussed above, we adopt rules to permit VLP devices to operate in the U-NII-5 and U-NII-7 portions of the 6 GHz band while protecting the licensed services that operate in the band from harmful interference. Enabling new unlicensed use types in the U-NII-5 and U-NII-7 bands will yield important economic benefits and will allow more extensive use of technologies, such as Wi-Fi and Bluetooth, by American consumers. Consumers are using more and more data, on average, and this is expected to continue to grow significantly.[395] One report estimated that in 2021, the economic benefits associated with Wi-Fi in the United States was valued at almost $979 billion and that by 2025, 40% of Wi-Fi traffic will rely on 6 GHz.[396] Another report estimated that making the 6 GHz band accessible to VLP devices would produce over $39 billion in economic value over five years.[397] Even if the rules that we adopt herein lead to expected benefits of 5% of $39 billion, or approximately $2 billion—a figure we find to be below the likely benefits of these rules—the expected benefits will be well in excess of the costs that we estimate.

99. Because there are presently no VLP devices in operation, the rules that we promulgate do not have cost implications for the existing unlicensed device ecosystem. And because we are not imposing

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[392] Qualcomm, Google July 27, 2023 *Ex Parte* at 2; Apple, Broadcom, et al. Nov. 4, 2020 *Ex Parte* at 2; Apple, Broadcom, et al. Reply at 27-28.

[393] *See supra* para. 64.

[394] In the *6 GHz Order*, the Commission renumbered paragraph (b)(7) of section 15.407 as paragraph (b)(9) but did not update the cross-reference to this paragraph in the introductory text to paragraph (b). *6 GHz Order*, 35 FCC Rcd at 3951-52, Appx. A. In the subsequent *5.9 GHz Order*, the Commission renumbered paragraph (b)(9) as (b)(10) but also did not update the cross-reference in the introductory text to paragraph (b). *5.9 GHz Order*, 35 FCC Rcd at 13521-22, Appx. A. Additionally, the Commission renumbered paragraph (b)(6) as (b)(7) in the *5.9 GHz Order* but did not update the cross reference in paragraph (l)(2)(ii). *Id.* at 13521-23, Appx. A.

[395] GSMA, The Mobile Economy, North America 2022 at 13 (Sept. 2022) https://www.gsma.com/mobileeconomy/wp-content/uploads/2022/09/290922-Mobile-Economy-North-America-2022.pdf. GSMA estimates that demand for mobile data in North America will increase from 15 GB per subscriber per month in 2021 to 52 GB per subscriber per month in 2027.

[396] Telecom Advisory Services, The Economic Value of Wi-Fi: a global view (2021 – 2025) at 34-35 (Sept. 2021), https://www.wi-fi.org/file/detail-global-economic-value-of-wi-fi-2021-2025.

[397] Telecom Advisory Services, LLC, Assessing the Economic Value of Unlicensed Use in the 5.9 GHz & 6 GHz Bands at 49-56 (Apr. 2020), http://wififorward.org/wp-content/uploads/2020/04/5.9-6.0-FINAL-for-distribution.pdf.

any requirements on any incumbent operator, there is also no cost implication on them. Thus, by promulgating these rules to enable VLP devices to operate in the U-NII-5 and U-NII-7 portions of the 6 GHz band, significant economic benefits will be bestowed on the American public.

IV. SECOND FURTHER NOTICE OF PROPOSED RULEMAKING

100. In this Second Further Notice of Proposed Rulemaking, we seek comment on how we can refine the VLP device rules to provide those devices greater use of the band while continuing to protect licensed incumbents. Below, we propose to allow VLP devices to operate in the U-NII-5 through U-NII-8 bands (i.e., a total of 1200 MHz of spectrum) at a PSD level greater than -5 dBm/MHz—up to 1 dBm/MHz EIRP PSD and 14 dBm EIRP—provided they operate under the control of a geofencing system that prevents devices from operating in close proximity to co-channel licensed incumbent services in these bands. VLP access points would obtain information from a geofencing system on locations where operation is prohibited on specific frequencies, and VLP client devices would operate only under the control of VLP access points. These geofenced VLP devices would be a new class of higher-power VLP devices in addition to those we are permitting in the Second Report and Order. We also seek comment on whether we should relax the restrictions on mobile use of VLP devices (e.g., on aircraft and oil platforms). In addition, we seek comment on whether we could allow VLP devices that operate without a geofencing system in the U-NII-6 and U-NII-8 bands in addition to the U-NII-5 and U-NII-7 bands where the Second Report and Order permits them to operate.[398] As the Commission stated in the *Policy Statement*, "[r]elevant information about services' transmitter and receiver standards, guidelines, and operating characteristics is needed to promote effective spectrum management and efficient co-existence."[399] Thus, going forward, we encourage representatives from the unlicensed device community and those representing the incumbent services to work collaboratively and provide relevant information on their systems to the Commission to allow us to continue to refine our rules for the 6 GHz band and to ensure that equipment designed for and used in the 6 GHz band can fully function within the spectral environment.

A. Power Limits for Geofenced VLP Devices in the U-NII-5 through U-NII-8 Bands

101. As discussed above in the Second Report and Order, we are permitting VLP devices to operate at power levels up to -5 dBm/MHz EIRP PSD and up to 14 dBm EIRP. Apple, Broadcom, et al. request that we permit a higher maximum level of 1 dBm/MHz EIRP PSD with the same maximum total power of 14 dBm EIRP, which they contend would enable important new VLP devices while protecting incumbent operations.[400] This PSD level would permit VLP devices to operate at the maximum 14 dBm EIRP levels for any channel bandwidth greater than 20 megahertz, whereas under the rules we are adopting in the Second Report and Order that maximum EIRP level can only be achieved for 80 megahertz and wider channel bandwidths. Based on the record and our analysis of that record, we declined to adopt rules permitting VLP devices to operate at this requested level of 1 dBm/MHz EIRP PSD at this time. However, we believe that we can leverage the AFC systems for use within a framework that combines higher power operation with geofencing to keep these higher powered VLP devices in locations where there have an insignificant potential to cause harmful interference to other users in the band. We note that these proposals are not intended to curtail the VLP use we are adopting in the Second Report and Order. Rather, they are designed to explore the possibility for providing more flexibility for higher power use at the expense of additional complexity to implement and use a geofencing capability so that additional use cases and applications can be brought to the American public.

[398] 47 CFR § 15.407(a)(4).

[399] *Id.* at 3, para. 5 (emphasis omitted); *accord id.* at 11-12, paras. 37-40.

[400] Apple, Broadcom et al. Comments Attachs. A, B, C (filed June 29, 2020).

1. In-band Power Limits

102. We believe that we could allow geofenced VLP devices to operate at the higher PSD level suggested by Apple, Broadcom, et al. if we require certain frequency and geographic area restrictions, specifically, that VLP devices with higher PSD be prohibited from operating co-channel and in close proximity to licensed incumbent services receive sites. Accordingly, we propose to allow VLP devices to operate in the U-NII-5 through U-NII-8 bands at a level greater than -5 dBm EIRP PSD and 14 dBm EIRP, specifically up to 1 dBm EIRP PSD and 14 dBm EIRP, provided they operate under the control of a geofencing system to minimize the likelihood of harmful interference to licensed incumbent services. Under this system, geofenced VLP devices would be required to incorporate a capability to ensure that they avoid transmitting on certain channels within certain geographic areas, i.e., this is analogous to erecting a fence to prevent VLP devices from operating on certain channels within certain geographic areas, hence the descriptive term "geofencing system." While a geofencing system is not identical to an AFC system that several parties requested be required for VLP device operation,[401] it will provide functionally equivalent protection to licensed incumbent operations.

103. We seek comment on these proposals. Should we allow VLP devices to operate with up to 1 dBm EIRP PSD and 14 dBm EIRP, provided they are prevented from operating in areas where there is an elevated risk of harmful interference? What are the advantages and disadvantages of allowing a higher PSD limit? What additional VLP applications could be enabled by this proposed increase? Could we allow a power limit higher than 14 dBm EIRP, e.g., up to 21 dBm EIRP, as suggested by some commenters?[402] What are the advantages and disadvantages of a higher power limit? Would higher power limits result in higher data usage and if so by how much? Would a higher power limit create new use cases for VLP? Would even higher PSD and EIRP limits increase the risk of harmful interference to licensed incumbent services, and would the proposed geofencing system described below be sufficient to reduce this risk? What are the costs and benefits of requiring higher power VLP devices to operate under a geofencing system? How would the additional benefits of geofenced U-NII-6 and U-NII-8 operations compare to the benefits we estimate for non-geofenced U-NII-5 and U-NII-7 operations in the Second Report and Order? Would the power level increase that we propose provide a sufficient incentive for equipment manufacturers to develop geofencing systems?

2. Transmit Power Control

104. Consistent with the rules we adopt for VLP devices in the Second Report and Order, we propose to require geofenced VLP devices operating within the U-NII-5 through U-NII-8 bands to employ a transmit power control mechanism that has the capability to operate at least 6 dB below the maximum EIRP we permit for the bands (e.g., 14 dBm or 21 dBm). Because VLP devices do not yet exist and we do not know what specific transmit power control algorithm these devices may employ, we do not propose any specific requirements in our rules as to how the transmit power control algorithm of the VLP devices will function. We do not expect that adopting this transmit power control requirement will present an undue burden on geofenced VLP device manufacturers since these are expected to be battery-powered devices that are likely to employ transmit power control to conserve battery power. We seek comment on this proposal. Is there a need to specify any additional transmit power control requirements for geofenced VLP devices that we propose could operate at a higher power than VLP devices? For example, should the Commission adopt a different requirement along the lines of the European requirement in the 5250-5350 MHz and 5470-5725 MHz bands? That requirement specifies that transmit power control shall provide, on average, a mitigation factor of at least 3 dB on the maximum permitted output power of the systems; or, if transmitter power control is not in use, then the maximum

[401] *See supra* footnote 287287.

[402] Apple, Broadcom et al. Comments at 3-10 (filed June 29, 2020). With a PSD limit of 1 dBm/MHz EIRP, a VLP device would have to operate with a channel bandwidth of approximately 125 MHz to achieve an EIRP of 21 dBm.

permitted mean EIRP and the corresponding mean EIRP density limit shall be reduced by 3 dB.[403] What information should manufacturers be required to include in their application for certification to show compliance with a transmit power control requirement, e.g., an attestation of compliance, a detailed operational description, actual equipment test data? What are the advantages and disadvantages of requiring a transmit power control mechanism in terms of spectrum efficiency, costs, and complexity? Commenters who favor the European requirement should provide specific information regarding how such an requirement could be implemented, verified during the equipment certification process, and enforced. In addition, noting that this requirement differs from the rule we are adopting for VLP devices in the Second Report and Order, what ramifications, if any, would arise if there were differing requirements on the two classes of VLP devices?

3. Emission Mask

105. We propose to require emissions from geofenced VLP devices within the U-NII-5 through U-NII-8 bands to comply with the transmission emission mask adopted for standard power and LPI devices in the *6 GHz Order*[404] and for VLP devices in the Second Report and Order.[405] That is, the power spectral density would have to be suppressed by 20 dB at one megahertz outside of an unlicensed device's channel edge, suppressed by 28 dB at one channel bandwidth from an unlicensed device's channel center, and suppressed by 40 dB at one and one-half times the channel bandwidth away from an unlicensed device's channel center.[406] At frequencies between one megahertz outside an unlicensed device's channel edge and one channel bandwidth from the center of the channel, the limits would be linearly interpolated between the 20 dB and 28 dB suppression levels.[407] At frequencies between one and one and one-half times an unlicensed device's channel bandwidth from the center of the channel, the limits would be linearly interpolated between the 28 dB and 40 dB suppression levels.[408] Emissions removed from the channel center by more than one and one-half times the channel bandwidth, but within the U-NII-5 and U-NII-8 bands, would have to be suppressed by at least 40 dB.[409] Because geofenced VLP devices would operate in the same bands and on the same channels as VLP devices, LPI and standard power 6 GHz devices and need to protect the same incumbent operations, we believe that using the same emission mask for geofenced VLP devices as we adopted for VLP devices, LPI and standard power devices is appropriate. Using the same mask would ensure that licensed incumbent operations are fully protected from unlicensed adjacent channel operations. Moreover, by specifying the same emission requirements, we anticipate that these requirements would act to reduce costs by permitting all devices throughout the VLP ecosystem to use the same filters and benefit from economies of scale for their acquisition.

4. Emission Limits Outside the U-NII-5 and U-NII-8 Bands.

106. We propose emissions limits at the edge of the U-NII-5 and U-NII-8 bands for geofenced VLP devices that are identical to the emissions limits that we adopted in the *6 GHz Order* and the Second Report and Order.[410] Specifically, we propose a -27 dBm/MHz EIRP limit for 6 GHz VLP devices at

[403] *See* ECC Decision (04)08, On the harmonised use of the 5 GHz frequency bands for Wireless Access Systems including Radio Local Area Networks (WAS/RLAN), amended 1 July 2022, available at: https://docdb.cept.org/download/4053.

[404] *6 GHz Order,* 35 Rcd at 3924-25, para. 196.

[405] *See supra* para. 82.

[406] *6 GHz Order,* 35 Rcd at 3925, para. 196.

[407] *Id*.

[408] *Id*.

[409] *Id*.

[410] 47 CFR § 15.407(b)(6); *6 GHz Order,* 35 Rcd at 3925, para. 197.

frequencies below the bottom of the U-NII-5 band (5.925 GHz) and above the upper edge of the U-NII-8 band (7.125 GHz), but propose to not require it between the sub-bands, i.e., between the U-NII-5 and U-NII-6, the U-NII-6 and U-NII-7, and the U-NII-7 and U-NII-8 bands; those emissions would be subject to the emission mask and OOBE limits proposed above.[411] These limits are intended to protect cellular vehicle-to-everything (C-V2X) operations below the 6 GHz band and federal operations above the band. The Commission previously determined that the -27 dBm/MHz limit will sufficiently protect C-V2X operations from harmful interference from U-NII devices operating in other bands.[412] Because geofenced VLP devices could be mobile and potentially used near C-V2X operations, to help protect these services below the U-NII-5 band from harmful interference, we propose to require that geofenced VLP devices prioritize spectrum above 6105 MHz, as we required in the Second Report and Order for VLP devices.[413]

107. We seek comment on the proposed emission mask and the proposed emission limits outside the U-NII-5 and U-NII-8 bands. Are these limits appropriate for geofenced VLP devices? Would they adequately protect licensed incumbent services, both within and outside of the U-NII bands? Would different emission limits be more appropriate? If so, what limits should we require and why? Is a requirement for geofenced VLP devices to prioritize spectrum use above 6105 MHz necessary? What are the costs and benefits of the proposed emission mask and limits? Would requiring the same emission limits for geofenced devices that we require for non-geofenced VLP devices reduce the cost of compliance with the emission mask?

B. Geofencing System for Geofenced VLP Devices in the U-NII-5 through U-NII-8 Bands

108. We propose to allow VLP devices to operate at a PSD greater than -5 dBm/MHz EIRP PSD, up to a maximum of 1 dBm/MHz EIRP PSD, when they operate under the control of a geofencing system to minimize the likelihood of causing harmful interference to licensed incumbent services.[414] The proposed geofencing system would ensure that geofenced VLP devices with greater than -5 dBm/MHz EIRP do not operate on the same channels as licensed incumbents inside of defined exclusion zones designed to minimize the potential for geofenced VLP devices to cause harmful interference. We propose requirements for geofencing systems and the criteria that would be used to calculate the exclusion zones as well as technical requirements for geofenced VLP devices. We also propose procedures for testing and approving geofencing systems to ensure that they would operate as intended and correctly restrict co-channel operation with licensed incumbents in the 6 GHz band at certain locations.

1. Requirement to use Geofencing

109. *Background*. Standard power access points and fixed client devices must register with and be authorized by an AFC system prior to their initial service transmission by providing their geographic coordinates, antenna height above ground level, FCC identification number, and

[411] *See supra* para. III.D.2.

[412] *6 GHz Order*, 35 FCC Rcd at 3925-26, paras. 197-98 (recognizing that -27 dBm/MHz is the appropriate out-of-band emission limit and that using a root-mean-square (RMS) measurement is sufficient to protect incumbent services from unlicensed 6 GHz devices.); *see Use of the 5.850-5.925 GHz Band*, ET Docket No. 19-138, First Report and Order, Further Notice of Proposed Rulemaking, and Order of Proposed Modification, 35 FCC Rcd 13440, 13474-76, paras. 80-83 (2020) (*5.9 GHz Order*); *see also Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band,* First Report and Order, 29 FCC Rcd 4127, 4158-60, paras. 114-20 (2014) (*5 GHz Order*); 47 CFR § 15.407(b)(6).

[413] *See supra* para. 90.

[414] As described below, a VLP access point (e.g., a smartphone) operates in the 5.925–7.125 GHz band and communicates with and receives authorization from a geofencing system to operate on certain frequencies. A VLP client device operates only under the control of a VLP access point.

manufacturer's serial number.[415] They may transmit only on frequencies and at power levels as indicated by an AFC system.[416] After registration, they must contact an AFC system at least once per day to obtain the latest list of available frequencies and the maximum permissible power the device may use on each frequency at their location.[417] As discussed in the Second Report and Order, we are permitting VLP device operation at levels up to -5 dBm/MHz PSD EIRP and 14 dBm EIRP maximum without the use of an AFC or other database system because we determined that the risk of harmful interference to licensed incumbent services is insignificant at that power level.

110. *Discussion*. For VLP device operation at PSD levels higher than -5 dBm/MHz EIRP where the risk of harmful interference to incumbent services is elevated, we propose to require VLP access points to use a geofencing system to protect fixed microwave service, BAS, CARS, radio astronomy, and FSS receive sites in the 6 GHz band. We believe that this would be an effective approach to protecting licensed incumbent services since it could be implemented using the same methodology that the Commission previously developed for standard power access points and fixed client devices to protect these services. A geofencing approach, as opposed to requiring VLP devices to access an AFC system, could help preserve VLP device battery life by not requiring each device to re-check a database every time it moves, as is the case for standard power access points. Similarly, a geofencing approach could help protect user privacy since devices would not be required to report their location to a centralized system.[418] A geofencing system would enable VLP devices to operate at PSD levels greater than -5 dBm/MHz EIRP to enable a variety of uses while protecting licensed incumbent services in the 6 GHz band. The Commission previously required certain types of devices to operate pursuant to a geofencing system. It adopted similar requirements to ensure protection to fixed service receivers in the 5925-6425 MHz portion of this band when it granted Higher Ground a blanket earth station license to operate SatPaqs on a non-interference basis through an automated frequency coordination system basis to enable cellphones to communicate with FSS space stations.[419] Additionally, the Commission permits unlicensed white space devices to operate in certain bands subject to their use of a geofencing system to protect licensed incumbent services.[420]

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[415] 47 CFR § 15.407(k)(8)(i)-(ii). Devices must also re-register with the database if they are moved after initial registration. *Id.* § 15.407(k)(8)(ii).

[416] *Id*. § 15.407(k)(8)(i).

[417] 47 CFR § 15.407(k)(8)(iv). "If the standard power access point or fixed client device fails to successfully contact the AFC system during any given day, the standard power access point or fixed client device may continue to operate until 11:59 p.m. of the following day at which time it must cease operations until it re-establishes contact with the AFC system and re-verifies its list of available frequencies and associated power levels." *Id*.

[418] We note that device manufacturers could opt to use a system that requires very low power devices to report their position to a centralized source.

[419] *See Higher Ground LLC; Application for Blanket Earth Station License*, IBFS File No.: SES-LIC-20150616-00357, Call Sign: E150095, Order and Authorization, 32 FCC Rcd 728, 739-741, paras. 38-40 (2017). In that Order and Authorization, the Commission permitted Higher Ground to operate up to 50,000 SatPaq earth stations subject to using an automated frequency coordination system with a maximum 9 dBW EIRP/Carrier and a maximum -24 dBW/4 kHz EIRP density/Carrier (this equates to 0 dBW/MHz/Carrier or 30 dBm/MHz/Carrier) over any 8 megahertz band with a limit of no more than 100 SatPaqs operating concurrently and with a maximum 9 dBW EIRP/Carrier and a maximum -21 dBW/4 kHz EIRP density/Carrier (this equates to 3 dBW/MHz/Carrier or 33 dBm/MHz/Carrier) over any 4 megahertz band with a limit of no more than 50 SatPaqs operating concurrently. Note that these power levels are substantially higher than the power levels we are permitting for VLP devices here.

[420] *See* 47 CFR § 15.711(d)(5) (permitting a Mode II personal/portable white space device to operate within a bounded area in which channel availability information has been calculated at all locations within the area); 47 CFR § 15.711(k)(1) (permitting mobile white space devices to operate within geo-fenced areas over which the white space database has determined channel availability).

111. We propose to protect licensed services in the 6 GHz band by prohibiting geofenced VLP access points with power levels greater than -5 dBm/MHz EIRP PSD from operating on certain channels within defined exclusion zones around the sites where licensed incumbent services operate. The geofencing system would prevent a VLP access point from operating on the frequencies within these exclusion zones where there may be a higher risk of causing harmful interference. We propose that the exclusion zones be determined based on the operational frequency being used by the incumbent service licensee as well as the power of the geofenced VLP access point. A geofenced VLP access point located within an exclusion zone would be prohibited from operating only on the specific frequencies excluded within that zone and would be permitted to operate on any other frequencies that are available at its location at the maximum power level permitted. Depending on the number of incumbent licensees in an area and the size of the exclusion zones, a geofenced VLP access point could fall within multiple overlapping exclusion zones at a particular location. In such cases, the device would have to avoid all excluded frequencies for all the overlapping zones in which it is located. To provide manufacturers flexibility in developing geofencing systems, we propose that geofencing systems may also determine areas where particular frequencies are available throughout the entire area based on the same protection criteria used to calculate exclusion zones. Each approach may have advantages in terms of spectrum availability or device complexity, so permitting either approach would provide manufacturers with the ability to determine the most suitable implementation for a specific use case.[421] The proposed methodology for calculating exclusion zones is described below.

112. We seek comment on these proposals. Is a geofencing system the most appropriate way to minimize the likelihood of harmful interference from VLP devices with a PSD greater than -5 dBm/MHz EIRP to licensed incumbent services in the 6 GHz band? Is the proposed method of using exclusion zones around licensed incumbent receive sites an appropriate way to protect these sites? Would the proposed alternative method allowing geofencing operators to calculate zones in which a channel is available over an entire zone provide the same protection to incumbent services as determining exclusion zones in which one or more channels are unavailable? Should we permit use of either method, or is one method preferable to the other, and if so, why? How would the benefits of higher power VLP operations in the 6 GHz band vary with differences in exclusion zone design?

113. We also seek comment on whether an approach other than geofencing, such as requiring the use of an AFC system for higher power VLP devices, would be more appropriate. What are the advantages and disadvantages of requiring a geofencing approach for protecting licensed services as opposed to other approaches? What are the benefits and costs of the various approaches for the public, unlicensed devices manufacturers, and incumbent users of the 6 GHz band? Are there any other factors that the Commission should consider in determining whether to require use of a geofencing system for VLP devices with a PSD greater than -5 dBm EIRP? Commenters advocating for the proposed approach or any alternatives should provide details explaining why their desired approach is most beneficial for enabling these higher powered geofenced VLP devices.

2. Geofencing Architecture

114. *Definition of geofenced VLP devices.* We propose to define a geofenced VLP access point as an access point that operates in the 5.925–7.125 GHz band, has an integrated antenna, and uses a geofencing system to determine channel availability at its location. We propose that these devices could

[421] Determining exclusion zones would make the most spectrum available for a device since it would be prohibited from operating only on specific frequencies in limited areas close to licensed incumbent receive sites, but the device would have to be capable of storing information on all exclusion zones and prohibited frequencies in the area where it will operate. Determining frequencies that are available at every point within a bounded area could be simpler to implement in a device since the device would only need to store information on the boundaries of the zone where operation is permitted and the available frequencies within that zone. However, this approach could result in less available spectrum for a device since a frequency that is excluded at any point within the device's operating area would have to be excluded everywhere in that area.

simultaneously operate as clients to other access points or telecommunications systems (e.g., low-power indoor access points, standard power access points, other U-NII band access points, commercial telecommunication carriers' networks, etc.) and very low power access points. We believe that this definition adequately describes the types of VLP devices that could operate under a geofencing system, and the proposed requirement for an integrated antenna, which is consistent with the current rules for indoor access points and subordinate devices, will help ensure that geofenced VLP devices cannot be easily modified to increase their EIRP.[422]

115. We propose to require that geofenced VLP access points obtain or calculate the exclusion zones—where some operational restrictions are required—that will protect licensed services, have the capability to determine their location, and intelligently choose their operating channel to avoid operating on a prohibited frequency within an exclusion zone. We further propose to require that client devices operating under the control of a geofenced VLP access point operate only on channels as determined by its connected geofenced VLP access point. Under these proposals, client devices would not be required to directly obtain or calculate exclusion zone information as they would only be operating on channels already cleared through the geofenced VLP access point. The same client devices may also be capable of operating under the control of LPI access points and standard power access points, in which case the client devices must adjust their power levels depending on which type of access point they are connected to. That is, when connected to an LPI access point or standard power access point, the client device would have to follow the client device rules for those operations, which require those client devices to reduce their power at least 6 dB below the access point power level.[423] Because geofenced VLP access points and client devices would operate at lower power levels than standard power and LPI devices, thus reducing the distance at which harmful interference may possibly occur, we do not propose to require client devices to reduce their power below that of the access point and propose to limit both geofenced VLP access points and client devices operating under the control of a geofenced VLP access point to the same power levels.

116. We seek comment on these proposals. Is the proposed geofenced VLP two-tier model based on access points and client devices in which a geofenced VLP access point is required to obtain geofencing information, but the client device is not, appropriate? Is the proposed definition of VLP access point appropriate, or are different or additional definitions that better describe the types of permissible geofenced VLP devices necessary? Should all geofenced VLP devices be required to incorporate an integrated antenna? Should client devices be permitted to operate at a different power level than geofenced access points? Is there any need for a 6 dB power reduction for a client to a geofenced VLP device?

117. *System architecture.* We propose to allow geofencing systems for VLP devices operating at greater than -5 dBm/MHz flexibility in their design by permitting the use of either a distributed architecture or a centralized model. One possible architecture would have a centralized geofencing system calculate exclusion zones based on information obtained from Commission databases, e.g., the Universal Licensing System (ULS) and Cable Operations and Licensing System (COALS) databases, as well the Commission's rules.[424] A VLP access point would contact this centralized geofencing system to

[422] 47 CFR § 15.407(a)(9).

[423] This is consistent with existing policy as articulated in the KDB guidance for 6 GHz devices, which provides for approval of composite devices where devices may require approval under multiple rule parts or sections. *See* KDB Pub. No. 987594 D01, U-NII 6GHz General Requirements v01r03, section V available at: https://apps.fcc.gov/oetcf/kdb/forms/FTSSearchResultPage.cfm?id=277034&switch=P#:~:text=987594-,D01%20U%2DNII%206GHz%20General%20Requirements%20v01r03,-provides%20general%20requirements.

[424] AFC systems are designed to provide lists of available channels and power levels to standard power access points and fixed client devices in the U-NII-5 and U-NII-7 bands at the single set of geographic coordinates where a device is registered. 47 CFR § 15.407(k)(4). Additional functionality would have to be added to an AFC system to enable (continued….)

download the exclusion zones and then manage its use of spectrum based on these areas. Another possible architecture would be for a VLP access point to regularly send its location to a centralized geofencing system, which would then inform the access point as to the channels it may use. Yet another possible architecture would be for the geofencing system to be integrated within a VLP access point. A VLP access point would download information about the licensed services to be protected from an external source. It would contain the data and software necessary to independently determine exclusion zones and manage its use of spectrum. We are not proposing specific details for the geofencing system architecture for VLP devices because we want to provide manufacturers with the flexibility to design appropriate geofencing systems for different equipment use cases, many of which may not be known at this time.

118. We seek comment on these proposals. How much flexibility should the Commission provide in geofencing system architecture? Should the Commission provide flexibility for different geofencing system implementations or should a single approach be specified? What are the benefits and drawbacks of each approach? How would costs for users of a geofencing system vary between different approaches? Is there a need to specify the overall framework of geofencing systems in more detail, e.g., whether they are centralized or decentralized? Do we need to provide more specific requirements for geofencing system architecture and if so, what requirements should be specified? Do we need to provide further details on the process that the Commission will use to approve geofencing systems, and if so, what additional details are necessary?

3. Protection of Incumbent Services

119. We propose requirements for geofenced VLP devices operating at greater than -5 dBm/MHz EIRP to protect licensed incumbent services in the 6 GHz band, specifically, fixed microwave services, BAS and CARS receive sites, as well as radio astronomy and FSS receive sites. Consistent with the requirements for standard power access points and fixed client devices, we propose that geofencing systems use data from Commission databases to protect fixed microwave services.[425] We propose that BAS and CARS receive sites be protected using data provided by licensees, as described below. We further propose that geofenced VLP devices protect certain radio astronomy sites and FSS receive sites as provided in the Commission's rules.[426] Geofenced VLP operations, like all other unlicensed 6 GHz band operations, would have to comply with international agreements with Canada and Mexico.[427]

120. *Fixed microwave services protection*. We propose to require geofencing systems to follow the same criteria for protecting fixed and temporary fixed microwave receive sites used for standard power access points and fixed client devices.[428] Specifically, we propose that geofenced VLP

it to provide information to very low power access points on the boundaries of the geofenced exclusion zones where they are prohibited from operating on certain frequencies, and to include the U-NII-6 and U-NII-8 bands to protect BAS receive sites when determining these exclusion zones. It is important to note that the relevant data to calculate the exclusion zones is currently in multiple Commission databases (i.e., ULS database is for fixed microwave and BAS, and COALS database is used for CARS). The requirements for protecting radio astronomy and fixed satellite receive sites are in section 15.407(q)-(r) of the amended rules and the coordinates of the radio astronomy sites are in section 2.106(c)(131), (c)(385) (United States footnotes US131 and US385).

[425] *6 GHz Order,* 35 FCC Rcd at 3864, para. 30; *see* 47 CFR § 15.407(k)(3).

[426] 47 CFR §§ 15.407(m), 2.106(c)(131), (c)(385) (United States footnotes US131 and US385).

[427] 47 CFR § 15.407(k)(14).

[428] VLP devices will be required to accommodate temporary fixed microwave stations similar to the requirement for standard power devices. *6 GHz Order,* 35 FCC Rcd at 3865, para. 32. The term "fixed microwave services" in this Second Report and Order includes temporary fixed stations. *See Wireless Telecommunications Bureau Announces that Temporary Fixed Stations in the 6 GHz Band Can Now Be Registered*, Public Notice, DA 23-814 (WTB Sep. 6, 2023).

device exclusion zones be calculated based on the same -6 dB I/N evaluation metric used in the *6 GHz Order*, where N (noise) represents the background noise level at the fixed microwave receiver, and I (interference) represents the co-channel signal from the VLP device at the fixed microwave service receiver.[429] The Commission noted in the *6 GHz Order* that use of this metric is a conservative approach that will ensure that the potential for harmful interference to the fixed microwave services is minimized and that the important fixed microwave services in the 6 GHz band are protected.[430] While geofenced VLP devices would operate at a lower power level than standard power access points and fixed client devices, we believe that the fact that geofenced VLP devices would operate in the same or nearby frequency bands and at similar bandwidths means that the same protection criteria that applies to standard power access points and fixed client devices is also appropriate for geofenced VLP devices.

121. We also propose to allow an assumption of 4 dB for body loss in the exclusion zone calculations because of our finding, discussed in the Second Report and Order, that due to the nature of VLP devices and how they will be used, an additional 4 dB attenuation for body loss is appropriate when analyzing the potential effect of their emissions.[431] We do not propose to consider aggregate interference from geofenced VLP devices since they will operate at a significantly lower power level than standard power access points and fixed client devices for which the Commission previously determined that an aggregate interference limit is not necessary.[432]

122. We seek comment on these proposals. Are the proposed interference metric and body loss assumption appropriate? Would other values be more appropriate? Are there other parameters in addition to body loss that should be accounted for when determining exclusion zones (e.g., transmit power control)? Commenters who advocate for additional parameters should specify the parameters, appropriate values, and a detailed justification for why that parameter and value are appropriate. We seek estimates of the benefits and costs of different parameter proposals. We also seek comment on whether there is a need for an aggregate interference limit. If so, what is the appropriate limit and why? How could we enforce an aggregate interference limit using a geofencing system? Would a centralized system be required and if so, who would build and run such a system?

123. We propose to require geofencing systems to use the same propagation models that are used for standard power access points and fixed client devices to determine the VLP device exclusion zones.[433] Specifically, we propose to require geofencing systems to use the free space path-loss model at separation distances of up to 30 meters, the Wireless World Initiative New Radio phase II (WINNER II) model at separation distances greater than 30 meters and up to and including 1 kilometer, and the Irregular Terrain Model (ITM) combined with the appropriate clutter model at separation distances greater than 1 kilometer.[434] Where such data are available, we propose that the exclusion zone calculation

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[429] *See* 47 CFR § 15.407(l)(2).

[430] *6 GHz Order,* 35 FCC Rcd at 3878, para. 71. The WinnForum created a consensus functional requirements document for 6 GHz band AFC systems which contains details for implementing the Commission's rules for standard power devices operating under the control of an AFC system. This document includes default input values as well as options for certain propagation model values depending on the amount of information known regarding the fixed service receiver. Wireless Innovation Forum, *Functional Requirements for the U.S. 6 GHz Band under the Control of an AFC System*, WINNF-TS-1014 Version V1.3.0 (Mar. 9, 2023), https://winnf.memberclicks.net/assets/work_products/Specifications/WINNF-TS-1014.pdf. We appreciate the work that industry stakeholders have done to implement the AFC systems and encourage them to continue this collaboration to implement geofencing systems for 6 GHz band very low power devices.

[431] *See supra* para. 40.

[432] *6 GHz Order,* 35 FCC Rcd at 3879, para. 72.

[433] 47 CFR § 15.407(l)(1).

[434] *Id.*

use site-specific information, including buildings and terrain data, for determining the line-of-sight/non-line-of-sight path component in the WINNER II model.[435] For evaluating paths where such data are not available, we propose that the calculation use a probabilistic model combining the line-of-sight path and non-line-of-sight path into a single path-loss as set forth in the requirements for AFC systems.[436] We believe that these propagation models are appropriate for determining exclusion zones for geofenced VLP access points for the same reasons that they are appropriate for determining channel availability for standard power devices described in the *6 GHz Order*.[437] We propose that these propagation models be implemented to determine the exclusion zones consistent with the way that they are being used to determine standard power device exclusion zones and consistent with the consensus methodology WinnForum published for AFC systems, which permits certain allowances for feeder loss and antenna mismatch.[438] Each of these models could be used at the antenna height above ground (1.5 meters) that we assumed for VLP operation in the Second Report and Order.[439]

124. We seek comment on these proposals. Are the proposed propagation models appropriate for calculating geofenced VLP device exclusion zones? Could we allow the use of different propagation models for calculating geofenced VLP device exclusion zones or simplify the methodology in some way? For example, could we require use of a single propagation model, such as ITM, for all distances? If so, what is the appropriate propagation model? If we specify a different propagation model for determining exclusion zones, should we make its use mandatory or should it be an optional alternative to the proposed propagation models? Parties should address how a different propagation model would ensure that incumbent services in the 6 GHz band are adequately protected. We also seek comment on the benefits and costs of requiring or allowing the use of different propagation models. Could this approach reduce the size of the exclusion zones where geofenced VLP devices are prohibited from operating on certain frequencies?

125. We also seek comment on whether there are land-use databases that could account, for example, for actual buildings and other structures, especially in cities and suburbs, that could allow a more accurate determination of where VLP devices can operate without causing harmful interference? If so, what databases are available for this purpose? If this information is not available, would it be possible for parties to develop it, either nationwide or for specific areas? Could we allow modifications to any parameters used in the specified propagation models, and if so, which ones? If we allow modifications to

[435] 47 CFR § 15.407(l)(1)(ii).

[436] *Id.*

[437] *6 GHz Order,* 35 FCC Rcd at 3875-77, para. 64-66. The free space path loss model is appropriate at short distances where the potential for a direct line-of-sight between an unlicensed device and a microwave receiver is greatest, and at greater distances (up to 1 kilometer) where the free space model may be overly conservative the WINNER II model is more appropriate because it accounts for obstructions by urban and suburban clutter which the free space model does not. *Id.* at 3875-76, paras. 64-65. The ITM model, which is defined at distances greater than 1 kilometer, is a widely accepted model that has been successfully used by the Commission to model interference in other instances. *Id.* at 3876-77, para. 66.

[438] 47 CFR § 15.407(l)(1); Functional Requirements for the U.S. 6 GHz Band under the Control of an AFC System, Document WINNF-TS-1014, available at https://winnf.memberclicks.net/assets/work_products/Specifications/WINNF-TS-1014.pdf.

[439] NTIA Report 82-100, A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode, at 7 (1982), https://www.ntia.gov/sites/default/files/publications/ntia_82-100_20121129145031_555510_0.pdf (showing that the ITM model can be used with an antenna height above ground as low as 0.5 meters); Information Society Technologies (IST), WINNER II Channel Models D1.1.2 V1.2, at 16-17 (2008), https://www.researchgate.net/publication/234055761_WINNER_II_channel_models (showing that the WINNER II model can be used with antenna heights of 1-2 meters above ground). The free space path loss model does not directly consider the antenna height above ground but rather determines path loss based on the line-of-sight distance from the transmit antenna to a specific point and can be used when the antenna height above ground is 1.5 meters.

the method of determining spectrum availability for VLP devices, what criteria would the Commission have to specify in the rules? Would we need to develop a process for modifying the locations where VLP devices can and cannot operate? Should a geofencing system operator be required to obtain prior permission from the Commission to use a modified methodology, or could the Commission adopt rules that do not require operators to obtain prior permission?

126. *Electronic news gathering central receive site protection*. We propose to require that geofencing systems protect BAS and CARS operations in the U-NII-6 and U-NII-8 bands, including low power auxiliary devices. Both U-NII-6 and U-NII-8 bands are used by mobile broadcast auxiliary services, including outdoor electronic news gathering (ENG) trucks and low power short range devices, such as portable cameras and microphones. Low Power Auxiliary Stations, which are licensed in portions of the U-NII-8 band, operate on an itinerant basis and transmit over distances of approximately 100 meters for uses such as wireless microphones, cue and control communications, and TV camera synchronization signals.[440] ENG trucks transmit video programming, generally using telescoping directional antennas that are oriented toward a central receive site from remote sites, such as the location of news or sporting events, to a central receive site.[441] According to the ITU, ENG collection sites are generally operated by TV networks in major city areas where the typical central collection site is located within the city center, on the roof of a high building (e.g., 150 m above the surrounding terrain) and that many TV networks also have alternative dedicated ENG collection sites mounted on their broadcast transmission towers.[442] The ITU also states that these receive sites include both steerable antennas and fixed arrays that may have up to 360° of azimuthal coverage.[443] The central receive sites, align with the locations of the ENG trucks. Hence, the communication link between the ENG truck and central receive site shares many of the characteristics of a fixed microwave link—i.e., they use directional antennas to send signals between two fixed locations that are located mostly above the local clutter—and can be protected by the geofencing system by creating exclusion zones to protect the receiver at the central receive site. However, due to the steerable nature of the central receive antennas, exclusion zones surrounding central receive sites would have to be circular to ensure protection in all directions, or could be only part of a circle, i.e., less than 360 degrees, if they only receive from specific directions and the directional pattern and range of orientations of the receive antenna are known.[444]

127. Because links from ENG trucks to BAS and CARS receive sites are essentially temporary fixed point-to-point links, we tentatively conclude that they be protected using the same -6 dB I/N evaluation metric and propagation models along with an additional 4 dB body loss consistent with our proposal for calculating geofenced VLP device exclusion zones for fixed microwave links. Since BAS and CARS operations are typically licensed for the entire band(s) in which they operate (i.e., U-NII-6, U-NII-8, or both), we propose that, unless more information about actual operations are known, geofenced VLP devices must avoid operation across the entire band that a BAS/CARS site receives within the area where the evaluation metric is calculated to be greater than -6 dB I/N. We also propose that the exclusion zones be circular when the directivity of the BAS/CARS receive antenna is not known.

[440] 47 CFR pt. 74, subpt. H.

[441] These are referred to as "TV pickup stations" in the part 74 rules. 47 CFR § 74.601(a).

[442] *See* Recommendation ITU-R F.1777-3 (02/2022), "System characteristic of television outside broadcast, electronic news gathering and electronic field production in the fixed service for use in sharing studies" at 3-4. ITU Recommendation ITU-R F.1777-3 is available at https://www.itu.int/dms_pubrec/itu-r/rec/f/R-REC-F.1777-3-202202-I!!PDF-E.pdf.

[443] *Id.*

[444] The Commission's ULS database currently only has the capability to store receive antenna information as an attachment to an application and not in a machine readable format.

128. A full record of BAS and CARS central receive sites would be needed in the Commission's licensing databases to calculate the geofencing exclusion zones.[445] The Wireless Telecommunications Bureau, the Media Bureau, and the Office of Engineering and Technology could collect information from BAS and CARS licensees regarding locations and associated information for existing central receive sites to ensure that our databases are complete and up-to-date.[446] We would not permit geofenced VLP unlicensed devices to operate in the U-NII-6 and U-NII-8 bands until after the Commission's databases are updated.[447]

129. We seek comment on these proposals. Although we tentatively conclude to protect BAS/CARS using the -6 dB I/N ratio and 4 dB body loss assumption, we seek comment on whether a different metric or assumption is more appropriate? Are the propagation models we propose above to protect fixed microwave links also appropriate for BAS/CARS? Commenters should provide detailed technical justification and analysis for any position that deviates from our tentative conclusion. We seek comment on whether there are ways that we could reduce the size of the exclusion zones to protect BAS and CARS receive sites, limit the number of frequencies excluded within those zones, or limit receive site protection to only the specific times when they are in use. For example, should we require BAS and CARS users to notify a geofencing system of their ENG operations, and for the geofencing systems to incorporate a push notification feature or similar functionality to provide information (e.g., actual operating locations and frequency usage, on a near real-time basis) to VLP devices so that the exclusion zones in the U-NII-6 and U-NII-8 bands can be tailored to actual usage rather than all possible usage areas?[448] What specific requirements would the Commission need to specify for a push notification system? Would it be better for the Commission to simply require the geofencing system to provide updated exclusion zone information to devices within a defined time interval from the time it receives

[445] BAS licensee information is contained in ULS, and CARS licensing information is contained in the Commission's Cable Operations and Licensing System (COALS).

[446] This information may include location, antenna gain, antenna height, antenna make/model, antenna tilt, antenna azimuth and beamwidth (if applicable), and equipment make/model.

[447] We seek comment below on whether non-geofenced VLP operations can be permitted at lower power levels (i.e., up to -5 dBm/MHz EIRP PSD) in the U-NII-6 and U-NII-8 bands.

[448] The Commission previously adopted rules to enable spectrum sharing where spectrum users with higher priority may begin operation on short notice, thus requiring users with lower priority to change frequency or cease operation. In the Citizens Broadband Radio Service, devices must operate under control of a SAS which is capable of rapidly managing spectrum use by three tiers of authorized users with different levels of priority. Devices are required to cease transmission, move to a different frequency or change power level within 60 seconds of notification by the SAS. 47 CFR § 96.39(c)(2). Unlicensed white space devices must operate only on frequencies that a database indicates are available at a device's location to protect operations in the TV bands, including licensed wireless microphones which may register for protection at any time. To ensure that newly registered licensed wireless microphones receive prompt protection, the Commission previously required the white space database to "push" changes in channel availability information to white space devices when a licensed wireless microphone registers to use a TV channel that is already in use by a white space device. The white space device must then change to a different channel or cease operation if no other channel is available. The Commission decided that requiring white space devices to re-check the database on a more frequent basis is simpler for manufacturers and database administrators to implement, so it replaced the push notification requirement with a requirement for more frequent database checks. However, because a push notification system could potentially be more efficient when the number of unlicensed devices that must contact a database is large, the Commission retained an option for manufacturers and database administrators to develop a push notification system in the future. *Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37; Amendment of Part 74 of the Commission's Rules for Low Power Auxiliary Stations in the Repurposed 600 MHz Band and the 600 MHz Duplex Gap, Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, *Unlicensed White Space Device Operations in the Television Bands, Unlicensed Operation in the TV Broadcast Bands*, ET Docket Nos. 14-165 and 20-36, GN Docket No. 12-268, 37 FCC Rcd 1384, 1393-97 (2022).

updated usage information, similar to the approach in the Citizens Broadband Radio Service, which requires devices to respond to instructions within a specific time limit,[449] and allow device manufacturers to determine the most appropriate way to comply with this requirement?

130. We seek comment on the benefits of obtaining more detailed information from BAS/CARS licensees and limiting protection to only the associated exclusion zones and times that these services actually operate. We also seek comment on how much spectrum ENG operations typically use. The *Policy Statement* emphasized data-driven regulatory approaches to promote co-existence.[450] In this regard, the Commission specifically noted that "[r]elevant information about services' transmitter and receiver standards, guidelines, and operating characteristics is needed to promote effective spectrum management and efficient coexistence."[451] We therefore propose that BAS/CARS licensees be required to register their receive site information in Commission databases so that geofencing systems can use site-specific data to create appropriate exclusion zones for these sites. We seek comment on what information should be collected. Should it be limited to information currently collected by Commission databases, such as location, antenna height, antenna model, and azimuth, or are there other information fields that the Commission should collect?. Is the current information in ULS and COALS appropriate for estimating the number of affected incumbents and their equipment? Could we use past activity on ULS and COALs systems to extrapolate the future number of necessary updates? We seek comment on this proposal and whether the Commission should conduct an information collection for these sites. Assuming that the Commission does initiate an information collection, what is an appropriate time frame over which to require licensees to provide their information?

131. We also seek comment on whether multiple ENG operations at a location use the same or different receive sites. What is the number of ENG operations that typically occur at a news event, sporting event, or other event where such operations may be used? And what is the maximum that might be used at larger national events such as political conventions or large scale sporting events? How much time do ENG operations typically need to transmit for these events? Is continuous operation required before, during, and after an event or only within discrete timeframes? Are there ways to predict when operation may be heaviest? Looking across these dimensions of time, location, and spectrum occupancy, how much additional spectrum, operating area, and time could this approach make available for VLP devices, as compared to assuming that ENG might always be operating within a circular or part of a circular area around an ENG receive site? How would this differ from a system where ENG operations simply preregistered their entire service areas and operating channels, but with no time limit to account for use at unscheduled breaking news events? If the specific location, antenna pattern, and look angle of an ENG receive antenna are known, is it necessary for the exclusion zone to be circular, or could we consider non-circular exclusion zones, such as keyhole shaped zones or arcs, to protect ENG receive sites? If we were to implement a registration requirement, should the ENG use be updated during in-use times or for non-real-time registration, or should the ENG use be updated on a regular basis? What is a reasonable time period for such updates? Can ENG operations be automated to inform a geofencing system when it is operating and on which channels and to which receive site it is broadcasting, or would registration have to be a manual process? What up-front and ongoing costs would be involved with setting up and using such a system and who would incur them?

132. Although we propose to allow either a distributed or centralized architecture model for VLP device geofencing systems, if we were to adopt a push notification or similar approach to protect BAS/CARS based on actual usage, it appears that there would be a need for one or more centralized systems to register BAS/CARS usage and provide the information to geofencing systems.[452] We seek

[449] 47 CFR § 96.39(c)(2).

[450] *Policy Statement* at 3, 11-13, paras. 5, 36-47.

[451] *Id*. at 3, 11 paras. 5, 37 (emphasis omitted).

[452] The Commission's ULS would not be suitable for this purpose since it is updated only once daily.

comment on whether this would be necessary. If so, who would develop and operate these systems? How should any information be shared amongst geofencing systems? For example, in the white space rules, white space device operators are required to share registration information with all other database administrators.[453] Would such a requirement be necessary here? If so, how would data sharing work to ensure that all geofencing systems, both centralized and decentralized, have up-to-date information to protect ENG operations at scheduled and unscheduled events? What information should licensees be required to file and what procedure would they use to get their information to the system? Should licensees be required to file or update information within a specific timeframe? What would be the burden on licensees for filing this information? Could the filing process be automated? We seek comment on any other options for transmitting channel utilization information to geofencing operators. Are there any other factors that should be considered in this process? Finally, we seek comment on whether there should be any channels (e.g, one or two channels) set aside as a safe harbor for ENG operations in these bands where ENG could operate without risk of harmful interference from VLP devices at times when the operator could not register its parameters? If so, how much spectrum would need to be set aside for such operation? Would spectrum be needed in both U-NII-6 and U-NII-8? Are there particular places in the band that would be most useful; e.g., the top of the band, bottom of the band, middle of the band, or on the same spectrum permitted for satellite downlink operations?[454] Would such safe harbor be needed nationwide or only in certain areas (e.g., around large cities)? Commenters advocating such an approach should provide detailed information regarding ENG requirements and fully support their position with technical information.

133. We seek comment, especially quantitative, on the benefits and costs of requiring a push notification system. Should any particular protocol or security measures be required? To what extent would a push notification system permit service continuity for geofenced VLP devices, as compared to how often such users would need to modify their channel usage to avoid exclusion zones when those areas are tailored to the specific situation rather than assuming that ENG might always be operating within a circular or part of a circular area around an ENG receive site? How would data rates be affected? What would be the potential costs associated with establishing, maintaining, and operating the push notification system? In particular, we seek comment on the costs for BAS and CARS licensees to report their location information to enable push notifications.

134. *Low-power short range mobile device protection.* We propose that low power short range BAS and CARS devices, such as portable cameras and microphones, and Low Power Auxiliary stations be protected from harmful interference by a combination of a required contention-based protocol and low probability of a VLP device operating on the same channel in a nearby location. This proposal is consistent with the *6 GHz Order* in which the Commission required that all 6 GHz unlicensed LPI access points, subordinate devices, and client devices employ a contention-based protocol.[455] Further, the *6 GHz Order* showed that the probability of channel overlap between 6 GHz unlicensed devices and incumbent station operations is low due to unlicensed devices having a full 1200 megahertz over which to operate.[456]

[453] *See* 47 CFR § 15.715(l).

[454] Limited satellite downlinks are permitted in the U-NII-7 and U-NII-8 bands. *See supra* para. 8.

[455] 47 CFR §§ 15.403, 15.407(d)(6). A contention-based protocol allows multiple users to share spectrum by providing a reasonable opportunity for the different users to transmit. *6 GHz Order*, 35 FCC Rcd at 3889, para. 101. In IEEE 802.11 standards, a "listen-before-talk" medium access scheme based on the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) protocol functions as a contention-based algorithm to provide spectrum access to all traffic. *Id.* Under this scheme, before initiating any packet delivery, a station listens to the wireless medium and if the medium is idle, the station may transmit; otherwise, the station must wait until the current transmission is complete before transmitting. *Id.*

[456] *See 6 GHz Order*, 35 FCC Rcd at 3901-02, para. 131, tbl. 6.

135. We believe that a similar approach for geofenced VLP devices will adequately reduce the risk that mobile service incumbents in the U-NII-6 and U-NII-8 bands will be subjected to harmful interference and keep that risk to an insignificant level. Our reasoning is consistent with the *6 GHz Order*, i.e., the sensing function associated with the contention-based protocol, along with the low probability for co-channel operation, is sufficient to ensure that geofenced VLP devices detect nearby mobile BAS operations and avoid transmitting co-channel to protect those operations from harmful interference.[457] While we are not proposing a specific technology protocol or contention method, we propose to require geofenced VLP devices to use a contention-based protocol as we require for LPI devices.[458] We believe that this proposal has additional benefits as it provides multiple geofenced VLP devices as well as LPI devices equal access to the spectrum, while protecting mobile incumbents' services. We also believe that the use of a contention-based protocol will limit the duty cycle of geofenced VLP devices as they will need to share the spectrum with other devices. Additionally, geofenced VLP devices would transmit at lower power levels than LPI devices, further reducing the risk of harmful interference to mobile services. Given all these reasons, we believe that requiring use of a contention-based protocol by geofenced VLP devices would protect mobile service incumbents.

136. We seek comment on this proposal. Would requiring geofenced VLP devices to incorporate a contention-based protocol adequately protect mobile service incumbents? If not, what other protection measures could be used by geofenced VLP devices to protect mobile services? For example, could a registration system with a push notification provide near real-time information to geofenced VLP devices to avoid transmitting near mobile BAS operations? Is there a need to provide greater specificity in the requirements for a contention-based protocol used by geofenced VLP devices? If so, what particular requirements should be specified and why? What are the costs and benefits of requiring the use of a contention-based protocol?

137. *Radio astronomy and fixed satellite protection*. We propose to require that geofencing systems implement the same exclusion zone rules for protecting radio astronomy sites in the 6650-6675.2 MHz band as standard power access points and fixed client devices, which are based on the distance to the radio horizon.[459] The locations of the protected radio astronomy sites and the protection criteria for these sites are specified in the rules for standard power access points and fixed client devices.[460] Additionally, the entire 6 GHz band is home to an FSS allocation (Earth-to-space), while the U-NII-8 band has a few space-to-Earth MSS feeder downlink earth stations operated by Globalstar.[461] The only requirement the Commission adopted to protect the Fixed Satellite Service in the *6 GHz Order* was restricting standard power access point EIRP to 21 dBm above a 30 degree elevation angle.[462] Because we propose to limit geofenced VLP devices to 14 dBm EIRP and seek comment on a maximum EIRP of

[457] *See 6 GHz Order*, 35 FCC Rcd at 3915, para. 168.

[458] *See* KDB Publication No. 987594.

[459] 47 CFR § 15.407(m).

[460] *Id.*

[461] 47 CFR § 2.106(b)(458)(ii), (d)(172) (non-federal government footnote NG172 and international footnote 5.458B). The space-to-Earth allocation is limited to use by non-geostationary mobile-satellite service feeder links and earth stations receiving in this band are limited to locations within 300 m of coordinates in Brewster, WA, Clifton, TX, and Finca Pascual, PR. *Id.* Globalstar also operates earth station receive sites at Naalehu, HI; Wasilla, AK; and Sebring, FL. These last two locations are authorized to operate on a co-primary basis for feeder downlinks for FSS, except for 7.025-7.055 GHz band, where they are authorized only on an unprotected basis. *See* GUSA Licensee LLC (Globalstar) license file numbers SES-MOD-20210303-00414 and SES-MOD-20210303-00415 for Wasilla, AK and license file numbers SES-MOD-20200728-00811, SES-RWL-20211102-01769, SES-RWL-20211102-01770, and SES-RWL-20211102-01775 for Sebring, FL. Each of these licenses is subject to the condition that operation in the 7.025-7.055 GHz band is on an unprotected basis.

[462] 47 CFR § 15.407(n).

no greater than 21 dBm, we propose no additional restrictions to protect FSS Earth-to-space operations. We seek comment on these proposals.

138. Globalstar operates receiving earth stations for non-geostationary Mobile-Satellite Service feeder links at five locations.[463] We propose to require that geofenced VLP access points protect Globalstar's earth stations using the same exclusion zone calculation methodology used to protect radio astronomy sites. We propose to require the geofencing system to implement these exclusion zones over 6875-7055 MHz at each of Globalstar's five feeder link earth station locations. As these exclusion zones are designed to protect extremely sensitive radio astronomy facilities, we believe that they will provide more than adequate protection for Globalstar's earth stations.

139. We seek comment on this proposal. If different criteria are appropriate, what are the key parameters that must be considered to protect these earth stations? Are parameters such as minimum elevation angle from the earth station to the satellite, gain of earth station antenna, and earth station receiver characteristics readily available? Are Commission databases, such as the International Communications Filing System (ICFS),[464] able to collect the necessary parameters for calculating exclusion zones? If not, and given the limited number of these Earth stations in the U-NII-8 band, could exclusion zones around these Earth stations be determined based on generalized parameters? What should those parameter values be? Would earth station receivers require a different level of protection than the -6 dB I/N ratio used to protect other incumbents in the band? If so, what is the protection criterion? What would be the cost of implementing and maintaining necessary protections for space-to-Earth stations from geofenced VLP devices? We also seek information on the economic harm from interference that these protections would prevent. Commenters should provide technical analysis to support their positions.

140. *Adjacent channel protection*. We propose that exclusion zones for geofenced VLP access points account for only co-channel operations and not consider adjacent channel operations. We believe that this proposal is appropriate due to the significantly lower power we propose for geofenced VLP devices as compared to standard power and fixed client devices. The out-of-band emission rules for 6 GHz unlicensed devices require such emissions to be suppressed by 20 dB at 1 MHz outside of channel edge, by 28 dB at one channel bandwidth from the channel center, and by 40 dB at one- and one-half times the channel bandwidth away from channel. center.[465] When compared to standard power devices that may operate at EIRP levels up to 23 dBm/MHz and must meet the same OOBE mask, VLP adjacent channel emissions begin at least 22 dBm below those standard power device OOBE levels. Thus, VLP OOBE levels must begin at -19 dBm/MHz and reduce from that level with spectral distance.[466] Moreover, we note that adding 20 dB or more additional emission reduction represents at least a tenfold reduction (assuming free space propagation) in distance along any radial for determining adjacent channel protection as compared to standard power device adjacent channel geofenced distances. In the *6 GHz Order*, the Commission concluded that the risk of adjacent channel interference to microwave receivers was low and stated that it expects these adjacent channel zones will be small and not significantly impact the amount of spectrum available to unlicensed devices at any given location, but included adjacent

[463] Globalstar indicates in its comments that it has earth stations located at Clifton, TX, Cabo Rojo, PR, Wasilla, AK, and Sebring, FL. Globalstar Comments, ET Docket No. 18-295 at 5 (filed Feb. 15, 2019). Globalstar subsequently received authorization for an additional earth station at Naalehu, HI. *See* GUSA Licensee LLC (Globalstar) license file numbers SES-LIC-20201211-01364, SES-LIC-20201211-01365, SES-LIC-20201211-01366 (granted July 2, 2021).

[464] The ICFS was formerly known as the International Bureau Filing System (IBFS). Only its name has changed; the ICFS functionality remains identical to what was available in IBFS.

[465] 47 CFR § 15.407(b)(7).

[466] We are permitting VLP devices to transmit at 1 dBm/MHz maximum, so a 20 dB reduction evaluates to -19 dBm/MHz.

channel protection in the adopted rules for standard power devices as part of a conservative approach to protecting the incumbent receivers.[467] Given the additional 22 dB in adjacent channel protection provided by geofenced VLP devices as compared to standard power devices, and the further reduction in protection areas size, we conclude that the risk of adjacent channel interference is so low as to not require geofencing systems to account for them. We seek comment on this proposal.

141. *Geofencing update interval*. We propose to require a geofencing system to obtain the most recent public access file data from Commission databases (e.g., ULS and COALS) for registered fixed microwave links and BAS/CARS central receive sites at least once per day and to recalculate the exclusion zones, as necessary, to account for any new or updated information.[468] We believe that once per day would be an appropriate re-check interval because the ULS and COALS, which contain the data that will be used to determine the exclusion zones to protect fixed microwave services and BAS/CARS central receive sites, are generally updated on a daily basis, and a daily re-check requirement would also ensure that newly registered microwave receive sites and BAS/CARS central receive sites are promptly protected.[469] We seek comment on this proposal. Is a daily update necessary, or recognizing that not many new stations get licensed on a daily basis and that there is often a lag between licensing and operation, could a longer interval be specified? If so, what update interval should be required? Conversely, as discussed above, could we or should we establish a process to update BAS/CARS information in a much shorter timeframe to enable more efficient use of spectrum in areas near BAS and CARS receive sites? How would the benefits and costs change with differing interval lengths?

4. Other Geofencing Requirements

142. We propose additional requirements for geofencing systems and operators that are similar to certain requirements for 6 GHz AFC systems.[470] Specifically, we propose that each geofencing system and operator thereof for centralized systems and the equipment certification responsible party for systems internal to the very low power device must: (1) ensure that a regularly updated geofencing system database that contains the information required for geofencing systems by paragraphs (o) through (r) of proposed section 15.407, including incumbent's information and very low power access points authorization parameters, is maintained;[471] (2) respond in a timely manner to verify, correct, or remove, as appropriate, data in the event that the Commission or a party presents a claim of inaccuracies in the geofencing system;[472] (3) establish and follow protocols to comply with enforcement instructions from the Commission, including discontinuance of very low power access point operations on specified frequencies in designated geographic areas and predetermined exclusion zones;[473] and (4) comply with instructions from the Commission to adjust exclusion zones to more accurately reflect the potential for harmful interference.[474]

143. We further propose that for centralized geofencing systems, geofencing system operators must provide continuous service to all VLP devices for which it has been designated to provide service, and that if a geofencing system ceases operation, the operator must provide at least 30-days' notice to the Commission and a description of any arrangements made for those devices to continue to receive

[467] *6 GHz Order*, 35 FCC Rcd at 3881, para. 77.

[468] COALS does not currently support automated data access in the same manner as the ULS. OET and Media Bureau would ensure that the information in COALS is readily accessible to geofencing system operators.

[469] *6 GHz Order,* 35 FCC Rcd at 3869-70, para. 46.

[470] *See* 47 CFR § 15.407(k).

[471] *See* 47 CFR § 15.407(k)(15)(i).

[472] *See* 47 CFR § 15.407(k)(15)(v).

[473] *See* 47 CFR § 15.407(k)(15)(vi).

[474] *See* 47 CFR § 15.407(k)(15)(vi).

exclusion zone update information.[475] In addition, we propose that a geofencing system operator may charge fees for providing service and that the Commission may, upon request, review the fees and can require changes to those fees if the Commission finds them to be unreasonable.[476] We also propose that at the time that a VLP device receives equipment certification, the device must either have its geofencing system approved or specify an already approved geofencing system that it is using.[477] We further propose that the Commission may specify criteria for such approval, which could require test results to be submitted.

144. We seek comment on these proposals. Are all the proposed requirements appropriate and necessary? Should we modify any of these proposed requirements or establish additional requirements for geofencing systems and operators? If so, what requirements are necessary? We seek quantitative analysis of the likely fee structure that would result under our proposal allowing fees. What would be the initial cost of developing a geofencing system and the ongoing cost of providing daily information to it? We also seek comment on how any fees would relate to usage or other costs of operating the geofencing system.

C. Client-to-Client Device Communications

145. In the *6 GHz Order*, the Commission prohibited unlicensed client devices from operating as "mobile hotspots" because "[p]ermitting a client device operating under the control of an access point to authorize the operation of additional client devices could potentially increase the distance between these additional client devices and the access point and increase the potential for harmful interference to fixed service receivers or electronic news gathering operations."[478] To avoid this situation, the Commission's rules prohibit 6 GHz unlicensed client devices from directly communicating with one another.[479] We propose two limited exceptions to this rule for VLP devices that operate above the -5 dBm/MHz EIRP PSD level.[480] First, we propose to permit higher powered VLP devices that are all operating under the control of the same LPI access point to directly communicate with each other. We further propose that these communications be limited to the LPI client device power spectral density level (i.e., 6 dB below the LPI access point power level) and the VLP device 14 dBm EIRP limit. Because both VLP devices under this approach would also meet the LPI requirements, we have assurance that their operations are indoors and thus that their emissions are subject to the same building entry loss as LPI devices. With their lower power limit, these client devices will have even lower potential to cause harmful interference to incumbent operations than the insignificant level the Commission already determined exists for LPI devices. This proposed exception could provide increased flexibility to a limited class of devices, such as laptop computers, that generally do not incorporate GPS or other geolocation technologies while protecting incumbent operations beyond levels that similar devices (i.e., LPI devices) already provide.

146. Second, we propose to permit direct client-to-client communications between VLP client devices when they are both under the control of the same VLP access point and the geofencing system determines that they are operating outside of any geofencing restrictions; i.e., there are channels available

[475] *See* 47 CFR § 15.407(k)(10).

[476] *See* 47 CFR § 15.407(k)(16).

[477] *See* KDB Publication No. 987594. An applicant for certification of a standard power or fixed client device must indicate that its device will operate with an approved AFC system.

[478] *6 GHz Order*, 35 FCC Rcd at 3927, para. 202.

[479] 47 CFR § 15.407(d)(5) (stating that "[c]lient devices are prohibited from connecting directly to another client device").

[480] Under the rules adopted in the Second Report and Order, non-geofenced VLP devices are already permitted to communicate directly with each other. In addition, we seek comment below on whether we could permit client-to-client device communications more broadly, including for LPI devices. *See* para. 180, *infra*.

for VLP use that are not subject to geofencing requirements in the location where these devices are being used. The rules we propose for geofenced VLP devices would permit up to 1 dBm/MHz EIRP PSD and up to 14 dBm EIRP when operating on channels that are not within an exclusion zone.[481] Thus, because each client device in this scenario would be permitted to operate at the maximum power permitted for VLP devices, there would be no increase in the potential for causing harmful interference to incumbent operations if the client devices being used are also able to communicate directly with each other. However, all VLP access points would still be subject to the applicable geofencing requirements including location and geofencing recheck intervals and switching channels or ceasing communications should they enter an exclusion zone and are currently using a channel that is prohibited within that area. In that case, client devices operating under the control of a VLP access point that switches channels would also be required to switch channels as directed by the VLP access point. This proposed limited exception, as with the first, could provide additional flexibility to implement novel VLP use cases without increasing the risk of harmful interference to incumbent operations.

147. We seek comment on these proposals. Are these proposed limited exceptions to the prohibition on client-to-client device communications appropriate? Would any other exceptions with respect to VLP devices be appropriate? Do we need to need to specify any additional requirements or limitations on client-to-client device communications? How much and what kinds of additional usage would these proposals create in client-to-client operations? Would these proposals impose any additional costs to users of the associated spectrum?

D. Very Low Power Device Requirements

148. In the *6 GHz Order*, the Commission established that an AFC system require a device's geographic coordinates—along with the accuracy of those coordinates—and the device's antenna height above ground to determine which channels are available for use at the device's location.[482] Standard power access points (APs) are required to contact an AFC system at least once per day, consistent with the frequency of the update to the ULS public access file, to obtain the latest lists of available channels at their locations.[483] The daily update ensures that stationary unlicensed devices do not operate on a channel in proximity of a newly licensed fixed service receiver. Although VLP devices may be mobile or stationary, mobile VLP devices may move to different locations, potentially resulting in a changing available channel list. In lieu of an AFC system, we propose to require that geofenced VLP devices access a simpler geofencing system to prevent them from operating where there may be an elevated risk of causing harmful interference to licensed incumbent services in the 6 GHz band.[484] Under this proposed geofencing system, geofenced VLP devices would have to incorporate provisions to ensure that they avoid transmitting on certain channels within certain geographic areas.

149. A mobile geofenced VLP device operating at a power level greater than -5 dBm/MHz EIRP PSD would have to consider exclusion zone(s) not only at its present location, but also at all areas that may be traversed by a mobile VLP device between the present time and a future location update. Naturally, the area traversed by the mobile VLP device is a function of the VLP device's speed and direction. For example, a mobile VLP device located in a vehicle traveling 35 miles per hour could cover

[481] *See supra* para. IV.A.1.

[482] *6 GHz Order*, 35 FCC Rcd at 3867, para. 38. In the event the ULS is down or a public access file is not created on a given day, the geofencing system may continue to use the most recently downloaded data until updated data becomes available.

[483] *Id.* at 3870, para. 46.

[484] *See supra* para. 110.

approximately one kilometer within one minute.[485] However, there are other mobile use cases in which a pedestrian using a VLP device will cover well under a hundred meters in the same one-minute time period. Accordingly, rather than proposing a set time period within which a mobile VLP device must update its location to check if it is in an area with different geofencing requirements than the previous area in which it checked, we propose a flexible approach with varying recheck times based on speed to better meet device usage requirements. Thus, the recheck interval can be tailored to require fewer rechecks when moving at slow speeds and thus ease processing requirements and save battery power.

150. *Incorporated geo-location.* Consistent with the requirements for standard power access points, we propose to require that geofenced VLP access points generally include a geo-location capability to determine their geographic coordinates.[486] We propose to require a geofenced VLP device's geo-location capability to determine its location uncertainty in meters, with a 95% confidence level, and that the applicant for certification of a VLP access point demonstrate the accuracy of the geo-location method used and the location uncertainty.[487] We further propose to require that a geofenced VLP access point, using its geographic coordinates, take this location uncertainty into account when it determines whether the VLP access point is within an exclusion zone. We seek comment on this proposal. We also seek quantitative information on the benefits and costs of this proposal to VLP device users, manufacturers and the wider public.

151. *Location Update.* We propose to require that geofenced VLP access points have the capability to timely adjust their operating frequencies when moving into, out of, or between exclusion zones. We propose flexible requirements to enable device designers to optimize efficiency while still meeting the requirement to avoid operating on channels where the -6 dB I/N evaluation metric is not met. Specifically, we propose that the time interval for a geofenced device to re-check its location and adjust its frequency usage must decrease proportionally based on an increase in the mobile device's speed. Under this proposal, a geofenced VLP access point that is in a powered state must regularly re-check its location and speed and identify its position with respect to any exclusion zones that may exist within the vicinity of its current location. We further propose that this geolocation update be done frequently enough that, based on the geofenced VLP access point's position and speed, the device will not transmit on a channel that is unavailable within an exclusion zone. We believe that this proposal provides flexibility to device designers to adjust how often the VLP access point must obtain geolocation information based on how fast the VLP access point is moving and how far it is from an exclusion zone where it would have to change its operating channel. As an additional safeguard, we propose to require the VLP access point to determine its location and speed at least once a minute. This one-minute update proposal is designed to provide additional assurance that the VLP access point avoids transmitting on frequencies that are not permitted by the geofencing system. We further propose to require applicants for geofenced VLP access point certification to submit an attestation describing their algorithm for updating the device's location with an explanation describing how these requirements are met.

152. We seek comment on these proposals. Do they provide sufficient flexibility for mobile geofenced VLP devices? Is it necessary for us to specify more detailed requirements on how often a geofenced device must re-check its speed and its position with respect to exclusion zones? If so, what additional requirements should be specified and why? Is a requirement for devices to re-check their location and speed at least once per minute necessary? Is the proposed information that applicants for

[485] Speed limits in urban and residential areas generally range between 30 to 40 miles per hour. Interstate highway speeds are generally permitted at rates up to 70 miles per hour. *See* https://en.wikipedia.org/wiki/Speed_limits_in_the_United_States_by_jurisdiction.

[486] 47 CFR § 15.407(k)(9)(i); *6 GHz Order*, 35 FCC Rcd at 3868, para. 40. As noted above, we propose a limited exception from the geo-location requirement when both a VLP access point and client are both also connected to the same LPI access point.

[487] 47 CFR § 15.407(k)(9)(i).

certification of geofenced VLP access points must submit appropriate, or should any additional information be required? If so, what information? We seek quantitative information on the benefits and costs to VLP device users, manufacturers and the wider public of our proposal and any proposed alternatives.

153. *Antenna Height.* We propose to require geofencing systems to use an assumed antenna height above ground level of 1.5 meters for geofenced VLP access points similar to the approach used in the Second Report and Order for interference modeling of VLP devices.[488] We seek comment on this proposal. Is an assumed 1.5 meter antenna height appropriate, or should we specify a different value? If so, what height should we require for the exclusion zone calculations? We also seek quantitative information on the benefits and costs to VLP device users, manufacturers and the wider public of our proposed antennas height. Commenters proposing alternative values should quantify the benefits and costs of alternatives.

154. *Fixed Infrastructure.* Consistent with our actions in the Second Report and Order, we propose to prohibit geofenced VLP devices from operating as part of a fixed outdoor infrastructure as an additional measure to reduce the likelihood of interference to licensed incumbent services. We seek comment on this proposal. Is a prohibition on fixed outdoor infrastructure necessary when a geofencing system is used? We seek quantitative information on the benefits and costs to VLP device users, manufacturers and the wider public of our proposal versus allowing operations as part of fixed outdoor infrastructure.

155. *Updates to exclusion zones.* The *6 GHz Order* established a requirement that standard power access points must recheck the frequency availability with an AFC system once per day.[489] Similarly, we propose to require geofencing systems to update the exclusion zones at least once per day using the data from Commission databases on the licensed microwave links and BAS/CARS central receive sites. We also propose to require geofenced VLP access points to obtain or calculate the updated exclusion zones from the geofencing system at least once per day.[490] This proposal is designed to ensure that newly registered microwave receive sites and BAS/CARS central receive sites are promptly protected.[491] Consistent with the rules for standard power access points and fixed client devices, we also propose that if a VLP device is unable to obtain the latest ULS or COALS data on a given day, it may continue operating until 11:59 p.m. of the following day at which time it must cease operation until it is able to obtain the latest geofencing data.[492] We seek comment on these proposals. We also seek quantitative information on the benefits and costs to VLP device users, manufacturers and the wider public of our proposal and alternative update schedules and requirements.

156. *Security Issues.* Consistent with our requirements for standard power devices and AFC systems in the 6 GHz Order, we propose to require that geofenced VLP access points incorporate adequate security measures to: 1) prevent them from accessing geofencing systems and geofencing methods not approved by the Commission, 2) ensure that unauthorized parties cannot modify devices to operate in a manner inconsistent with the rules and licensed incumbent protection criteria, and 3) ensure that communications between VLP access points and geofencing systems are secure to prevent corruption

[488] The Second Report and Order noted that the computer simulations used to model potential interference independent VLP devices assumed 90% of devices were used at a height above ground of 1.5 meters, but also noted that assuming 10% of devices are used at greater heights is a conservative assumption.

[489] *6 GHz Order,* 35 FCC Rcd at 3869-3870, para. 46.

[490] As stated in paragraph 117, *supra*, the geofencing system may be integrated into the VLP access point. In that case the requirement that the geofencing system update the exclusion zones daily and the VLP device obtain updated exclusion zones daily are synonymous.

[491] *See 6 GHz Order,* 35 FCC Rcd at 3870, para. 46.

[492] *See* 47 CFR § 15.407(k)(8)(iv).

or unauthorized interception of data. We also propose to require that geofencing systems, whether centralized or internal to a VLP device, must ensure that all communications and interactions between the geofencing system and VLP access points and/or all communications between the geofencing system and Commission databases are accurate and secure and that unauthorized parties cannot access or alter the database, the exclusion zones, or the list of excluded or available frequencies. We further propose to require that a geofencing system incorporate security measures to protect against unauthorized data input or alteration of stored data, including establishing communications authentication procedures between client devices and VLP access points.[493] These proposed requirements are intended to prevent a VLP device from using geofencing methods not approved by the Commission and to ensure that unauthorized parties cannot modify a device to operate in a manner inconsistent with the rules. We seek comment on these proposals. What would be the cost of implementing our security proposals versus alternatives? We seek quantitative information on the costs of geofenced VLP device security requirements.

157. *Device testing and approval.* As indicated above, we propose to require that VLP devices operating with greater than -5 dBm/MHz PSD EIRP incorporate a geofencing capability that prevents them from operating where there may be an elevated risk of causing harmful interference to licensed incumbents in the 6 GHz band. Under this proposal, geofenced systems in the 6 GHz band would determine exclusion zones within which specific channels are prohibited from use by geofenced VLP access points when the -6 dB I/N evaluation metric is not met (e.g., areas around fixed microwave and BAS/CARS central receive sites), and each geofenced VLP access point would have to be able to connect to a geofencing system or have an integrated geofencing system capability.

158. Applicants seeking VLP device certifications would have to show in their applications how their device will comply with any geofencing requirements adopted in this proceeding. For example, applicants for geofenced VLP access point certification would have to demonstrate that the device operates only pursuant to a geofencing system and that the geofencing system prevents operation in areas where the -6 dB I/N metric is not met when calculated in accordance with the proposed methodology. They would also have to demonstrate that their devices could not operate on any channel that the geofencing system determines is prohibited at its location at a power level greater than -5 dBm/MHz EIRP PSD. Applicants would also be required to demonstrate that their VLP access points comply with the proposed requirements to periodically check their location and comply with the database recheck intervals proposed above as well as adjust their operating channel if they move into an exclusion zone where that channel is not available. They would further have to demonstrate how geofenced VLP access points obtain exclusion zone data either from a geofencing system or through calculations based on data downloaded from Commission databases.

159. We seek comment on testing and certification issues for geofenced VLP access points and client devices. Are there any specific testing or certification issues that the Commission will need to address, either in a subsequent item in this proceeding or subsequent to adopting rules, e.g., through the KDB process? If so, what issues would need to be addressed? Would industry groups such as the Wi-Fi Alliance or WinnForum be likely to develop procedures for testing geofencing systems? We seek quantitative information on the benefits and costs to VLP device users, manufacturers and the wider public of geofenced VLP testing and certification requirements.

E. Spectrum Availability for Very Low Power Devices

160. We seek comment on any changes that we could make that would allow for increased spectrum availability for geofenced VLP devices without increasing the likelihood of harmful interference to incumbent services, i.e., more efficient spectrum use. Consistent with the Commission's recent *Policy Statement*, we seek additional data that can be used to assess geofenced VLP device operation and the

[493] *6 GHz Order,* 35 FCC Rcd at 3881-82, paras. 79-80; 47 CFR §§ 15.407(k)(8)(v), (k)(13), (k)(15)(iii).

potential impact on incumbent services.[494] Are there any particular characteristics of geofenced VLP devices, e.g., size, operating location, specific applications, operating bandwidth, modulation types, data rates, duty cycle/activity factor, or mobility or lack thereof, that could be considered in enabling increased spectrum availability for these devices? Is there currently any operational or other data that would be helpful in this regard? How much additional spectrum could be made available for geofenced VLP devices? Would there be any significant increase in the areas where they could operate as compared to the rules proposed above? We recognize that actual operational data that may help us reach a decision on these issues may not yet be available. In this regard, we encourage parties with additional data to approach the Commission in the future when such data becomes available. We also seek information from incumbents regarding their systems, particularly with respect to the amount of fade margin incorporated into system design, statistics on when fades occur, their severity, and how long they last, and how systems are designed to cope with fading events using techniques such as adaptive modulation or adjusting their data streams to focus on more time-sensitive critical data over less critical data.

F. Restrictions on very low power device mobile operations

161. We also seek comment on whether to relax the restrictions on VLP device mobile operations (e.g., on aircraft, boats on the ocean, oil platforms, and terrestrial vehicles). In the *6 GHz Order*, the Commission prohibited standard power and LPI access points from operating on board aircraft, with the exception of LPI use in the U-NII-5 band on large passenger aircraft while flying above 10,000 feet.[495] In the Second Report and Order, we are largely adopting the same operational restriction for VLP devices, except we are permitting them to operate on boats.[496] Similar to the rules for standard power and LPI access points, the Commission is prohibiting VLP devices from operating on oil platforms.[497] The restrictions on oil platforms is being put in place to protect incumbent EESS remote sensing operations, which, in this band are used *inter alia* for monitoring ocean temperature.[498]

162. As noted, these decisions were made largely to provide consistency with the Commission's prior decision regarding standard power and LPI devices. However, given the inherent differences between those devices and VLP devices, we seek comment on whether these restrictions on mobile operations on aircraft and oil platforms can be relaxed for non-geofenced VLP devices, geofenced VLP devices, or both. First, emissions from both types of VLP devices will be lower than standard power and LPI devices; geofenced VLP access points and associated client devices are permitted to operate with no more than 1 dBm/MHz EIRP PSD and 14 dBm EIRP while standard power and LPI devices may operate at 23 dBm/MHz EIRP PSD and 36 dBm EIRP and 5 dBm/MHz EIRP PSD and 30 dBm EIRP, respectively. VLP devices operate at an even lower -5 dBm/MHz EIRP PSD. Second, both types of VLP devices are mobile, generally operate close to the ground and in proximity to the body or other objects,

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[494] In its recent *Policy Statement*, the Commission stated that, "[q]uantitative analyses of interactions between services that are fact- and evidence-based, sufficiently robust, transparent, and reproducible are needed to better inform spectrum management decision-making." *Policy Statement* at 3, 12, paras. 5, 41 (emphasis omitted). The Commission added that "[t]ransparent and reproducible quantitative analyses best inform the Commission's decision-making. Transparency—particularly about transmitters, receivers, and degradation metrics—gives stakeholders and the Commission the ability to validate the fidelity of interference models and ensure that they represent realistic operating conditions and scenarios, with balanced protection criteria." *Id.* at 12, para. 42; *see also id.* at 1-2, 2-3, 12-13, paras. 3, 5, 41-44.

[495] *6 GHz Order*, 35 FCC Rcd at 3929, para. 207; *see* 47 CFR § 15.407(d)(1), (4).

[496] *See supra* para. 92.

[497] *6 GHz Order*, 35 FCC Rcd at 3931, para. 212; *see* 47 CFR § 15.407(d)(1), (4).

[498] CORF comments at 3 (filed Feb. 14, 2019) ("Instruments operating in the EESS bands provide data that are important … for scientific research … Examples are measurement of parameters—such as ocean surface temperature …").

are likely to be battery powered, and either operate pursuant to a geo-location system or at or below -5dBm/MHz EIRP PSD.

163. Considering expected use cases and the minimal potential for VLP and geofenced VLP devices to cause harmful interference, we propose to permit mobile operation on commercial and general aviation aircraft more generally, but not on UAS. We can speculate that several prominent use cases will occur on aircraft. We seek comment on permitting more general use of VLP and geofenced VLP devices onboard commercial and general aviation aircraft. For example, because FAA guidance specifies that aircraft operators, when operating aircraft that have been certified to meet portable electronic device tolerance standards, may permit certain portable electronic devices to operate in all phases of flight (i.e., from gate-to-gate), body-worn VLP and geofenced VLP devices could be used to monitor a person's health metrics or to stream a movie (e.g., from a smartphone to smart glasses).[499] In such cases, operation is not likely to be near a fixed microwave, BAS, or CARS receive site and is likely to be low power, given the short transmission distance and the fact that emissions will be shielded by the aircraft fuselage and will be subject to clutter loses from nearby seats and passengers. In addition, we note that the worst case for harmful interference potential is likely to be on take-off or landing when the aircraft is lower to the ground and thus, potentially closer to an incumbent receiver. However, good engineering practice should prevent microwave links in locations where aircraft are likely to fly as their mere presence could cause link degradation. And even if an aircraft were to fly in an area where it may be seen by a microwave receive antenna main beam, the aircraft will be moving at significant speed[500] and the time a VLP or geofenced VLP device's emission could be within an incumbent's receiver main beam will be fleeting and handled by forward error correction or other techniques. In addition, when operated on the ground, geofenced VLP access points and associated clients would operate under the control of a geofencing system, while non-geofenced VLP devices would operate at even lower power. As an initial matter, considering operation on aircraft, should we consider permitting all VLP devices to operate across all phases of flight or just VLP devices that are not geofenced? Or should geofenced VLP devices be limited to only operating when above 10,000 feet or not permitted to operate on aircraft at all? We are already permitting non-geofenced VLP devices to operate on large aircraft above 10,000 feet and ask if there is a different metric that could be used for the specific case of aircraft. For example, noting the very fast take-off and landing speeds, could we implement a rule stating that if a geofenced VLP access point is moving at an average speed over 100 mph, it would no longer need to check the geofencing system? Moving at or above this speed would imply operation on a very fast moving vehicle, such as an aircraft. If we allow a minimum average speed metric for this purpose, should it apply only to devices operated on aircraft, or could it apply to other modes of transportation such as rail? Is there a different speed or metric that would work better in providing a demarcation between when the geofencing system must be used and when it is not necessary when considering use on aircraft? What other considerations need to be taken into account? For example, could there be issues that affect radio astronomy sites? If so, should certain

[499] *See* FAA Advisory Circular 91.21-1D, "Use of Portable Electronic Devices Aboard Aircraft." That Advisory Circular, in Section 7.2.1, states that, "[i]f an aircraft model has demonstrated tolerance for both transmitting and non-transmitting PEDs, the operator may allow PED use during all phases of flight on this aircraft model."

[500] Aircraft take-off and landing speeds vary based on aircraft size, wing shape and size, aircraft weight, as well as other factors, including weather conditions. *See How Fast Do Airplanes Take Off?*, Flying Magazine (July 12, 2022), https://www.flyingmag.com/guides/how-fast-do-airplanes-take-off/; *How Fast Do Commercial Planes Fly*, Flying Magazine (June 24, 2022), https://www.flyingmag.com/guides/how-fast-do-commerical-planes-fly/. Take-off speed for a Cessna 172 is about 55 knots (63 mph), while the take-off speed for a Boeing 747 is around 160 knots (184 mph). *See How Fast Do Airplanes Take Off?*, Flying Magazine (July 12, 2022), https://www.flyingmag.com/guides/how-fast-do-airplanes-take-off/; *How Fast Do Commercial Planes Fly*, Flying Magazine (June 24, 2022), https://www.flyingmag.com/guides/how-fast-do-commerical-planes-fly/. Commercial aircraft typically land between 112 to 156 knots (130-160 mph). *See How Fast Do Airplanes Take Off?*, Flying (July 12, 2022), https://www.flyingmag.com/guides/how-fast-do-airplanes-take-off/; *How Fast Do Commercial Planes Fly*, Flying (June 24, 2022), https://www.flyingmag.com/guides/how-fast-do-commerical-planes-fly/.

channels be prohibited from use until an aircraft exceeds 10,000 feet? We seek comment on our proposal to permit any or all VLP devices to operate gate-to-gate while on aircraft.

164. We continue to believe that any VLP operation when such devices are mounted on a UAS could pose more than an insignificant harmful interference risk, given the potential of UAS to fly almost anywhere and to have clear line of sight to an incumbent's receiver. In addition, because the geofencing system determines exclusion zones based on an assumed 1.5 meter antenna height, any exclusion zone associated with a UAS would be much larger than for general VLP device usage. Nevertheless, we seek comment on whether there are operational limitations or guidelines we could adopt that could permit VLP devices to operate when mounted on a UAS. Are there applications that are specifically well-suited for use on a UAS? Are there methods using the geofencing system or otherwise that could be implemented to ensure that incumbent receivers are protected from harmful interference? If so, how complex and feasible would these methods be to implement? Would the costs associated with additional complexity outweigh any benefits that might be gained from permitting such operation?

165. In the Second Report and Order, we maintained our prohibition on all types of 6 GHz device usage on oil platforms to protect EESS operations but did not prohibit the use of VLP devices on boats. We now seek comment on whether the prohibition on all types of 6 GHz device usage on oil platforms can be scaled back or lifted. For example, given the differences between VLP devices (both geofenced and non-geofenced) and standard power and LPI devices, does the use of VLP devices on oil platforms pose the same risk of harmful interference to EESS operations? Could standard power, LPI or either type of VLP devices be used on oil platforms without causing a risk to EESS ocean temperature monitoring operations? We can foresee applications where a 6 GHz device could provide utility through augmented reality to a worker on an oil platform to provide relevant information, such as for safety, maintenance tasks, or general operating instructions. Is any restriction of VLP device use on boats appropriate to protect EESS operations? If such a restriction were adopted, could it be limited to boats located in the ocean, given that EESS is used for sensing over the ocean? How could the prohibition on use of VLP devices on oil platforms or a prohibition on use on boats, if adopted, be implemented for non-geofenced VLP devices?

166. Finally, we seek comment on whether there is additional flexibility that can be provided for terrestrial in-vehicle use (e.g., cars, buses, and trucks). For example, are there devices that are designed to be used solely in vehicles, such as an in-car hotspot, that can only be used in a vehicle where due to the nature of use - within a vehicle cabin, generally in motion at high speeds – different requirements regarding power or exclusion zones could apply? If so, are there requirements that could provide assurance that a VLP device (geofenced or non-geofenced) is, in fact, in a vehicle, such as having a connection to Carplay or Android Auto?

167. We invite commenters to address these issues and provide detailed information regarding whether we can provide more flexibility to VLP devices, both geofenced and non-geofenced, for expanded use in aircraft, on boats, in vehicles, and in more places while still ensuring that incumbent operators' facilities are protected from harmful interference. We seek quantitative estimates of benefits or costs of our proposals for relaxing the VLP prohibition in these locations and potential alternatives. How much and what kinds of additional VLP operations might occur? How much and what kind of costs would be incurred to accommodate these increased operations?

G. Expanding Very Low Power Operations to U-NII-6 and U-NII-8

168. In the Second Report and Order, we adopted rules to permit VLP devices to operate in the U-NII-5 and U-NII-7 bands at power levels up to -5 dBm/MHz EIRP PSD and 14 dBm EIRP. We determined that the risk of harmful interference to incumbent services in those bands, e.g., fixed microwave links and radio astronomy, was insignificant for VLP devices operating at that power level. In this Second Notice of Proposed Rulemaking, we propose to permit VLP devices to also operate in the U-NII-6 and U-NII-8 bands without geofencing. Given that fixed microwave links in the U-NII-8 band have the same characteristics as those in U-NII-5 and U-NII-7, we conclude that any risk of harmful

interference from VLP devices to these microwave links is insignificant. We seek comment on whether allowing VLP devices on U-NII-6 and U-NII-8 band devices will yield comparable benefits to those that stem from allowing VLP devices in the U-NII-5 and U-NII-7 bands in the Second Report and Order. We tentatively conclude that at a minimum the benefits would be in proportion to the amount of spectrum in U-NII-6 and U-NII-8 bands relative to the amount of spectrum in the U-NII-5 and U-NII-7 bands.[501] We anticipate that these benefit estimates are conservative, as making available the full 1200 MHz in the 6 GHz band could lead to larger channel sizes that could increase speed and decrease latency. We seek comment on this and alternate methods of estimating these benefits.

1. Protection of Mobile Services

169. As discussed above, both the U-NII-6 and U-NII-8 bands are used by mobile BAS and CARS, including outdoor electronic news gathering (ENG) trucks and low power short range devices, such as portable cameras and microphones. Low Power Auxiliary Stations, which are licensed in portions of the U-NII-8 band, operate on an itinerant basis and transmit over distances of approximately 100 meters for uses such as wireless microphones, cue and control communications, and TV camera synchronization signals. There are also BAS and CARS fixed microwave links in these bands, which are used for such purposes as video links between studios and transmitters and to relay video signals between cities.

170. *Outdoor electronic news gathering central receive sites*. As described above, the communications link between ENG trucks and a central receive site shares many of the characteristics of a fixed microwave link—i.e., they use directional antennas to send signals between two fixed locations that are mostly above the local clutter.[502] We propose to permit VLP devices to also operate in the U-NII-6 and U-NII-8 bands and seek comment on whether VLP devices could operate at up to -5 dBm/MHz EIRP PSD and 14 dBm EIRP while keeping the risk of harmful interference to ENG central receive sites to an insignificant level. Would the same type of analysis discussed in the Second Report and Order showing an insignificant risk of harmful interference to fixed microwave receive sites be appropriate with respect to ENG receive sites? Are there inherent differences between BAS/CARS operations as compared to fixed point-to-point operations that must be considered when analyzing the harmful interference risk? For example, are there differences in antenna types, e.g., beamwidth and gain, or in typical antenna heights or the locations of receive antennas? Commenters noting differences should provide detailed descriptions and information regarding how any difference could affect the potential for VLP devices to cause harmful interference? Are there specific VLP device characteristics that need to be considered in analyzing their interference potential to ENG operations and if so, what are they? We seek to provide uniform rules for operations across the full 6 GHz band, but recognizing that there could be differences in how VLP emissions may interact with different incumbent systems, we also seek comment on what effect a lower power limit for VLP devices might have regarding protecting ENG operations in the U-NII-6 and U-NII-8 bands. Commenters advocating for a lower power level should provide detailed analysis regarding their preferred power level and the incremental effect such a power level would have on the ability for VLP devices to access spectrum as well as to what extent ENG operations would have additional protection from harmful interference. Are there any other requirements that we could adopt for VLP devices to protect ENG operations?

171. Apple, Broadcom, and Meta submitted a Monte Carlo simulation addressing the potential for VLP devices operating at -5 dBm/MHz to exceed the -6 dB I/N evaluation metric for two specific ENG receive sites.[503] For the ENG receivers, the simulation used the same two ENG receive sites and technical parameters that were used in a Monte Carlo simulation previously submitted by NAB that

[501] *See* para. 98 *supra*.

[502] *See para. 127 supra..*

[503] Apple, Broadcom, and Meta Sept. 11, 2023 *Ex Parte* 2; Apple, Broadcom, and Meta Sept. 21, 2023 *Ex Parte* at 3-4.

examined the potential for 6 GHz band unlicensed access points to interfere with ENG receivers.[504] As the ENG receive antennas are directional but generally are able to provide 360° azimuthal coverage, it is not practical to simulate every azimuth. Thus, Apple, Broadcom, and Meta limited their simulation to the same three antenna orientations that NAB simulated for the two ENG receive sites.[505] For the VLP devices, the simulation used similar assumptions for body loss, transmit power control, and propagation models as the Apple, Broadcom et al. and Apple simulations that assessed the potential for VLP devices to exceed the -6 dB I/N evaluation metric for microwave links in San Franscisco and Houston.[506] The Apple, Broadcom, and Meta Monte Carlo analysis found no instances where the VLP devices caused the signal received at the ENG receive sites to exceed -6 dB I/N.[507] We note that NAB previously expressed skepticism about the accuracy of a similar Monte Carlo simulation provided by Apple, Broadcom, et al. that likewise found that the -6 dB I/N threshold was never exceeded for one of these ENG receive sites.[508] We seek comment on the Apple, Broadcom, and Meta simulation regarding its inputs, assumptions, and methodology. Based on that evaluation, we seek comment on its conclusions that the -6 dB I/N evaluation metric will not be exceeded or will only be exceeded in so few instances at ENG central receive sites that we can conclude that the risk of harmful interference from VLP devices operating at -5 dB/MHz EIRP PSD is insignificant. Given that this simulation was based on the simulation NAB placed in the record, can we assume that the analysis for the three azimuths at each site are representative of operations over all azimuths? Why or why not? Similarly, because these two ENG receive sites were chosen by NAB, can we assume that they are representative of BAS and CARS receive sites in general? Are there particular scenarios that need further study?

172. *Outdoor electronic news gathering ENG trucks*. ENG trucks are generally situated near news or sporting events and receive signals from hand-held cameras or other portable news gathering devices. Based on a study previously submitted by NAB, the ENG truck receive antenna may be omni-directional or sectoral with adjustable height and location. Additionally, the ENG truck signals may use various bandwidths between 3 to 20 megahertz.[509] For its study, NAB evaluated harmful interference based on free space path loss and on whether an unlicensed device would cause the I/N to exceed -10 dB.[510]

173. Broadcom submitted a simulation showing a low probability (< 0.001%) that a VLP device operating at -5 dBm/MHz will cause the signal-to-interference-plus-noise ratio (SINR) at the ENG truck receiver to fall below 1 dB.[511] Broadcom's 1 dB SINR threshold is based on a previously submitted Broadcom study showing that a 10 megahertz ENG channel with a 7/8 coding rate can maintain a signal with a bit-error-rate (BER) less than 1e-8 in the presence of an RLAN signal operating with a 2% duty cycle.[512] Charter, Comcast, Cox and CableLabs also previously submitted studies of the ENG truck signal

[504] *Id*.; Alion Study, NAB Dec. 5, 2019 *Ex Parte* at 3-8, 11.

[505] Apple, Broadcom, and Meta Sept. 21, 2023 Ex Parte at 4; Alion Study, NAB Dec. 5, 2019 *Ex Parte* at 43, 47-70.

[506] Apple, Broadcom, and Meta Sept. 11, 2023 *Ex Parte* at 3; Apple Feb. 13, 2023 Ex Parte at 10,11; Apple, Broadcom, et al. Feb. 28, 2023 *Ex Parte* at 8; Apple, Broadcom, Google, Meta Aug. 31, 2023 *Ex Parte* at 1.

[507] Apple, Broadcom, and Meta Sept. 11, 2023 *Ex Parte* at 3.

[508] NAB claimed that they expected an interference level tens of decibels above the receiver's noise floor. NAB Reply Comments at 7 (filed July 27, 2020) (discussing Apple, Broadcom et al. Comments Attachs. A (filed June 29, 2020)).

[509] Alion Study, NAB Dec. 5, 2019 *Ex Parte* at 5.

[510] *Id.* Also, note that in the 6 GHz Order, the Commission disagreed with NAB's use of free space path loss and a -10 dB I/N metric as being overly conservative. *6 GHz Order*, 35 FCC Rcd at 3914, para. 154.

[511] Broadcom Study, Sep 11, 2023 *Ex Parte* at 1.

[512] Broadcom Letter, Feb 28, 2020 *Ex Parte* at 2.

SINR requirements in the presence of RLANs operating at various duty cycles.[513] While these studies examined the impact of LPI transmissions, which operate at a higher power than is proposed for VLP, their findings with respect to SINR are also applicable to assessing VLP impact to BAS operations. CableLabs finds that a 10 dB SINR "provides an accurate view of system requirements for high-quality BAS video delivery".[514]

174. We propose to permit non-geofenced VLP devices operate in the U-NII-6 and U-NII-8 bands and seek comment on whether those devices could operate at up to -5 dBm/MHz EIRP PSD and 14 dBm EIRP while minimizing the risk of harmful interference to ENG truck receive sites. Is SINR an appropriate metric for evaluating harmful interference risk to a ENG truck receiver, which is fixed during operation but otherwise transportable, from a mobile or transient VLP transmission? Or should the Commission continue to evaluate all VLP device interactions with incumbent operations based on an I/N metric? Regarding potentially using SINR, because actual signal levels are not known prior to any transmission, what value or range of values should be used for the ENG signal level for any analysis? Commenters should provide insight and data regarding how any assumed signal level is consistent with the signal levels used for ENG operations. Previously submitted studies show that the required SINR will vary according to channel bandwidth and coding rate. What are the typical bandwidths and coding rates used by ENG truck receivers? If the Commission were to rely on evaluating SINR, what SINR threshold should be assumed to be necessary at the ENG truck receive site to maintain a high quality signal? Broadcom's study predicted an impact when the VLP device was within 5 meters of the receiver.[515] Under normal operating conditions, how close could a random user's VLP device actually come to an ENG truck receiver? Is assuming at least a 5 meter separation distance realistic? Or is that distance too short or too long? Will the itinerant nature of VLP devices help reduce the likelihood of a VLP device causing harmful interference? Are there any particular connections we should make between our reliance on an I/N metric when evaluating ENG trucks connecting to a central receive site and potentially evaluating the harmful interference risk from portable devices to an ENG truck based on SINR? In evaluating analysis methodology and protection metrics, commenters should detail how such an approach supports permitting non-geofenced VLP operations at power levels up to -5 dBm/MHz EIRP PSD or indicates that a different power level may be appropriate.

175. *Low-power short range mobile devices*. We propose that low power short range BAS and CARS devices, such as portable cameras and microphones, and Low Power Auxiliary stations be protected from harmful interference by a combination of a required contention-based protocol and the low probability of a VLP device operating on the same channel in a nearby location. This proposal is consistent with the *6 GHz Order* in which the Commission required that all 6 GHz unlicensed LPI access points, subordinate devices, and client devices employ a contention-based protocol as well as our proposal above with respect to geofenced VLP devices.[516] Further, the *6 GHz Order* showed that the probability of

[513] Comcast Communications, Inc. CableLabs, Feb 21, 2020 *Ex Parte* at 1; CableLabs, Charter Communications, Comcast Corporation, Cox Communication, Mar 9, 2020 *Ex Parte* attachment at 1.

[514] Comcast Communications, Inc. CableLabs, Feb 21, 2020 *Ex Parte* at 3.

[515] Broadcom Study, Sep 11, 2023 *Ex Parte* at 3.

[516] 47 CFR §§ 15.403, 15.407(d)(6). A contention-based protocol allows multiple users to share spectrum by providing a reasonable opportunity for the different users to transmit. *6 GHz Order*, 35 FCC Rcd at 3889, para. 101. In IEEE 802.11 standards, a "listen-before-talk" medium access scheme based on the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) protocol functions as a contention-based algorithm to provide spectrum access to all traffic. *Id.* Under this scheme, before initiating any packet delivery, a station listens to the wireless medium and if the medium is idle, the station may transmit; otherwise, the station must wait until the current transmission is complete before transmitting. *Id.*

channel overlap between 6 GHz unlicensed devices and incumbent station operations is low due to unlicensed devices having a full 1200 megahertz over which to operate.[517]

176. We believe that a similar approach for VLP devices will adequately reduce the risk that mobile service incumbents in the U-NII-6 and U-NII-8 bands would be subjected to harmful interference and keep that risk to an insignificant level. Our reasoning is consistent with the *6 GHz Order*, i.e., the sensing function associated with the contention-based protocol, along with the low probability for co-channel operation, is sufficient to ensure that VLP devices detect nearby mobile BAS operations and avoid transmitting co-channel to protect those operations from harmful interference.[518] While we are not proposing a specific technology protocol or contention method, we propose to require VLP devices to use a contention-based protocol as we require for LPI devices.[519] We believe that this proposal has additional benefits as it provides multiple VLP devices as well as LPI devices equal access to the spectrum, while protecting mobile incumbents' services. We also believe that the use of a contention-based protocol will limit the duty cycle of VLP devices as they will need to share the spectrum with other devices. Additionally, VLP devices would transmit at lower power levels than LPI devices, further reducing the risk of harmful interference to mobile services. Given all these reasons, we believe that requiring use of a contention-based protocol by VLP devices would protect mobile service incumbents.

177. We seek comment on this proposal. Would requiring VLP devices to incorporate a contention-based protocol adequately protect mobile service incumbents in the U-NII-6 and U-NII-8 bands? If not, are there any other protection measures that could be used by VLP devices to protect mobile services? Is there a need to provide greater specificity in the requirements for a contention-based protocol used by VLP devices? If so, what particular requirements should be specified and why? What are the costs and benefits of requiring the use of a contention-based protocol?

2. Fixed Satellite Services

178. The U-NII-7 and U-NII-8 bands contain Fixed Satellite Service (FSS) space-to-Earth allocations and are restricted to feeder links for Mobile-Satellite Service non-geostationary satellite systems. No such earth stations are currently licensed in the U-NII-7 band.[520] The U-NII-8 space-to-Earth allocation is limited to use by Globalstar's non-geostationary Mobile-Satellite Service feeder links and earth stations receiving at locations within 300 m of coordinates in Brewster, WA, Clifton, TX, and Finca Pascual, PR.[521] Globalstar also operates earth station receive sites at Naalehu, HI, Wasilla, AK, and Sebring, FL. These last two locations are authorized to operate on a co-primary basis for FSS feeder downlinks, except for the 7.025-7.055 GHz band, where they are authorized only on an unprotected basis.[522] In the *6 GHz Order*, the Commission determined that the probability of harmful interference to

[517] *See 6 GHz Order*, 35 FCC Rcd at 3901-02, para. 131, tbl. 6.

[518] *6 GHz Order*, 35 FCC Rcd at 3915, para. 168.

[519] *See* KDB Publication No. 987594.

[520] 47 CFR § 2.106(b)(458)(ii) (international footnote 5.458B). In the 2018 Notice of Proposed Rulemaking, the Commission stated that there is an allocation for space-to-Earth satellite use of the 6.7-6.875 GHz portion of the U-NII-7 band for feeder links for non-geostationary Mobile-Satellite Service systems. *Notice*, 33 FCC Rcd at 10518, para. 58. As the Commission noted, however, no earth stations are currently licensed to use this allocation in the space-to-Earth direction. *6 GHz Order*, 35 FCC Rcd at 3885, para. 89 n.224.

[521] 47 CFR § 2.106(b)(458)(ii), (d)(172) (international footnote 5.458B and non-governmental footnote NG172). The space-to-Earth allocation is limited to non-geostationary Mobile-Satellite Service feeder links and earth stations receiving in this band are limited to locations within 300 meters of coordinates in Brewster, WA, Clifton, TX, and Finca Pascual, PR. *Id.*

[522] *See supra* footnote 461.

FSS space-to-Earth stations from LPI device operations in U-NII-8 is low, primarily due to the restriction that LPI devices operate indoors and at EIRP power levels no greater than 30 dBm.[523]

179. We seek comment on whether any restrictions on VLP device operation is necessary to protect space-to-Earth stations. Because VLP devices would operate at significantly lower PSD levels than geofenced VLP access points and associated client devices, how does this impact the analysis of the potential for harmful interference occurring? As VLP devices operate without the supervision of a geofencing system, how could such restrictions, if needed, be implemented? Would there be differences in the cost of protection for VLP devices compared to geofenced VLP access point and associated client devices? We also seek comment on how the earth station antenna sites themselves provide interference protection by creating a physical barrier (e.g., fencing) or using geographic features to keep members of the public that could be using a VLP device beyond some minimum distance from those earth stations. Commenters should provide technical analysis to support their positions.

H. LPI Client-to-client Communications

180. In this section, we seek comment on whether the Commission should permit direct communications between clients to LPI devices. We also seek comment on the requirements that we would have to specify to enable client-to-client communications without causing harmful interference to licensed incumbent operations in the 6 GHz band.

181. *Background.* Standard-power access points can operate in the U-NII-5 and U-NII-7 bands and require use of an AFC system for providing access to spectrum in the band.[524] LPI access points can operate across the entire 6 GHz band but at lower power levels than standard power devices.[525] Client devices operate under the control of either a standard-power or LPI access point and communicate using power levels that depend on the type of access point to which they are connected.[526] To ensure that client devices not associated with standard power access points transmit indoors, the Commission required that these devices operate under the control of an indoor access point and prohibited 6 GHz U-NII client devices from directly communicating with one another.[527] The Commission prohibited unlicensed client devices from acting as "mobile hotspots" because "[p]ermitting a client device operating under the control of an access point to authorize the operation of additional client devices could potentially increase the distance between these additional client devices and the access point and increase the potential for harmful interference to fixed service receivers or electronic news gathering operations."[528] To avoid this situation, the Commission's rules prohibit 6 GHz U-NII client devices from directly communicating with one another.[529] The Commission did not, however, consider whether a more limited approach to indoor client-to-client communications should be permissible, such as when a client is not acting as a mobile hotspot.

182. In response to suggestions by Apple, Broadcom et al. that client devices could be permitted to directly communicate with each under certain conditions,[530] OET released a public notice on

[523] *6 GHz Order*, 35 FCC Rcd at 3916-17, para. 171.

[524] *6 GHz Order*, 35 FCC Rcd at 3860, paras. 17-18.

[525] *Id.*.

[526] *Id.*

[527] *6 GHz Order*, 35 FCC Rcd at 3926, para. 199; 47 CFR § 15.407(d)(5).

[528] *6 GHz Order*, 35 FCC Rcd at 3927, para. 202.

[529] 47 CFR § 15.407(d)(5) (stating that "[c]lient devices are prohibited from connecting directly to another client device").

[530] Apple, Broadcom et al. Nov. 6, 2020 *Ex Parte* at 1-2. Other submissions by unlicensed proponents also support permitting client-to-client communications. *See, e.g.*, Apple, Broadcom, Google, and Microsoft Comments at 13-

(continued….)

January 11, 2021 seeking information regarding client-to-client device communications in the 6 GHz band.[531] The conditions that Apple, Broadcom et al. suggest for permitting client-to-client communications include requiring client devices to decode an enabling signal transmitted by an LPI device within the last four seconds, and requiring that an enabling signal be received at a signal strength of at least -99 dBm/MHz.[532] These parties assert that these requirements would ensure each individual client participating in client-to-client communications is safely inside the area where a client device is authorized to communicate with an access point.[533]

183. Fourteen parties filed comments and 12 parties filed reply comments in response to the OET public notice. Advocates of unlicensed operation support permitting client-to-client communications by LPI devices, arguing that they will enable new applications that benefit the public, such as AR/VR and digital education and training.[534] Incumbent operators in the 6 GHz band (e.g., fixed microwave and broadcast) and in adjacent bands express concern about permitting client-to-client operations; specifically the potential for harmful interference and a lack of interference testing with devices operating under the current rules.[535]

184. *Discussion.* We invite comment on whether and under what circumstances LPI client devices could be permitted to directly communicate with each other in a limited manner while protecting incumbent licensed services. We recognize that OET previously sought comment on these issues. However, more than two years have passed since the we received responses to OET's public notice. During that time, many LPI devices have been certified and put into operation. In addition, the approval process for AFC systems for standard power devices has advanced, and as discussed in the Second Report and Order, several parties have provided detailed analyses on the potential for interference from 6 GHz

14; Wi-Fi Alliance Comments at 19-20; Qualcomm Comments at 7; Dynamic Spectrum Alliance Comments at 19-20; Broadcom, Microsoft Reply at 3-4; Apple, Intel, and Microsoft Oct. 22, 2020 *Ex Parte* at 1-2.

[531] *The Office of Engineering & Technology Seeks Additional Information Regarding Client-to-Client Device Communications in the 6 GHz Band*, ET Docket No. 18-295, Public Notice, 36 FCC Rcd 36 (2021).

[532] *See supra* footnote 530,

[533] *Id*. at 2.

[534] Wireless Broadband Alliance Comments at 1 (client-to-client technology will support a range of innovative use cases without impacting incumbents); Nokia Comments at 1 (supports client-to-client communications so long as technical rules are established to ensure no potential disruption to incumbent fixed services); Wi-Fi Alliance Comments at 1-3 (client-to-client communications can facilitate important technologies in fields such as industrial/healthcare AR/VR, immersive learning applications for students, and training applications for workers in offices); DSA Comments at 3 (client-to-client technology can allow devices unable to connect to infrastructure to transfer files and enhance immersive indoor applications, e.g., VR/AR/MR, 4K QAM); OTI Comments at 3 (client-to-client technology offers improved capacity and low-latency that will benefit user experiences such as AirDrop, communication with smartphone accessories, and emerging digital educational applications).

[535] NAB Comments at 1-2 (the proposal to allow client-to-client communications will fail to protect licensed operations, therefore the Commission should not allow such communications in the band); Alliance for Automotive Innovation Comments at 1-2 (the extended range of client-to-client communications would put V2X technologies, and other licensees in the 5.9 GHz band, at increased risk of harmful interference); Southern Company Comments at 1-2 (urges the Commission to wait until sufficient testing between incumbent and unlicensed operations is undertaken to evaluate the effect the current rules may have on incumbent operations); FWCC Comments at 1-3 (opposes permitting any client-to-client operation before current unlicensed operations are rigorously tested and demonstrate no harmful interference); Incumbent Stakeholders of 6 GHz Comments at 1 (oppose client-to-client communications because of the increased risk of interference for licensed microwave systems); AT&T Comments at 1-3 (the Commission should not authorize client-to-client communications unless such devices operate with AFC or other adequate protections in the band); Association of American Railroads Comments at 1-2 (opposes the authorization of client-to-client communications because this technology would extend the transmission range of unlicensed devices closer to fixed microwave links).

devices to incumbent services such as fixed microwave and broadcast services. Given that there is now more information available or that could become available in the near future concerning the interference potential of 6 GHz devices, we believe it is now appropriate to refresh and further build the record on whether we could permit LPI client-to-client operations.

185. Specifically, we seek comment on whether the Commission should permit 6 GHz client devices to directly communicate when they are under the control of or have received an enabling signal from a LPI access point. Commenters should explain how to define an enabling signal (e.g., power level, modulation type, how often it should be broadcast if it is discrete from the regular data stream, etc.), what characteristics it should have, how it would be similar or different from signals, such as beacons, that access points already use to connect with client devices, and the degree to which an enabling signal would tether a client device not under the direct control of an access point to that access point. Commenters should also provide information on the types of applications that direct client-to-client communications would enable that cannot be accomplished by communications through an access point. In addition, commenters advocating for rule changes should address whether direct client-to-client communications should be under the current power limits or restricted to lower power limits to reduce the potential for harmful interference to incumbent operations.[536]

186. The requirement that 6 GHz client devices operate under the control of either a standard-power or low-power indoor access point is intended to prevent client devices from causing harmful interference by limiting their operation either to outdoors in areas where an AFC system has determined that interference is unlikely to occur, or in the case of LPI devices to indoor locations where other factors such as building entry loss prevent harmful interference.[537] It may be possible for a client device to receive an enabling signal from an access point even when the enabling signal is too weak to enable the client device to conduct communications with the access point. In such situations, the weak received signal level makes it more likely that the client device could be outdoors. By requiring that the enabling signal have a specific signal strength, this problem could be potentially avoided. If the Commission were to adopt rules permitting client-to-client communications, should it require the enabling signal from the low-power indoor access point to be received by the client device with a particular signal level, such as -99 dBm/MHz as suggested by Apple, Broadcom et al.?[538] If not, what signal level would be appropriate? How can a specific signal level be correlated with the requirement that the client device be under the control of an access point? Should the enabling signal level be of sufficient strength to effectively require that the signal levels between the access point and client device be sufficiently strong to permit bi-directional communications between the client devices and the access point, thereby ensuring that both client devices are close to the access point? How frequently should a client device be required to receive an enabling signal to continue transmitting to another client device?

187. We also seek comment on whether client devices should be limited to receiving an enabling signal from the same access point or whether client-to-client communications could be permitted so long as each client device receives an enabling signal from any authorized access point. Apple, Broadcom et al.'s suggestion would potentially permit two client devices to communicate even if they receive enabling signals from two different access points. For example, client devices in two different buildings receiving enabling signals from different low-power indoor access points could attempt to communicate with each other. Would permitting this situation to occur increase the potential for the client devices to cause harmful interference to licensed services? Should other configurations be permitted? For example, could a client device controlled by a standard power access point be permitted to communicate with a client device controlled by a low-power indoor access point? In such a case,

[536] Client devices under the control of a LPI access point are permitted to operate up to 24 dBm EIRP over 320-megahertz channels (or -1 dBm/MHz). 47 CFR § 15.407(a)(8).

[537] *6 GHz Order*, 35 FCC Rcd 3926, para. 199.

[538] Apple, Broadcom et al. Nov. 6, 2020 *Ex Parte* at 1-2.

should the client device power level be restricted to the standard power client device power level? Could client-to-client communications be permitted between devices when both clients are controlled by a standard power access point? If so, are any changes needed to the AFC systems? Must an enabling signal be received on the same channel for each device under any of the scenarios contemplated? Under any envisioned client-to-client communication scenario, commenters should provide detailed descriptions of how such communications can be enabled including how such communications fit under the current rules that limit client devices to operating only under the control of a standard power access point or a low-power indoor access point or whether, and which, rules would need to be modified. Commenters should provide detailed analysis of how any client-to-client communication configurations they prefer would protect incumbent operations from harmful interference. Finally, commenters should provide any other information relevant to evaluating whether direct client-to-client communications should be permitted, including any alternative methods or necessary rule changes not directly discussed above.

V. MEMORANDUM OPINION AND ORDER ON REMAND

A. Introduction

188. In this order, we address a remand from the United States Court of Appeals for the District of Columbia Circuit concerning the rules that govern the use of unlicensed devices in the 6 GHz band.[539] After rejecting a number of challenges to the rules, the court of appeals remanded a single narrow issue for further consideration. Specifically, the court directed us to consider whether, in light of broadcasters' claims that they have experienced interference from unlicensed devices in the 2.4 GHz band, a portion of the 6 GHz band should be reserved for mobile broadcast operations.[540] For the reasons set forth below, we conclude that broadcasters' unsubstantiated claims of interference in the 2.4 GHz band do not warrant any modification of our 6 GHz rules.

B. Background

189. In the spring of 2020, the Commission adopted rules to make 1200 megahertz of spectrum available for use by unlicensed devices in the 6 GHz band (5.925-7.125 GHz).[541] Those rules imposed certain restrictions on unlicensed use of the spectrum in order to protect incumbent licensed operations in the 6 GHz band from harmful interference.[542] In particular, the Commission required that unlicensed low power indoor access points: (1) "operate only indoors," so that "[t]he signals transmitted by these unlicensed devices will be significantly attenuated when passing through the walls of buildings";[543] (2) "employ a contention-based protocol," such as "a listen-before-talk . . . scheme";[544] and (3) operate at "lower power levels than . . .standard-power access points," with "a maximum radiated power spectral density of 5 dBm per 1 megahertz"[545] The Commission concluded that "the[se] restrictions and requirements . . . for low-power indoor access points eliminate[] any significant risk of causing harmful interference" to incumbent licensed services.[546]

[539] *See AT&T Servs., Inc. v. FCC*, 21 F.4th 841 (D.C. Cir. 2021).

[540] *Id*. at 853-54.

[541] *6 GHz Order*.

[542] *See id*. at 3861-88, paras. 20-95 (describing restrictions on standard power unlicensed operations); *id*. at 3888-917, paras. 96-173 (describing restrictions on low-power indoor unlicensed operations).

[543] *Id*. at 3889, para. 100; *see* 47 CFR § 15.407(d)(3) .

[544] *6 GHz Order*, 35 FCC Rcd at 3889, para. 101 (internal quotation marks omitted); *see* 47 CFR § 15.407(d)(6).

[545] *6 GHz Order*, 35 FCC Rcd at 3889, para. 103; *see* 47 CFR § 15.407(a)(5).

[546] *6 GHz Order*, 35 FCC Rcd at 3907, para. 146.

190. Several parties, including NAB, filed petitions for review of the rules in the D.C. Circuit.[547] They asserted that the Commission erred in concluding that its restrictions on unlicensed use of the 6 GHz band would protect incumbent licensed services from a significant risk of harmful interference.[548] In an opinion issued on December 28, 2021, the D.C. Circuit largely upheld the 6 GHz rules. It held that for the most part, petitioners "failed to provide a basis for questioning the Commission's conclusion" that the rules "will protect against a significant risk of harmful interference."[549] The court denied the petitions for review "in all respects save one."[550] The sole issue that the court remanded concerned NAB's assertion that "after the Commission allowed unlicensed access in the 2.4 GHz band, 'a contention-based protocol . . . failed to protect . . . licensed users[,] . . .rendering that band partially unusable.'"[551] Based on broadcasters' concern that unlicensed devices could create similar problems in the 6 GHz band, NAB had asked the Commission to "reserve a sliver of [the] 6 GHz band for licensed mobile [broadcast] operation."[552] In the court's view, "the Commission failed adequately to respond to [this] request"[553] because it "never responded" to NAB's concerns about interference in the 2.4 GHz band.[554] "Given the Commission's failure to respond" to these concerns, the court concluded that "further explanation is called for."[555] Accordingly, the court "remand[ed] to the Commission for it to respond to [NAB's] concerns about interference in the 2.4 GHz band."[556]

191. After the court issued its mandate, the Office of Engineering and Technology (OET) issued a Public Notice inviting comments regarding the court's remand.[557] OET sought comment "on NAB's arguments in the Commission's proceeding regarding broadcasters' experience in the 2.4 GHz band, how that experience relates to the kinds of contention-based protocol operations prescribed for indoor use in the 6 GHz rules, and whether the 2.4 GHz experience warrants reservation of a portion of the 6 GHz band for mobile indoor operations or any other modification to the Commission's 6 GHz rules."[558] Noting "the limited scope of the court's remand," OET emphasized that it did not "seek comment on any other aspects of the *6 GHz Report and Order*."[559]

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[547] In addition to NAB, the other parties seeking review of the rules were AT&T Services, Inc., Lumen Technologies, Inc., APCO International, Edison Electric Institute, the Utilities Technology Council, the National Rural Electric Cooperative Association, and the American Public Power Association.

[548] *See* Joint Brief of Petitioners, *AT&T Servs., Inc. v. FCC*, D.C. Cir. No. 20-1190 (and consolidated cases) (Petitioners' Brief).

[549] *AT&T Services*, 21 F.4th at 843.

[550] *Id*.

[551] *Id*. at 853 (quoting Petitioners' Brief at 71).

[552] *Id*.; *see* Letter from Patrick McFadden, Associate General Counsel, NAB, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295 & GN Docket No. 17-183, at 1-2 (filed Apr. 15, 2020) (NAB April 15, 2020 Letter).

[553] *AT&T Services*, 21 F.4th at 843.

[554] *Id*. at 853.

[555] *Id*. at 854.

[556] *Id*. at 853. The court declined NAB's request for vacatur of the *6 GHz Order*. *Id*. at 853-54. It concluded that vacatur would be "disruptive," and that "the Commission may be able to explain" on remand "why its experience in the 2.4 GHz band supports its ability to protect licensed mobile [broadcast] operators from harmful interference." *Id*. at 854.

[557] *Office of Engineering and Technology Seeks Comment Following Court Remand of 6 GHz Band Order*, Public Notice, 37 FCC Rcd 3182, 3182 (OET 2022).

[558] *Id*. at 3183-84.

[559] *Id*. at 3184.

192. A number of parties submitted comments in response to the Public Notice.[560] In its comments, NAB reiterated its assertion that "[b]roadcasters' prior experience in the 2.4 GHz band confirms that the use of a [contention-based protocol] . . . has repeatedly failed to prevent harmful interference to licensed users."[561] Based on that claim, NAB argued that a contention-based protocol would not protect mobile broadcast operations in the 6 GHz band from interference caused by unlicensed devices.[562] NAB proposed that the Commission reserve 55 MHz of the 6 GHz band (at 7070-7125 MHz) for the exclusive use of licensed mobile broadcast operations, including electronic news gathering (ENG) systems.[563] In separate submissions, the Society of Broadcast Engineers, Inc. (SBE) and Engineers for the Integrity of Broadcast Auxiliary Services Spectrum (EIBASS) also expressed concern about interference in the 2.4 GHz band and supported NAB's proposal to reserve a portion of the 6 GHz band for licensed mobile broadcast operations.[564]

193. All of the other parties that filed comments in response to the Public Notice urged the Commission to reject NAB's argument that allegations of interference in the 2.4 GHz band warranted additional measures to protect broadcasters from interference in the 6 GHz band.[565] Those parties maintained that the record contained insufficient evidence to substantiate NAB's claims that unlicensed devices have caused harmful interference to broadcast operations in the 2.4 GHz band.[566] They also argued that even if there were evidence of interference in the 2.4 GHz band, it would not justify any changes to the rules governing unlicensed use of the 6 GHz band because there are material differences between these two spectrum bands.[567]

C. Discussion

194. When NAB challenged the 6 GHz rules in the D.C. Circuit, it argued that broadcasters were particularly vulnerable to interference in the 6 GHz band "because mobile 6 GHz facilities often operate indoors."[568] In the *6 GHz Report and Order*, the Commission concluded that a contention-based

[560] To the extent that any parties have raised issues in their comments that go beyond the scope of the narrow issue presented by the remand, we decline to consider those issues in this order.

[561] NAB Remand Comments, May 25, 2022, at 3.

[562] *Id*. at 2-4.

[563] *Id*. at 4-6; *see also* NAB Remand Reply, June 9, 2022, at 6-8. NAB had previously proposed that the Commission reserve "at least 80 MHz" of the 6 GHz band for use by licensed broadcasters. NAB April 15, 2020 Letter at 2.

[564] SBE Remand Comments, May 25, 2022, at 7-10; EIBASS Remand Comments, May 25, 2022, at 1-3; EIBASS Remand Reply, June 9, 2022, at 1.

[565] *See* App Association Remand Comments, May 25, 2022; Apple, Broadcom et al. Remand Comments, May 25, 2022; NCTA Remand Comments, May 25, 2022; Public Knowledge/Open Technology Institute (PK/OTI) Remand Comments, May 25, 2022; Wi-Fi Alliance Remand Comments, May 25, 2022; WISPA Remand Comments, May 25, 2022; Apple, Broadcom et al. Remand Reply, June 9, 2022; NCTA Remand Reply, June 9, 2022; Wi-Fi Alliance Remand Reply, June 9, 2022.

[566] *See* App Association Remand Comments at 4-5; Apple, Broadcom et al. Remand Comments at 4-7; NCTA Remand Comments at 5-8; PK/OTI Remand Comments at 4-6; Wi-Fi Alliance Remand Comments at 5-7; Apple, Broadcom *et al*. Remand Reply Comments at 3-5; NCTA Remand Reply Comments at 4-5; Wi-Fi Alliance Remand Reply at 5-6.

[567] *See* App Association Remand Comments at 5; Apple, Broadcom et al. Remand Comments at 7-10; NCTA Remand Comments at 11-16; PK/OTI Remand Comments at 6-11; Wi-Fi Alliance Remand Comments at 7-8; WISPA Remand Comments at 2-5; Apple, Broadcom et al. Remand Reply at 5-6; NCTA Remand Reply at 6-7.

[568] Petitioners' Brief at 71; *see also AT&T Services*, 21 F.4th at 853. In its brief filed with the D.C. Circuit, NAB did not complain about interference with outdoor broadcast operations. Thus, consideration of outdoor operations is not at issue in this remand.

protocol requirement would ensure that "the risk of harmful interference" to indoor broadcast operations from indoor unlicensed devices in the 6 GHz band would be "insignificant."[569] NAB argued before the court that the Commission reached this conclusion without considering NAB's claims that "a contention-based protocol . . . failed to protect" broadcasters from interference in the 2.4 GHz band, "rendering that band partially unusable."[570] In response to the court's remand, we have further examined NAB's claims concerning the 2.4 GHz band, and we find that those claims lack merit. The record in this proceeding contains no concrete evidence that unlicensed Wi-Fi devices have caused harmful interference to mobile broadcast operations in the 2.4 GHz band. By contrast, the record contains concrete evidence that contention-based protocols would be effective in the 6 GHz band.[571] Consequently, we find that NAB's claims of interference in the 2.4 GHz band do not warrant any modifications to our 6 GHz rules.

195. In a series of letters filed before the 6 GHz rules were adopted, NAB told the Commission that a contention-based protocol requirement for unlicensed devices in the 2.4 GHz band had not protected broadcasters and that this experience should lead the Commission to conclude that a contention-based protocol likewise would not protect broadcasters from harmful interference in the 6 GHz band.[572] NAB claimed that "the penetration of Wi-Fi has so polluted the shared portion of the 2.4 GHz band as to render it unusable for" ENG operations.[573] But NAB offered no specific evidence to support this broad claim. Instead, NAB cited comments filed in this proceeding by EIBASS in February 2019.[574]

196. Although EIBASS asserted in its February 2019 comments that "Part 15 devices have a long history of causing chronic interference to TV BAS [Broadcast Auxiliary Service] operations" on certain channels in the 2.4 GHz band,[575] it offered only two very specific pieces of evidence regarding this claim: an unsubstantiated account of an incident that allegedly occurred in a single market more than a decade ago and a spectrum analyzer screenshot from a specific location purporting to show that Wi-Fi caused an increase in the 2.4 GHz band noise floor.[576] EIBASS described a presentation made by the BAS frequency coordinator for Phoenix, Arizona, during a conference of broadcast engineers in April

[569] *6 GHz Order*, 35 FCC Rcd at 3915, para. 168.

[570] Petitioners' Brief at 71 (quoted in *AT&T Services*, 21 F.4th at 853).

[571] *See* discussion *infra* para. 152.

[572] *See* Letter from Patrick McFadden, Associate General Counsel, NAB, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295 & GN Docket No. 17-183, at 2-3 (filed Mar. 23, 2020) (NAB March 23, 2020 Letter); Letter from Patrick McFadden, Associate General Counsel, NAB, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295 & GN Docket No. 17-183, at 1-2 (filed Mar. 27, 2020) (NAB March 27, 2020 Letter); Letter from Patrick McFadden, Associate General Counsel, NAB, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 18-295 & GN Docket No. 17-183, at 3-4 (filed Apr. 10, 2020) (NAB April 10, 2020 Letter). Although the Commission's rules do not require the use of a contention-based protocol by unlicensed devices operating in the 2.4 GHz band, all Wi-Fi devices are required by IEEE Standard 802.11 (the industry technical standard for Wi-Fi) to use a contention-based protocol.

[573] *See* NAB March 23, 2020 Letter at 2-3; NAB March 27, 2020 Letter at 1-2; *see also* NAB April 10, 2020 Letter at 4 (claiming that a contention-based protocol "has demonstrably failed to control interference in the 2.4 GHz spectrum that is also shared with ENG").

[574] *See* NAB March 23, 2020 Letter at 3 n.5; NAB March 27, 2020 Letter at 2 n.1.

[575] Comments of EIBASS, ET Docket No. 18-295 & GN Docket No. 17-283, at 8 (rec. Feb. 15, 2019) (EIBASS Comments). The Broadcast Auxiliary Service (BAS) operates in the U-NII-6 band on a mobile basis and in the U-NII-8 band on both a fixed and mobile basis. *6 GHz Order*, 35 FCC Rcd at 3855, para. 8 (citing 47 CFR § 74.602(a), (i)). Licensees use BAS stations to transmit programming material from special events or remote locations, *including electronic news gathering*, back to the studio or other central receive locations. *Id.* (emphasis added) (citing 47 CFR § 74.631).

[576] EIBASS Comments at 8-9, 17.

2004.[577] But EIBASS did not submit either a transcript of the presentation or a sworn declaration from the Phoenix coordinator (whom EIBASS did not identify). Instead, EIBASS simply offered its undocumented recollection of the presentation, which had been made 15 years earlier.[578] According to EIBASS, the Phoenix coordinator stated during the April 2004 presentation that "about every six months or so," one of the four ENG receive-only sites in the Phoenix area "becomes unusable" for certain channels in the 2.4 GHz band "because of the proliferation of 2.4 GHz WiFi devices at the site."[579] As EIBASS recounted the presentation, the Phoenix coordinator said that the interference issue was temporarily cured when "the operators of the offending Part 15 devices [were] instructed to cease and desist their interference-causing operations," but those devices resumed operation after a while, and "the process [had] to be repeated."[580]

197. Even if we were persuaded that broadcasters in the Phoenix area had experienced interference in the 2.4 GHz band nearly two decades ago, as EIBASS claimed, this isolated incident would not convince us that we need to take additional measures that would affect the entirety of the U.S. to protect broadcasters from harmful interference in the 6 GHz band. But we have serious questions concerning the details of EIBASS's second-hand account of the alleged Phoenix interference episode. According to EIBASS, the Phoenix frequency coordinator in the early 2000s (whom EIBASS did not identify) traced the alleged interference in Phoenix to Wi-Fi devices.[581] Even assuming that harmful interference did in fact occur, we have no way of verifying that Wi-Fi devices caused the problem.[582] If the alleged interference did, in fact, occur, we note that many unlicensed part 15 non-Wi-Fi devices also operate in the 2.4 GHz band, including baby monitors, cordless phones, wireless microphones, speakers and earbuds, and computer peripherals;—and those devices do not use a contention-based protocol.[583] Similarly, industrial, scientific, and medical (ISM) devices operate on a primary basis[584] in the 2.4 GHz band with unlimited power under the Commission's part 18 rules, and they also do not use a contention-based protocol.[585] ISM devices use RF energy for industrial, scientific, medical, domestic, or similar

[577] *Id.*

[578] *Id.*

[579] *Id.*

[580] *Id.* Although EIBASS claimed that the users of the interfering devices resumed operations after they were told to stop using the devices, our records contain no evidence (and neither EIBASS nor NAB provides any) that any of the affected broadcasters filed a complaint with our Enforcement Bureau. If the Bureau had received such a complaint, it could have taken steps to identify the nature of the use (whether Wi-Fi or otherwise) and directed any users of the offending devices to cease operations until the interference issue was resolved. The Bureau also could have warned any such users of the devices that if they resumed operation before the interference issue was addressed, they would be violating federal law and could face "severe penalties, including, but not limited to, substantial monetary fines, *in rem* arrest action to seize the offending . . . equipment, and criminal sanctions including imprisonment." *See, e.g.,* Notification of Harmful Interference, Victor Rosario, Case No. EB-FIELDNER-17-00025658, 2018 WL 923275, at *1 (EB Feb. 15, 2018) (citing 47 U.S.C. §§ 401, 501, 503, and 510).

[581] EIBASS Comments at 8.

[582] *See* Apple, Broadcom et al. Remand Comments at 5 (noting "the absence of any meaningful detail" in the account of the Phoenix incident that would allow the Commission "to assess the conclusory interference claims").

[583] *See id*. at 7; NCTA Remand Comments at 6-7; PK/OTI Remand Comments at 9; Wi-Fi Alliance Remand Comments at 6; WISPA Remand Comments at 4-5; Apple, Broadcom et al. Remand Reply at 4-5; NCTA Remand Reply at 4-5.

[584] 47 CFR § 2.106(b)(150) (noting, in international footnote 5.150, that the 2400-2500 MHz band is designated for ISM applications and that radiocommunication services operating in that band must accept harmful interference which may be caused by these applications).

[585] *Id*. §§ 18.301, 18.305(a).

purposes[586] and are found in many locations such as factories, medical facilities, and even residences (microwave ovens). Because EIBASS does not attribute any alleged harmful interference to any specific Wi-Fi device(s) and does not appear to consider any of the other numerous devices operating in the band without using a contention-based protocol, the Phoenix incident does not support NAB's assertion that a contention-based protocol failed to prevent interference in the 2.4 GHz band.

198. The other evidence that EIBASS provided was a spectrum analyzer screenshot that was captured at an ENG receive-only site in Phoenix in 2013.[587] According to EIBASS, this screenshot Ishows that the noise floor increases by 11 dB in 2.450-2.467 GHz and 5 dB in 2.467-2.483.5 GHz compared to ENG channel A10 at the upper end of the 2.4 GHz band.[588] While this screenshot shows that some type of signal could have been present in the 2.4 GHz band at that time, it does not provide evidence of what devices may be causing any noise floor increase nor that a contention-based protocol would have failed to protect BAS receivers in the band. In fact, any noise floor increase could be attributable to any of the non-Wi-Fi devices or ISM devices that operate in the 2.4 GHz band and do not employ a contention-based protocol. Moreover, as this screenshot is merely an indication of the spectrum at a single point in time, it offers no indication as to the behavior of a device employing a contention-based protocol when in the vicinity of a BAS transmitter in the band. Given the limited information this screenshot conveys, it provides no grounds to support NAB's assertion that a contention-based protocol had failed to prevent interference in the 2.4 GHz band.

199. Furthermore, even if the devices that EIBASS alleged were causing interference in Phoenix used a contention-based protocol, we cannot determine from the sparse evidence in the record whether those devices were operating in compliance with the Commission's part 15 rules.[589] Notably, the contention based protocol used by Wi-Fi devices is part of the IEEE 802.11 standard and not required by the Commission's rules nor do the Commission's rules limit such devices to indoor locations. In contrast, the Commission adopted a requirement that low-power indoor (LPI) 6 GHz unlicensed devices use a contention-based protocol to work in tandem with other restrictions these unlicensed devices—including indoor-only operation and power limits on LPI access points—to guard against harmful interference to incumbent operations in the 6 GHz band.[590] Because of the lack of a Commission-mandated requirement for a contention-based protocol or indoor operation on 2.4 GHz devices, and no insight into whether devices in the Phoenix area at the time of the alleged interference were actually using such a protocol or operating indoors, it is impossible to draw any conclusions from those operations and the operations anticipated in the 6 GHz band. Thus, the alleged Phoenix incidents shed no light on the relevant question raised by NAB: that is, whether the purported experience regarding potential harmful interference to BAS devices in the 2.4 GHz band has any relevance to the potential for such interference from LPI devices in the 6 GHz band. Additionally, as an added safeguard and as several commenters note, the 6 GHz rules impose much lower power limits on unlicensed LPI devices than the 2.4 GHz rules do.[591]

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[586] *Id*. § 18.107(c).

[587] EIBASS Comments at 8.

[588] *Id*. at 8-9, 17.

[589] *See* NCTA Remand Comments at 6; NCTA Remand Reply at 4.

[590] The Commission adopted three restrictions designed to prevent harmful interference from devices using low-power indoor access points. Such devices are (1) limited to indoor operation; (2) required to use a contention-based protocol; and (3) subject to low-power operation. *See 6 GHz Order*, 35 FCC Rcd at 3888-90, paras. 99-103. The Commission concluded that these restrictions "eliminate[d] any significant risk" that the devices would cause "harmful interference." *Id*. at 3907, para. 146; *see also AT&T Services*, 21 F.4th at 845, 850-51.

[591] *See* Apple, Broadcom et al. Remand Reply at 6 ("[T]he 6 GHz rules require [low-power indoor unlicensed] devices to operate at far lower power (*e.g.*, at a power spectral density '63 times' less powerful in a 20-megahertz

(continued….)

200. In contrast to NAB's unsubstantiated claims of harmful interference in the 2.4 GHz band, the record persuades us that "the risk of harmful interference to indoor electronic news gathering receivers from indoor unlicensed devices" in the 6 GHz band "is insignificant."[592] A study by Apple, Broadcom et al. "simulated the receive power level from electronic news gathering transmitters at 20 unlicensed access points operating within the US House of Representatives chamber. The results of this simulation demonstrate[d] that, even at the lowest electronic news gathering transmit power level, all unlicensed access points would detect the electronic news gathering signal at greater than -62 dBm and therefore not transmit co-channel."[593] This study "confirm[ed]" that contention-based protocols "could be used to mitigate interference to indoor electronic news gathering receivers" in the 6 GHz band.[594]

201. Because the record contains no substantial evidence of harmful interference to broadcast operations in the 2.4 GHz band, we find no basis for NAB's assertion that a contention-based protocol failed to protect broadcasters from interference in that band, much less under the parameters established for operation in the 6 GHz band. As the Commission noted in the *6 GHz Report and Order*, "Wi-Fi devices have been deployed" in the 2.4 GHz band "in abundance for well over 20 years."[595] For most of that time, the 2.4 GHz band was the primary band used by Wi-Fi devices. If (as NAB and others have claimed) interference from Wi-Fi devices prevented broadcasters from using portions of the 2.4 GHz band, we would expect the record to reflect evidence of numerous instances of such interference. Yet apart from an unsubstantiated account of an alleged incident in Phoenix almost two decades ago and a spectrum analyzer screenshot captured in Phoenix more than a decade ago, the record contains no specific evidence that any broadcaster has experienced harmful interference from unlicensed Wi-Fi devices in the 2.4 GHz band. Moreover, neither NAB nor any other party has cited a single complaint filed with our Enforcement Bureau by any broadcaster alleging interference by unlicensed Wi-Fi devices in the 2.4 GHz band. The absence of any such complaints undermines NAB's contention that interference from unlicensed Wi-Fi devices is a serious problem for broadcasters in the 2.4 GHz band.

202. Following the remand, SBE and EIBASS attempted to supplement the record by presenting new evidence of harmful interference in the 2.4 GHz band.[596] Such evidence falls outside the scope of this remand proceeding. The narrow question presented by the court's remand is whether the Commission adequately considered NAB's concerns about interference in the 2.4 GHz band when it adopted the 6 GHz rules. That is the only question on which OET sought further comment. In this context, the relevant record is "the record before the agency at the time of its decision."[597]

203. In any event, even assuming that the new evidence proffered by SBE and EIBASS were properly before us, this evidence does not persuade us that Wi-Fi devices have caused harmful interference to broadcast operations in the 2.4 GHz band, much less at the far lower power at which Wi-Fi operations are required to operate in the 6 GHz band. SBE asserts that it conducted an "informal survey" in which local frequency coordinators reported "harmful interference from Wi-Fi systems [in the 2.4 GHz

channel) than the 2.4 GHz rules permit.") (quoting NCTA Remand Comments at 13); *see also* App Association Remand Comments at 5; PK/OTI Remand Comments at 9-10; WISPA Comments at 2-3.

[592] *6 GHz Order*, 35 FCC Rcd at 3915, para. 168.

[593] *Id.* (citing Apple, Broadcom et al. Feb. 28, 2020, *Ex Parte* at 13).

[594] *Id.*

[595] *Id.* at 3908, para. 147.

[596] *See* SBE Remand Comments at 5 (citing "an informal survey" in which frequency coordinators reported "harmful interference from Wi-Fi systems" in the 2.4 GHz band "in at least 13 markets"); EIBASS Remand Comments at 2, Figure 1 (attributing the high "noise floor" at 2.5 GHz to the proliferation of unlicensed Wi-Fi devices operating at 2.4 GHz).

[597] *See Northstar Wireless, LLC v. FCC*, 38 F.4th 190, 212 (D.C. Cir. 2022); *see also* NCTA Remand Reply at 11-12.

band] . . . in at least 13 markets."[598] But as Apple, Broadcom et al. point out, SBE's "informal survey" was "backed in most cases by no supporting evidence or incident descriptions."[599] The only evidence offered by SBE to support its "informal survey" is a spectrum plot that purports to show interference in Milwaukee.[600] We agree with Apple, Broadcom et al. that this spectrum plot does not constitute "meaningful technical evidence" because it contains "no supporting detail" concerning how the measurement of interference in Milwaukee was made.[601] In particular, we note that SBE offers "no explanation why" it attributes the alleged interference in Milwaukee "to Wi-Fi, rather than to the many other technologies operating in the 2.4 GHz band that do not use a contention-based protocol."[602] The same is true of EIBASS's comparison of the noise floors for mobile broadcast operations at 2 GHz and 2.5 GHz.[603] Although EIBASS claims that part 15 Wi-Fi devices are responsible for the higher noise floor at 2.5 GHz,[604] the higher noise floor could also be attributable to "the many other technologies operating in the 2.4 GHz band that do not use a contention-based protocol."[605]

204. The post-remand submissions by SBE and EIBASS also fail to cite any complaints filed with our Enforcement Bureau claiming that Wi-Fi devices caused harmful interference to mobile broadcast operations in the 2.4 GHz band. The absence of any such complaints casts further doubt on the assertions made by NAB and its supporters that broadcasters have routinely experienced such interference.

205. In sum, despite NAB's claims that interference issues in the 2.4 GHz band are pervasive and longstanding, the record contains no credible evidence of such interference. The specific incident of alleged interference cited in the record occurred about two decades ago in Phoenix, and it was never reported to our Enforcement Bureau. EIBASS's sketchy description of the details of that incident does not provide us with enough information to draw any firm conclusions about how—or even whether—interference occurred. The spectrum analyzer screenshot showing an increase in the noise floor in Phoenix more than a decade ago also lacks the details needed to reach a conclusion about whether harmful interference was occurring. Given the absence of any concrete evidence that broadcasters have experienced harmful interference in the 2.4 GHz band or in the 6 GHz band, where LPI devices have been operating since December 2020,[606] and in light of the substantial record evidence demonstrating that there is no significant risk of harmful interference given the constraints under which Wi-Fi devices are required to operate in the 6 GHz band, we reject NAB's contention that broadcasters' experience with interference in the 2.4 GHz band justifies the reservation of a portion of the 6 GHz band for mobile broadcast operations.

[598] SBE Remand Comments at 5.

[599] Apple, Broadcom et al. Remand Reply at 8.

[600] *See* SBE Remand Comments at 5-6.

[601] *See* Apple, Broadcom et al. Remand Reply at 8.

[602] *Id.*

[603] *See* EIBASS Remand Comments at 2, Figure 1. In this context, the noise floor is the sum of all signals emitted by other noise sources in the same part of the spectrum as a broadcast signal. The higher the noise floor, the more likely the broadcast signal will experience harmful interference.

[604] *Id*. at 2.

[605] *See* Apple, Broadcom et al. Remand Reply at 8; *see also* NCTA Remand Reply at 4-5 (stating that "non-Wi-Fi devices" using the 2.4 GHz band "could have caused the alleged harmful interference, and many of those devices do not use a contention-based protocol").

[606] *Grant of Equipment Authorization*, ASUSTek Computer Inc., FCC ID MSQ-RTAXJF00 (granted Dec. 30, 2020).

D. Conclusion

206. For the foregoing reasons, we conclude that NAB's unsubstantiated claims of interference in the 2.4 GHz band do not justify any modifications to our 6 GHz rules to provide broadcasters with further protections from harmful interference. We reaffirm that the rules the Commission adopted in the *6 GHz Order* eliminate any significant risk of harmful interference to mobile broadcast operations and other incumbent licensed services in the 6 GHz band. Therefore, we decline to adopt NAB's proposal to reserve part of the 6 GHz band for the exclusive use of mobile broadcast operations.

VI. PROCEDURAL MATTERS

207. *Ex Parte Presentations*. The proceeding shall be treated as a "permit-but-disclose" proceeding in accordance with the Commission's *ex parte* rules.[607] 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.

208. *Filing of Comments and Reply Comments.* 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: https://www.fcc.gov/ecfs/..

- 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 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.

    - 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.

[607] 47 CFR § 1.1200 *et seq.*

- U.S. Postal Service first-class, Express, and Priority mail must be addressed to 45 L Street NE, Washington, D.C. 20554.

- Effective March 19, 2020, and until further notice, the Commission no longer accepts any hand or messenger delivered filings. This is a temporary measure taken to help protect the health and safety of individuals, and to mitigate the transmission of COVID-19. See *FCC Announces Closure of FCC Headquarters Open Window and Change in Hand-Delivery Policy*, Public Notice, 35 FCC Rcd 2788 (OMD 2020), https://www.fcc.gov/document/fcc-closes-headquarters-open-window-and-changes-hand-delivery-policy.

209. *Paperwork Reduction Act*. The Second Report and Order does not contain new or modified information collection requirements subject to the Paperwork Reduction Act of 1995 (PRA), Public Law 104-13. In addition, therefore, it does not contain any new or modified information collection burden for small business concerns with fewer than 25 employees, pursuant to the Small Business Paperwork Relief Act of 2002, Public Law 107-198, see 44 U.S.C. 3506(c)(4).

210. The Second Further Notice of Proposed Rulemaking 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

211. *Regulatory Flexibility Act*. The Regulatory Flexibility Act of 1980, as amended (RFA),[608] requires that an agency prepare a regulatory flexibility analysis for notice and comment rulemakings, unless the agency certifies that "the rule will not, if promulgated, have a significant economic impact on a substantial number of small entities."[609] Accordingly, we have prepared a Final Regulatory Flexibility Analysis (FRFA) concerning the possible impact of the rule changes contained in this *Second Report and Order* on small entities. The FRFA is set forth in Appendix C.

212. We have also prepared an Initial Regulatory Flexibility Analysis (IRFA) concerning the potential impact of the rule and policy changes contained in the Second Further Notice of Proposed Rulemaking. The IRFA is set forth in Appendix D. Written public comments are requested on the IRFA. Comments must be filed by the deadlines for comments on the Second Further Notice of Proposed Rulemaking indicated on the first page of this document and must have a separate and distinct heading designating them as responses to the IRFA.

213. *Congressional Review Act*. The Commission will submit this draft Second Report and Order to the Administrator of the Office of Information and Regulatory Affairs, Office of Management and Budget, for concurrence as to whether this rule is "major" or "non-major" under the Congressional Review Act, 5 U.S.C. § 804(2). The Commission will send a copy of this Second Report and Order to Congress and the Government Accountability Office pursuant to 5 U.S.C. § 801(a)(1)(A).

214. *People with Disabilities*: To request materials in accessible formats for people with disabilities (braille, large print, electronic files, audio format), send an e-mail to fcc504@fcc.gov or call the Consumer & Governmental Affairs Bureau at 202-418-0530 (voice), 202-418-0432 (tty).

[608] 5 U.S.C. §§ 601–612. The RFA 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).

[609] *See* 5 U.S.C. § 605(b).

215. *Additional Information*. For additional information on this proceeding, contact Nicholas Oros of the Office of Engineering and Technology, Policy and Rules Division, at 202-418-0636 or Nicholas.Oros@fcc.gov.

VII. ORDERING CLAUSES

216. Accordingly, IT IS ORDERED, pursuant to sections 2, 4(i), 302, and 303 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 152, 154(i), 302a, and 303, this *Second Report and Order and Second Further Notice of Proposed Rulemaking*, is hereby ADOPTED.

217. IT IS FURTHER ORDERED, pursuant to sections 4(i), 4(j), 201, 302, and 303 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 154(i), (j), 201, 302a, 303, that this *Memorandum Opinion and Order on Remand* is hereby ADOPTED.

218. IT IS FURTHER ORDERED that the amendments of the Commission's rules as set forth in Appendix A ARE ADOPTED, effective 60 days from the date of publication in the Federal Register.

219. IT IS FURTHER ORDERED that this *Memorandum Opinion and Order on Remand* SHALL BECOME EFFECTIVE thirty (30) days after publication in the Federal Register.

220. IT IS FURTHER ORDERED that the Office of the Secretary, Reference Information Center, SHALL SEND a copy of the *Second Report and Order* and *Second Further Notice of Proposed Rulemaking* including the Final Regulatory Flexibility Analysis and the Initial Regulatory Flexibility Analysis, to the Chief Counsel for Advocacy of the Small Business Administration.

221. IT IS FURTHER ORDERED that the Office of Managing Director, Performance Program Management SHALL SEND a copy of this *Second Report and Order* in a report to be sent to Congress and the Government Accountability Office pursuant to the Congressional Review Act, 5 U.S.C. § 801(a)(1)(A).

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

APPENDIX A

Final Rules

For the reasons set forth in the preamble, the Federal Communications Commission amends part 15 of Title 47 of the Code of Federal Regulations to read as follows:

PART 15 – RADIO FREQUENCY DEVICES

1. 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.

1. Section 15.403 is amended by adding a definition for "Very low power device" in alphabetical order. The addition reads as follows:

§ 15.403 Definitions.

* * * * *

Very Low Power Device. For the purpose of this subpart, a device that operates in the 5.925-6.425 GHz and 6.525-6.875 GHz bands and has an integrated antenna. These devices do not need to operate under the control of an access point.

* * * * *

2. Section 15.407 is amended by redesignating paragraphs (a)(9) through (a)(12) as (a)(10) through 3); adding new paragraph (a)(9); revising the introductory text to paragraph (b); revising paragraph (c); combining and revising paragraph (d)(1) and (d)(2); reserving paragraph (d)(2); adding new paragraphs (d)(8), (d)(9), and (d)(10); revising (l)(2)(ii) to read as follows.

§ 15.407 General technical requirements.

(a) * * *

(9) For very low power devices operating in the 5.925-6.425 GHz and 6.525-6.875 GHz bands, the maximum power spectral density must not exceed -5 dBm e.i.r.p in any 1-megahertz band and the maximum e.i.r.p must not exceed 14 dBm.

* * *

(b) **Undesirable emission limits.** Except as shown in paragraph (b)(10) of this section, the maximum emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:

* * *

(c) **Transmission discontinuation requirement.** The device shall automatically discontinue transmission in case of either absence of information to transmit or operational failure. These provisions are not intended to preclude the transmission of control or signaling information or the use of repetitive codes used by certain digital technologies to complete frame or burst intervals. Applicants shall include in their application for equipment authorization a description of how this requirement is met.

(d) * * *

(1) Operational restrictions:

(i) Oil platforms: Operation of standard power access points, fixed client devices, very low power devices, and indoor access points in the 5.925–7.125 GHz band is prohibited on oil platforms.

(ii) Land vehicles: Operation of standard power access points, fixed client devices, and indoor access points in the 5.925–7.125 GHz band is prohibited on vehicles (e.g., cars, trains).

(iii) Boats: Operation of standard power access points, fixed client devices, and indoor access points in the 5.925–7.125 GHz band is prohibited on boats.

(iv) Aircraft: Standard power access points, fixed client devices, very low power devices, and indoor access points in the 5.925–7.125 GHz band are prohibited from operating on aircraft, except that very low power devices and indoor access points are permitted to operate in the 5.925–6.425 GHz bands in large aircraft while flying above 10,000 feet.

(v) Operation of transmitters in the 5.925–7.125 GHz band is prohibited for control of or communications with unmanned aircraft systems.

(2) [Reserved]

* * *

* * *

(8) Very low power devices may not employ a fixed outdoor infrastructure. Such devices may not be mounted on outdoor structures, such as buildings or poles.

(9) Very low power devices must prioritize operations on frequencies above 6.105 GHz prior to operating on frequencies between 5.925 GHz and 6.105 GHz.

(10) Transmit power control (TPC). Very low power devices operating in the 5.925–6.425 and 6.525-6.875 GHz bands shall employ a TPC mechanism. A very low power device is required to have the capability to operate at least 6 dB below the maximum EIRP PSD value of -5 dBm/ MHz.

* * *

(l) * * *

(2) * * *

(ii) The AFC system must use −6 dB I/N as the interference protection criteria in determining the size of the adjacent channel exclusion zone, where I (interference) is the signal from the standard power access point or fixed client device's out of channel emissions at the fixed microwave service receiver and N (noise) is background noise level at the fixed microwave service receiver. The adjacent channel exclusion zone must be calculated based on the emissions requirements of paragraph (b)(7) of this section.

* * *

APPENDIX B

Proposed Rules

For the reasons set forth in the preamble, the Federal Communications Commission proposes to amend part 15 of Title 47 of the Code of Federal Regulations to read as follows:

PART 15 – RADIO FREQUENCY DEVICES

1. 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.

2. Section 15.403 is amended by adding definitions for "Geofenced very low power access point" and "Geofencing" in alphabetical order. The additions read as follows:

§ 15.403 Definitions.

* * * * *

Geofenced Very Low Power Access Point. For the purpose of this subpart, an access point that operates in the 5.925–7.125 GHz band, has an integrated antenna, and uses a geofencing system to determine channel availability at its location.

Geofencing. For the purposes of this subpart, a method of establishing exclusion zones within which very low power devices are not permitted to operate on frequencies specified by the geofencing system.

* * * * *

3. Section 15.407 is amended by redesignating paragraph (a)(7) and (a)(8) as (a)(8)(i) and (a)(8)(ii); adding new paragraph (a)(8)(iii); adding new paragraph (a)(7); revising paragraph (a)(10); revising paragraph (d)(3), (d)(5), (d)(6), (d)(8), (d)(9), and (d)(10); redesignating paragraph (d)(7) as (d)(5)(ii); reserving paragraph (d)(7); and adding new paragraphs (o) through (r) to read as follows.

§ 15.407 General technical requirements.

(a) * * *

(7) For a geofenced very low power access point operating in the 5.925–7.125 GHz band, the maximum power spectral density must not exceed 1 dBm e.i.r.p in any 1-megahertz band. In addition, the maximum e.i.r.p over the frequency band of operation must not exceed 14 dBm.

(8) Client device operation:

(i) For client devices, except for fixed client devices as defined in this subpart, operating under the control of a standard power access point in 5.925–6.425 GHz and 6.525–6.875 GHz bands, the maximum power spectral density must not exceed 17 dBm e.i.r.p. in any 1-megahertz band, and the maximum e.i.r.p. over the frequency band of operation must not exceed 30 dBm and the device must limit its power to no more than 6 dB below its associated standard power access point's authorized transmit power.

(ii) For client devices operating under the control of an indoor access point in the 5.925–7.125 GHz bands, the maximum power spectral density must not exceed −1 dBm e.i.r.p. in any 1-megahertz band, and the maximum e.i.r.p. over the frequency band of operation must not exceed 24 dBm.

(iii) For client devices operating under the control of a geofenced very low power access point in the 5.925–7.125 GHz bands, the maximum power spectral density must not exceed 1 dBm e.i.r.p in any 1-megahertz band, and the maximum e.i.r.p over the frequency band of operation must not exceed 14 dBm.

* * *

(10) Access points operating under the provisions of paragraphs (a)(5), (6), and (7) of this section must employ a permanently attached integrated antenna.

* * *

(d) * * *

* * *

(3) Transmitters operating under the provisions of paragraphs (a)(5), (6), and (8)(ii) of this section are limited to indoor locations.

* * *

(5) Client Devices:

(i) In the 5.925–7.125 GHz band, client devices must operate under the control of a standard power access point, low-power indoor access point, subordinate device, or geofenced very low power access point; Subordinate devices must operate under the control of a low-power indoor access point.

(ii) Fixed client devices may only connect to a standard power access point.

(iii) In all cases, an exception exists such that a client device may transmit brief messages to an access point when attempting to join its network after detecting a signal that confirms that an access point is operating on a particular channel.

(iv) Client-to-client communications: Client devices are prohibited from connecting directly to another client device, except that client devices under the control of the same indoor access point or geofenced very low power access point may communicate directly with each other.

Client devices under the control of indoor access point, that directly connect to another client, transmit power must not exceed -1 dBm e.i.r.p. in any 1-meghertz band, and the maximum e.i.r.p. over the frequency band of operation must not exceed 14 dBm.

(6) All U-NII transmitters, except for standard power access points, operating in the 5.925–7.125 GHz band must employ a contention-based protocol.

(7) [Reserved]

(8) Geofenced very low power and very low power devices may not employ a fixed outdoor infrastructure. Such devices may not be mounted on outdoor structures, such as buildings or poles.

(9) Geofenced very low power and very low power devices must prioritize operations on frequencies above 6.105 GHz prior to operating on frequencies between 5.925 GHz and 6.105 GHz.

(10) Transmit power control (TPC). Geofenced very low power devices operating in the 5.925-7.125 GHz bands shall employ a TPC mechanism. A very low power device is required to have the capability to operate at least 6 dB below the maximum EIRP PSD value of -5 dBm/ MHz.

* * * * *

(o) *Geofencing system.*

(1) A geofencing system must obtain information on protected services within the 5.925–7.125 GHz band from Commission databases and use that information to determine frequency-specific exclusion zones where very low power access points and associated client devices may not operate on specified frequencies based on the propagation models and protection criteria specified in paragraph (p) of this section. The geofencing system must access the Commission's licensing databases and update the frequency-specific exclusion zones at least once per day to ensure that they are based on the most recent information in the Commission's databases.

(2) Geofencing systems may be implemented using a centralized database or may be integrated into geofenced very low power access point devices.

(3) A geofenced very low power access point operating under paragraph (a)(7) of this section must access a geofencing system to obtain frequency-specific exclusion zones for the area in which it is operating or intends to operate (e.g., within a specific point radius or within specific geopolitical boundaries) prior to transmitting. If the geofenced very low power access point moves outside this area, it must obtain additional frequency-specific exclusion zones for the area and adjust its operating frequency, if necessary, prior to operating in this new area. The geofenced very low power access point must obtain updated frequency-specific exclusion zones from the geofencing system at least once per day. If the geofenced very low power access point fails to obtain the updated frequency specific exclusion zones on any given day, the geofenced very low power access point may continue to operate until 11:59 p.m. of the following day at which time it must cease operations until it can obtain updated frequency-specific exclusion zones.

(4) A geofenced very low power access point must determine its location and avoid transmitting on frequencies that are not available in accordance with the frequency specific exclusion zones. The geofenced very low power access point may not permit a client device operating under its control to transmit on frequencies that are not available in accordance with the frequency specific exclusion zones. The geofenced very low power access point must determine its location frequently enough that, based on

its position and speed, it will not transmit on an unavailable frequency. The geofenced very low power access point must determine its location and speed at least once a minute.

(5) A geofenced very low power access point must incorporate adequate security measures to prevent it from accessing geofencing systems and geofencing methods not approved by the FCC and to ensure that unauthorized parties cannot modify the device to operate in a manner inconsistent with the rules and protection criteria set forth in this section and to ensure that communications between geofenced very low power access points and geofencing systems are secure to prevent corruption or unauthorized interception of data.

(6) Geofenced very low power access point device geo-location capability:

(i) A geofenced very low power access point must include an internal geo-location capability to automatically determine the geofenced very low power access point's geographic coordinates and location uncertainty (in meters), with a confidence level of 95%. The geofenced very low power access point must use such coordinates and location uncertainty when comparing the devices specific location to the exclusion zone boundaries.

(ii) The applicant for certification of a geofenced very low power access point must demonstrate the accuracy of the geo-location method used and the location uncertainty.

(7) Service requirements:

(i) For centralized geofencing systems, geofencing system operators must provide continuous service to all very low power devices for which it has been designated to provide service. If a geofencing system ceases operation, the operator must provide at least 30-days' notice to the Commission and a description of any arrangements made for those devices to continue to receive exclusion zone update information.

(ii) For geofencing systems internal to the geofenced very low power device, the equipment certification responsible party must ensure that the device continues to be capable of receiving Commission database updates as required by this section.

(iii) As required by paragraph (o)(3) of this section, devices that do not receive timely geofencing update information or timely Commission database updates necessary to calculate up-to-date exclusion zones must cease operating.

(8) The geofencing system whether centralized or internal to the geofenced very low power device must ensure that all communications and interactions between the geofencing system and the geofenced very low power access point and/or all communications between the geofencing system and Commission databases are accurate and secure and that unauthorized parties cannot access or alter the database, the exclusion zones, or the list of excluded or available frequencies. Additionally, the geofencing system must incorporate security measures to protect against unauthorized data input or alteration of stored data, including establishing communications authentication procedures between client devices and geofenced very low power access points.

(9) A geofencing system must implement the terms of international agreements with Mexico and Canada.

(10) At the time that the geofenced very low power device receives equipment certification, the device must either have its geofencing system approved or specify an already approved geofencing

system that it is using. The Commission may specify criteria for such approval, which could require test results to be submitted.

(11) Each geofencing system and operator thereof for centralized systems and the equipment certification responsible party for systems internal to the geofenced very low power device must:

(i) Ensure that a regularly updated geofencing system database that contains the information described in this section, including incumbent's information and geofenced very low power access points authorization parameters, is maintained.

(ii) Respond in a timely manner to verify, correct, or remove, as appropriate, data in the event that the Commission or a party presents a claim of inaccuracies in the geofencing system.

(iii) Establish and follow protocols to comply with enforcement instructions from the Commission, including discontinuance of geofenced very low power access point operations on specified frequencies in designated geographic areas and predetermined exclusion zones.

(iv) Comply with instructions from the Commission to adjust exclusion zones to more accurately reflect the potential for harmful interference.

(12) A geofencing system operator may charge fees for providing service. The Commission may, upon request, review the fees and can require changes to those fees if the Commission finds them to be unreasonable.

(p) *Incumbent Protection by Geofencing system:* A very low power access point or very low power client device must not cause harmful interference to fixed microwave services and Broadcast Auxiliary Service and Cable Television Relay Service receive sites authorized to operate in the 5.925–7.125 GHz bands. Based on the criteria set forth below, a geofencing system must establish location and frequency-based exclusion zones around fixed microwave receivers, fixed Broadcast Auxiliary Service receive sites, and fixed Cable Television Relay Service receive sites operating in the 5.925–7.125 GHz bands. Individual very low power access points and their associated client devices must not operate co-channel to the frequencies licensed for fixed microwave systems, fixed Broadcast Auxiliary Service receive sites, and fixed Cable Television Relay Service sites within an exclusion zone.

(1) Propagation Models: Geofencing systems must use the following propagation models to determine exclusion zones for very low power access points. For a separation distance between geofenced very low power devices and fixed microwave receive sites , fixed Broadcast Auxiliary Service receive sites, or fixed Cable Television Relay Service receive sites

(i) Up to 30 meters, the geofencing system must use the free space path-loss model.

(ii) More than 30 meters and up to and including one kilometer, the geofencing system must use the Wireless World Initiative New Radio phase II (WINNER II) model. The geofencing system must use site-specific information, including buildings and terrain data, for determining the line-of-sight/non-line-of-sight path component in the WINNER II model, where such data are available. For evaluating paths where such data are not available, the geofencing system must use a probabilistic model combining the line-of-sight path and non-line-of-sight path into a single path-loss as follows:

Path-loss (L) = $\sum_i P(i) * L_i = P_{LOS} * L_{LOS} + P_{NLOS} * L_{NLOS;}$

Where:

P_{LOS} is the probability of line-of-sight;

L_{LOS} is the line-of-sight path loss;

P_{NLOS} is the probability of non-line-of sight;

L_{NLOS} is the non-line-of-sight path loss; and

L is the combined path loss.

The WINNER II path loss models include a formula to determine P_{LOS} as a function of antenna heights and distance. P_{NLOS} is equal to $(1-P_{LOS})$.

In all cases, the geofencing system will use the correct WINNER II parameters to match the morphology of the path between a very low power access point and a fixed microwave receiver,fixed Broadcast Auxiliary Service receiver, or fixed Cable Television Relay Service receiver (i.e., Urban, Suburban, or Rural).

(iii) More than one kilometer, the geofencing system must use Irregular Terrain Model (ITM) combined with the appropriate clutter model. To account for the effects of clutter, such as buildings and foliage, the geofencing system must combine the ITM with the ITU–R P.2108–0 (06/2017) clutter model for urban and suburban environments and the ITU–R P.452–16 (07/2015) clutter model for rural environments. The geofencing system should use the most appropriate clutter category for the local morphology when using ITU–R P.452–16. However, if detailed local information is not available, the "Village Centre" clutter category should be used. The geofencing system must use 1 arc-second digital elevation terrain data and, for locations where such data are not available, the most granular available digital elevation terrain data.

(iv) Geofencing systems may include up to 4 dB additional loss to account for losses due to scattering and absorption from a nearby body or object.

(v) Geofencing systems may calculate exclusion zones based on a 1.5 meter very low power access point antenna height above ground level, regardless of the actual antenna height above ground level.

(2) Interference Protection Criteria: The geofencing system must use −6 dB I/N as the interference protection criteria when calculating the exclusion zones where I (interference) is the co-channel signal from the very low power access point at the fixed microwave service receiver, fixed Broadcast Auxiliary Service receiver, or fixed Cable Television Relay Service receiver and N (noise) is background noise level at the fixed microwave service receiver, fixed Broadcast Auxiliary Service receiver, or fixed Cable Television Relay Service receiver.

(q) *Incumbent Protection by Geofencing System: Radio Astronomy Services.*

(1) The geofencing system must enforce exclusion zones to the following radio observatories that observe between 6650-6675.2 MHz: Arecibo Observatory, the Green Bank Observatory, the Very Large Array (VLA), the 10 Stations of the Very Long Baseline Array (VLBA), the Owens Valley Radio Observatory, and the Allen Telescope Array.

(2) The exclusion zone sizes are based on the radio line-of-sight and determined using 4/3 earth curvature and the following formula:

dkm_los = 4.12*(sqrt(Htx) + sqrt(Hrx))

Where:

Htx is the height of the very low power access point and is set at 1.5 meters above ground level; and

Hrx is the height of the radio astronomy antenna in meters above ground level. Coordinate locations of the radio observatories are listed in section 2.106(c)(131), (c)(385) of this part.

(r) *Incumbent Protection by Geofencing System: FSS (space-to-Earth) Earth Stations.*

(1) The geofencing system must enforce exclusion zones to protect FSS earth stations that receive in the 6875-7055 MHz band at Clifton, TX, Cabo Rojo, PR, Wasilla, AK, Sebring, FL, and Naalehu, HI.

(2) The exclusion zone sizes are based on the radio line-of-sight and determined using 4/3 earth curvature and the following formula:

dkm_los = 4.12*(sqrt(Htx) + sqrt(Hrx))

Where:

Htx is the height of the very low power access point and is set at 1.5 meters above ground level; and

Hrx is the height of the FSS antenna in meters above ground level. Coordinate locations of the FSS sites are listed in the following table

Location	Coordinates
Clifton, Texas	**31° 47' 59.22" N, 97° 36' 46.71" W**
Clifton, Texas	**31° 48' 2.149" N, 97° 36' 44.37" W**
Clifton, Texas	**31° 47' 57.4" N, 97° 36' 47.9" W**
Clifton, Texas	**31° 48' 0.1" N, 97° 36' 48.9" W**
Clifton, Texas	**31° 48' 3" N, 97° 36' 49.2" W**
Clifton, Texas	**31° 47' 57.5" N, 97° 36' 44.7" W**
Clifton, Texas	**31° 48' 0.2" N, 97° 36' 44.3" W**
Sebring, Florida	**27° 27' 34.3" N, 81° 21' 26.6" W**
Sebring, Florida	**27° 27' 35.6" N, 81° 21' 26.8" W**
Sebring, Florida	**27° 27' 35.6" N, 81° 21' 28.4" W**

Sebring, Florida	**27° 27' 34.3" N, 81° 21' 28.3" W**
Wasilla, Alaska	**61° 35' 24.9" N, 149° 29' 9.6" W**
Wasilla, Alaska	**61° 35' 24.1" N, 149° 29' 6" W**
Wasilla, Alaska	**61° 35' 24.6" N, 149° 29' 2.4" W**
Cabo Rojo, Puerto Rico	**17° 58' 48" N, 67° 8' 15" W**
Cabo Rojo, Puerto Rico	**17° 58' 50" N, 67° 8' 13" W**
Cabo Rojo, Puerto Rico	**17° 58' 49" N, 67° 8' 14" W**
Cabo Rojo, Puerto Rico	**17° 58' 48" N, 67° 8' 12" W**
Naalehu, Hawaii	**19° 0' 51.99" N, 155° 39' 47" W**
Naalehu, Hawaii	**19° 0' 52.99" N, 155° 39' 48.99" W**
Naalehu, Hawaii	**19° 0' 51" N, 155° 39' 48.9" W**

APPENDIX C
Final Regulatory Flexibility Analysis

1. As required by the Regulatory Flexibility Act of 1980, as amended (RFA),[1] an Initial Regulatory Flexibility Analysis (IRFA) was incorporated in the *Further Notice of Proposed Rulemaking* (*Further Notice*) released in April 2020.[2] The Federal Communications Commission (Commission) sought written public comment on the proposals in the *Further Notice*, including comment on the IRFA. No comments were filed addressing the IRFA. This present Final Regulatory Flexibility Analysis (FRFA) conforms to the RFA.[3]

A. Need for, and Objectives of, the Second Report and Order

2. In the *Second Report & Order*, the Commission builds upon existing part 15 rules by permitting the operation of both standard power devices under the control of an Automated Frequency Coordination (AFC) system and of indoor low-power unlicensed devices in the 5.925-7.125 GHz band (6 GHz band) by adding a new class of very low power (VLP) unlicensed devices. Through its *Second Report & Order*, the Commission also adopts rules to permit VLP devices to operate in the U-NII-5 (5.925-6.425 GHz) and U-NII-7 (6.525-6.875 GHz) sub-bands of the 6 GHz band. Further, the rules will permit VLP devices to operate anywhere with a power level up to -5 dBm./MHz EIRP power spectral density (PSD) in order to permit maximum flexibility for such devices. In addition, this action makes 850 megahertz of spectrum available for new and innovative high-speed, short-range devices. The rules adopted in the *Second Report & Order* are designed to balance the need to develop and introduce exciting new applications in the 6 GHz band while protecting the incumbent licensed services currently operating in the 6 GHz band from harmful interference. Specifically, the rules adopted in the *Second Report & Order* will permit VLP devices to operate anywhere in the U-NII-5 (5.925-6.425 GHz) and U-NII-7 (6.525-6.875 GHz) sub-bands of the 6 GHz band at power levels up to -5 dBm/MHz EIRP PSD without using a geofencing system or having a geo-location capability.

3. Through the Second Report & Order, the Commission meets two primary objectives. First, the adopted rules meet the demand for new services utilizing the 6 GHz band without sacrificing the quality of existing services. Second, the adopted rules maximize the benefits of growth in the band for small entities, whether they are unlicensed or incumbent operators, without incurring additional costs. Opening usage of the band to VLP unlicensed devices while ensuring there are no cost implications for either unlicensed devices or incumbent operators successfully accomplish these objectives.

B. Summary of Significant Issues Raised by Public Comments in Response to the IRFA

4. There were no comments filed that specifically addressed the proposed rules and policies presented in the IRFA.

C. Response to Comments by the Chief Counsel for Advocacy of the Small Business Administration

5. Pursuant to the Small Business Jobs Act of 2010, which amended the RFA, the Commission is required to respond to any comments filed by the Chief Counsel for Advocacy of the Small Business

[1] *See* 5 U.S.C. § 603. The RFA, 5 U.S.C. §§ 601-612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996, (SBREFA) Pub. L. No. 104-121, Title II, 110 Stat. 857 (1996).

[2] *Unlicensed Use of the 6 GHz Band*, Report and Order and Further Notice of Proposed Rulemaking, 35 FCC Rcd 3852, Appendix C, 3968-3975, paras. 1-20 (2020) (*6 GHz Order*).

[3] 5 U.S.C. § 604.

Administration (SBA), and to provide a detailed statement of any change made to the proposed rules as a result of those comments.[4]

6. The Chief Counsel did not file any comments in response to the proposed rules in this proceeding.

D. Description and Estimate of the Number of Small Entities To Which the Rules Will Apply

7. 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 rules adopted herein.[5] The RFA generally defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction."[6] In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.[7] A "small business concern" is one that: (1) is independently owned and operated; (2) is not dominant in its field of operation; and (3) satisfies any additional criteria established by the SBA.[8]

8. *Small Businesses, Small Organizations, Small Governmental Jurisdictions.* Our actions, over time, may affect small entities that are not easily categorized at present. We therefore describe, at the outset, three broad groups of small entities that could be directly affected herein.[9] First, while there are industry specific size standards for small businesses that are used in the regulatory flexibility analysis, according to data from the Small Business Administration's (SBA) Office of Advocacy, in general a small business is an independent business having fewer than 500 employees.[10] These types of small businesses represent 99.9% of all businesses in the United States, which translates to 33.2 million businesses.[11]

9. Next, the type of small entity described as a "small organization" is generally "any not-for-profit enterprise which is independently owned and operated and is not dominant in its field."[12] The Internal Revenue Service (IRS) uses a revenue benchmark of $50,000 or less to delineate its annual electronic filing requirements for small exempt organizations.[13] Nationwide, for tax year 2020, there

[4] *Id.* § 604 (a)(3).

[5] *Id*. § 604(a)(4).

[6] *Id*. § 601(6).

[7] *Id*. § 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."

[8] 15 U.S.C. § 632.

[9] *See* 5 U.S.C. § 601(3)-(6).

[10] *See* SBA, Office of Advocacy, "What's New With Small Business?," https://advocacy.sba.gov/wp-content/uploads/2023/03/Whats-New-Infographic-March-2023-508c.pdf. (Mar. 2023)

[11] *Id*.

[12] *See* 5 U.S.C. § 601(4).

[13] The IRS benchmark is similar to the population of less than 50,000 benchmark in 5 U.S.C § 601(5) that is used to define a small governmental jurisdiction. Therefore, the IRS benchmark has been used to estimate the number of small organizations in this small entity description. S*ee* Annual Electronic Filing Requirement for Small Exempt Organizations – Form 990-N (e-Postcard), "Who must file," https://www.irs.gov/charities-non-profits/annual-electronic-filing-requirement-for-small-exempt-organizations-form-990-n-e-postcard. We note that the IRS data

(continued….)

were approximately 447,689 small exempt organizations in the U.S. reporting revenues of $50,000 or less according to the registration and tax data for exempt organizations available from the IRS.[14]

10. Finally, the small entity described as a "small governmental jurisdiction" is defined generally as "governments of cities, counties, towns, townships, villages, school districts, or special districts, with a population of less than fifty thousand."[15] U.S. Census Bureau data from the 2017 Census of Governments[16] indicate there were 90,075 local governmental jurisdictions consisting of general purpose governments and special purpose governments in the United States.[17] Of this number, there were 36,931 general purpose governments (county,[18] municipal, and town or township[19]) with populations of less than 50,000 and 12,040 special purpose governments—independent school districts[20] with enrollment populations of less than 50,000.[21] Accordingly, based on the 2017 U.S. Census of Governments data, we estimate that at least 48,971 entities fall into the category of "small governmental jurisdictions."[22]

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does not provide information on whether a small exempt organization is independently owned and operated or dominant in its field.

[14] *See* Exempt Organizations Business Master File Extract (EO BMF), "CSV Files by Region," https://www.irs.gov/charities-non-profits/exempt-organizations-business-master-file-extract-eo-bmf. The IRS Exempt Organization Business Master File (EO BMF) Extract provides information on all registered tax-exempt/non-profit organizations. The data utilized for purposes of this description was extracted from the IRS EO BMF data for businesses for the tax year 2020 with revenue less than or equal to $50,000 for Region 1-Northeast Area (58,577), Region 2-Mid-Atlantic and Great Lakes Areas (175,272), and Region 3-Gulf Coast and Pacific Coast Areas (213,840) that includes the continental U.S., Alaska, and Hawaii. This data does not include information for Puerto Rico.

[15] *See* 5 U.S.C. § 601(5).

[16] *See* 13 U.S.C. § 161. The Census of Governments survey is conducted every five (5) years compiling data for years ending with "2" and "7". *See also* Census of Governments, https://www.census.gov/programs-surveys/cog/about.html.

[17] *See* U.S. Census Bureau, 2017 Census of Governments – Organization Table 2. Local Governments by Type and State: 2017 [CG1700ORG02], https://www.census.gov/data/tables/2017/econ/gus/2017-governments.html. Local governmental jurisdictions are made up of general purpose governments (county, municipal and town or township) and special purpose governments (special districts and independent school districts). *See also* tbl.2. CG1700ORG02 Table Notes_Local Governments by Type and State_2017.

[18] *See id.* at tbl.5. County Governments by Population-Size Group and State: 2017 [CG1700ORG05], https://www.census.gov/data/tables/2017/econ/gus/2017-governments.html. There were 2,105 county governments with populations less than 50,000. This category does not include subcounty (municipal and township) governments.

[19] *See id.* at tbl.6. Subcounty General-Purpose Governments by Population-Size Group and State: 2017 [CG1700ORG06], https://www.census.gov/data/tables/2017/econ/gus/2017-governments.html. There were 18,729 municipal and 16,097 town and township governments with populations less than 50,000.

[20] *See id.* at tbl.10. Elementary and Secondary School Systems by Enrollment-Size Group and State: 2017 [CG1700ORG10], https://www.census.gov/data/tables/2017/econ/gus/2017-governments.html. There were 12,040 independent school districts with enrollment populations less than 50,000. *See also* tbl.4. Special-Purpose Local Governments by State Census Years 1942 to 2017 [CG1700ORG04], CG1700ORG04 Table Notes_Special Purpose Local Governments by State_Census Years 1942 to 2017.

[21] While the special purpose governments category also includes local special district governments, the 2017 Census of Governments data does not provide data aggregated based on population size for the special purpose governments category. Therefore, only data from independent school districts is included in the special purpose governments category.

[22] This total is derived from the sum of the number of general purpose governments (county, municipal and town or township) with populations of less than 50,000 (36,931) and the number of special purpose governments -

(continued….)

11. *Fixed Microwave Services.* Fixed microwave services include common carrier,[23] private-operational fixed,[24] and broadcast auxiliary radio services.[25] They also include the Upper Microwave Flexible Use Service (UMFUS),[26] Millimeter Wave Service (70/80/90 GHz),[27] Local Multipoint Distribution Service (LMDS),[28] the Digital Electronic Message Service (DEMS),[29] 24 GHz Service,[30] Multiple Address Systems (MAS),[31] and Multichannel Video Distribution and Data Service (MVDDS),[32] where in some bands licensees can choose between common carrier and non-common carrier status.[33] Wireless Telecommunications Carriers (*except* Satellite)[34] is the closest industry with a SBA small business size standard applicable to these services. The SBA small size standard for this industry classifies a business as small if it has 1,500 or fewer employees.[35] U.S. Census Bureau data for 2017 show that there were 2,893 firms that operated in this industry for the entire year.[36] Of this number, 2,837 firms employed fewer than 250 employees.[37] Thus under the SBA size standard, the Commission estimates that a majority of fixed microwave service licensees can be considered small.

12. The Commission's small business size standards with respect to fixed microwave services involve eligibility for bidding credits and installment payments in the auction of licenses for the various frequency bands included in fixed microwave services. When bidding credits are adopted for the auction of licenses in fixed microwave services frequency bands, such credits may be available to several types of small businesses based average gross revenues (small, very small and entrepreneur) pursuant to the competitive bidding rules adopted in conjunction with the requirements for the auction and/or as

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independent school districts with enrollment populations of less than 50,000 (12,040), from the 2017 Census of Governments - Organizations tbls.5, 6 & 10.

[23] *See* 47 CFR pt. 101, Subt. C and I.

[24] *See id*. Subt. C and H.

[25] 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.

[26] *See* 47 CFR pt. 30.

[27] *See* 47 CFR pt. 101, Subt. Q.

[28] *See id*. Subt. L.

[29] *See id*. Subt. G.

[30] *See id*.

[31] *See id.* Subt. O.

[32] *See id*. Subt. P.

[33] *See* 47 CFR §§ 101.533, 101.1017.

[34] *See* U.S. Census Bureau, *2017 NAICS Definition, "517312 Wireless Telecommunications Carriers* (*except Satellite*)," https://www.census.gov/naics/?input=517312&year=2017&details=517312.

[35] *See* 13 CFR § 121.201, NAICS Code 517312 (as of 10/1/22, NAICS Code 517112).

[36] *See* U.S. Census Bureau, *2017 Economic Census of the United States*, *Employment Size of Firms for the U.S.: 2017,* Table ID: EC1700SIZEEMPFIRM, NAICS Code 517312, https://data.census.gov/cedsci/table?y=2017&n=517312&tid=ECNSIZE2017.EC1700SIZEEMPFIRM&hidePreview=false.

[37] *Id*. The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard.

identified in Part 101 of the Commission's rules for the specific fixed microwave services frequency bands.[38]

13. In frequency bands where licenses were subject to auction, the Commission notes that as a general matter, the number of winning bidders that qualify as small businesses at the close of an auction does not necessarily represent the number of small businesses currently in service. Further, the Commission does not generally track subsequent business size unless, in the context of assignments or transfers, unjust enrichment issues are implicated. Additionally, since the Commission does not collect data on the number of employees for licensees providing these services, at this time we are not able to estimate the number of licensees with active licenses that would qualify as small under the SBA's small business size standard.

14. *Public Safety Radio Licensees.* As a general matter, Public Safety Radio Pool licensees include police, fire, local government, forestry conservation, highway maintenance, and emergency medical services.[39] Because of the vast array of public safety licensees, the Commission has not developed a small business size standard specifically applicable to public safety licensees. Wireless Telecommunications Carriers (*except* Satellite)[40] is the closest industry with a SBA small business size standard applicable to these services. The SBA small business size standard for this industry classifies a business as small if it has 1,500 or fewer employees.[41] U.S. Census Bureau data for 2017 show that there were 2,893 firms that operated in this industry for the entire year.[42] Of this number, 2,837 firms employed fewer than 250 employees.[43] Thus under the SBA size standard, the Commission estimates that a majority of licensees in this industry can be considered small.

15. *Satellite Telecommunications.* This industry comprises firms "primarily engaged in providing telecommunications services to other establishments in the telecommunications and broadcasting industries by forwarding and receiving communications signals via a system of satellites or reselling satellite telecommunications."[44] Satellite telecommunications service providers include satellite and earth

[38] *See* 47 CFR §§ 101.538(a)(1)-(3), 101.1112(b)-(d), 101.1319(a)(1)-(2), and 101.1429(a)(1)-(3).

[39] *See* subparts. A and B of pt. 90 of the Commission's Rules, 47 CFR §§ 90.1-90.22. Police licensees serve state, county, and municipal enforcement through telephony (voice), telegraphy (code), and teletype and facsimile (printed material). Fire licensees are comprised of private volunteer or professional fire companies, as well as units under governmental control. Public Safety Radio Pool licensees also include state, county, or municipal entities that use radio for official purposes. State departments of conservation and private forest organizations comprise forestry service licensees that set up communications networks among fire lookout towers and ground crews. State and local governments are highway maintenance licensees that provide emergency and routine communications to aid other public safety services to keep main roads safe for vehicular traffic. Emergency medical licensees use these channels for emergency medical service communications related to the delivery of emergency medical treatment. Additional licensees include medical services, rescue organizations, veterinarians, persons with disabilities, disaster relief organizations, school buses, beach patrols, establishments in isolated areas, communications standby facilities, and emergency repair of public communications facilities.

[40] *See* U.S. Census Bureau, *2017 NAICS Definition, "517312 Wireless Telecommunications Carriers* (*except Satellite*)," https://www.census.gov/naics/?input=517312&year=2017&details=517312.

[41] *See* 13 CFR § 121.201, NAICS Code 517312 (as of 10/1/22, NAICS Code 517112).

[42] *See* U.S. Census Bureau, *2017 Economic Census of the United States*, *Employment Size of Firms for the U.S.: 2017,* Table ID: EC1700SIZEEMPFIRM, NAICS Code 517312, https://data.census.gov/cedsci/table?y=2017&n=517312&tid=ECNSIZE2017.EC1700SIZEEMPFIRM&hidePreview=false.

[43] *Id*. The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard.

[44] *See* U.S. Census Bureau, *2017 NAICS Definition, "517410 Satellite Telecommunications,"* https://www.census.gov/naics/?input=517410&year=2017&details=517410.

station operators. The SBA small business size standard for this industry classifies a business with $38.5 million or less in annual receipts as small.[45] U.S. Census Bureau data for 2017 show that 275 firms in this industry operated for the entire year.[46] Of this number, 242 firms had revenue of less than $25 million.[47] Additionally, based on Commission data in the 2022 Universal Service Monitoring Report, as of December 31, 2021, there were 65 providers that reported they were engaged in the provision of satellite telecommunications services.[48] Of these providers, the Commission estimates that approximately 42 providers have 1,500 or fewer employees.[49] Consequently, using the SBA's small business size standard, a little more than half of these providers can be considered small entities.

16. *Wireless Telecommunications Carriers (except Satellite).* This industry comprises establishments engaged in operating and maintaining switching and transmission facilities to provide communications via the airwaves.[50] Establishments in this industry have spectrum licenses and provide services using that spectrum, such as cellular services, paging services, wireless Internet access, and wireless video services.[51] The SBA size standard for this industry classifies a business as small if it has 1,500 or fewer employees.[52] U.S. Census Bureau data for 2017 show that there were 2,893 firms in this industry that operated for the entire year.[53] Of that number, 2,837 firms employed fewer than 250 employees.[54] Additionally, based on Commission data in the 2022 Universal Service Monitoring Report, as of December 31, 2021, there were 594 providers that reported they were engaged in the provision of wireless services.[55] Of these providers, the Commission estimates that 511 providers have 1,500 or fewer employees.[56] Consequently, using the SBA's small business size standard, most of these providers can be considered small entities.

[45] *See* 13 CFR § 121.201, NAICS Code 517410.

[46] *See* U.S. Census Bureau, *2017 Economic Census of the United States*, *Selected Sectors: Sales, Value of Shipments, or Revenue Size of Firms for the U.S.: 2017,* Table ID: EC1700SIZEREVFIRM, NAICS Code 517410, https://data.census.gov/cedsci/table?y=2017&n=517410&tid=ECNSIZE2017.EC1700SIZEREVFIRM&hidePreview=false.

[47] *Id*. The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard. We also note that according to the U.S. Census Bureau glossary, the terms receipts and revenues are used interchangeably, *see* https://www.census.gov/glossary/#term_ReceiptsRevenueServices.

[48] Federal-State Joint Board on Universal Service, Universal Service Monitoring Report at 26, Table 1.12 (2022), https://docs.fcc.gov/public/attachments/DOC-391070A1.pdf.

[49] *Id.*

[50] *See* U.S. Census Bureau, *2017 NAICS Definition, "517312 Wireless Telecommunications Carriers (except Satellite),"* https://www.census.gov/naics/?input=517312&year=2017&details=517312.

[51] *Id.*

[52] *See* 13 CFR § 121.201, NAICS Code 517312 (as of 10/1/22, NAICS Code 517112).

[53] *See* U.S. Census Bureau, *2017 Economic Census of the United States*, *Employment Size of Firms for the U.S.: 2017,* Table ID: EC1700SIZEEMPFIRM, NAICS Code 517312, https://data.census.gov/cedsci/table?y=2017&n=517312&tid=ECNSIZE2017.EC1700SIZEEMPFIRM&hidePreview=false.

[54] *Id*. The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard.

[55] Federal-State Joint Board on Universal Service, Universal Service Monitoring Report at 26, Table 1.12 (2022), https://docs.fcc.gov/public/attachments/DOC-391070A1.pdf.

[56] *Id.*

17. The Commission's own data—available in its Universal Licensing System—indicate that, as of May 17, 2018, there are 264 Cellular licensees.[57] The Commission does not know how many of these licensees are small, as the Commission does not collect that information for these types of entities. Similarly, according to internally developed Commission data, 413 carriers reported that they were engaged in the provision of wireless telephony, including cellular service, Personal Communications Service (PCS), and Specialized Mobile Radio (SMR) Telephony services.[58] Of this total, an estimated 261 have 1,500 or fewer employees, and 152 have more than 1,500 employees.[59] Thus, using available data, we estimate that the majority of wireless firms can be considered small.

18. *Auxiliary, Special Broadcast and Other Program Distribution Services*. This service involves a variety of transmitters, generally used to relay broadcast programming to the public (through translator and booster stations) or within the program distribution chain (from a remote news gathering unit back to the station). Neither the SBA nor the Commission have developed a small business size standard applicable to broadcast auxiliary licensees. The closest applicable industries with a SBA small business size standard fall within two industries - Radio Stations[60] and Television Broadcasting.[61] The SBA small business size standard for Radio Stations classifies firms having $41.5 million or less in annual receipts as small.[62] U.S. Census Bureau data for 2017 show that 2,963 firms operated in this industry during that year.[63] Of that number, 1,879 firms operated with revenue of less than $25 million per year.[64] For Television Broadcasting, the SBA small business size standard also classifies firms having $41.5 million or less in annual receipts as small.[65] U.S. Census Bureau data for 2017 show that 744 firms in this industry operated for the entire year.[66] Of that number, 657 firms had revenue of less

[57] *See* http://wireless.fcc.gov/uls. For the purposes of this IRFA, consistent with Commission practice for wireless services, the Commission estimates the number of licensees based on the number of unique FCC Registration Numbers.

[58] *See* Federal Communications Commission, Wireline Competition Bureau, Industry Analysis and Technology Division, Trends in Telephone Service at Table 5.3 (Sept. 2010) (*Trends in Telephone Service*), https://apps.fcc.gov/edocs_public/attachmatch/DOC-301823A1.pdf.

[59] *See id*.

[60] *See* U.S. Census Bureau, *2017 NAICS Definition, "515112 Radio Stations*," https://www.census.gov/naics/?input=515112&year=2017&details=515112.

[61] *See* U.S. Census Bureau, *2017 NAICS Definition, "515120 Television Broadcasting,*" https://www.census.gov/naics/?input=515120&year=2017&details=515120.

[62] *See* 13 CFR § 121.201, NAICS Code 515112 (as of 10/1/22 NAICS Code 516110).

[63] *See* U.S. Census Bureau, *2017 Economic Census of the United States*, *Selected Sectors: Sales, Value of Shipments, or Revenue Size of Firms for the U.S.: 2017,* Table ID: EC1700SIZEREVFIRM, NAICS Code 515112, https://data.census.gov/cedsci/table?y=2017&n=515112&tid=ECNSIZE2017.EC1700SIZEREVFIRM&hidePreview=false. We note that the US Census Bureau withheld publication of the number of firms that operated for the entire year.

[64] *Id.* The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard. We note that the U.S. Census Bureau withheld publication of the number of firms that operated with sales/value of shipments/revenue in the individual categories for less than $100,000, and $100,000 to $249,999 to avoid disclosing data for individual companies (see Cell Notes for the sales/value of shipments/revenue in these categories). Therefore, the number of firms with revenue that meet the SBA size standard would be higher that noted herein. We also note that according to the U.S. Census Bureau glossary, the terms receipts and revenues are used interchangeably, *see* https://www.census.gov/glossary/#term_ReceiptsRevenueServices.

[65] *See* 13 CFR § 121.201, NAICS Code 515120 (as of 10/1/22 NAICS Code 516120).

[66] *See* U.S. Census Bureau, *2017 Economic Census of the United States*, *Selected Sectors: Sales, Value of Shipments, or Revenue Size of Firms for the U.S.: 2017,* Table ID: EC1700SIZEREVFIRM, NAICS Code 515120,

(continued….)

than $25 million per year.[67] Accordingly, based on the U.S. Census Bureau data for Radio Stations and Television Broadcasting, the Commission estimates that the majority of Auxiliary, Special Broadcast and Other Program Distribution Services firms are small under the SBA size standard.

19. *Fixed Satellite Small Transmit/Receive Earth Stations.* Neither the SBA nor the Commission have developed a small business size standard specifically applicable to Fixed Satellite Small Transmit/Receive Earth Stations. Satellite Telecommunications[68] is the closest industry with an SBA small business size standard. The SBA size standard for this industry classifies a business as small if it has $38.5 million or less in annual receipts.[69] For this industry, U.S. Census Bureau data for 2017 show that there was a total of 275 firms that operated for the entire year.[70] Of this total, 242 firms had revenue of less than $25 million.[71] Additionally, based on Commission data in the 2022 Universal Service Monitoring Report, as of December 31, 2021, there were 65 providers that reported they were engaged in the provision of satellite telecommunications services.[72] Of these providers, the Commission estimates that approximately 42 providers have 1,500 or fewer employees.[73] Consequently, using the SBA's small business size standard, a little more than half of these providers can be considered small entities.

E. Description of Projected Reporting, Recordkeeping, and Other Compliance Requirements for Small Entities

20. The rules adopted in the *Second Report & Order* will impose new or modified reporting, recordkeeping or other compliance requirements on small and other entities. The Commission is not in a position to determine whether these new rules will require small entities to hire attorneys, engineers, consultants, or other professionals, however the adopted rules will provide opportunities for small entities to grow their businesses by allowing the expansion of VLP devices to operate across the entire 6 GHz band.

21. The adopted rules will permit VLP devices to operate across the U-NII-5 (5.925-6.425 GHz) and U-NII-7 (6.525-6.875 GHz) sub-bands of the 6 GHz band and will also permit VLP devices to operate at a power level no greater than -5 dBm/MHz EIRP PSD to avoid causing harmful interference to fixed microwave, Broadcast Auxiliary Service (BAS), Cable Television Relay Service (CARS), and radio astronomy receive sites.

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https://data.census.gov/cedsci/table?y=2017&n=515120&tid=ECNSIZE2017.EC1700SIZEREVFIRM&hidePreview=false.

[67] *Id*. The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard. We also note that according to the U.S. Census Bureau glossary, the terms receipts and revenues are used interchangeably, *see* https://www.census.gov/glossary/#term_ReceiptsRevenueServices.

[68] *See* U.S. Census Bureau, *2017 NAICS Definition, "517410 Satellite Telecommunications,"* https://www.census.gov/naics/?input=517410&year=2017&details=517410.

[69] *See* 13 CFR § 121.201, NAICS Code 517410.

[70] *See* U.S. Census Bureau, *2017 Economic Census of the United States*, *Selected Sectors: Sales, Value of Shipments, or Revenue Size of Firms for the U.S.: 2017,* Table ID: EC1700SIZEREVFIRM, NAICS Code 517410, https://data.census.gov/cedsci/table?y=2017&n=517410&tid=ECNSIZE2017.EC1700SIZEREVFIRM&hidePreview=false.

[71] *Id*. The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard. We also note that according to the U.S. Census Bureau glossary, the terms receipts and revenues are used interchangeably, *see* https://www.census.gov/glossary/#term_ReceiptsRevenueServices.

[72] Federal-State Joint Board on Universal Service, Universal Service Monitoring Report at 26, Table 1.12 (2022), https://docs.fcc.gov/public/attachments/DOC-391070A1.pdf.

[73] *Id.*

22. We will require applicants for certification of VLP devices to show in their application for device certification how their devices will comply with all technical requirements set in this proceeding. This new requirement will not increase the cost of applying for certification.

23. The Commission estimates the economic value to service providers operating in the 6 GHz band will vastly exceed their cost. By opening access to the 6 GHz band, the adopted rules will foster extensive growth in the market for VLP devices, with one report estimating that VLP devices would product over $39 billion in economic value over five years.[74] Lastly, the adopted rules will permit unlicensed small entities to operate VLP devices in the 6 GHz band without the additional complications or costs incurred to obtain a license.

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

24. The RFA requires an agency to provide, "a description of the steps the agency has taken to minimize the significant economic impact on small entities…including a statement of the factual, policy, and legal reasons for selecting the alternative adopted in the final rule and why each one of the other significant alternatives to the rule considered by the agency which affect the impact on small entities was rejected."[75]

25. The rules adopted by the Commission in the *Second Report and Order* should benefit small entities by giving them more options for gaining access to valuable spectrum while creating little to no harmful interference to licensed incumbents sharing the 6 GHz band. Through comments provided during the rulemaking proceeding, the Commission considered various proposals from small and other entities. The adopted rules reflect the Commission's efforts to balance the desire of unlicensed VLP devices to utilize as much power as possible to maximize the benefits provided to their customers while protecting incumbent operators in the 6 GHz band from harmful interference. Additionally, the Commission considered alternative proposals and weighed their benefits against their potential costs to small businesses and other entities. For example, in determining the maximum power level rules for VLP devices, the Commission considered proposals from various commenters representing incumbents, but ultimately used the Monte Carlo computer simulation analysis submitted by VLP proponents to determine VLP devices should operate at a power level up to -5 dBm/MHz without requiring geofencing or exclusion zones. This decision minimizes the economic impact of small and other entities seeking to operate in the 6 GHz band. Further, it also allows for operations at a higher power level with only insignificant potential for harmful interference to incumbent operators. [76]

26. Many of the entities holding licenses for use of the 6 GHz band qualify as small entities. The adopted rules for unlicensed operation in this band are designed to prevent the unlicensed VLP devices from causing harmful interference to the licensed services operating in the band. Consequently, we do not expect that the current and future licensees in the band, including small entities, would experience a significant economic impact from permitting VLP unlicensed devices to operate in the 6 GHz band. As an alternative, the Commission considered comments by microwave incumbents recommending the adoption of rules requiring the use of Automated Frequency Coordination (AFC) systems to control spectrum access by VLP devices operating at -5 dBm/MHz as a means of preventing interference. However, the Commission concluded that adopting this approach would be both unnecessary and

[74] Telecom Advisory Services, LLC, Assessing the Economic Value of Unlicensed Use in the 5.9 GHz & 6 GHz Bands at 49-56 (Apr. 2020), http://wififorward.org/wp-content/uploads/2020/04/5.9-6.0-FINAL-for-distribution.pdf.

[75] 5 U.S.C. § 604(a)(6).

[76] A Monte Carlo simulation uses random sampling and statistical modeling to estimate mathematical functions and mimic the operations of complex systems. Harrison RL., *Introduction To Monte Carlo Simulation*, AIP Conf Proc. 2010;1204:17–21. doi:10.1063/1.3295638.

burdensome, as the risk of harmful interference from VLP devices operating at that power level is insignificant and would create an unnecessary cost to VLP device operators.

27. Users of devices operating under our part 15 rules do not need to obtain a Commission license. Therefore, we expect that small entities would make use of 6 GHz VLP devices under the adopted rules and would also provide small entities with access to valuable spectrum without the expense and inconvenience of having to obtain a license.

28. The Commission believes that this rulemaking, by permitting VLP devices to operate in the 6 GHz band, will provide an advantage to small entities, as these entities would benefit from being able to access this spectrum without the complication or cost of needing to obtain a license. On balance, this would constitute a significant economic benefit for small businesses.

G. Report to Congress

29. The Commission will send a copy of the *Second Report and Order*, including this FRFA, in a report to Congress pursuant to the Congressional Review Act.[77] In addition, the Commission will send a copy of the *Second Report and Order*, including this FRFA, to the Chief Counsel for Advocacy of the SBA. A copy of the *Second Report and Order* and FRFA (or summaries thereof) will also be published in the Federal Register.[78]

[77] *See* 5 U.S.C. § 801(a)(1)(A).

[78] *See id*. § 604(b).

APPENDIX D

Initial Regulatory Flexibility Analysis

1. As required by the Regulatory Flexibility Act of 1980, as amended (RFA),[1] the Federal Communications Commission (Commission) has prepared this Initial Regulatory Flexibility Analysis (IRFA) of the possible significant economic impact on a substantial number of small entities by the policies and rules proposed in the *Second Further Notice of Proposed Rulemaking (Second Further Notice)*. 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 in the *Second Further Notice*. The Commission will send a copy of the *Second Further Notice*, including this IRFA, to the Chief Counsel for Advocacy of the Small Business Administration (SBA).[2] In addition, the *Second Further Notice* and IRFA (or summaries thereof) will be published in the Federal Register.[3]

A. Need for, and Objectives of, the Proposals

2. In the *Second Further Notice*, the Commission seeks comment on several proposals to expand the use of the 5.925-7.125 GHz band (6 GHz band) by unlicensed very low power (VLP) devices operating under the Commission's part 15 rules. These proposals are designed to provide increased flexibility for these unlicensed devices while preventing harmful interference from occurring to the licensed services currently operating in the 6 GHz band such as point-to-point microwave links, broadcast auxiliary service (BAS) operations, and satellite systems. These proposals have evolved in response to the Commission's previous efforts to address these longstanding issues.

3. In April 2020, the Commission adopted rules for two types of unlicensed operations in the 6 GHz band.[4] First, unlicensed standard-power access points in the U-NII-5 (5.925-6.425 GHz) and U-NII-7 (6.525-6.875 GHz) bands were now able to access spectrum through use of an Automated Frequency Coordination (AFC) system.[5] Second, unlicensed low-power indoor (LPI) access points were now able to operate without an AFC system over the entire 6 GHz band.[6] Further in the *Second Report and Order,* the Commission adopted rules to permit very low power (VLP) devices, an additional type of unlicensed device, to operate in the 6 GHz band.

4. Currently, the Commission's rules permit VLP devices to operate at up to -5 dBm/MHz EIRP power spectral density (PSD) and a maximum EIRP of 14 dBm. In the *Second Further Notice*, the Commission seeks comment on several proposals to enhance VLP operations and standard-power operations in the 6 GHz band. One proposal is to permit VLP devices to operate at a power level higher than -5 dBm/MHz EIRP PSD if they incorporate a geofencing system to avoid causing harmful interference to fixed microwave, Broadcast Auxiliary Service (BAS), Cable Television Relay Service (CARS), and radio astronomy receive sites. The geofencing system will ensure that these VLP access

[1] *See* 5 U.S.C. § 603. The RFA, *see* 5 U.S.C. §§ 601–612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), Pub. L. No. 104-121, Title II, 110 Stat. 857 (1996).

[2] *See* 5 U.S.C. § 603(a).

[3] *Id*.

[4] *Unlicensed Use of the 6 GHz Band; Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, Report and Order and Further Notice of Proposed Rulemaking, 35 FCC Rcd 3852 (2020) (*6 GHz Order*), *reversed in part, aff'd in part and remanded*, *AT&T Servs. Inc., v. FCC*, 21 F.4th 841, 853-54 (D.C. Cir. 2020) (affirming 6 GHz Order and reversing and remanding to address issue of whether to "reserve a sliver of the 6 GHz band for licensed mobile operation").

[5] *6 GHz Order,* 35 FCC Rcd at 3860, para. 17.

[6] *6 GHz Order,* 35 FCC Rcd at 3860, para. 18.

points operate only outside of defined exclusion zones designed to protect these services. To achieve this, the proposed rules would adopt requirements for geofencing systems and specify the criteria that will be used to calculate the exclusion zones as well as the technical requirements that VLP devices must meet. Each VLP access point that operates at a power greater than -5 dBm/MHz EIRP PSD should be able to connect to a valid geofencing system and applicants should be able to demonstrate such a capability during device certification and the geofencing system test and approval process.

5. Additional modifications to the current rules could be based on the characteristics of the VLP devices, the use geofencing systems to allow VLP devices to operate at higher power levels without causing harmful interference to licensed incumbents, the use of land use databases to more accurately determine where the devices may operate, the use of different propagation models by the geofencing systems to determine where VLP devices may operate, or the use of a different protection criteria by the geofencing systems for determining exclusion zones.

6. The Commission also seeks comment on proposals to relax several restrictions on the use of VLP devices in the current rules. The current rules prohibit the devices from operating on aircraft, except for large passenger aircraft while flying over 10,000 feet in the U-NII-5 portion of the band. The rules also prohibit the operation of VLP devices on oil platforms. The *Second Further Notice* proposes to permit VLP devices to be used on commercial and general aviation aircraft except for unmanned aircraft. Additionally, the *Second Further Notice* seeks comment on removing or scaling back the prohibition on use of VLP devices on oil platforms, on boats on the ocean, and in terrestrial vehicles.

7. Another area in which the Commission seeks comment regards having the geofencing systems use a push notification method to more efficiently manage spectrum use of VLP devices in the U-NII-6 and U-NII-8 portions of the 6 GHz band. In the U-NII-6 (6.425-6.525 GHz) and U-NII-8 (6.875-7.125 GHz) portions of the band BAS and CARS licensees use pick-up stations to transmit programming from news events or other special events at remote locations. This involves transmitting from trucks which employ directional antennas to central receive sites that also use directional antennas typically located on towers or rooftops. Because news events can occur anywhere at any time, the use of this spectrum by the BAS and CARS licensees changes frequently. Under the current rules the geofencing systems have to protect the BAS and CARS central receive sites in all directions and across the entire U-NII-6 and U-NII-8 bands because they do not know when and where the spectrum will actually be used. The proposal outlined in the *Second Further Notice* would require the BAS and CARS licensees to register the location and times they will use the pickup stations. The geofencing systems will then send a "push" notification to the VLP access points to have them avoid transmitting on frequencies at locations where they could interfere with the BAS and CARS use of the band.

8. At present, the Commission's rules do not permit standard power unlicensed devices to operate in the U-NII-6 and U-NII-8 bands. In order to address this issue, the *Second Further Notice* proposes directing the Commission's Office of Engineering and Technology to collect information on the location of receive sites used by BAS and CARS licensees in these bands to enable geofencing systems to create exclusion zones to protect these receivers. Once this information has been collected, the AFC systems which control access to spectrum by standard power devices will be able to protect the BAS and CARS receive sites in these bands. Consequently, the *Second Further Notice* seeks comment on permitting standard power devices to operate in the U-NII-6 and U-NII-8 bands.

9. Currently there are fixed satellite service (FSS) receive earth stations at five location in the 7.025-7.055 GHz band. The Commission's rules require geofencing systems to prohibit operation of VLP access points in this band for a large zone around these locations. The *Second Further Notice* seeks comment on whether geofencing is necessary to protect the operation of these earth stations from harmful interference from VLP devices, the restriction of VLP device operation that may be necessary, and the technical parameters that could be needed for a geofencing system to determine exclusion zones around these earth station locations. Lastly, the *Second Further Notice* seeks comment on whether any changes

to the rules governing standard power devices are needed to protect these earth stations if the Commission permits standard power devices to operate in the U-NII-8 band.

B. Legal Basis

10. The proposed action is taken pursuant to sections 2, 4(i), 302a, and 303 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 152, 154(i), 302a, and 303.

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

11. The RFA directs agencies to provide a description of and, where feasible, an estimate of the number of small entities that may be affected by the proposed rules, if adopted.[7] The RFA generally defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction."[8] In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.[9] A small business concern is one that: (1) is independently owned and operated; (2) is not dominant in its field of operation; and (3) satisfies any additional criteria established by the SBA.[10]

12. ***Small Businesses, Small Organizations, Small Governmental Jurisdictions***. Our actions, over time, may affect small entities that are not easily categorized at present. We therefore describe, at the outset, three broad groups of small entities that could be directly affected herein.[11] First, while there are industry specific size standards for small businesses that are used in the regulatory flexibility analysis, according to data from the Small Business Administration's (SBA) Office of Advocacy, in general a small business is an independent business having fewer than 500 employees.[12] These types of small businesses represent 99.9% of all businesses in the United States, which translates to 33.2 million businesses.[13]

13. Next, the type of small entity described as a "small organization" is generally "any not-for-profit enterprise which is independently owned and operated and is not dominant in its field."[14] The Internal Revenue Service (IRS) uses a revenue benchmark of $50,000 or less to delineate its annual electronic filing requirements for small exempt organizations.[15] Nationwide, for tax year 2020, there

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[7] *Id*. § 603(b)(3).

[8] *Id*. § 601(6).

[9] *Id*. § 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."

[10] 15 U.S.C. § 632.

[11] *See* 5 U.S.C. § 601(3)-(6).

[12] *See* SBA, Office of Advocacy, "What's New With Small Business?,"

https://advocacy.sba.gov/wp-content/uploads/2023/03/Whats-New-Infographic-March-2023-508c.pdf. (Mar. 2023)

[13] *Id*.

[14] *See* 5 U.S.C. § 601(4).

[15] The IRS benchmark is similar to the population of less than 50,000 benchmark in 5 U.S.C § 601(5) that is used to define a small governmental jurisdiction. Therefore, the IRS benchmark has been used to estimate the number of small organizations in this small entity description. S*ee* Annual Electronic Filing Requirement for Small Exempt Organizations – Form 990-N (e-Postcard), "Who must file," https://www.irs.gov/charities-non-profits/annual-electronic-filing-requirement-for-small-exempt-organizations-form-990-n-e-postcard. We note that the IRS data

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were approximately 447,689 small exempt organizations in the U.S. reporting revenues of $50,000 or less according to the registration and tax data for exempt organizations available from the IRS.[16]

14. Finally, the small entity described as a "small governmental jurisdiction" is defined generally as "governments of cities, counties, towns, townships, villages, school districts, or special districts, with a population of less than fifty thousand."[17] U.S. Census Bureau data from the 2017 Census of Governments[18] indicate there were 90,075 local governmental jurisdictions consisting of general purpose governments and special purpose governments in the United States.[19] Of this number, there were 36,931 general purpose governments (county,[20] municipal, and town or township[21]) with populations of less than 50,000 and 12,040 special purpose governments—independent school districts[22] with enrollment populations of less than 50,000.[23] Accordingly, based on the 2017 U.S. Census of Governments data, we estimate that at least 48,971 entities fall into the category of "small governmental jurisdictions."[24]

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does not provide information on whether a small exempt organization is independently owned and operated or dominant in its field.

[16] *See* Exempt Organizations Business Master File Extract (EO BMF), "CSV Files by Region," https://www.irs.gov/charities-non-profits/exempt-organizations-business-master-file-extract-eo-bmf. The IRS Exempt Organization Business Master File (EO BMF) Extract provides information on all registered tax-exempt/non-profit organizations. The data utilized for purposes of this description was extracted from the IRS EO BMF data for businesses for the tax year 2020 with revenue less than or equal to $50,000 for Region 1-Northeast Area (58,577), Region 2-Mid-Atlantic and Great Lakes Areas (175,272), and Region 3-Gulf Coast and Pacific Coast Areas (213,840) that includes the continental U.S., Alaska, and Hawaii. This data does not include information for Puerto Rico.

[17] *See* 5 U.S.C. § 601(5).

[18] *See* 13 U.S.C. § 161. The Census of Governments survey is conducted every five (5) years compiling data for years ending with "2" and "7". *See also* Census of Governments, https://www.census.gov/programs-surveys/cog/about.html.

[19] *See* U.S. Census Bureau, 2017 Census of Governments – Organization Table 2. Local Governments by Type and State: 2017 [CG1700ORG02], https://www.census.gov/data/tables/2017/econ/gus/2017-governments.html. Local governmental jurisdictions are made up of general purpose governments (county, municipal and town or township) and special purpose governments (special districts and independent school districts). *See also* tbl.2. CG1700ORG02 Table Notes_Local Governments by Type and State_2017.

[20] *See id.* at tbl.5. County Governments by Population-Size Group and State: 2017 [CG1700ORG05], https://www.census.gov/data/tables/2017/econ/gus/2017-governments.html. There were 2,105 county governments with populations less than 50,000. This category does not include subcounty (municipal and township) governments.

[21] *See id.* at tbl.6. Subcounty General-Purpose Governments by Population-Size Group and State: 2017 [CG1700ORG06], https://www.census.gov/data/tables/2017/econ/gus/2017-governments.html. There were 18,729 municipal and 16,097 town and township governments with populations less than 50,000.

[22] *See id.* at tbl.10. Elementary and Secondary School Systems by Enrollment-Size Group and State: 2017 [CG1700ORG10], https://www.census.gov/data/tables/2017/econ/gus/2017-governments.html. There were 12,040 independent school districts with enrollment populations less than 50,000. *See also* tbl.4. Special-Purpose Local Governments by State Census Years 1942 to 2017 [CG1700ORG04], CG1700ORG04 Table Notes_Special Purpose Local Governments by State Census Years 1942 to 2017.

[23] While the special purpose governments category also includes local special district governments, the 2017 Census of Governments data does not provide data aggregated based on population size for the special purpose governments category. Therefore, only data from independent school districts is included in the special purpose governments category.

[24] This total is derived from the sum of the number of general purpose governments (county, municipal and town or township) with populations of less than 50,000 (36,931) and the number of special purpose governments -

(continued….)

15. *Fixed Microwave Services.* Fixed microwave services include common carrier,[25] private-operational fixed,[26] and broadcast auxiliary radio services.[27] They also include the Upper Microwave Flexible Use Service (UMFUS),[28] Millimeter Wave Service (70/80/90 GHz),[29] Local Multipoint Distribution Service (LMDS),[30] the Digital Electronic Message Service (DEMS),[31] 24 GHz Service,[32] Multiple Address Systems (MAS),[33] and Multichannel Video Distribution and Data Service (MVDDS),[34] where in some bands licensees can choose between common carrier and non-common carrier status.[35] Wireless Telecommunications Carriers (*except* Satellite)[36] is the closest industry with a SBA small business size standard applicable to these services. The SBA small size standard for this industry classifies a business as small if it has 1,500 or fewer employees.[37] U.S. Census Bureau data for 2017 show that there were 2,893 firms that operated in this industry for the entire year.[38] Of this number, 2,837 firms employed fewer than 250 employees.[39] Thus under the SBA size standard, the Commission estimates that a majority of fixed microwave service licensees can be considered small.

16. The Commission's small business size standards with respect to fixed microwave services involve eligibility for bidding credits and installment payments in the auction of licenses for the various frequency bands included in fixed microwave services. When bidding credits are adopted for the auction of licenses in fixed microwave services frequency bands, such credits may be available to several types of small businesses based average gross revenues (small, very small and entrepreneur) pursuant to the competitive bidding rules adopted in conjunction with the requirements for the auction and/or as

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independent school districts with enrollment populations of less than 50,000 (12,040), from the 2017 Census of Governments - Organizations tbls.5, 6 & 10.

[25] *See* 47 CFR pt. 101, Subts. C and I.

[26] *See id*. Subts. C and H.

[27] 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.

[28] *See* 47 CFR pt. 30.

[29] *See* 47 CFR pt. 101, Subt. Q.

[30] *See id*. Subt. L.

[31] *See id*. Subt. G.

[32] *See id*.

[33] *See id.* Subpart O.

[34] *See id*. Subpart P.

[35] *See* 47 CFR §§ 101.533, 101.1017.

[36] *See* U.S. Census Bureau, *2017 NAICS Definition, "517312 Wireless Telecommunications Carriers* (*except Satellite*)," https://www.census.gov/naics/?input=517312&year=2017&details=517312.

[37] *See* 13 CFR § 121.201, NAICS Code 517312 (as of 10/1/22, NAICS Code 517112).

[38] *See* U.S. Census Bureau, *2017 Economic Census of the United States*, *Employment Size of Firms for the U.S.: 2017,* Table ID: EC1700SIZEEMPFIRM, NAICS Code 517312, https://data.census.gov/cedsci/table?y=2017&n=517312&tid=ECNSIZE2017.EC1700SIZEEMPFIRM&hidePreview=false.

[39] *Id*. The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard.

identified in Part 101 of the Commission's rules for the specific fixed microwave services frequency bands.[40]

17. In frequency bands where licenses were subject to auction, the Commission notes that as a general matter, the number of winning bidders that qualify as small businesses at the close of an auction does not necessarily represent the number of small businesses currently in service. Further, the Commission does not generally track subsequent business size unless, in the context of assignments or transfers, unjust enrichment issues are implicated. Additionally, since the Commission does not collect data on the number of employees for licensees providing these services, at this time we are not able to estimate the number of licensees with active licenses that would qualify as small under the SBA's small business size standard.

18. ***Public Safety Radio Licensees***. As a general matter, Public Safety Radio Pool licensees include police, fire, local government, forestry conservation, highway maintenance, and emergency medical services.[41] Because of the vast array of public safety licensees, the Commission has not developed a small business size standard specifically applicable to public safety licensees. Wireless Telecommunications Carriers (*except* Satellite)[42] is the closest industry with a SBA small business size standard applicable to these services. The SBA small business size standard for this industry classifies a business as small if it has 1,500 or fewer employees.[43] U.S. Census Bureau data for 2017 show that there were 2,893 firms that operated in this industry for the entire year.[44] Of this number, 2,837 firms employed fewer than 250 employees.[45] Thus under the SBA size standard, the Commission estimates that a majority of licensees in this industry can be considered small.

19. With respect to local governments, in particular, since many governmental entities comprise the licensees for these services, we include under public safety services the number of government entities affected. According to Commission records as of December 2021, there were approximately 127,019

[40] *See* 47 CFR §§ 101.538(a)(1)-(3), 101.1112(b)-(d), 101.1319(a)(1)-(2), and 101.1429(a)(1)-(3).

[41] *See* subparts A and B of Part 90 of the Commission's Rules, 47 CFR §§ 90.1-90.22. Police licensees serve state, county, and municipal enforcement through telephony (voice), telegraphy (code), and teletype and facsimile (printed material). Fire licensees are comprised of private volunteer or professional fire companies, as well as units under governmental control. Public Safety Radio Pool licensees also include state, county, or municipal entities that use radio for official purposes. State departments of conservation and private forest organizations comprise forestry service licensees that set up communications networks among fire lookout towers and ground crews. State and local governments are highway maintenance licensees that provide emergency and routine communications to aid other public safety services to keep main roads safe for vehicular traffic. Emergency medical licensees use these channels for emergency medical service communications related to the delivery of emergency medical treatment. Additional licensees include medical services, rescue organizations, veterinarians, persons with disabilities, disaster relief organizations, school buses, beach patrols, establishments in isolated areas, communications standby facilities, and emergency repair of public communications facilities.

[42] *See* U.S. Census Bureau, *2017 NAICS Definition, "517312 Wireless Telecommunications Carriers* (*except Satellite*)," https://www.census.gov/naics/?input=517312&year=2017&details=517312.

[43] *See* 13 CFR § 121.201, NAICS Code 517312 (as of 10/1/22, NAICS Code 517112).

[44] *See* U.S. Census Bureau, *2017 Economic Census of the United States*, *Employment Size of Firms for the U.S.: 2017,* Table ID: EC1700SIZEEMPFIRM, NAICS Code 517312, https://data.census.gov/cedsci/table?y=2017&n=517312&tid=ECNSIZE2017.EC1700SIZEEMPFIRM&hidePreview=false.

[45] *Id*. The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard.

active licenses within these services.[46] Since the Commission does not collect data on the number of employees for licensees providing these services, at this time we are therefore not able to estimate the number of licensees with active licenses that would qualify as small under the SBA's small business size standard.

20. ***Satellite Telecommunications.*** This industry comprises firms "primarily engaged in providing telecommunications services to other establishments in the telecommunications and broadcasting industries by forwarding and receiving communications signals via a system of satellites or reselling satellite telecommunications."[47] Satellite telecommunications service providers include satellite and earth station operators. The SBA small business size standard for this industry classifies a business with $38.5 million or less in annual receipts as small.[48] U.S. Census Bureau data for 2017 show that 275 firms in this industry operated for the entire year.[49] Of this number, 242 firms had revenue of less than $25 million.[50] Additionally, based on Commission data in the 2022 Universal Service Monitoring Report, as of December 31, 2021, there were 65 providers that reported they were engaged in the provision of satellite telecommunications services.[51] Of these providers, the Commission estimates that approximately 42 providers have 1,500 or fewer employees.[52] Consequently, using the SBA's small business size standard, a little more than half of these providers can be considered small entities.

21. ***Wireless Telecommunications Carriers (except Satellite)***. This industry comprises establishments engaged in operating and maintaining switching and transmission facilities to provide communications via the airwaves.[53] Establishments in this industry have spectrum licenses and provide services using that spectrum, such as cellular services, paging services, wireless Internet access, and wireless video services.[54] The SBA size standard for this industry classifies a business as small if it has 1,500 or fewer employees.[55] U.S. Census Bureau data for 2017 show that there were 2,893 firms in this

[46] Based on a FCC Universal Licensing System search on December 13, 2021. https://wireless2.fcc.gov/UlsApp/UlsSearch/searchAdvanced.jsp. Search parameters: Service Group = All, "Match only the following radio service(s)", Radio Service = GE, GF, GP, PA, PW, YE, YF, YP, YW; Authorization Type = All; Status = Active. We note that the number of active licenses does not equate to the number of licensees. A licensee can have one or more licenses.

[47] *See* U.S. Census Bureau, *2017 NAICS Definition, "517410 Satellite Telecommunications,"* https://www.census.gov/naics/?input=517410&year=2017&details=517410.

[48] *See* 13 CFR § 121.201, NAICS Code 517410.

[49] *See* U.S. Census Bureau, *2017 Economic Census of the United States*, *Selected Sectors: Sales, Value of Shipments, or Revenue Size of Firms for the U.S.: 2017,* Table ID: EC1700SIZEREVFIRM, NAICS Code 517410, https://data.census.gov/cedsci/table?y=2017&n=517410&tid=ECNSIZE2017.EC1700SIZEREVFIRM&hidePreview=false.

[50] *Id*. The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard. We also note that according to the U.S. Census Bureau glossary, the terms receipts and revenues are used interchangeably, *see* https://www.census.gov/glossary/#term_ReceiptsRevenueServices.

[51] Federal-State Joint Board on Universal Service, Universal Service Monitoring Report at 26, Table 1.12 (2022), https://docs.fcc.gov/public/attachments/DOC-391070A1.pdf.

[52] *Id.*

[53] *See* U.S. Census Bureau, *2017 NAICS Definition, "517312 Wireless Telecommunications Carriers (except Satellite),"* https://www.census.gov/naics/?input=517312&year=2017&details=517312.

[54] *Id.*

[55] *See* 13 CFR § 121.201, NAICS Code 517312 (as of 10/1/22, NAICS Code 517112).

industry that operated for the entire year.[56] Of that number, 2,837 firms employed fewer than 250 employees.[57] Additionally, based on Commission data in the 2022 Universal Service Monitoring Report, as of December 31, 2021, there were 594 providers that reported they were engaged in the provision of wireless services.[58] Of these providers, the Commission estimates that 511 providers have 1,500 or fewer employees.[59] Consequently, using the SBA's small business size standard, most of these providers can be considered small entities.

22. The Commission's own data—available in its Universal Licensing System—indicate that, as of May 17, 2018, there are 264 Cellular licensees.[60] The Commission does not know how many of these licensees are small, as the Commission does not collect that information for these types of entities. Similarly, according to internally developed Commission data, 413 carriers reported that they were engaged in the provision of wireless telephony, including cellular service, Personal Communications Service (PCS), and Specialized Mobile Radio (SMR) Telephony services.[61] Of this total, an estimated 261 have 1,500 or fewer employees, and 152 have more than 1,500 employees.[62] Thus, using available data, we estimate that the majority of wireless firms can be considered small.

23. ***Auxiliary, Special Broadcast and Other Program Distribution Services***. This service involves a variety of transmitters, generally used to relay broadcast programming to the public (through translator and booster stations) or within the program distribution chain (from a remote news gathering unit back to the station). Neither the SBA nor the Commission have developed a small business size standard applicable to broadcast auxiliary licensees. The closest applicable industries with a SBA small business size standard fall within two industries - Radio Stations[63] and Television Broadcasting.[64] The SBA small business size standard for Radio Stations classifies firms having $41.5 million or less in annual receipts as small.[65] U.S. Census Bureau data for 2017 show that 2,963 firms operated in this industry during that year.[66] Of that number, 1,879 firms operated with revenue of less than $25 million

[56] *See* U.S. Census Bureau, *2017 Economic Census of the United States*, *Employment Size of Firms for the U.S.: 2017,* Table ID: EC1700SIZEEMPFIRM, NAICS Code 517312, https://data.census.gov/cedsci/table?y=2017&n=517312&tid=ECNSIZE2017.EC1700SIZEEMPFIRM&hidePreview=false.

[57] *Id*. The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard.

[58] Federal-State Joint Board on Universal Service, Universal Service Monitoring Report at 26, Table 1.12 (2022), https://docs.fcc.gov/public/attachments/DOC-391070A1.pdf.

[59] *Id.*

[60] *See* http://wireless.fcc.gov/uls. For the purposes of this IRFA, consistent with Commission practice for wireless services, the Commission estimates the number of licensees based on the number of unique FCC Registration Numbers.

[61] *See* Federal Communications Commission, Wireline Competition Bureau, Industry Analysis and Technology Division, Trends in Telephone Service at Table 5.3 (Sept. 2010) (*Trends in Telephone Service*), https://apps.fcc.gov/edocs_public/attachmatch/DOC-301823A1.pdf.

[62] *See id*.

[63] *See* U.S. Census Bureau, *2017 NAICS Definition, "515112 Radio Stations*," https://www.census.gov/naics/?input=515112&year=2017&details=515112.

[64] *See* U.S. Census Bureau, *2017 NAICS Definition, "515120 Television Broadcasting,*" https://www.census.gov/naics/?input=515120&year=2017&details=515120.

[65] *See* 13 CFR § 121.201, NAICS Code 515112 (as of 10/1/22 NAICS Code 516110).

[66] *See* U.S. Census Bureau, *2017 Economic Census of the United States*, *Selected Sectors: Sales, Value of Shipments, or Revenue Size of Firms for the U.S.: 2017,* Table ID: EC1700SIZEREVFIRM, NAICS Code 515112,

(continued….)

per year.[67] For Television Broadcasting, the SBA small business size standard also classifies firms having $41.5 million or less in annual receipts as small.[68] U.S. Census Bureau data for 2017 show that 744 firms in this industry operated for the entire year.[69] Of that number, 657 firms had revenue of less than $25 million per year.[70] Accordingly, based on the U.S. Census Bureau data for Radio Stations and Television Broadcasting, the Commission estimates that the majority of Auxiliary, Special Broadcast and Other Program Distribution Services firms are small under the SBA size standard.

24. ***Fixed Satellite Small Transmit/Receive Earth Stations***. Neither the SBA nor the Commission have developed a small business size standard specifically applicable to Fixed Satellite Small Transmit/Receive Earth Stations. Satellite Telecommunications[71] is the closest industry with an SBA small business size standard. The SBA size standard for this industry classifies a business as small if it has $38.5 million or less in annual receipts.[72] For this industry, U.S. Census Bureau data for 2017 show that there was a total of 275 firms that operated for the entire year.[73] Of this total, 242 firms had revenue of less than $25 million.[74] Additionally, based on Commission data in the 2022 Universal Service Monitoring Report, as of December 31, 2021, there were 65 providers that reported they were engaged in the provision of satellite telecommunications services.[75] Of these providers, the Commission estimates that approximately 42 providers have 1,500 or fewer employees.[76] Consequently, using the

https://data.census.gov/cedsci/table?y=2017&n=515112&tid=ECNSIZE2017.EC1700SIZEREVFIRM&hidePreview=false. We note that the US Census Bureau withheld publication of the number of firms that operated for the entire year.

[67] *Id.* The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard. We note that the U.S. Census Bureau withheld publication of the number of firms that operated with sales/value of shipments/revenue in the individual categories for less than $100,000, and $100,000 to $249,999 to avoid disclosing data for individual companies (see Cell Notes for the sales/value of shipments/revenue in these categories). Therefore, the number of firms with revenue that meet the SBA size standard would be higher that noted herein. We also note that according to the U.S. Census Bureau glossary, the terms receipts and revenues are used interchangeably, *see* https://www.census.gov/glossary/#term_ReceiptsRevenueServices.

[68] *See* 13 CFR § 121.201, NAICS Code 515120 (as of 10/1/22 NAICS Code 516120).

[69] *See* U.S. Census Bureau, *2017 Economic Census of the United States*, *Selected Sectors: Sales, Value of Shipments, or Revenue Size of Firms for the U.S.: 2017,* Table ID: EC1700SIZEREVFIRM, NAICS Code 515120, https://data.census.gov/cedsci/table?y=2017&n=515120&tid=ECNSIZE2017.EC1700SIZEREVFIRM&hidePreview=false.

[70] *Id*. The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard. We also note that according to the U.S. Census Bureau glossary, the terms receipts and revenues are used interchangeably, *see* https://www.census.gov/glossary/#term_ReceiptsRevenueServices.

[71] *See* U.S. Census Bureau, *2017 NAICS Definition, "517410 Satellite Telecommunications,"* https://www.census.gov/naics/?input=517410&year=2017&details=517410.

[72] *See* 13 CFR § 121.201, NAICS Code 517410.

[73] *See* U.S. Census Bureau, *2017 Economic Census of the United States*, *Selected Sectors: Sales, Value of Shipments, or Revenue Size of Firms for the U.S.: 2017,* Table ID: EC1700SIZEREVFIRM, NAICS Code 517410, https://data.census.gov/cedsci/table?y=2017&n=517410&tid=ECNSIZE2017.EC1700SIZEREVFIRM&hidePreview=false.

[74] *Id*. The available U.S. Census Bureau data does not provide a more precise estimate of the number of firms that meet the SBA size standard. We also note that according to the U.S. Census Bureau glossary, the terms receipts and revenues are used interchangeably, *see* https://www.census.gov/glossary/#term_ReceiptsRevenueServices.

[75] Federal-State Joint Board on Universal Service, Universal Service Monitoring Report at 26, Table 1.12 (2022), https://docs.fcc.gov/public/attachments/DOC-391070A1.pdf.

[76] *Id.*

SBA's small business size standard, a little more than half of these providers can be considered small entities.

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

25. We expect that the proposed rules set forth in the *Second Further Notice* will impose new or additional filing, recordkeeping and reporting requirements for small and other entities. At this time, the Commission is not in a position to determine whether, if adopted, the proposals and matters upon which we seek comment in the *Second Further Notice* will require small entities to hire attorneys, engineers, consultants, or other professionals in order to comply and cannot quantify the cost of compliance with the potential rule changes discussed herein. Under the proposals set forth in the *Second Further Notice*, and consistent with the Commission's general approach, we expect that all the reporting, recordkeeping, and other compliance requirements associated with the proposals would remain the same for small entities; however, we seek comment on any steps that could be taken to minimize any significant economic impact on small businesses.

26. In the *Second Further Notice*, the Commission proposes to allow VLP devices to operate across the entire 1200 megahertz of the 6 GHz band by utilizing a geofencing system to prevent operation at locations where they may cause harmful interference to licensed incumbents that share the 6 GHz band. The proposed rules will require: (1) VLP access points to obtain updated exclusion zones for particular frequencies from a geofencing system at least once per day; (2) VLP access points to have a geo-location capability and to avoid operating within the exclusion zones on the corresponding frequencies; (3) applicants for certification of these VLP access points to show in their applications how their VLP devices will comply with all geofencing requirements; and (4) VLP client devices to operate under the control of a VLP access point.

27. These proposed rules will require VLP access points operating at greater than -5 dBm/MHz EIRP PSD to use a geofencing system to avoid causing harmful interference to fixed microwave, BAS, CARS, and radio astronomy receive sites. The geofencing system will ensure that these VLP access points operate only outside of defined exclusion zones designed to protect these services. Therefore the proposed rules would adopt requirements for geofencing systems and specify the criteria that will be used to calculate the exclusion zones as well as the technical requirements that VLP device must meet. Each VLP access point that operates at a power greater than -5 dBm/MHz EIRP PSD should be able to connect to a valid geofencing system and applicants should be able to demonstrate such a capability during device certification and the geofencing system test and approval process. A VLP client device will operate only under the control of a VLP access point and will not need to have a geolocation capability or need to obtain geofencing data. Independent VLP devices which operate at power levels up to -5 dBm/MHz EIRP PSD also do not need to have a geolocation capability or obtain geofencing data. The proposed rules will require a VLP access point to obtain updated information from a geofencing system at least once per day and will provide this information based on the most recent data from the Commission's databases. Under the proposed rules, this daily communication would be required in order to keep the exclusion zones up to date and minimize the risk of harmful interference to incumbent operators within the 6 GHz band.

28. Additionally, the proposed rules will require applicants for certification of VLP access points to show in their application for device certification how their devices will comply with all geofencing requirements set in this proceeding. Based on this approach, a fully certified VLP access point is a device that has an approved geo-location capability and that obtains exclusion zones from a geofencing system and a fully certified VLP client device would operate only when under the control of a VLP access point. A geofencing system may be either integrated into the VLP access point or may be an external database from which the VLP access point obtains exclusion zones.

29. The only reporting requirement proposed in the *Second Further Notice* is that under the "push" notification proposal BAS and CARS licensees would be required to report their expected use of

pickup stations in the U-NII-6 and U-NII-8 bands. The push notification proposal would require the geofencing systems to have the ability to send notifications to VLP access points to modify exclusion zones based on information provided by BAS and CARS licensees on the locations and times they will use pickup stations. This reported information would enable the geofencing systems to create exclusion zones that would protect BAS and CARS operations from potential harmful interference. While many of these BAS and CARS licensees may be small businesses, we note that the compliance burden to those small entities would likely be minimal, as this would be a one-time reporting requirement of a small amount of information. Reporting this information will provide a significant benefit to many small businesses as it will enable the Commission to make the 6.425-6.525 GHz and 6.875-7.125 GHz portions of the 6 GHz band available for use by VLP unlicensed devices. In considering this proposed requirement, we specifically seek comment from any small entities that would find this requirement to be onerous to them.

30. Lastly, the *Second Further Notice* makes a number of proposals which would change the operation of the geofencing systems used to manage spectrum access for VLP devices or the AFC systems used to manage spectrum access for standard power devices. One proposal would modify the current rules for how the geofencing systems operate to take into account the characteristics of the VLP devices, the use of land use databases to more accurately determine where the devices may operate, the use of different propagation models by the geofencing systems to determine where VLP devices may operate, or the use of a different protection criteria by the geofencing system for determining exclusion zones. Another proposal would modify the AFC systems to permit standard power devices to operate in the U-NII-6 and U-NII-8 bands, while an additional proposal would modify how receiving earth stations in the 7.025-7.055 GHz band are protected by the geofencing and AFC systems.

31. The Commission acknowledges that some entities who design and manufacture VLP devices may in fact be small entities and welcome their input through their comments. We note the proposed rules requiring VLP access points to use geofencing to prevent harmful interference would place a burden on device manufacturers by making the devices more complex than if there were no geofencing requirement. However, because Part 15 unlicensed devices must not cause harmful interference to licensed services the Commission has concluded that geofencing requirements are necessary to allow operation of the devices at greater than -5 dBm/MHz EIRP PSD. Hence, not including the geofencing requirement would have reduced the utility of VLP devices, thus leading to a negative impact on small and other entities that are users of the devices. As a result, we believe that having a geofencing requirement in the adopted rules is on the whole a significant economic benefit to small entities.

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

32. The RFA requires an agency to describe any significant, specifically small business, alternatives for small businesses 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."[77]

33. In the *Second Further Notice,* the Commission is taking steps to minimize the economic impact on small entities and is considering significant alternatives by proposing and seeking alternative proposals designed to increase the use of the 6 GHz band by unlicensed devices while protecting licensed incumbents from harmful interference. The Commission considered alternatives that would provide greater protection to incumbent operators in the 6 GHz band but that would also create limitations for growth in the band by unlicensed devices. For example, requiring geofencing at power spectral density

[77] 5 U.S.C. § 604(a)(6).

(PSD) levels lower than -5 dBm/MHz or restricting unlicensed devices to operate at lower power levels. However, the steps the Commission has taken through its proposed rules will foster significant growth for unlicensed operators that are small entities, as they will provide them with more options for gaining access to valuable spectrum. Many BAS and CARS licensees who will need to report their expected use of pickup stations in the U-NII-6 and U-NII-8 bands under the "push" notification proposal may be small entities. The Commission considered alternatives to the use of a push notification system, such as the Citizens Broadband Radio Service's approach of requiring VLP devices to respond to instructions within a specific time limit, and allowing device manufacturers to determine the most appropriate way to comply with this requirement. However, while the push notification requirement will be a burden on these licensees, it will also enable the geofencing systems to more efficiently manage use of the U-NII-6 and U-NII-8 bands by users of unlicensed VLP devices, many of which will be small entities. As a result of the increased use of the U-NII-6 and U-NII-8, we believe this reporting requirement overall provides a positive benefit for small entities that outweighs the potential economic burden.

34. Entities that operate geofencing systems and AFC systems may be small entities. If the *Second Further Notice* proposals which permit the operation of geofencing systems and change the operation of AFC systems are adopted, they may potentially experience a significant economic impact. The Commission considered alternatives such as developing a process for modifying the locations where VLP devices can and cannot operate or rejecting a geofencing approach and instead requiring VLP devices to access an AFC system instead. However, a geofencing approach could help preserve the VLP device battery life of small entities by not requiring each device to re-check a database every time it moves, as is the case for standard power access points. Additionally, the proposed rules will provide protection from harmful interference for small entities that are incumbent operators in the 6 GHz band. Further, these changes will also result in the more intensive use of the 6 GHz band by unlicensed devices. As many of the users of these unlicensed devices are small entities, we believe these proposals overall will have a positive economic benefit for small entities.

35. The *Second Further Notice* seeks comment from all interested parties. Small entities are encouraged to bring to the Commission's attention any specific concerns they may have with the proposals outlined herein. The rules the Commission adopts should benefit small entities by giving them more options for gaining access to valuable spectrum while still protecting incumbent licensed services that operate in the band from harmful interference. The Commission expects to more fully consider the economic impact and alternatives for small entities following the review of comments filed in response to the *Second Further Notice*, prior to reaching its final conclusions and adopting final rules in this proceeding.

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

1. None.

APPENDIX E

List of Commenters

Comments

5G Automotive Association
ACT | The App Association (App Association)
Alliance for Automotive Innovation
Alliant Energy
American Petroleum Institute, Energy Telecommunications and Electrical Association
Apple Inc., Broadcom Inc., Cisco Systems Inc., Facebook Inc., Google LLC, Hewlett Packard Enterprise, Intel Corporation, Microsoft Corporation, NXP Semiconductors, Qualcomm Incorporated, Ruckcus Networks
Apple Inc., Broadcom Inc., Google LLC, Microsoft Corporation
The Association of Public-Safety Communications Officials-International, Inc. (APCO)
Association of American Railroads
AT&T Services, Inc.
Broadcom Inc., Microsoft Corporation, Intel Corporation
CenturyLink Communications
CORF – National Academy of Sciences
Consumer Technology Association (CTA)
CTIA
Dominion Energy Services Inc.
Duke Energy Corporation
Dynamic Spectrum Alliance
Edison Electric Institute
Environmental Health Trust
The Evergy Companies
Facebook Inc.
Fixed Wireless Communications Coalition (FWCC)
Hewlett Packard Enterprise (HPE)
International Association of Fire Chiefs
Kevin Mottus
Microsoft Corporation
National Association of Broadcasters (NAB)
NCTA
National Public Safety Telecommunications Council
Nokia
Panasonic Corporation of North America
Public Interest Spectrum Coalition
Qualcomm Inc.
Sirius XM Radio Inc.
Sony Electronics Inc.
Southern Company Services Inc.
Ultra Wide Band Alliance (UWBA)
Utilities Technology Council, American Public Power Association, National Rural Electric Cooperative Association, American Gas Association, American Water Works Association
Wi-Fi Alliance
Wireless Internet Service Providers Association (WISPA)
Wireless Broadband Alliance Ltd.
Zebra Technologies

Reply Comments

Apple Inc., Broadcom Inc., Cisco Systems Inc., Facebook Inc., Google LLC, Hewlett Packard Enterprise, Intel Corporation, Microsoft Corporation, NXP Semiconductors, Qualcomm Incorporated, Ruckcus Networks

Alliance for Automotive Innovation

American Trucking Associations

Association of American railroads

AT&T Services Inc.

Broadcom Inc., Microsoft Corporation

CenturyLink Communications

City of Los Angeles, California

CTIA

Dynamic Spectrum Alliance

Edison Electric Institute

Facebook Inc.

Globalstar Inc.

International Association of Fire Chiefs

National Association of Broadcastesr (NAB)

NCTA

Public Interest Spectrum Coalition

Sirius XM Radio Inc.

Southern Company Services Inc.

Tuscon Electric Power Company

Wi-Fi Alliance

Wireless Internet Service Providers Association (WISPA)

Ultra Wide Band Alliance (UWBA)

Utilities Technology Council, American Public Power Association, National Rural Electric Cooperative Association, American Gas Association, American Water Works Association

Zebra Technologies

Ex Parte Comments

5G Automotive Association

ACT | The App Association (App Association)

Ameren

APCO International

APCO International, AT&T Services Inc., Comsearch, Edison, Fixed Wireless Communications Coalition, Utilities Technology Council

Apple Inc.

Apple Inc., Broadcom Inc., Cisco Systems Inc., Facebook Inc., Google LLC, Hewlett Packard Enterprise, Intel Corporation, Microsoft Corporation, NXP Semiconductors, Qualcomm Incorporated, Ruckcus Networks

Apple Inc., Broadcom Inc., Cisco Systems Inc., Facebook Inc., Google LLC, Intel Corporation, Microsoft Corporation, NXP Semiconductors, Qualcomm Incorporated

Apple Inc., Broadcom Inc., Cisco Systems Inc., Facebook Inc., Google LLC, Intel Corporation, Microsoft Corporation, Qualcomm Incorporated

Apple Inc., Broadcom Inc., Cisco Systems Inc., Facebook Inc., Google LLC, Microsoft Corporation, NXP Semiconductors, Qualcomm Incorporated, Ruckcus Networks

Apple Inc., Broadcom Inc., Cisco Systems Inc., Google LLC, Hewlett Packard Enterprise

Apple Inc., Broadcom Inc., Cisco Systems Inc., Google LLC, Intel Corporation, Meta Platforms Inc.

Apple Inc., Broadcom Inc., Cisco Systems Inc., Google LLC, Intel Corporation, Meta Platforms

Inc., Microsoft Corporation
Apple Inc., Broadcom Inc., Cisco Systems Inc., Google LLC, Qualcomm Incorporated
Apple Inc., Broadcom Inc., Facebook Inc., Intel Corporation, Microsoft Corporation
Apple Inc., Google LLC, Meta Platforms Inc.
Amazon.com Services LLC
AT&T Services Inc.
Bluetooth ISG
Broadcom Inc.
Broadcom Inc., Cisco Systems Inc., Google LLC, Hewlett Packard Enterprise, Meta Platforms Inc., Microsoft Corporation, Qualcomm Incorporated
Broadcom Inc., Cisco Systems Inc., Microsoft Corporation
Broadcom Inc., Facebook Inc., Cisco Systems Inc.
Broadcom Inc., Facebook Inc., Intel Corporation, Cisco Systems Inc., Qualcomm Corporation
Broadcom Inc., Kyrio, Wi-Fi Alliance
Broadcom Inc., Microsoft Corporation, Intel Corporation
Cisco Systems Inc., Hewlett Packard Enterprise
Cisco Systems Inc., Extreme Networks, Hewlett Packard Enterprise, Juniper
Citizens against government waste
Chairs of the 6 GHz Multi-Stakeholder Group
Charter
Commscope
Consumer Technology Association
CTIA
Dominion Energy
Edison Electric Institute
Edison Electric Institute, Pacific Gas & Electric Company, Lockard & White Inc., Utilites Technology Council
EIBASS
Encina Communications
Enterprise Wireless Alliance
Enterprise Wireless Alliance, Edison Electric Institute
Environmental Health Trust
The Evergy Companies
Facebook Inc.
Facebook Inc., Qualcomm Inc.
First Energy
Fixed Wireless Communications Coalition (FWCC)
Google LLC
Hewlett Packard Enterprise
Idaho Power
Intel Corporation
International Association of Fire Chiefs
Kevin Mottus
Land Mobile Communcations Council
Meta Platforms Inc.
Major Cities Chiefs Association
Marc-Anthony Signorino
Media Justice, Civil Rights, Public Interest, Labor, and Consumer Advocacy Organizations
Meta Platforms Inc.
National Association of Broadcasters (NAB)
National Spectrum Management Association

National Wireless Communications Council
NCTA
Netgear Inc.
Nevada Power
Next Energy
Nokia
North End Woodward Community Coalition
Open Technology Institute at New America (OTI)
Open Technology Institute at New America, Public Knowledge
Pacific Gas & Electric
Public Knowledge
Qualcomm Corporation, Cambrium Networks
RLAN Group
Rev. Dante King
Southern Company Services Inc.
Ultra Wide Band Alliance
Utilities Technology Council
Utilities Technology Council, Edison Electric Institute, American Public Power Association, National Rural Electric Cooperative Association, American Gas Association, American Water Works Association, APCO International, International Association of Fire Chiefs, National Public Safety Telecommunications Council
Utilities Technology Council, Edison Electric Institute, National Rural Electric Cooperative Association, American Gas Association, American Petroleum Institute, American Water Works Association
Utilities Technology Council, Edison Electric Institute, National Rural Electric Cooperative Association, American Gas Association, APCO International, International Association of Fire Chiefs (6 GHz Industry Stakeholders)
Utility Broadband Alliance
Wi-Fi Alliance
Wi-Fi Alliance, The Wireless Innovation Forum (WinnForum)
Wireless Application Corporation
The Wireless Innovation Forum (WinnForum)
Wireless Internet Service Providers Association (WISPA)
Verizon
Xcel Energy