FEDERAL COMMUNICATIONS COMMISSION

47 CFR Parts 0 and 15

[ET Docket No. 18-295 and GN Docket No. 17-183; FCC 26-1; FR ID 331544]

Unlicensed Use of the 6 GHz Band; Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz

AGENCY: Federal Communications Commission.

ACTION: Final rule.

SUMMARY: In this document, the Federal Communications Commission (Commission or FCC) adopts rules allowing unlicensed geofenced variable power (GVP) devices to operate in the U-NII-5 and U-NII-7 portions of the 6 GHz band (5.925-7.125 GHz) at up to 11 dBm/MHz EIRP power spectral density and 24 dBm EIRP. GVP devices must use geofencing systems to prevent harmful interference to licensed microwave links and radio astronomy observatories. The geofencing systems will calculate exclusion zones where GVP devices cannot operate on specified frequencies. Each GVP access point must have a geolocation capability to determine its location and avoid operating on prohibited frequencies within the exclusion zones. Client devices must operate 6 dB below the access point's authorized power. These rules permit the GVP devices to operate at higher power than very lower power 6 GHz band unlicensed devices.

DATES: This rule is effective **[INSERT DATE 60 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER]**.

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SUPPLEMENTARY INFORMATION: This is a summary of the Commission's *Fourth Report and Order*, in ET Docket No. 18-295 and GN Docket No. 17-183, FCC 26-1, adopted on January 29, 2026, and released on January 30, 2026. The full text of this document is available for public inspection and can be downloaded at https://docs.fcc.gov/public/attachments/FCC-26-1A1.pdf. Alternative formats are available for people with disabilities (Braille, large print, electronic files, audio format) by sending an

email to *fcc504@fcc.gov* or calling the Commission's Consumer and Governmental Affairs Bureau at (202) 418–0530 (voice), (202) 418–0432 (TTY).

Regulatory Flexibility Act. The Regulatory Flexibility Act of 1980, as amended (RFA) 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." Accordingly, the Commission has prepared a Final Regulatory Flexibility Analysis (FRFA) concerning the possible impact of the rule changes contained in the *Fourth Report and Order* on small entities. The FRFA is set forth in Appendix C, https://www.fcc.gov/document/fcc-votes-enable-better-faster-wi-fi-and-next-gen-connectivity-0.

Paperwork Reduction Act. This document does not contain new or modified information collection requirements subject to the Paperwork Reduction Act of 1995, 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, 44 U.S.C. 3506(c)(4).

Congressional Review Act. The Commission has determined, and the Administrator of the Office of Information and Regulatory Affairs, Office of Management and Budget, concurs, that this this rule is "major" under the Congressional Review Act, 5 U.S.C. 804(2). The Commission will send a copy of the *Fourth Report and Order* to Congress and the Government Accountability Office pursuant to 5 U.S.C. 801(a)(1)(A).

SYNOPSIS

INTRODUCTION

In this document, the Commission adopts rules for geofenced variable power (GVP) 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 at up to 11 dBm/MHz EIRP power spectral density (PSD) and 24 dBm EIRP. GVP devices must work in tandem with a geofencing system to minimize the likelihood of a significant risk of harmful interference to licensed fixed microwave links and radio astronomy observatories. The geofencing systems will calculate exclusion zones in which the GVP devices will not be permitted to operate co-frequency with microwave links or in a portion of the U-NII-7 band used by radio astronomy. Each GVP access point

will be required to have a geolocation capability to determine its location and avoid operating on prohibited frequencies within the exclusion zones. GVP client devices will operate under the control of GVP access points at 6 dB less power than the authorized power of the controlling GVP access point. Using geofencing will enable GVP devices to operate at significantly higher power levels than the -5 dBm/MHz EIRP PSD and 14 dBm EIRP at which non-geofenced very low power (VLP) devices are permitted to operate. At this time, the Commission is limiting the GVP device operation to the U-NII-5 and U-NII-7 portions of the 6 GHz band and defer considering such action for the U-NII-6 and U-NII-8 bands.

Power Limits for GVP Access Points

In the *6 GHz Second FNPRM* (89 FR 874, January 8, 2024), the Commission sought comment on the appropriate power limits for GVP devices in the U-NII-5 and U-NII-7 bands. As an initial matter, the Commission noted that Apple, Broadcom et al. had requested that it permit VLP devices to operate at up to 1 dBm/MHz EIRP PSD and 14 dBm EIRP. Based on the technical record, the Commission declined in the *6 GHz Second Order* (89 FR 874, January 8, 2024) to adopt this PSD level and instead limited VLP operations to a maximum of -5 dBm/MHz EIRP PSD and 14 dBm EIRP. However, the Commission explained that it could allow GVP devices to operate at a higher PSD level if such devices are prohibited from operating co-channel and in close proximity to licensed microwave receive sites. The Commission proposed that VLP devices be permitted to operate across the entire 6 GHz band—U-NII-5, U-NII-6, U-NII-7, and U-NII-8—at up to 1 dBm/MHz EIRP PSD and 14 dBm EIRP while under the control of a geofencing system to minimize the likelihood of harmful interference to licensed incumbent services. Although the Commission expressly sought comment on these proposed power limits, it also asked whether it should allow GVP devices to operate with higher PSD and EIRP limits. The Commission sought comment on a range of power limits and specifically asked whether it could "allow a power limit higher than 14 dBm EIRP," identifying as one such example power levels "up to 21 dBm EIRP." Furthermore, the Commission asked whether "even higher PSD and EIRP limits [would] increase the risk of harmful interference to licensed incumbent services" and whether "the proposed geofencing system . . . [would] be sufficient to reduce this risk." By using the phrase "even higher," the Commission signaled that it sought comment on power limits higher than those discussed earlier in the paragraph—i.e., higher

than 1 dBm/MHz EIRP PSD and 21 dBm EIRP.

Apple, Broadcom et al. request that GVP devices be permitted to operate at up to 8 dBm/MHz EIRP PSD and 21 dBm EIRP across the entire 6 GHz band. According to Apple, Broadcom et al., creating geofencing-capable devices "will require manufacturers to add expensive new hardware and software to a wide range of consumer and enterprise equipment," and such investment cannot be justified for the marginal benefit that would be provided by the proposed power limits. Apple, Broadcom et al. stress that unless the GVP maximum permitted power is 21 dBm EIRP, consumers will not experience any additional benefit from a higher PSD when using channels wider than 80-megahertz because total power transmitted is proportional to the PSD and capping the maximum EIRP at 21 dBm would allow all channel bandwidths to operate with more than 14 dBm EIRP total power. They explain that "increas[ing] power limits for *all* channel sizes available in the 6 GHz band . . . is important because wider channels are subject to more noise and therefore require additional power to maintain a sufficient signal-to-noise ratio. Apple, Broadcom et al. similarly recommend permitting a maximum PSD of 8 dBm/MHz EIRP so that all channels, regardless of bandwidth, can operate at the maximum power level. They further claim that "an increase in the PSD limit would not result in any higher risk of harmful interference because of the limitations imposed by the proposed geofencing system" (e.g., the proposal that "the size of an exclusion zone must increase in proportion to a GVP device's power level").

Apple, Broadcom et al. point to several computer simulations they submitted prior to the issuance of the *6 GHz Second FNPRM* as evidence that GVP devices can operate at up to 21 dBm EIRP without creating a significant risk of harmful interference to licensed incumbents. One computer simulation that modeled the interaction between outdoor VLP devices and the 97,888 6 GHz band fixed microwave links in the United States for 20-, 40-, 80-, and 160-megahertz bandwidth VLP signals concluded that there was only a 0.00059% probability that a VLP device operating at 21 dBm EIRP would cause a microwave link to experience an interference-to-noise (I/N) ratio greater than -6 dB. According to Apple, Broadcom et al., the computer simulation demonstrates that VLP devices operating at 21 dBm with no additional mitigation rules would not create a significant harmful interference risk. Apple, Broadcom et al. argued that this minimal risk would be mitigated by the proposed geofencing rules, which "would prohibit transmissions in the very rare instances where the [computer simulations] found that [VLP] operations

could exceed the -6 dB I/N metric."

The Dynamic Spectrum Alliance (DSA) and Wi-Fi Alliance support the same power levels for GVP devices as Apple, Broadcom et al. DSA believes that the GVP power levels proposed by the Commission, 14 dBm EIRP and 1 dBm/MHz EIRP PSD, do not "provide[] a sufficient economic incentive for companies to make the necessary investments [to] develop[] and commercializ[e] such [devices]." DSA points out that the proposed power levels would only benefit devices operating on 20-megahertz or 40-megahertz channels, but that most use cases are better suited to larger channel sizes. DSA urges the Commission to instead adopt a geofenced VLP framework with a 21 dBm EIRP limit and 8 dBm/MHz EIRP PSD. According to DSA, "[t]he higher EIRP limit . . . will provide greater reliability for [augmented reality/virtual reality] applications," and "[t]he increased EIRP PSD limits will enable narrow band applications, which may not be feasible under the [current] VLP limits." The Wi-Fi Alliance ask that the Commission "create a new device class for higher power VLP devices capable of operating at up to 21 dBm EIRP and 8 dBm/MHz EIRP PSD. According to the Wi-Fi Alliance, allowing VLP devices to operate at up to 21 dBm EIRP "will enable new applications that are not possible at the current VLP power levels and enable a more robust connectivity for existing applications."

While Apple initially joined Apple, Broadcom et al. in requesting GVP power levels of up to 8 dBm/MHz EIRP PSD and 21 dBm maximum EIRP, Apple later proposed a simplified geofencing version with only two power levels: 1 dBm/MHz EIRP PSD and 8 dBm/MHz EIRP PSD, both with a maximum 21 dBm EIRP, instead of permitting variable power up to the 8 dBm/MHz EIRP PSD and 21 dBm EIRP limits. The geofencing systems would calculate two exclusion zones—one for each PSD level—and a GVP device would check its location to determine whether it may operate and, if so, its maximum power level. This version would reduce the calculations needed by the geofencing systems because they would not need to support variable GVP power levels.

More recently, Apple and Meta contend that maximum authorized power levels of at least 11 dBm/MHz PSD and 24 dBm EIRP for GVP access points and 5 dBm/MHz PSD and 18 dBm EIRP for GVP client devices are "essential for adequate reliability and performance for GVP use cases." They claim that "GVP devices are likely to predominately be wearable devices," such as smartwatches and augmented reality glasses, which have "significant latency and throughput requirements." These

wearable devices would face up to 96 dB of attenuation communicating across the user's body. They also point to other use cases, such as multiple peer-to-peer links, which would also greatly benefit from higher power levels. They claim that their analysis shows that these higher power levels are essential to meet the performance goals for these and other envisioned use cases.

Federated Wireless supports the Commission's proposal to allow greater power for VLP devices operating under the control of a geofencing system, but instead of spending time and resources developing a new system for geofencing, Federated Wireless advocates relying on the currently authorized AFC systems. Federated Wireless also encourages permitting GVP devices to operate at higher power than the proposed 1 dBm/MHz EIRP PSD and 14 dBm EIRP because AFC systems are "capable of offering the same level of protection to incumbents regardless of the unlicensed device transmit power."

The Wi-Fi Alliance points out that the computer simulations upon which the Commission relied in permitting VLP operations "show virtually no impact on the microwave links even for VLP devices operating at 1 dBm/MHz EIRP PSD." The Wi-Fi Alliance claims that VLP devices will be predominantly used indoors, that their signals will be attenuated by body loss when they are used outdoors, and that outdoor VLP transmitters will operate far below the likely height of any 6 GHz microwave facilities. Therefore, the Wi-Fi Alliance claims that existing mitigation requirements are sufficient to protect microwave operations from VLP devices operating at up to 1 dBm/MHz EIRP PSD and 14 dBm EIRP. The Wi-Fi Alliance contends that because the risk of harmful interference from VLP devices operating at this power level "is already extremely low," there is no benefit in imposing geofencing requirements. The IEEE LAN/MAN Standards Committee (IEEE LMSC) also does not believe that the Commission should require geofencing if it increases the power level to 1 dBm/MHz EIRP PSD and 14 dBm EIRP because it effectively only would permit higher power for 20-megahertz and 40-megathertz channels and would not result in increased risk to incumbent services. IEEE LMSC claims that the incremental improvement from this power increase does not justify mandating the relatively complex geofencing mechanism and that developing this geofencing mechanism will potentially delay this VLP mode from deploying.

Cisco and HP Enterprise support slightly higher VLP power levels to accommodate body loss,

but caution that increasing VLP power needs to be done so as to ensure that unlicensed LPI devices continue to coexist among themselves and with VLP devices. According to Cisco and HP Enterprise, the top request of enterprise customers is that Wi-Fi be more predictable and reliable. Cisco and HP Enterprise explain that interference to enterprise Wi-Fi means less spectrum availability, which results in smaller channels with decreased capacity and increased latency. They point out that "[g]eofencing does not consider coexistence with enterprise [Wi-Fi] networks" and that "[h]igher power VLP . . . could interfere with other VLP use[s]." They claim that enterprise customers would like VLP to be coordinated by the infrastructure when in the presence of LPI access points. Cisco and HP state that the actual affect that VLP and GVP devices will have on enterprise Wi-Fi networks is unknown, but that CableLabs is currently studying that issue. Cisco and HP Enterprise recommend that the Commission "adopt reasonable limits on GVP/VLP while standards develop"—i.e., "slightly higher powered VLP to accommodate body loss"—that improve coexistence among the different types of Wi-Fi devices.

AT&T urges caution with respect to liberalizing the 6 GHz unlicensed rules and expresses concern that the computer simulations on which VLP device rules are based remain unfiled and untested. AT&T suggests that the Commission "gain some understanding of the impact of actual, commercially deployed VLP devices before liberalizing the rules by which they operate and, if it ultimately determines to do so, to act with caution in a manner that is reversible." AT&T suggests that the power limits for GVP devices "should start conservatively, provide for future modification, and be capped with reference to [the] risks defined by geolocation parameters," with the power levels lower if the Commission adopts a geofencing framework that carries substantial risk to incumbent microwave receivers. AT&T is concerned that the proposal of 1 dBm/MHz EIRP PSD limit "does not appear to be a conservative starting point" and, "[e]ven more dire, the *6 GHz Second FNPRM* seeks comment on increasing the [maximum] EIRP to 21 dBm." AT&T complains that "the [GVP] proponents' response to the *6 GHz Second FNPRM* amounts to platitudes that geofencing . . . will self-evidently protect incumbents and the Commissions needs not worry because their prior studies . . . should nonetheless carry the day." AT&T claims that "no geofencing advocate has advanced a proposal for geofencing that allows incumbents to rationally evaluate the potential for harmful interference." AT&T demands that before the Commission authorizes GVP operations, the record should contain proposed rules that cover such topics as location determination and

accuracy, how geofencing boundaries will be implemented, additive interference, the geofencing model (geofencing system architecture), GVP device elevation, database and geofence reauthorization intervals, and an exclusion zone buffer to account for mobility.

Evergy cautions that the Commission "should hold off on further expanding unlicensed operations in the 6 GHz band until enough real-world experience has occurred to gain the confidence of incumbents in the utility industry." Evergy is concerned that unlicensed devices will raise the noise floor and result in harmful interference to incumbent licensed operations. Evergy cautions that if harmful interference occurs, its "existing mission-critical systems may become unreliable and inoperable while its engineers engage in . . . [the] extremely difficult, if not impossible, task" of identifying the responsible unlicensed device(s). Evergy describes the proposed 1 dBm/MHz EIRP PSD as "a dramatic increase in power that poses significant risk to incumbent licensees" and urges the Commission to reject this proposal as well as the request by GVP advocates for maximum power levels of 21 dBm EIRP and 8 dBm/MHz EIRP PSD. Evergy asks that the Commission ensures that any geofencing solution protect microwave links commensurate with the protection provided by the AFC system.

The American Petroleum Institute (API) does not support permitting VLP devices to operate at 1 dBm/MHz EIRP PSD until more field data on VLP devices and interference is collected, which it predicts would take two years or more. Provided data is collected over the proper time frame and the results show VLP devices are operating without impacting incumbents, API claims that the proposed geofencing system allowing GVP devices to operate at up to 1 dBm/MHz EIRP PSD and 14 dBm EIRP appears to have merit. The Utilities Technology Council and the Edison Electric Institute (UTC/EEI) joint comments advise the Commission to "refrain from further expanding unlicensed operations in the 6 GHz band" until it better understands the interference environment from currently authorized 6 GHz unlicensed devices. The Association of Public-Safety Communications Officials, International (APCO), noting the rules for that VLP devices have only recently been implemented, advises the Commission to let "[r]eal-world operational experience and testing . . . guide any future decision-making rather than risk essential public safety communications networks with theoretical models and lab testing alone."

The Electric Power Research Institute (EPRI) states that if VLP devices "[are] allowed to operate at 1 dBm/MHz [EIRP] PSD, then it is imperative that the method used to prevent operation in areas with

elevated risk of harmful interference be infallible." EPRI claims that its research shows that even at the -5 dBm/MHz EIRP PSD level at which VLP devices operate, a scheme to prevent VLP devices from operating co-channel in a microwave receiver's main beamwidth is necessary to prevent harmful interference and that exclusion zones could be an effective method to protect these sites provided the propagation models align with the findings from real-world testing.

Discussion. The Commission is adopting rules to permit GVP devices to operate in the U-NII-5 and U-NII-7 portions of the 6 GHz band at up to 11 dBm/MHz EIRP PSD and 24 dBm EIRP while under the control of a geofencing system. As discussed in more detail in this document, the geofencing system must comply with various requirements to prevent GVP operations at locations where they may cause a significant risk of harmful interference to licensed incumbent services that share the 6 GHz band. The geofencing system will use the same propagation models and protection criteria that are employed by AFC systems to calculate exclusion zones in which the GVP access points will not be permitted to operate co-channel with a microwave receiver. The geofencing system will also prevent GVP access points from operating near certain radio astronomy observatories. The GVP access points will be required to have a geolocation capability to determine when they enter an exclusion zone and must adjust their operating frequency, if necessary, to meet this condition. GVP client devices, which will not be required to have a geolocation capability, will operate only under the control of a GVP access point at 6 dB less than the controlling access point's authorized power.

The Commission adopts the 11 dBm/MHz EIRP PSD and 24 dBm EIRP power levels rather than the 1 dBm/MHz EIRP PSD and 14 dBm EIRP power levels proposed in the *6 GHz Second FNPRM* for several reasons. First, the geofencing systems will be equally effective in preventing a significant risk of harmful interference at the higher power levels because the size of the exclusion zones will increase to account for the higher power—i.e., the size of the exclusion zones scales with the power level. Second, the Commission agrees with commenters who opine that permitting higher power levels than those proposed in the *6 GHz Second FNPRM* provides a stronger incentive for manufacturers to invest in geofencing systems and GVP devices. Moreover, the Commission recognizes that adopting the proposed GVP power levels, which are only an incremental power increase to the VLP power levels, may not convince industry to undertake the expenses associated with developing this new class of devices. Lastly,

the Commission believes that 11 dBm/MHz EIRP PSD and 24 dBm EIRP are necessary for GVP access points to deliver the required reliability and performance for body worn applications, as Apple and Meta point out. According to measurements conducted by the Wireless Research Center of North Carolina, which examined the attenuation between two body worn devices for six test subjects, body attenuation can range from 28 to 96 dB. Considering the high level of signal attenuation that must be overcome between body-worn devices, the Commission concludes that the higher power levels it's permitting are appropriate.

Commenters agree that permitting higher power levels will enable more versatile GVP devices to be developed and result in a wide variety of innovative products. As Apple, Broadcom et al., point out, the higher PSD level will be particularly useful for applications that rely on narrow channels such as high bitrate audio and control signaling while the higher maximum power will benefit data-intensive tasks in applications such as artificial reality/virtual reality, automotive technologies, screen mirroring, hotspots, and indoor location and navigation. Adopting the higher power levels requested by industry with a geofencing requirement provides more versatility to encourage innovative uses and incentivize investment without increasing the harmful interference risk to incumbent users. The Commission also points out that even though it's permitting up to 11 dBm/MHz PSD and 24 dBm EIRP levels, the Commission expects the majority of devices to operate below these maximum levels most of the time. For many reasons, including to increase battery life, portable devices generally operate at the minimum power level necessary to close the link. In addition, the Commission notes that Apple and Meta's filing shows that body attenuation is highly variable based on individual factors; the maximum power is only needed for the extreme cases when body attenuation is at its highest. Thus, the higher power levels the Commission is allowing combined with a geofencing system that scales exclusion zones to the power level provides maximum flexibility for the development of versatile devices to provide new applications to the public while continuing to protect incumbent services from a significant risk of harmful interference.

The Commission declines to adopt the two-power level model suggested by Apple. The Commission appreciates the desire to simplify geofencing system implementation, but believe this decision is best driven by geofencing system providers based on intended customers and applications or

through industry consensus within a standards process. The rules the Commission adopts simply define maximum PSD and EIRP and permit geofencing system providers to determine whether to calculate a single exclusion zone based on the maximum power or to calculate multiple exclusion zones indexed for lower power levels. Thus, geofencing system providers can determine the proper tradeoff between the flexibility and complexity associated with calculating a single or multiple exclusion zones.

The Commission also does not find it appropriate to limit the power available to GVP devices to protect enterprise LPI Wi-Fi devices, as suggested by Cisco and HP Enterprise. 6 GHz band unlicensed devices are expected to share the band with other unlicensed devices. The operators of enterprise Wi-Fi networks have no basis to expect that they can manage use of the 6 GHz band spectrum solely for their benefit. One of the Commission's goals for expanding unlicensed use in the 6 GHz bands is to encourage the development of innovative consumer devices. By increasing the power available to VLP devices that employ geofencing, the Commission will enable exciting new applications, such as body-worn devices for augmented reality/virtual reality, as well as provide for higher data rates for existing uses, such as Wi-Fi hotspots. The Commission does not believe that it would be in the public interest to forego these new applications to potentially prevent harmful interference from occurring to other unlicensed device users. The new applications and higher data rates will be widely available to all consumers and businesses. The Commission believes this is preferrable to the alternative of restricting the capabilities of GVP devices by limiting their power in order to, in effect, permit enterprises to exclusively use the shared 6 GHz band spectrum within their facilities. Moreover, the Commission notes that its rules contain provisions designed to promote coexistence among all devices operating in the 6 GHz bands. For example, GVP devices will need to comply with the same contention-based protocol requirements already in place for LPI and VLP devices and the dynamic transmit power control requirement in place for VLP devices.

The Commission declines to delay adopting GVP rules in order to collect more data or conduct testing, as suggested by API, UTC/EEI, APCO, Evergy, and AT&T. The Commission also sees no reason to adopt the incremental approach of initially adopting a lower GVP power level and potentially increasing it after the Commission gains more experience with GVP operations. The Commission's rules for AFC-enabled standard-power devices were adopted in 2020, (85 FR 31390, May 26, 2020), and AFC systems have been approved for commercial operation since February 2024. The Commission has not

received any interference complaints related to 6 GHz standard-power devices operating under the control of AFC systems. Because GVP geofencing systems will employ the same propagation models and determine exclusion zones using the same I/N threshold as the AFC systems, the Commission is confident that the geofencing systems will be equally effective at preventing a significant risk of harmful interference. Also, in the unlikely event that harmful interference occurs, the Commission will require geofencing systems to adjust any or all exclusion zones. Thus, the rules contain an effective mitigation strategy should harmful interference occur.

The Commission is unpersuaded by Evergy's concerns regarding increasing the noise floor or causing harmful interference to microwave receivers. The geofencing system will prevent operation of GVP access points and associated client devices at locations where they present a risk of causing harmful interference to microwave receivers. The Commission notes that Evergy has not presented any technical analysis indicating that such harmful interference will occur in practice or that GVP devices operating in conjunction with a geofencing system will raise the noise floor. The Commission's experience with AFC systems and the fact that the exclusion zones can be adjusted, if necessary, indicate that harmful interference is unlikely to be an issue and that if any interference issues do arise, they can be addressed by the Commission. As to EPRI's contention that any method used to prevent VLP device operation in areas with elevated interference risk must be "infallible," we acknowledge that no spectrum management system is infallible. However, based on past experience with using databases to effect spectrum management opportunities, such as with the AFC systems and the spectrum access systems (SAS) used to manage access to the 3550-3700 MHz band in the Citizens Broadband Radio Service, the Commission believes that the geofencing systems that its rules are enabling will permit GVP operation without posing a significant risk of harmful interference.

The Commission disagrees with AT&T that the lack of a specific proposal by GVP advocates prevented incumbents from rationally evaluating the potential for harmful interference. The rules the Commission is adopting closely mirror its proposal in the *6 GHz Second FNPRM* and require GVP devices to operate pursuant to a geofencing system that will be based on the same propagation models as used for the AFC systems. The *6 GHz Second FNPRM* sufficiently discussed the topics that AT&T claims must be included in a serious proposed set of GVP rules.

The Commission is not increasing the general (i.e., non-geofenced) VLP PSD to 1 dBm/MHz EIRP, as suggested by the Wi-Fi Alliance and the IEEE LMSC. The *6 GHz Second FNPRM* explicitly declined to seek comment on modifying the VLP rules for devices operating without a geofencing system except for some aspects of the out-of-band emission limits. Thus, any consideration of higher power for non-geofenced VLP devices is beyond the scope of the FCC's proceeding.

Finally, AT&T questions the computer simulations on which the Commission relied when adopting the VLP device rules. However, the Commission is not relying on those computer simulation results in reaching our decision to permit GVP operations. Instead, the Commission bases its decision to permit GVP on the adoption of rules requiring the use of a geofencing system to prevent any significant risk of harmful interference. Therefore, the veracity of the simulations the Commission relied on when authorizing VLP devices is not relevant to the Commission's decision here permitting GVP operations.

GVP Client Device Power

The *6 GHz Second FNPRM* proposed to require client devices operating under the control of a GVP access point to transmit only on channels determined by that GVP access point. Under this proposal, client devices would not be required to directly obtain or calculate exclusion zones. The *6 GHz Second FNPRM* proposed that client devices operating under the control of a GVP access point be permitted to operate at the same power level as the GVP access point.

AT&T expresses concern that the *6 GHz Second FNPRM* proposed to permit client devices connected to GVP access points to operate at the same power as the GVP access point, even though only the GVP access points will be subject to geolocation and geofencing requirements. AT&T calls this a "significant and unexplained departure from the requirement" for standard-power and LPI operations that client devices operate at power levels at least 6 dB less than the associated access points. AT&T suggests that if the Commission does not require GVP client devices to similarly operate at lower power levels, the exclusion zones should be extended by 365 meters, the range over which AT&T claims that two GVP devices could communicate.

Apple, Broadcom et al. suggest that the Commission's rationale for adopting lower power limits for standard-power and LPI client devices does not apply to GVP devices. Apple, Broadcom et al., note that the Commission mandated lower power for standard-power and LPI client devices "as a precaution

against the theoretical scenario that a client device could operate in a location with a substantially different interference potential compared to its associated standard-power [access point]." Apple, Broadcom et al. claim that scenario will not occur for GVP client devices because they "must operate in close proximity [to their access point] due to their lower power levels relative to standard power [access points]." Apple, Broadcom et al. further explain that the power level for LPI client devices was specifically lowered to prevent outdoor use, an issue that is not relevant for GVP client devices, which would be allowed to operate outdoors.

Apple supports the Commission's proposal to authorize the same power levels for GVP access points and client devices because the devices will rely on symmetrical bi-directional communication. Apple suggests that if the Commission decides to adjust the size of the exclusion zones determined by the geofencing system to account for the potential separation distance between a GVP access point and client device, "expanding the exclusion zones by 75 meters would be a very conservative approach," as demonstrated by data presented by Apple and Meta. The Apple and Meta data show the separation distance that can be achieved between GVP access points and client devices when operating a communication link at different Wi-Fi modulation and coding schemes (MCS) in urban and suburban areas. These calculations were based on operation with 21 dBm EIRP, 4 dB of body loss, 0 dBi antenna gain, a transmit frequency of 6.5 GHz, and the use of the propagation models specified in the Commission's rules for AFC operation. This data illustrates that as the MCS level increases the GVP access points and client devices must be closer together to successfully communicate. Apple and Meta maintain that these calculations show that "a 75-meter buffer would more than account for the potential distance between a [GVP access point] and client [device] . . . because this would be larger than the maximum separation distance established using AFC modeling for devices operating at MCS 4." Apple and Meta claim that "[GVP] devices are likely to overwhelmingly operate at MCS 4 and above" because "[o]peration at MCS 1 would not support the throughput requirements needed for this class of devices, which will enable [augmented reality], video, and other high-throughput applications." They also maintain that "in the real world, [GVP] devices will rarely, if ever, be separated by 75 meters" because they "may not be fixed, must be workable at far lower power than standard Wi-Fi, and include a geolocation-capable [access point]." Apple and Meta note that GVP devices "[t]ypically will be body-

worn devices that operate with negligible separation distances." Apple and Meta also claim that AT&T's suggested 365-meter buffer distance cannot be replicated and that AT&T relies on unrealistic assumptions, such as using only the free-space propagation model.

Recently, Apple and Meta have implicitly supported a 6 dB power differential between GVP access points and associated client devices by advocating that maximum authorized power levels of at least 11 dBm/MHz PSD and 24 dBm EIRP for GVP access points and 5 dBm/MHz PSD and 18 dBm EIRP for GVP client devices are essential for adequate reliability and performance for GVP use cases.

Discussion. The Commission is adopting GVP access point power levels that are higher than were proposed in the *6 GHz Second FNPRM*—up to 11 dBm/MHz EIRP PSD and 24 dBm EIRP instead of the proposed 1 dBm/MHz EIRP PSD and 14 dBm EIRP. At these higher power levels, it is possible for client devices to operate at distances farther from the controlling GVP access point than anticipated under the Commission's proposal. Although many potential GVP applications, such as body-worn devices for augmented reality/virtual reality, will involve access points and client devices located on the same person, other applications, such as a GVP mobile hotspot, would likely involve client devices that are distant from the access point. Consequently, a client device operating at the same power as its controlling GVP access point could be located within an exclusion zone even when the GVP access point is safely outside of the exclusion zone. Therefore, consistent with existing 6 GHz client device rules, the Commission will require client devices under the control of a GVP access point to operate at power levels at least 6 dB less than the power level determined by the geofencing system for the associated GVP access point. Because the Commission is implementing this power reduction requirement for GVP client devices, the Commission declines to extend the exclusion zone boundaries, as AT&T suggests.

Apple, Broadcom et al. provide no rationale to support its claim that GVP client devices must operate in close proximity to GVP access points. While Apple, Broadcom et al. are correct that one of the motivations for the 6 dB power differential between LPI access points and their associated client devices was to limit the client devices to indoor operation, client devices connected to standard-power access points are also restricted to 6 dB less power than their associated access point and such access points and client devices are not limited to indoor operation. This illustrates that when adopting the rules for standard-power devices the Commission believed that it is necessary to impose a 6 dB power difference

between access points and client devices to prevent the client devices from operating too close to microwave receivers even when the associated access point is operating under the control of an AFC system. The Commission continues to hold to that reasoning and reach the same conclusion for GVP devices. In addition, Apple provides no basis for contending that GVP devices will rely on symmetrical bi-directional communication. Other 6 GHz unlicensed devices such as standard-power and LPI devices function with a 6 dB power differential between access points and client devices and the Commission sees no basis for concluding that GVP devices cannot also be designed to account for this power difference.

The Commission finds that providing 6 dB lower power for GVP client devices is a superior approach for compensating for the separation distance between GVP access points and client devices than adding a 75-meter buffer to the exclusion zone boundaries, as suggested by Apple and Meta. The 75-meter buffer size is based on the assumption that at least MCS 4 will always be necessary for these devices. While this may be the case for the augmented-reality glasses and wristband electromyography technology that are the subject of Apple and Meta's presentation, the Commission is not limiting GVP devices to particular technologies or applications. GVP devices operating under the rules the Commission is adopting are expected to operate at a range of MCS levels as needed for different applications and will be able to employ technologies other than Wi-Fi. Consequently, the Commission cannot conclude that GVP access points and client devices will always be limited to a 75-meter separation distance. Applying the same 6 dB power level differential between access points and client devices as the Commission have used for other types 6 GHz unlicensed devices is a more straightforward approach to protecting licensed operations that share the 6 GHz band, while also enabling GVP client devices to operate at the power levels that Apple and Meta state are necessary to ensure reliable communications. This approach also maintains the coexistence scheme already in place to protect incumbents from a significant risk of harmful interference.

The Commission does not believe that imposing a 6 dB power differential between GVP access points and associated client devices will hinder the usefulness of GVP devices. As noted above, Apple and Meta have advocated that GVP client devices should have a maximum permitted power level of at least 18 dBm and 5 dBm/MHz to support the envisioned use cases, such as body-worn devices for augmented reality applications and multiple peer-to-peer links. While Apple, Broadcom et al. have

indicated that they support 8 dBm/MHz EIRP PSD and 21 dBm EIRP power levels and also advocate for no power differential between GVP assess points and client devices, they have not indicated that limiting client devices to 3 dB below these power levels will hinder the implementation of particular use cases. Therefore, the Commission has no reason to conclude that the power limits its establishing for client devices under the control of GVP access points will inhibit the usefulness of GVP devices.

Under the rules the Commission is adopting, GVP client devices are limited to a maximum of 5 dBm/MHz EIRP PSD and 18 dBm EIRP. In addition, for GVP access points operating within an exclusion zone and pursuant to geofencing instructions limiting power below the maximum permitted, associated client devices will similarly be required to reduce power such that they are at least 6 dB less than the maximum power permitted for the GVP access point. For example, if a GVP access point is operating in an exclusion zone and limited by the geofencing system to 1 dBm/MHz EIRP PSD and 14 dBm EIRP, an associated client device will be limited to -5 dBm/MHz EIRP PSD and 8 dBm EIRP. However, if a GVP access point transmits at less than its maximum permitted power level, the maximum power for the client device is determined by subtracting 6 dB from the access points maximum permitted power, not by subtracting 6 dB from the access points transmit power. For example, if a GVP access point that is operating outside of any exclusion zone transmits at 5 dBm/MHz PSD and 18 dBm EIRP, an associated client device could transmit at this same power level because the maximum permitted power level of the access point is 11 dBm/MHz PSD and 24 dBm EIRP.

GVP Operations in U-NII-6 and U-NII-8

In the *6 GHz Second FNPRM,* the Commission proposed that geofencing systems protect BAS and CARS operations in the U-NII-6 and U-NII-8 bands. The Commission noted that both the 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. 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. The

Commission proposed that the geofencing systems protect the BAS and CARS operations using the same propagation models, interference protection criterion, and body loss assumptions as used to protect microwave receivers in the U-NII-5 and U-NII-7 bands.

Due to the steerable nature of the central receive antennas, the Commission asked if exclusion zones surrounding central receive sites need to be circular to ensure protection in all directions, or could they be only part of a circle, i.e., less than 360 degrees. The Commission noted that 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) and asked whether GVP devices should avoid operation across the entire band that a BAS/CARS site receives within the exclusion zones. The Commission sought comment on whether there are ways to 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. More specifically, the Commission asked whether BAS and CARS users should be required 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 GVP 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. The Commission noted that if it were to adopt a push notification or similar approach to protect BAS/CARS based on usage, there would be a need for one or more centralized systems to register BAS/CARS usage and provide the information to geofencing systems.

The Commission proposed 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 GVP device operating on the same channel in a nearby location. The Commission explained that the sensing function associated with the contention-based protocol, along with the low probability for co-channel operation, is sufficient to ensure that GVP devices detect nearby mobile BAS operations and avoid transmitting co-channel to protect those operations from harmful interference.

Apple, Broadcom et al. point to a computer simulation they submitted prior to the issuance of the *6 GHz Second FNPRM* as evidence that harmful interference will not occur to ENG receive sites from

GVP operations at 21 dBm EIRP. This simulation examined two ENG receive sites at Cowles Mountain, San Diego, CA, and the Old Post Office in Washington, DC. The simulations analyzed mobile links from ENG trucks to BAS central receive sites for a total of six links per site. The simulations purport to show that both sites had a close to zero percent probability of experiencing an I/N higher than -6 dB due to VLP devices operating at 21 dBm. While Apple, Broadcom et al. claim the record shows there will be an insignificant risk of harmful interference when GVP operates at 21 dBm EIRP, they "support the Commission's belt-and-suspenders use of geofencing for this GVP device class." They note that adopting a contention-based protocol requirement and the opportunity for broadcasters to report on ENG link locations will further diminish the risk of harmful interference to ENG incumbent licensees.

NAB contends that the Commission's proposal to protect mobile operations using exclusion zones around registered ENG central receive sites is based on an incomplete view of how this spectrum is used. It points out that "[w]hile transmission from a mobile ENG truck to a central receive site is a common way that licensed users of this spectrum operate," "[b]roadcasters make use of this spectrum in myriad ways when covering newsworthy events, including from camera-back transmitters to temporary receivers mounted on trucks that can operate nationwide." NAB claims that the proposal for BAS users to provide operating locations and frequencies to a database administrator would "add[] significant burden and delay to the newsgathering process" and require "untold expense to implement a system to capture this information." NAB also criticizes the computer simulation upon which Apple, Broadcom et. al. rely, claiming that the analysis showing absolutely no interference to ENG receivers is plainly unreasonable because many hypothetical VLP transmitter locations near an ENG receive antenna would present a signal exceeding a –6 dB I/N level.

Discussion. The Commission defers adoption of rules to permit GVP operation in the U-NII-6 and U-NII-8 bands because it does not believe that the record currently contains sufficient details to adopt geofencing that will efficiently manage spectrum while protecting mobile BAS and CARS operations. Because news events can occur anywhere with little notice, a geofencing system that is based on the actual location and directionality of the links between ENG truck transmitters and the central receive sites will require updated information on the locations of ENG truck transmitters. If the ENG operations are not tracked in a centralized database, the geofencing systems will have to protect the ENG receivers over

a 360-degreee radius at all times. This large area will need to be protected across the entire U-NII-6 and U-NII-8 bands because BAS and CARS licenses typically permit transmissions across the entire bands. Because ENG news gathering is conducted by broadcasters throughout the nation, establishing exclusion zones at every ENG central receive site that covers the entire U-NII-6 and U-NII-8 bands will remove a tremendous amount of spectrum from use by GVP devices. Hence, to efficiently manage access to this spectrum the Commission finds that it should consider how geofencing systems can be designed to use information on actual ENG use to quickly update the exclusion zones governing GVP device use.

While Apple, Broadcom et al. support the use of geofencing systems for GVP devices operating in the U-NII-6 and U-NII-8 band and contend that NAB has not substantiated its claim that providing real-time information on BAS/CARS use would be a burden to newsgathering operations, they have not provided any details on how geofencing systems would collect BAS/CARS usage information and manage GVP device spectrum use. For the Commission to adopt rules for geofencing systems that use real-time information on BAS/CARS use, the Commission would have to address many issues such as: How would the information on BAS/CARS use be collected? Who would collect this information? What specific information would be collected? How would the information be propagated to the various geofencing systems? How would updated exclusion zones based on this information be pushed to the GVP access points? How quickly would the GVP access points need to adjust their spectrum use as BAS/CARS spectrum use changes? Given the lack of record on how this process would work in practice, the Commission does not believe that it has sufficient information to adopt rules for geofencing systems for the U-NII-6 and U-NII-8 bands. In adopting rules to permit GVP device operations in the U-NII-5 and U-NII-7 bands while deferring consideration of operations in the U-NII-6 and U-NII-8 bands, the Commission is following the same path it used to adopt rules for VLP devices. In the 2023 *6 GHz Second Order,* the Commission adopted rules to permit VLP device operation in U-NII-5 and U-NII-7. In 2024, after obtaining a more robust record, the Commission expanded VLP operations to the U-NII-6 and U-NII-8 bands in the *6 GHz Third Order* (90 FR 11373, March 6, 2025).

Geofencing System Architecture

In the *6 GHz Second FNPRM* the Commission proposed to provide manufacturers with flexibility to design appropriate geofencing systems for different equipment use cases rather than mandate a specific

geofencing system architecture and provided three examples. A first example architecture could have a centralized geofencing system calculate exclusion zones based on information obtained from Commission databases, e.g., the Universal Licensing System (ULS), as well the Commission's rules. A GVP access point would contact the centralized geofencing system to download exclusion zones and then manage its spectrum use based on the downloaded information. A second example architecture could have a GVP access point regularly send its location to a centralized geofencing system, which would then inform the access point as to the channels it may use. This second example architecture would use the same methodology as the existing AFC systems that manage standard-power access point spectrum access with the added requirement to account for the inherent mobility associated with GVP access points. A third example architecture could integrate the geofencing system within a GVP access point. A GVP access point would obtain local licensing data by downloading information from an external source. The GVP device would need to contain software necessary to use that data to independently determine exclusion zones and manage its spectrum use. The first and second examples are categorized as "centralized" architectures because they rely on a central server to perform the calculations necessary to implement the geofenced exclusion zones, while the last is a "distributed architecture" in which the calculations are performed by each GVP access point. The Commission proposed to permit either a distributed or centralized architecture. The Commission also sought comment on whether it should provide flexibility for the geofencing system implementations or specify a single approach.

AT&T suggests that the Commission require a geofencing architecture where the GVP device downloads keyhole-shaped geofenced exclusion zones from a central server because such a system would be simpler than the Commission's other two example architectures. This suggested architecture is a specific example of the first example architecture which uses simplified exclusion zone boundaries rather than permitting more complex exclusion zones determined by propagation models consistent with the AFC systems as the Commission has proposed. AT&T notes that the simplified approach of the first example architecture would "reduce[] the complexity and storage requirements of those [GVP] devices." By contrast, AT&T claims that the Commission's second example architecture, in all practicality, would revert to the existing AFC system and result in overly complex exclusion zones. AT&T also advises the Commission not to authorize a distributed architecture, i.e., the Commission's third example architecture.

According to AT&T, a distributed architecture would effectively require each device to be its own AFC system but without the controls in place for AFC systems, such as the standards-based interference calculation, AFC system public validation through trials, and a common interference reporting system. AT&T claims that AFC system and device implementation variations would render device certification untenable. AT&T argues that permitting these types of devices would "impose[] massive burdens on [fixed microwave] incumbents to continually monitor every VLP device application and conduct assessments to determine if a multiplicity of self-coordinating devices using proprietary mechanisms will actually protect [fixed microwave] incumbents. Evergy advocates that the Commission require a centralized architecture to calculate exclusion zones to ensure licensed incumbents are protected in a consistent and predictable manner. UTC/EEI also favor a centralized architecture, noting that a distributed framework would not be as effective and would pose a greater interference risk to incumbents.

Apple, Broadcom et al. explain that the Commission's proposal to "allow[] both centralized and distributed geofencing systems affords device manufacturers sufficient flexibility to facilitate higher-power operations while still providing robust protections for incumbent operators." According to Apple, Broadcom et al., "AT&T's opposition to the Commission's proposal fails to recognize that (1) the AFC rules prohibit mobile devices and (2) the Commission's geofencing proposal has several critical benefits compared to an AFC—energy efficiency, consumer privacy, and flexibility." Apple, Broadcom et al. claim that the fundamental difference between what the Commission proposes and AT&T's proposal is that the Commission's proposal facilitates mobile operations. They note that the AFC rules prohibit mobile operations and that the Commission's proposal is "simple enough to facilitate mobile operations without imposing unnecessary device or AFC system complexity." Apple, Broadcom et al. also claim that AT&T's proposal "would require frequent AFC system queries, which would drain consumers' batteries" and would compromise consumer privacy due to the need to constantly transmit the access point's location to third parties. Apple, Broadcom et al. also claim that the Commission's proposal will support GVP technology adoption for a broad range of applications. Apple, Broadcom et al. also disagree with AT&T's claim that consumer devices will not be capable of implementing a distributed architecture. They explain that device manufacturers can choose which approach is best for its device; noting that the Commission's proposal allows more capable devices to use the distributed approach.

Comsearch recommends that the Commission allow flexibility for the geofencing architecture, noting that the GVP device use case should determine which architecture is most feasible. According to Comsearch, if a centralized approach, such as the current AFC systems, is used, the need for a mobile device to keep the centralized system informed of its location, direction, and velocity "would substantially complicate message exchange and spectrum availability calculations" compared to AFC systems. However, Comsearch states that a centralized approach, such as an AFC system, would be more feasible for stationary GVP devices.

Federated Wireless urges the Commission to "adapt the currently authorized AFC systems for the new [GVP] class" rather than certifying a novel system. According to Federated Wireless, "[t]he information that AFC systems currently provide to [s]tandard [p]ower devices in the 6 GHz band is identical to what would be needed to allow higher-power [GVP] devices to access those frequencies." In order to account for GVP device mobility, Federated Wireless suggests that information on channel availability and power levels could be calculated for a predefined area, with the device only needing to check-in with the AFC system again if it moves outside that area. Federated Wireless recommends that "AFC system operators work with [GVP] device manufacturers to specify how this interaction would work in practice and to address other challenges that are specific to [GVP] devices, including battery power consumption and privacy." Federated Wireless also agrees with other commenters, such as Comsearch, that the Commission should accommodate any geofencing system architecture that allows GVP devices to operate without causing harmful interference to incumbents. API claims that the geofencing calculation is best done by an AFC system rather than by a separate geofencing provider.

Discussion. The Commission will require geofencing systems to use a centralized architecture to control GVP access points. Although the Commission sought comment on also permitting a distributed geofencing architecture, the Commission finds that it is appropriate to limit geofencing systems to a centralized architecture because of concerns that it would be difficult to test a distributed architecture geofencing system and that such a system would make it difficult to address any instance of harmful interference, should it occur. As AT&T notes, a distributed geofencing architecture would essentially permit each device to act as its own AFC system, but without any of the controls placed on AFC systems. AFC systems are only authorized after extensive lab testing using industry developed test vectors and a

public trial where interested parties have the opportunity to examine AFC system outputs for specific locations. Because each GVP access point in a distributed geofencing system would need to calculate the exclusion zones, each GVP access point model would need to be tested to verify compliance with the Commission's exclusion zone rules. As AT&T states, the need to monitor every VLP device application and conduct sophisticated assessments on those devices would impose massive burdens on primary microwave incumbents to determine whether the VLP device adequately protects those systems. Although AT&T raises concerns with testing the operation of distributed geofencing systems in its comments, no commenters provide any suggestions on how such systems may be tested. Given the importance that the Commission places on preventing harmful interference from occurring to licensed incumbents and the need to verify through adequate testing the proper functioning of the geofencing systems, the Commission will not permit use of a distributed geofencing architecture.

In the *6 GHz Second FNPRM*, the Commission proposed that each geofencing system operator for centralized systems establish and follow protocols to comply with Commission instructions regarding enforcement actions and to adjust exclusion zones, as necessary, to more accurately reflect the potential for harmful interference. The Commission is adopting these requirements for centralized geofencing systems. These provisions enable the Commission to take action in the unlikely event that a GVP device causes harmful interference to a licensed incumbent. Under a centralized architecture, the Commission can simply issue necessary instructions to the approved geofencing systems to mitigate any harmful interference instances by either eliminating certain devices from operating as GVP devices or to adjust exclusion zones. However, it is not apparent, and commenters have not addressed, how these requirements can be satisfied for a distributed geofencing architecture where each GVP access point may not have regular contact with a database to receive such instructions in a timely manner. This is another reason the Commission is not permitting a distributed geofencing architecture.

While the Commission noted two examples of centralized geofencing architectures, the Commission is providing flexibility for geofencing administrators to implement various centralized architectures. The Commission's approach will permit geofencing systems to leverage existing AFC systems which could accelerate the time for GVP technology becoming commercially available. However, the Commission will not require that geofencing systems be based on the currently authorized

AFC systems, as Federated Wireless and API suggest, because this may discourage innovation and limit the number of geofencing systems that are developed with no apparent benefit. So long as a geofencing system uses a centralized architecture and meets our other requirements, the Commission will not restrict administrators from implementing their preferred method. The Commission believes that this flexible approach will lead to GVP devices that meet a wide variety of use cases. The Commission believes that the first example architecture, where GVP access points determine whether they are in an exclusion zone by downloading information describing those zones from a centralized geofencing system, may be most likely to be deployed, but the Commission will not require use of this specific architecture. Apple, Broadcom et al. argue that AT&T's opposition to the Commission's proposal to permit flexibility in the geofencing architecture fails to recognize the benefits that the proposal has compared to requiring an AFC system, such as energy efficiency, consumer privacy, and flexibility. While the Commission is not adopting the proposal to permit use of a distributed architecture, the flexibility that we are providing to permit use of any type of centralized architecture provides these benefits. Under the first example architecture, only infrequent communication is needed between the GVP access point and geofencing server because the GVP access point can download exclusion zones for a large area, thereby enhancing device battery life. Because only infrequent communication will be required, use of the first example architecture will not substantially complicate message exchange and spectrum availability calculations as Comsearch implies. The first example architecture will also protect consumer privacy because the device does not need to inform the database as it changes position. The rules the Commission are adopting provide the flexibility to use any type of centralized architecture, which should provide device manufacturers with the flexibility to work with geofencing system providers and design appropriate geofencing systems for different use cases.

Protection of Fixed Microwave Systems

As proposed in the *6 GHz Second FNPRM*, the Commission will protect fixed microwave services from a significant risk of harmful interference by requiring geofencing systems to determine location- and frequency-based exclusion zones for GVP access points around fixed microwave receivers based on the same criterion used by AFC systems to protect microwave receivers from standard-power access points and fixed client devices. Specifically, the geofencing systems will calculate frequency-

based exclusion zones using the same propagation models used by the AFC systems to avoid causing an I/N greater than the –6 dB interference protection criterion established for the AFC systems. The – 6 dB criterion was established as an appropriate threshold to protect fixed microwave receivers. Individual GVP devices will use these exclusion zones to determine where they are prohibited from transmitting on particular frequencies to prevent harmful interference from occurring.

Interference protection criterion. The *6 GHz Second FNPRM* proposed that geofencing systems calculate the GVP exclusion zones based on the same – 6 dB I/N interference protection criterion that the Commission adopted in the *6 GHz First Order* (85 FR 31390, May 26, 2020) for AFC systems. EPRI characterizes -6 dB as the appropriate interference protection metric, while AT&T states that this metric "should be adjusted in view of additive impacts and the 'at sufferance' nature of Part 15 RLAN devices."

The Commission adopted the – 6 dB I/N criterion for use by AFC systems based on an extensive technical record and was supported by the Fixed Wireless Communications Coalition, the Utilities Technology Council et al., and other representatives of fixed microwave incumbents. The – 6 dB I/N metric has also been extensively used in numerous computer simulations developed for analyzing the harmful interference risk posed by unlicensed devices in the 6 GHz band. The – 6 dB I/N interference protection criterion used by AFC systems has been widely supported by 6 GHz unlicensed device proponents and microwave incumbents. The –6 dB metric in conjunction with the propagation models required in the Commission's rules have proven sufficient in enabling adequate protection to fixed microwave receivers when standard power devices access spectrum under the supervision of an AFC system. The geofenced systems can similarly use this proven methodology to ensure microwave receivers are protected when unlicensed GVP devices access spectrum in a manner the geofenced system has determined will not present a significant risk of harmful interference. Therefore, the Commission is adopting this same metric for geofencing systems to use when determining exclusion zones. Geofencing systems will be required to determine exclusion zone boundaries based on calculating locations where the I/N ratio exceeds – 6 dB using the propagation models specified in the Commission's rules.

While AT&T argues that additive interference undermines the technical justification for using the – 6 dB I/N metric, 6 GHz unlicensed devices only present a risk of interference if they are in the microwave antenna's main beam at a close enough distance. The geofenced system that controls GVP

access points' spectrum access will prevent those devices from operating at locations where they would present a significant risk of harmful interference. Furthermore, Monte Carlo analysis by Apple shows that the additive effects of LPI and VLP devices, operating without any frequency management mechanism such as a geofencing or AFC system, do not present a significant risk of harmful interference to microwave links. Therefore, the Commission does not agree with AT&T that additive effect undermine the technical reasoning for adopting the –6 dB metric. By adopting this metric, the Commission ensures consistency between the calculation methods used by AFC and geofencing systems which should enable geofencing administrators to easily develop and implement these systems. Moreover, use of this metric by AFC systems has been effective in preventing harmful interference from occurring to licensed incumbents from standard power device operations. In adopting the use of this metric by geofencing systems, the Commission is not making a determination that any signal received with an I/N greater than – 6 dB would constitute "harmful interference" but are instead using this as a conservative means to ensure that microwave receivers are protected.

Propagation models. The *6 GHz Second FNPRM* proposed that geofencing systems, to determine the VLP device exclusion zones, use the same propagation models that are used by AFC systems to provide channel and power information to standard power access points and fixed client devices. Specifically, the Commission proposed 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. The Commission also proposed to require geofencing systems to use site-specific information, including buildings and terrain data, to determine 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 Commission proposed that geofencing systems 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. The *6 GHz Second FNPRM* proposed that these propagation models be used to calculate the GVP exclusion zones. These proposals were designed to ensure consistency among operating locations and parameters for various GVP systems, as well as consistency with the consensus

methodology WinnForum published for AFC systems.

EPRI agrees with the Commission that exclusion zones can be an effective method to protect microwave receivers, "provided that the propagation models that define the zones align with findings from real-world interference testing" and that the models account for line-of-sight paths between outdoor unlicensed devices and microwave receivers. EPRI suggests using a purely geometric exclusion zone rather than relying on the Commission's proposed propagation models. The geometric exclusion zone would be based on a 30-meter radius around the microwave receiver that extends into a keyhole shape with edges defined by the microwave receive antenna 3 dB bandwidth out to a distance of 10 kilometers. EPRI states that such distance is necessary to eliminate a discontinuity between the WINNER II and ITM propagation models used by the AFC systems, which EPRI claims implies that AFC systems under-protect FS systems. If the Commission uses a propagation model approach to defining exclusion zones, EPRI advocates using free space path loss as a reliable conservative approach. EPRI also questions whether the ITM clutter models used by the AFCs are relevant for GVP devices because they do not contain a specific category for roads and highways. EPRI opines that automotive GVP devices are likely to be the first to market and that clutter may not be accurately modeled because the WINNER II model includes morphologies for "urban" and "suburban" areas but lacks guidance for roads and highways.

AT&T similarly advocates for a simple keyhole exclusion zone that can be defined by a few discrete numbers such as latitude and longitude of the microwave receiver, direction of the main beam, radius of a circle around the receiver, and angle and distance defining a triangle with its apex at the microwave receiver and its base perpendicular to the main beam. It points out that if the exclusion zone is more terrain-dependent, "it could only be defined with a string of high-precision latitude/longitude pairs," which is more complex and similar to the AFC systems that already exist. AT&T suggests using free space path loss to determine the geofencing area and including a 1.9-kilometer buffer for mobility. According to AT&T, the ITM propagation models "are extremely nuanced and susceptible to major variations even with minor changes in distance" and that the algorithms can be implemented in different ways leading to significantly different results.

Apple, Broadcom et al. state that the AFC propagation models, which are based on the distance between a GVP device and a microwave receiver, "sufficiently protects incumbents and can be easily

applied in the [GVP] context." Further, they claim that using these models "ensures that the exclusion zones are effectively tailored to the actual operating conditions." Apple, Broadcom et al. object to the suggestion that only free space path loss be used for calculating exclusion zones. They point out that the Commission previously found the free space path loss model inappropriate "because it fails to account for obstruction and terrain variation." According to Apple, Broadcom et al., while free space path loss can be appropriate for short paths to account for a higher line-of-sight potential, "it does not reflect real-world operating conditions for other locations."

The Commission is adopting rules that base the exclusion zones on the same propagation models as used for AFC systems, which were adopted after carefully considering the record. The Commission explained that the adopted approach, which uses a combination of propagation models to accommodate a variety of environments and distances, is the best way to balance unlicensed device access and incumbent protection. Because GVP devices will operate on the same spectrum as standard power devices, their transmissions are subject to the same physical and temporal environment as those devices. Thus, the Commission concludes that its experience with these propagation models, which account for the 6 GHz operating environment, since adopting the standard-power device rules provides strong support for concluding that they are similarly appropriate for managing GVP device spectrum access. Since the first AFC systems were approved for commercial operation in February 2024, the Commission has not received any reports that harmful interference occurred to microwave receivers from standard-power access points.

When the Commission adopted the standard-power device rules, the record included contentions by microwave licensees that terrain and clutter losses should not be assumed using statistical models and that the appropriate propagation model should be free space path loss. The Commission disagreed with the claims that a free space model must be used in cases where clutter and terrain data are not known. While the Commission adopted the free space path loss model for short separation distances (up to 30 meters), it noted that this model drastically underpredicts path loss for longer distances because there is almost always interaction with the environment that reduces the signal level below free space. As with standard power devices, using the free space path loss model to protect microwave receivers from GVP devices would overprotect such systems and unnecessarily restrict GVP devices resulting in less efficient

spectrum use.

By deciding to use the AFC propagation models, the Commission rejects the notion that geofencing exclusion zones should be defined using purely geometric models or simplified circle and triangle shapes, as suggested by EPRI and A&T. Instead, the Commission will permit geofencing systems flexibility to specify exclusion zones using more complex boundaries, which the Commission recognizes can result in exclusion zones with complex shapes. Therefore, to simplify and reduce the data that needs to be conveyed to a GVP device, the Commission will permit geofencing system administrators to simplify the exclusion zone boundaries, so long as they do not provide any less protection to microwave receivers. In other words, the exclusion zones can be simplified or smoothed to ease implementation, as long as the result protects microwave receivers to the same level or more than what the propagation models and the -6 dB I/N metric indicate. To accommodate GVP devices from different manufacturers and potentially multiple geofencing systems, and to ensure that exclusion zones are calculated and provided to GVP devices in a consistent manner, the Commission expects that industry groups will create necessary standards, including an interface specification.

The Commission disagrees with EPRI's concern that the ITM model under-protects microwave systems due to a discontinuity between the predicted propagation loss with the Winner II model at a distance of 1 kilometer. EPRI provides no actual evidence that the ITM model is under-protecting the microwave receivers. In the *6 GHz First Order*, the Commission concluded that the ITM model was the appropriate propagation model for the AFC systems to use for distances greater than 1 kilometer, noting that it is supported by the record and has served reliably as a propagation model. In addition, the ITM model has been used to determine spectrum availability in the spectrum access systems (SAS) used to manage access to the 3550-3700 MHz band in the Citizens Broadband Radio Service. Given the lack of actual evidence that the ITM and Winner II models are not appropriate for use by the geofencing systems and the Commission's previous experience with these models for the AFC systems, the Commission sees no grounds to depart from the propagation models proposed in the *6 GHz Second FNPRM*.

Additionally, the Commission disagrees with EPRI's concern that the clutter models used with the ITM model do not represent device use along roads. The clutter models specify clutter levels based on broad land use categories such as urban, suburban, and rural with the model for rural areas using

different modeling based on barren areas, high crop yield fields, deciduous trees, coniferous trees, and village center. Because roads are surrounded by buildings or trees that are reflective of these categories, the Commission would expect the signals from devices transmitting on or along roadways to experience attenuation from clutter in the same manner as signals transmitted by devices located away from the roadway. For example, a signal transmitted from a GVP device located along a roadway in a suburban area would experience clutter effects from the buildings and trees in the surrounding environment that are reflective of a suburban environment. EPRI appears to be expecting a degree of precision from clutter models that is not realistic. The same considerations apply to EPRI's concerns regarding the WINNER II model's lack of guidance for use on roads.

GVP Transmit Height. The *6 GHz Second FNPRM* stated that the geofencing systems could use an antenna height above ground of 1.5 meters in the propagation models when creating the GVP exclusion zones. AT&T points out that for unlicensed whitespace devices, the "geofencing parameters explicitly consider the elevation—antenna height—of the potentially interfering device." AT&T also contends that an assumed antenna height of 1.5 meters is inappropriate because the microwave receiver main beam is highly directional and therefore is sensitive to changes in interferer elevation. AT&T suggests that the "geofencing boundaries . . . should be determined using the worst-case antenna elevation based on terrain, topology, or LIDAR data."

The Commission expects that antenna height will not be a significant factor in calculating exclusion zones because most GVP device use will occur indoors. The computer simulations submitted by Apple, Broadcom et al. that the Commission relied on when adopting the rule to permit VLP operation assumed that only 6% of the people using VLP devices would be outdoors. The Commission concluded that this assumption was reasonable because it was based on Department of Transportation and Environmental Protection Agency statistics. Because transmissions from indoor GVP devices will be subject to significant building attenuation, the Commission believes that operation of indoor GVP devices at any elevation will not present a harmful interference risk. Hence, for 94% of GVP device use, the device elevation will not be a factor.

The Commission also expects the vast majority of outdoor GVP device use will occur at ground level— that is, people will use the portable devices outdoors at ground level. For such use, the

Commission finds that 1.5 meters above ground level is an appropriate approximate height. The Commission also notes that the ITM model does account for terrain and hence does compensate for any difference in terrain height between the microwave receiver location and a GVP device being used at an elevation of 1.5 meters above the ground level. While the WINNER II model does not account for the actual terrain, because this model is only used for distances less than one kilometer we do not expect that there will be significant variations in terrain for most cases.

There will be a small number of situations where GVP devices are used on building balconies and rooftops. In such cases, assuming a 1.5-meter device height above ground level would not be appropriate. However, the Commission cannot endorse AT&T's proposed worst-case height solution based on terrain, topology, or LIDAR data as it would result in significantly overprotecting microwave receivers in most situations, such as when GVP devices are being used indoors, or at lower heights. Considering the ever-increasing demand for spectrum, the Commission cannot justify eliminating more spectrum than is necessary from GVP use. Also, using such data, where available, would, in effect, assume all in-building GVP use is on the building rooftops instead of indoors or on lower elevation balconies, dramatically reducing the GVP operating area absent an increased harmful interference risk. The Commission also notes that LIDAR data is not available in all locations.

To compensate for the relatively fewer GVP devices that may be operating on building rooftops and balconies, the Commission is requiring geofencing systems to assume a 10-meter height above ground level for GVP devices when calculating exclusion zones. The Commission is using a 10-meter height for the GVP access points because this is the height assumed in *OET Bulletin No. 69*, which describes using the terrain-dependent Longley-Rice point-to-point propagation model for estimating received signal strength of television signals. *OET Bulletin No. 69* was used by the Commission to make broadcast television signal coverage predictions when assigning channels during the transition from analog to digital television. *OET Bulletin No. 69* provides an appropriate precedent for the assumed GVP device height for two reasons. First, GVP devices, like television sets, will be used where people live or work, which may be in buildings ranging in size from one-story houses to multi-story buildings. When choosing the height to use for *OET Bulletin No. 69*, the Commission chose a height that was appropriate to represent the wide variety of possible antenna locations. This height is also appropriate to represent the

wide variety of indoor GVP use. Second, the Longley-Rice propagation model is the basis of the ITM model, which the Commission is requiring geofencing systems to use for distances greater than one kilometer. While using a 10-meter height will, in most cases, result in larger than necessary exclusion zones, the Commission also notes that some outdoor GVP use could occur at greater heights. In the latter case, however, such use will only present a harmful interference risk if it occurs on the same channel as being used by a microwave link and within a microwave receiver's main beam within a few kilometers from the microwave receiver location. The Commission concludes that such cases are likely to be so rare as to present an insignificant risk of harmful interference occurring. Moreover, similar to VLP devices, GVP devices are designed to be inherently mobile, and any instances of potential interference are expected to be fleeting.

Body Loss. The *6 GHz Second FNPRM*, similar to the Commission's conclusion for VLP devices in the *6 GHz Second Order*, proposed to allow geofencing systems to assume 4 dB for body loss when calculating exclusion zones. AT&T urges the Commission not to assume that all GVP devices will be body worn and subject to 4 dB of body loss, noting that "there is no rule that requires VLP devices to be body worn" and therefore "no basis for assuming [GVP] devices will, in fact, be body worn." If the Commission adopts an assumption for body loss, AT&T suggests that the rules bar certification for GVP devices that are not explicitly designed to be body worn. AT&T also asserts that because "VLP devices are likely to be deployed in pairs, . . . it is irrational to assume that both endpoints of the [communication] will be subject to body attenuation." UTC/EEI point out that not all VLP devices will be oriented or used on the body where 4 dB of body loss can be assumed to occur. EPRI states that if the GVP device is oriented such that there is no body shielding to the microwave receiver, a 0 dB body loss would be appropriate. EPRI also suggests that "the first mass-market VLP devices will be automotive" and that, "[b]ecause automotive bodies have glass in all directions[,] . . . more study is needed to determine what value of loss or gain is required to match real-world deployments."

Apple, Broadcom et al. disagree with AT&T's suggestion that the Commission ignore body loss unless the rules require a device to be body worn, noting that "even if a device is not directly worn on the body, proximity effects can still be present." Apple, Broadcom et al. notes that the Commission previously concluded that "'such losses [still] 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.'" Apple, Broadcom et al. also claim that "[GVP device] operations in cars will actually be *more protective* than on-body operations" because automotive bodies have close to 9 dB mean attenuation – far higher than our assumed body loss value. API supports using 4 dB body loss for GVP devices.

In the *6 GHz Second Order*, the Commission explained that 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. The Commission noted that a 4 dB body loss is appropriate because "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." The Commission also found that a 4 dB body loss "appears to be a conservative assumption" because "the body loss measurements submitted by Apple, Broadcom et al. and Meta show a distribution with a mean higher than 4 dB and some measured attenuations were much greater than the 8 dB maximum of the truncated distributions used in the simulations."

In the *6 GHz Third Order*, the Commission recognized that several related technical studies filed by Broadcom and Apple, Broadcom et al., referred to as the ENG Truck Receiver Studies, provided evidence to support its conclusion that harmful interference would not occur to electronic newsgathering (ENG) truck receivers from VLP device operations. The ENG Truck Receiver Studies assumed 4 dB of body loss for the transmissions from the VLP device. The Commission concluded in the *6 GHz Third Order* that using 4 dB for body loss in these link budget calculations is consistent with assumptions that it found were appropriate in the *6 GHz Second Order*.

The Commission finds, consistent with its previous conclusions in the *6 GHz Second Order* and *6 GHz Third Order*, that it is appropriate for geofencing systems to assume a 4 dB body loss value when calculating the exclusion zones to protect microwave receivers. Several commenters object to an assumption of 4 dB of body loss because not all GVP devices will be body worn. While the Commission agrees with commenters that not all GVP devices will be body worn, the Commission reiterates its statement from the *6 GHz Second Order* that the term "body loss" refers not only to the attenuation when a GVP device is used on or near a human body, but also to the attenuation from other nearby objects, such as a table that the device is sitting on or a vehicle's passenger cabin. Apple, Broadcom et al. concurs that

"body loss" can occur "even if a device is not directly worn on the body" because "proximity effects can still be present." Although some commenters appear to claim that the 4 dB body loss assumption should not apply in certain scenarios, the Commission notes that they did not submit any technical data to support those claims. Thus, based on the record before the Commission, it will permit geofencing systems to account for up to 4 dB body loss consistent with the Commission's previous conclusion as to the appropriate body loss to assume for interference related VLP device calculations.

The body-loss measurements that Apple, Broadcom et al. previously submitted on the record illustrate that 4 dB is a conservative body-loss value. According to these measurements of a smartphone transmitting in six different locations on six different people, the measured body loss was greater than 4 dB 90% of the time and could be as high as 30 dB. These measurements indicate that excluding body loss from the exclusion zone calculation will result in larger exclusion zones than are necessary to protect the microwave links the vast majority of the time. Therefore, assuming no body loss, as several commenters suggest, would conflict with the Commission's goal to promote efficient spectrum use.

The Commission does not agree with EPRI that more study is needed regarding VLP use in automobiles before the Commission adopts a body loss value for the geofencing systems. As noted, body loss also refers to loss from nearby objects. Notably, Apple, Broadcom, et al. cited a technical study finding that, on average, vehicles cause 9 dB of signal attenuation to devices operating in the 2 GHz band. While the 6 GHz band was not explicitly tested, this study demonstrates that devices operating in-vehicle at 6 GHz would experience some level of attenuation. Therefore, because signals transmitted by a GVP device within an automobile will be subject to some amount of attenuation from the vehicle cabin, the Commission believes it is appropriate to assume that at least 4 dB of attenuation will be present for this use case.

Aggregate interference. The *6 GHz Second FNPRM* proposed that geofencing systems not be required to consider aggregate interference effects from multiple GVP devices, noting that these devices 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. Apple, Broadcom et al. agree that the risk of aggregate interference from GVP is even lower than for standard-power devices because "GVP devices will operate at a considerably lower power level

compared to standard power [access points]" and the required contention-based protocol will "greatly decrease[] the likelihood of simultaneous transmission that could lead to aggregate interference." EPRI claims that its real-world testing confirms that additive interference effects are real and that geofencing systems must acknowledge additive interference. According to EPRI, locations where line-of-sight paths occur between unlicensed devices and microwave receivers are not rare corner cases and that when multiple devices operate at such locations the aggregate interference effects significantly increase the potential for harmful interference. AT&T suggests that the Commission follow the practice adopted in the United Kingdom and the European Union "where an additional 4 dB margin was included to adjust for aggregate effects." AT&T also cites an instance where the Commission assumed a 4 dB margin to account for aggregate interference when setting a power flux density interference limit into satellite earth station receivers. AT&T notes that the Commission's previous finding regarding aggregate interference pre-dates the two technical studies filed by EPRI and FirstEnergy and the technical study filed by Southern Company.

The two studies conducted by EPRI and FirstEnergy, which AT&T references, purport to show measured reduction in microwave link fade margin from aggregate effects of multiple access points. However, these two studies show inconsistencies that cast doubt on the results. For example, the first study shows that, in some instances, the reduction in link fade margin actually decreases when multiple access points are transmitting compared to when just one access point is transmitting but increases in other instances. The Commission speculates that the inconsistencies in the two EPRI and FirstEnergy studies are related to the methodology employed for measuring the impact from unlicensed device operation on microwave links. EPRI and FirstEnergy regularly measured a baseline fade margin with no unlicensed devices transmitting by reducing the microwave transmitter power level until bit errors occurred. One or more unlicensed devices were then turned on and the microwave link power level was reduced until errors occurred. The difference in the microwave link power level at which errors occurred between these two cases was the "reduction in fade margin," which EPRI and FirstEnergy claims is due to unlicensed device operation. But this methodology is flawed because the fading level experienced on a microwave link constantly changes, which means that the baseline fade margin does not remain constant during the testing. To account for variation in link fading, EPRI and FirstEnergy either used the baseline

fade margin before the unlicensed devices were turned on or interpolated or calculated the average of the baseline fade margin measurements made before and after the measurements with the unlicensed devices. As the fade margin measurement plot in the second EPRI and FirstEnergy test report shows, the baseline fade margin over the three-day testing period varied between 25 and 29 dB and the difference between two successive baseline fade margin measurements was as much as 2 dB. Based on the data in these test reports, it is difficult to conclude whether the fade margin reduction was due to variation in the baseline fade margin over time or was caused by the additive effect from multiple unlicensed devices simultaneously transmitting. The Commission also notes that when using multiple simultaneously transmitting unlicensed devices, EPRI and FirstEnergy set them to use "iperf-tenstreams" which generates "10 concurrent streams of maximum rate TCP." This produced continuous extremely high-rate transmissions instead of the bursty discontinuous transmissions typical of Wi-Fi. Hence, the Commission would not expect this type of testing to accurately model the effects of typical unlicensed devices. The technical study by Southern Company, which AT&T also references, is also lacking because it merely speculates that aggregate interference could occur from multiple access points in a specific building rather than actually measuring whether such aggregate interference actually occurs. Therefore, the Commission does not find these technical studies persuasive and concludes that there is no need to adjust the exclusion zones based on the potential for aggregate interference from multiple GVP devices.

AT&T points out that the Commission assumed a 4 dB factor for aggregate interference when setting a power flux density (PFD) limit for out-of-band emissions from base and mobile stations in the 3.7-3.98 GHz band into satellite earth station antennas in the adjacent 4-4.2 GHz band. The 3.7-3.98 GHz band has been auctioned to wireless mobile broadband carriers. Spectrum use by wireless carriers typically differs from spectrum use by unlicensed devices. Wireless carriers set up their networks to provide ubiquitous coverage with higher power levels than are permitted for unlicensed devices. Base stations employed by wireless carriers transmit continuously, unlike the bursty transmissions of unlicensed Wi-Fi devices. Given the differences in how the licensed 3.7-3.98 GHz band is being used compared to the likely characteristics of GVP devices, the Commission does not believe that its prior decision assuming a 4 dB margin for aggregate interference in the 3.7-3.98 GHz band is relevant to 6 GHz GVP devices.

AT&T refers to a statement from the United Kingdom spectrum regulator on 5 and 6 GHz band Wi-Fi use and a report on a simulation study conducted by the Electronic Communications Committee of the European Conference on Postal and Telecommunications Administrations to support a claim that the United Kingdom and the European Union use a 4 dB margin for aggregate effects. The Commission notes that neither of these documents mention a 4 dB margin to compensate for the aggregate interference effects.

Adjacent channel protection. The *6 GHz Second FNPRM* proposed that GVP exclusion zones only account for co-channel operations and not consider adjacent channel operations. This is a departure from the rules for standard-power devices, which require AFC systems to account for the potential of standard-power devices causing harmful interference to microwave links operating on an adjacent channel. The *6 GHz Second FNPRM* explained that this was appropriate due to the significantly lower operating power of GVP devices compared to standard-power devices. AT&T argues that there is "no basis to exclude adjacent channel protection if the keyhole calculations indicate that adjacent channel geofencing is warranted." Apple, Broadcom et al. agree with the *6 GHz Second FNPRM* proposal, noting that the Commission already concluded in the *6 GHz First Order* that the adjacent channel interference risk to microwave receivers from standard-power devices is low. They argue that because "[GVP] devices will operate at significantly lower power levels than standard-power devices, . . . the already low risk [is] insignificant."

The Commission will not require that geofencing systems account for potential adjacent channel interference effects when determining exclusion zones because the Commission does not believe that such adjacent channel operations will present a significant harmful interference risk to microwave receivers. The rules the Commission is adopting for GVP devices require emissions to be suppressed by 20 dB at 1 megahertz outside the 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. This means that energy from a GVP device will be limited to -9 dBm/MHz at one megahertz outside the channel edge with even lower power at greater spectral distance. Given the low energy level that GVP devices will emit into adjacent channels, the Commission concludes that they are unlikely to present an interference risk to microwave receivers on adjacent channels. Thus, the Commission cannot justify

imposing such additional complexity on geofencing systems. The Commission recognizes that this is a departure from its rules for standard-power devices. However, the Commission concludes that the lower GVP signal levels compared to standard-power devices (i.e., standard-power client devices operate at a maximum 17 dBm/MHz) justifies our approach.

Exclusion zone update interval. The *6 GHz Second FNPRM* proposed to require geofencing systems to obtain the most recent public access file data from the Commission's ULS database at least once per day and to recalculate the exclusion zones, as necessary, to account for any new or updated information. The *6 GHz Second FNPRM* explained that a once-per-day interval is appropriate because ULS, which contains the data required to determine exclusion zones to protect fixed microwave receivers, is generally updated on a daily basis. Therefore, a daily update interval would ensure that newly registered microwave receive sites are promptly protected. Furthermore, the *6 GHz Second FNPRM* proposed to require GVP access points to obtain updated exclusion zones from the geofencing systems at least once per day.

There were no comments opposing the daily ULS update interval for geofencing systems. AT&T agrees that a daily ULS database update is reasonable. The Commission will require geofencing systems to update their data from the ULS database at least once per day and to update the exclusion zones daily based on the updated data.

AT&T asks the Commission to require GVP access points to obtain updated exclusion zones from the geofencing system every hour. AT&T notes that this one-hour reauthentication interval would be consistent with the rules for unlicensed whitespace devices and contends that the Commission provided no rationale for not proposing the same rule for GVP access points. However, this fails to acknowledge that GVP devices will have different operational characteristics than white space devices. White space devices are required to update hourly because there are wireless microphones in the band that can be registered at any time. In the 6 GHz band, newly registered microwave receivers are added to the ULS database once a day. Consequently, it is unnecessary for the geofencing systems to update the exclusion zones or for the GVP access points to download the updated exclusion zones more than once a day. Therefore, the Commission will require a GVP access point to obtain updated exclusion zones from the geofencing system at least once per day. If the GVP access point fails to obtain the updated

information on any given day, the GVP 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 information for its location.

Microwave links may begin operation prior to obtaining a license so long as certain criteria are met, such as completing successful frequency coordination and filing an application that appears in the ULS database as pending. In addition, temporary fixed microwave links may be authorized by a blanket authorization, in which case the licensee is not required to obtain approval from the Commission prior to operating at specific locations or report the technical details of their operation to the Commission. The *6 GHz Second FNPRM* sought comment on requiring geofencing systems to follow the same criteria for protecting fixed and temporary fixed sites as AFC systems use for standard power access points and fixed client devices. No comments from the record directly address this issue. Accordingly, for the reasons set forth in the *6 GHz First Report and Order*, the Commission will require that the geofencing systems protect pending facilities and temporary fixed stations that are registered in ULS. Because the geofencing systems must have knowledge of the location of temporary fixed links in order to protect them from harmful interference, the Commission will require operators of temporary fixed stations register the details of their operations (transmitter and receiver location, antenna height, antenna azimuth, antenna make, and model, etc.) in the ULS database if they desire to be protected from potentially receiving harmful interference from GVP devices in the U-NII-5 and U-NII-7 bands.

Exclusion or Inclusion Zones. Under the requirements the Commission is adopting, geofencing systems will determine exclusion zones around microwave receiver and radio astronomy observatories where GVP access points are required to avoid operating on particular frequencies. The *6 GHz Second FNPRM* proposed that as an alternative to defining exclusion zones, the geofencing systems may also determine areas where particular frequencies are available throughout the entire area based on the same criteria used to calculate exclusion zones. Allowing geofencing systems to specify "inclusion zones" instead of exclusion zones could provide increased flexibility for implementing geofencing. No commenters addressed this alternative. Because using either exclusion zones or inclusion zones will provide equivalent protection to microwave receivers and radio astronomy observatories, the Commission will permit geofencing systems to use either an exclusion-zone or an inclusion-zone approach. The

Commission expects that industry groups will create necessary standards, including addressing the most efficient method for implementing incumbent protection.

Protection of FSS

The entire 6 GHz band is allocated for the FSS in the Earth-to-space direction, except for the 7.075-7.125 GHz portion of the band. Additionally, portions of the U-NII-7 and U-NII-8 bands are allocated for FSS space-to-Earth (downlink) operations. However, there are no licensed downlink earth stations in the U-NII-7 band. Sirius XM and Globalstar, the only satellite licensees who filed comments in response to the *6 GHz Second FNPRM*, limited those comments to their U-NII-8 band operations. Because the Commission is permitting GVP devices to operate only in the U-NII-5 and U-NII-7 bands at this time, Sirius XM's and Globalstar's concerns regarding their operations in the U-NII-8 band are not relevant to GVP operation.

In the *6 GHz First Order*, the Commission concluded that because the satellites receiving in the U-NII-5 and U-NII-7 bands are limited to geostationary orbits, approximately 35,800 kilometers above the equator, the Commission found that standard power unlicensed devices would be unlikely to cause harmful interference to the space station receivers. The only restriction that the Commission adopted to protect the satellite receivers, which it characterized as a "precautionary measure," was to require that outdoor standard-power access points limit their maximum EIRP above a 30-degree elevation angle to 21 dBm. In the *6 GHz Second Order*, the Commission determined that no restrictions on VLP devices are necessary to protect FSS Earth-to-space operations. This conclusion was based on the fact that VLP devices, operating at up to 14 dBm EIRP, transmit at significantly lower power than the 21 dBm allowed for standard power access points above 30 degrees elevation.

The Commission concludes that GVP operations will not cause harmful interference to FSS satellite receivers. FSS satellites in geostationary orbits are unlikely to receive harmful interference from GVP devices because of the relatively low transmit powers of the GVP devices and the large distance to the satellites. This conclusion is supported by a study conducted by RKF Engineering (2018 RKF Study), which found that the interference level at the satellites would be less than -20 dB I/N from 6 GHz unlicensed devices that included outdoor access points operating at up 36 dBm. While Sirius XM criticized a number of the assumptions used in the 2018 RKF Study, as the Commission explained in the

6 GHz Third Order, Sirius XM's contentions do not provide a reason to reconsider our conclusion about the likelihood of interference occurring to FSS uplinks. The Commission also notes that no one has produced any technical studies illustrating that GVP devices operating at the power levels we are adopting will present a harmful interference risk to geostationary satellite receivers.

The Commission does not believe it is necessary to adopt a restriction on GVP EIRP for higher elevation angles as we did for standard power access points. Because the Commission is prohibiting GVP devices from use on fixed infrastructure, these will be portable, battery-powered devices. Such devices will generally operate at the lowest power necessary to maximize their operating time. While these devices may operate at the maximum power the Commission is permitting in certain situations, such as to overcome large body losses or to compensate for longer than typical distances, we expect such situations to be rare. This differs from access points, which typically operate at a constant power level. Therefore, the Commission sees no reason to adopt the precautionary restriction on power transmitted above 30 degrees elevation that the Commission applied to standard power access points.

Protection of Passive Services

Radio astronomy. Several radio astronomy observatories located in remote areas observe methanol spectral lines in the 6.65-6.6752 GHz portion of the U-NII-7 band. The table of frequency allocations urges that the Commission takes "all practicable steps" to protect the radio astronomy service in the 6.650-6.675.2 GHz range from harmful interference. In the *6 GHz Second FNPRM*, the Commission proposed to require that geofencing systems implement the same exclusion zone rules for protecting radio astronomy sites in the 6.650-6.6752 GHz band as standard power access points and fixed client devices, which are based on the distance to the radio horizon. The locations of the protected radio astronomy sites and the protection criteria for these sites are specified in the standard power access point and fixed client device rules.

The National Academy of Sciences' Committee on Radio Frequencies (CORF) points to its previous arguments that VLP devices should avoid channels that overlap the 6.7 GHz radio astronomy band. In the *6 GHz Second Order*, the Commission considered and rejected CORF's request to prohibit VLP devices from using certain frequencies or channels to protect radio astronomy operations, stating that VLP devices' interference potential in the U-NII-7 band is even lower than for LPI devices that were

already permitted to operate at higher power levels than those adopted for VLP devices. However, GVP devices will operate at higher power than VLP, which increases their potential for causing harmful interference to radio astronomy operations. Therefore, the Commission will prohibit GVP access points from operating inside of exclusion zones in the 6.65-6.6752 GHz portion of the U-NII-7 band used by radio astronomy. The Commission concludes that the geofencing system will prevent higher power GVP devices from operating co-frequency inside exclusion zones around radio observatory sites where they could cause harmful interference.

Earth-Exploration Satellite Service (EESS). Remote sensing using the EESS, which CORF states is critical to weather prediction and studying climate change and the Earth in general, operates in the 6.425-7.250 GHz band, which includes the U-NII-6, U-NII-7, and U-NII-8 bands. In the *6 GHz Second FNPRM*, the Commission sought comment on the harmful interference risk from GVP devices on oil platforms to EESS monitoring operations. The Commission also sought comment on appropriate restrictions for VLP device use on boats to protect EESS operations, and if so, should those restrictions be limited to boats in the oceans, given that EESS is used for sensing over the ocean. CORF suggests that EESS (passive) observations in the U-NII-6, U-NII-7, and U-NII-8 bands can be protected by programming GVP devices to avoid these bands while in oceanic zones and coastal waters. The Commission agrees with CORF and concludes that geofencing will prevent GVP devices in the U-NII-7 band from operating co-frequency with EESS observations within ocean exclusion zones. However, CORF has not indicated what boundary should be used to designate ocean exclusion zones. To balance EESS protection requirements with providing flexibility to maximize locations in which GVP devices can operate, the Commission will use the United States territorial sea border to define the boundary of the ocean exclusion zones, which is 12 nautical miles (nm) from the baseline of each coastal State. This will allow GVP devices to operate near the coastlines while ensuring that EESS sensing ocean temperatures avoid receiving harmful interference over ocean areas.

The Commission will also exclude GVP access points from oil platforms to mirror the rules for VLP devices, standard-power access points, and low power indoor access points. The Commission notes that Apple, Broadcom et al. and API support not permitting GVP access on oil platforms. The Wi-Fi Alliance suggests removing all restrictions on unlicensed operation on oil platforms, claiming the 2023

World Radio Conference (WRC-23) resolved to migrate all EESS ocean sensor measurements to other frequency bands. The Commission notes, however, that the WRC-23 resolution cited by the Wi-Fi Alliance only resolved to study other frequency bands for EESS and does not indicate that EESS would stop using the 6 GHz band. Therefore, the Commission has no grounds to change our policy regarding 6 GHz unlicensed devices on oil platforms.

CORF also indicates that EESS sensing operations may be extended to large inland bodies of water, such as the Great Lakes, and requests that the Commission not allow VLP devices on boats in these bodies of water. It suggests geofencing could also be used to prevent GVP operations in these inland lakes The Commission finds these concerns about potential future EESS use to be speculative and declines to prohibit GVP devices from operating on boats in the Great Lakes or in other large inland bodies of water at this time.

GVP Device Requirements

Geolocation capability. Consistent with the requirements for standard power access points, in the *6 GHz Second FNPRM,* the Commission proposed to require that GVP access points include a geolocation capability to determine their geographic coordinates. Additionally, the Commission proposed that the geolocation capability include the ability to determine location uncertainty in meters, with a 95% confidence level, and that the applicant for certification of a GVP access point demonstrate the accuracy of the geo-location method used and the location uncertainty. The Commission further proposed to require a GVP access point, using its geographic coordinates, to take this location uncertainty into account when determining whether it is within an exclusion zone. AT&T contends that geofencing proponents should describe how devices will determine not only their location, but also the accuracy associated with that location determination. Furthermore, AT&T claims that the location accuracy determination must be specific to the area in which the location measurement is being taken. Alternatively, AT&T suggests that geofencing proponents explain how the Commission's rules will ensure that any flexibility granted to equipment manufacturers to develop individualized systems for determining a device's location will meet those requirements.

The Commission sees no reason why geofencing proponents should have to describe how GVP access points will determine their location and the accuracy associated with that location determination,

as suggested by AT&T, because device manufacturers will be required to provide this information as part of the equipment certification process. The Commission's rules will require GVP device manufacturers to provide an attestation describing the geolocation method used, the method's accuracy, and the location uncertainty accuracy as part of the FCC certification process. Therefore, the GVP manufacturers will be required to demonstrate the accuracy of the geolocation method used and the location uncertainty estimate. Device manufacturers of standard-power access points have successfully demonstrated their devices' compliance with the Commission's previous geolocation requirements.

Consistent with the Commission's previous actions for standard-power access points and white space devices, the Commission will require GVP access points to include a geolocation capability to determine its geographic coordinates. Unlike for standard-power access points, the Commission will not provide the option for the GVP access points to use an external geolocation source. This is because the Commission expects that most GVP access points will be devices, such as mobile phones, that have a built-in geolocation capability. The Commission also notes that no commenters have indicated that we should provide the option for GVP access points to use an external geolocation source. The Commission is requiring GVP access points to determine their location uncertainty in meters with a 95% confidence level, as is the case for standard-power access points. Furthermore, the Commission is requiring that the GVP access point use its determined coordinates and location uncertainty when comparing the device's specific location to frequency-specific information (i.e., exclusion zones) obtained from the geofencing system. This means that when the access point estimates that the geolocation coordinates are less accurate, the GVP access point will have to operate at a greater distance from the boundary of the exclusion zone. Taking into account the uncertainty estimate when determining whether the GVP access point is outside of an exclusion zone recognizes the fact that no geolocation technique is absolutely accurate and thereby provides a greater level of protection to the microwave receivers. These geolocation requirements serve as part of the multi-faceted methodology in protecting fixed microwave receivers by ensuring GVP devices operate appropriately based on their location respective to exclusion zones.

Geofence re-check interval. In the *6 GHz Second FNPRM*, the Commission proposed to require GVP access points to have the capability to timely adjust their operating frequencies when moving into, out of, or between exclusion zones. The Commission proposed flexible requirements for the device re-

check or update interval to enable device designers to optimize efficiency while still ensuring that the devices do not operate on channels where the – 6dB I/N metric is not met. The Commission proposed 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. This would require a GVP access point to regularly re-check its location and speed to properly identify its position with respect to any exclusion zones that may exist within its vicinity. As an additional safeguard, the Commission proposed to require a GVP access point to determine its location and speed at least once every minute. The Commission sought comment on the efficacy of its proposals and on any alternatives that may better provide GVP device designers sufficient flexibility without degrading the protection granted to incumbents.

Apple, Broadcom et al. recommend the Commission permit manufacturers to comply with a location re-check interval in a manner that does not result in unnecessary, frequent checks that drain the device's battery and impact the user experience. To that end, they advocate that the Commission not require GVP access points to determine their location and speed at least once per minute as this would unnecessarily undermine device performance. Instead, they recommend the Commission adopt a flexible and technology-neutral approach that does not require a specific time interval or a particular technology solution. Additionally, they urge the Commission to permit manufacturers to demonstrate that their approach effectively complies with the exclusion zone rules when submitting a new device for certification.

AT&T suggests that the rules for unlicensed whitespace devices could provide a model for how to protect fixed microwave incumbents and points to white space provisions for a 60-second reauthorization interval, a 1.9 km buffer, and a 100-meter reauthorization requirement. Regarding an appropriate re-check interval, AT&T suggests that a GVP access point be required to re-check its location every 60 seconds. AT&T also suggests that a GVP access point be required to re-check its location upon a location change (i.e., if the device moves a certain distance), or due to a device's proximity to the nearest exclusion zone.

The Commission will not require a specific methodology for the re-check interval at which the GVP access point must re-check its location and determine whether it is complying with the geofencing

information. Instead, the Commission will require that the GVP access point re-check its location at an interval that ensures that the device adjusts its operating frequencies within one second of when any portion of the device's location uncertainty area crosses into an exclusion zone, so as to ensure that no harmful interference occurs to incumbents. Rather than being prescriptive, the Commission will permit device manufacturers to choose any re-check interval methodology that ensures that a GVP access point complies with this requirement. This requirement will provide flexibility for device manufacturers and promote innovative solutions without compromising incumbent protection. The Commission disagrees with AT&T that it should follow an approach based on the white space device requirements. The white space device rules addressed mobility using rigid assumptions, such as a 60 second recheck interval and a 1.9 km buffer, which was based on a mobile device traveling at 70 mph and re-checking every 60 seconds. These rigid assumptions deviate from the flexible approach the Commission is taking with GVP devices. This flexible approach recognizes that some geolocation solutions are able to provide additional information beyond a device's current position, such as its velocity and acceleration. The flexible approach will ensure that GVP devices re-check less frequently if they are stationary or moving at slow speeds, thus conserving power. Similarly, GVP devices traveling faster or near the boundary of an exclusion zone will be required to re-check their location more frequently. In this way, the flexible approach will provide superior protection to licensees while enhancing GVP device operations. This flexible approach is intended to facilitate the benefits of these devices for the public while still protecting licensees. Given the benefits of this flexible approach, the Commission sees no need to follow the more rigid approach it used for mobile white space devices. The Commission also notes that no mobile white space devices have ever been certified and therefore the Commission has no real-world experience with the efficacy of those more rigid restrictions in protecting other users. Furthermore, AT&T does not present any specific concerns that the proposed re-check interval, or any alternatives presented on the record, will contribute to an increased harmful interference risk.

Transmit Power Control. In the *6 GHz Second FNPRM*, the Commission proposed to require GVP devices operating within the U-NII-5 through U-NII-8 bands to employ a transmit power control (TPC) mechanism that has the capability to operate at least 6 dB below the maximum EIRP permitted for the bands (e.g., 14 dBm or 21 dBm). The Commission proactively determined that it did not expect that a

TPC requirement for GVP devices would present an undue burden on device manufacturers because GVP devices were expected to be battery-powered devices and were likely to implement TPC in order to conserve battery power. As a result, the Commission reasoned that "[b]ecause many VLP devices will be capable of both geofenced and non-geofenced operation, these devices will by necessity incorporate the ability to implement at least a 6 dB power reduction." The Commission sought comment on a variety of issues related to the relative power levels necessary for GVP devices to mitigate any potential for harmful interference. More specifically, the Commission asked whether there was a need to specify any additional TPC requirements for GVP devices given that they would be permitted to operate with higher power than VLP devices. The Commission noted that there is a European requirement that TPC shall provide, on average, a mitigation factor of at least 3 dB on the maximum permitted output power of the systems; or, if transmit power control is not in use, then the maximum permitted mean EIRP and the corresponding mean EIRP density limit shall be reduced by 3 dB.

In response, API recommends that the Commission require TPC on all VLP devices, not just those operating at higher powers. It suggests a more expansive TPC power reduction with a 12 dB range, applied in steps no greater than 3 dB, with the output power reduced to as low as 2 dBm EIRP / -11 dBm/MHz EIRP PSD. It claims that this would help to minimize interference to incumbents and other unlicensed 6 GHz users. Apple Broadcom et al. notes that the Commission has already determined that "a 6 dB [TPC] range is sufficient to protect incumbents," and that API has provided "no new evidence demonstrating that this conclusion was incorrect." They claim that requiring a 12 dB TPC range would negatively impact consumers and would dissuade manufacturers from investing in both VLP and GVP devices because it would increase transceiver complexity and cost.

The Commission will require GVP access points to meet the same TPC requirements as stipulated in the Commission's rules for VLP devices. GVP access points will be required to employ a TPC mechanism with the capability to operate at least 6 dB below the maximum 11 dBm/MHz EIRP PSD. The record lacks technical justification to adopt a different TPC requirement than what is already in place for VLP devices. TPC would help minimize the risk of interference to incumbents as it provides GVP devices with the ability to adjust power levels and subsequently operate at power levels that do not increase the risk of harmful interference. The Commission believes that requiring GVP devices to

comply with the same rule in place for VLP devices is sufficient to ensure that devices have the capability to dynamically adjust power to operate both efficiently and in a manner that continues to minimize the harmful interference risk to incumbents.

Contention-Based Protocol. To add to the protections afforded to licensed incumbents, the *6 GHz Second FNPRM* proposed to require that GVP devices implement a contention-based protocol. While no comments directly support requiring GVP devices to implement a contention-based protocol and no comments oppose such a requirement, several commenters highlight the efficacy of contention-based protocols in mitigating the risk of harmful interference. GVP devices will be operating co-channel with both LPI and VLP unlicensed devices. Requiring use of a contention-based protocol will help promote efficient spectrum sharing between the different types of unlicensed devices. Furthermore, GVP devices will likely also be capable of operating as VLP devices, which are required to employ a contention-based protocol. Consistent with the Commission's rules for VLP unlicensed devices, the Commission will require GVP devices to implement a contention-based protocol that will act to avoid channels on which incumbent systems are transmitting and to promote efficient spectrum usage in channels where other unlicensed users are transmitting.

Fixed Infrastructure. In the *6 GHz Second FNPRM*, the Commission proposed to prohibit GVP devices from operating as part of a fixed outdoor infrastructure as an additional measure to reduce the likelihood of harmful interference to licensed incumbent users. The Commission notes that no commenters oppose the adoption of this prohibition. API, the only commenter to address this issue, agrees that GVP devices attached to fixed outdoor infrastructure should be prohibited. Consistent with the requirements adopted for VLP devices in the *6 GHz Second Order*, the Commission will prohibit GVP devices from operating as part of a fixed outdoor infrastructure. Thus, GVP devices will be prohibited from attaching to outdoor infrastructure, such as poles or buildings, which will help ensure that the GVP devices are used only for mobile applications. Device mobility prevents GVP devices from remaining in potentially problematic locations for significant periods of time. In addition, as the *6GHz Second Order* explained with regard to VLP devices, by prohibiting GVP use as part of fixed outdoor infrastructure, the Commission is ensuring that the GVP devices will be subject to body and/or clutter loss and that most of the GVP devices will operate at 1.5 meters above ground.

Integrated Antenna. In the *6 GHz Second FNPRM,* the Commission proposed to require that GVP access points employ a permanently attached integrated antenna. An identical provision requiring use of an integrated antenna currently applies to LPI access points and subordinate devices. No commenters addressed the proposed integrated antenna requirement. As proposed, the Commission will require GVP access points to use a permanently attached integrated antenna. Because this requirement will prevent users from replacing GVP antennas with high gain directional antennas, it will help ensure that GVP use complies with the power limits that are specified in terms of radiated power (i.e., EIRP).

In the *6 GHz Second Order*, the Commission defined a VLP device as "a device that operates in the 5.925-6.425 GHz and 6.525-6.875 GHz bands and has an integrated antenna." However, the Commission inadvertently did not add VLP devices to the rule provision requiring a permanently attached integrated antenna for low power indoor and subordinate devices. For consistency, the Commission now adds VLP devices to this rule provision. The Commission finds that notice and comment are unnecessary as simply extending the application of this requirement from LPI and subordinate devices to VLP devices for the sake of consistency with the existing rule definition is insignificant in nature and the impact would be inconsequential to the industry and to the public.

GVP Client-to-Client Communications

In the *6 GHz Second FNPRM*, the Commission proposed to permit direct client-to-client communications between GVP client devices when they are both under the control of the same GVP access point and the geofencing system determines that they are operating outside of any geofencing restrictions; i.e., there are channels available for GVP use that are not subject to geofencing requirements in the location where these devices are being used. Apple, Broadcom et al. "support the concept of direct client communications between client devices when operating under geofencing requirements." The Ultra Wide Band Alliance (UWBA) also supports client-to-client communications, emphasizing that clients can use reduced transmit power to reach another client directly and that overall traffic will be reduced by reducing clients communicating through an access point. UTC/EEI raise concerns that "client-to-client operations will exponentially increase the interference threat to licensed microwave systems, and the Commission should refrain from authorizing [client-to-client] for low power indoor ("LPI") and VLP operations." They suggest that the record does not provide sufficient evidence that

geofencing will be able to control VLP client-to-client communications.

The Commission adopts its proposal to allow direct communication between two client devices under control of a GVP access point subject to the client devices being required to operate on the frequency in either the U-NII-5 or U-NII-7 band that they are using to communicate with the GVP access point. All GVP access points will 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. If a GVP access point switches frequencies, the client devices will also be required to switch frequencies to continue operating in a client-to-client mode. The Commission notes that UTC/EEI's concerns do not address direct communication between client devices under the control of GVP access points but instead are directed at LPI and VLP operations. The GVP access point and the client devices under its control will operate only on a frequency consistent with the exclusion zones obtained from the geofencing system. Because each client device will be limited to 6 dB less power than what is permitted for the controlling GVP access point, they will operate close enough to the access point to keep them from operating within any exclusion zone, thus ensuring they do not operate in locations and on channels that could potentially increase the risk of harmful interference to microwave receivers. Because each client device in this scenario would be limited to using the maximum power permitted for GVP client devices for the intra-client communications, there would be no increase in the potential for causing harmful interference to microwave receivers compared to the client devices each individually communicating with the controlling GVP access point. As Wi-Fi Alliance and UWBA point out, direct client-to-client communication will allow reduced overall traffic through an access point thus promoting a more efficient use of spectrum.

In the *6 GHz Second FNPRM*, the Commission also proposed to permit GVP devices that are operating under the control of the same low power indoor access point to directly communicate with each other. In addition, the Commission sought comment on permitting direct communication between clients of low power indoor access points. The Commission is deferring any decision on client-to-client communications for devices operating under the control of low power indoor access points.

The Commission notes that the rules it is adopting permit GVP access points to directly

communicate with each other. This communication can be conducted at the power levels permitted for GVP access points — i.e. at a maximum 11 dBm/MHz EIRP PSD and 24 dBm EIRP in accordance with the exclusion zones provided by a geofencing system. Therefore, devices that would typically operate as client devices, such as body-worn augmented reality glasses, smart wristwatches, or laptop computers, can operate at the higher access point power level if they meet the requirements of GVP access points, such as having a geolocation capability and operating on frequencies and at power levels only in accordance with the exclusion zones provided by a geofencing system. These devices will not be able to operate at the higher GVP access point power level unless they have first obtained exclusion zone information. This may require them to initially operate at lower power levels as a GVP client device or VLP device to communicate with an access point to obtain the exclusion zones before they can operate at the higher GVP access point power level. The Commission notes that nothing in its rules prohibits a GVP access point from relaying exclusion zone information obtained from a geofencing system to another GVP access point. Consequently, a GVP access point could operate as a client device to another GVP access point, use this connection to register with and obtain exclusion zone information from a geofencing system, and then switch to operation as a GVP access point and increase its transmit power level accordingly.

Approval of Geofencing Systems

The Commission delegates to the Office of Engineering and Technology (OET) the authority to administer the geofencing systems and geofencing system operator functions in accordance with the rules the Commission is adopting to govern 6 GHz band geofencing systems. The Commission also delegates OET authority to develop specific methods that will be used to designate geofencing system operators; to designate geofencing system operators; to develop procedures that these geofencing system operators will use to ensure compliance with the requirements for geofencing system operations; to make determinations regarding the continued acceptability of individual geofencing system operators; and to perform other functions as needed to administer the geofencing systems. The Commission amends part 0 of its rules to delegate to OET authority to oversee the geofencing systems.

OET's review process to designate geofencing system operators should ensure adequate testing to verify that the geofencing systems are calculating appropriate exclusion zones in conformance with the

Commission's geofencing system rules. When the Commission adopted rules for AFC systems, it directed OET to follow a multi-step testing and review process to approve AFC operators and to ensure that AFC system operators administered their systems with minimal chance of harmful interference occurring to licensed incumbents. In doing so, the Commission and OET gained substantial experience in determining the specific steps necessary to ensure efficient administration of unlicensed device access to spectrum using automated coordination mechanisms. Given this history of review, certification, and testing, the Commission is confident that OET has sufficient expertise overseeing spectrum access management system development. As such, the Commission does not believe it is necessary to require or specifically spell out overly prescriptive review, testing, and administration procedures here. Instead, the Commission delegates authority to OET to develop a review and testing process for geofencing systems.

During AFC system development, industry groups took an active role in developing the AFC systems and the AFC test process. Specifically, the WInnForum developed a functional requirements document that specified many operational requirements for the AFC systems, and the Wi-Fi Alliance developed an interface standard for the communications between the standard-power access points and AFC systems. The Wi-Fi Alliance developed a plan for AFC system lab testing, and the WInnForum and the Wi-Fi Alliance jointly developed test vectors for lab testing. The test plan and test vectors were used as one step in the AFC system test process before approval for commercial operations. The development of the geofencing systems may be distinct from that of the AFC systems, and the Commission anticipates the development and approval of a diverse set of solutions. The Commission encourages industry groups, including, but not limited to WInnForum and the Wi-Fi Alliance, to develop geofencing system specifications as well as test processes and test vectors that can be used to verify the proper geofencing system functioning. The Commission notes that the WInnForum has indicated its willingness to support geofencing system development and a desire "to work with the Commission as well as all stakeholders in the development of specifications, recommendations and reports that will be required to develop and ultimately certify VLP geofencing systems." FWCC indicates that its members "stand ready to work with other stakeholders through the WInnForum to develop and test appropriate geofencing systems." The Commission welcomes industry group efforts, such as those from the WInnForum and Wi-Fi Alliance, to develop geofencing systems to enable GVP device deployment and encourages microwave incumbents to

participate in such efforts.

The Commission will permit OET to designate multiple geofencing systems as implied in the *6 GHz Second FNPRM.* While the *6 GHz Second FNPRM* did not explicitly address whether there should be multiple or a single geofencing system operator, the Commission clearly contemplated the potential designation of multiple geofencing system operators by proposing several rules that presumed there would be multiple geofencing system operators. For example, the Commission proposed that "[f]or centralized geofencing systems, geofencing system *operators* must provide continuous service." It also proposed requirements "for geofencing system *operators*" and for "*[e]ach* geofencing system and operator thereof." In seeking comment on these proposed rules, the Commission implicitly expressed that it intended to consider permitting multiple geofencing system operators rather than only a single operator. No commenters addressed whether the Commission should designate multiple geofencing operators. Designating multiple geofencing system operators is consistent with the Commission's actions for 6 GHz AFC systems, television white spaces, and CBRS. Designating multiple geofencing systems will prevent one party from obtaining a monopoly, which should provide an incentive for geofencing system operators to provide reliable service and to keep costs low.

In the *6 GHz Second FNPRM*, the Commission proposed that geofencing systems may charge fees for providing service and that the Commission may, upon request, review the fees and require changes to the fees if it finds them to be unreasonable. No commenters addressed this fee issue. The Commission appreciates that different financial models are likely to be employed by geofencing systems. For example, a device manufacturer may operate a geofencing system to provide service to GVP access points it manufactures without charging any fees to the access point user. Other geofencing systems may employ a subscription model requiring the device user to pay for services. The Commission will not prohibit geofencing systems from charging fees for their services. As has been the case for AFC systems, the Commission expects that there will be multiple geofencing systems approved for commercial operations and that competition from these different systems will keep any fees charged to reasonable levels. However, as a safeguard, the Commission adopts its proposal that it may, upon request, review the fees charged and require changes if they are unreasonable.

In the *6 GHz Second FNPRM*, the Commission proposed that centralized geofencing systems

must provide continuous service to all GVP devices for which they are 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 make arrangements for those devices to continue to receive exclusion zone update information. No commenters addressed this proposal. This requirement addresses a concern that if a geofencing system stops operating, GVP devices may be stranded with no means to obtain updated geofencing exclusion zones. To ensure that consumers who use GVP devices are protected from such an occurrence, the Commission is adopting this requirement. However, upon review, the Commission believes the term "designated" is potentially unclear as it implies that some entity has designated that the geofencing system is to provide service to particular GVP devices. Instead, the Commission shall replace "are designated" with "have agreed" in the rule to avoid any confusion.

Technical Rules

Emission mask. In the *6 GHz Second FNPRM*, the Commission proposed to require GVP 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 First Order* and for VLP devices in the *6 GHz Second Order*. The Commission reasoned that because GVP devices would likely operate in the same bands and on the same channels as VLP, LPI, and standard-power 6 GHz devices and need to protect the same incumbent operations, utilizing the same emission mask for GVP devices is appropriate. The Commission stated that using the same mask would ensure that licensed incumbents are fully protected from unlicensed adjacent channel operations. The Commission believed that specifying the same emissions requirements would reduce costs by permitting devices throughout the VLP ecosystem to use the same filters and benefit from economies of scale. No commenters addressed the proposed transmission GVP emission mask. For the reasons discussed in *6 GHz Second FNPRM,* the Commission adopts the proposed transmission emission mask.

This emission mask requires GVP devices to suppress their power spectral density by 20 dB at one megahertz outside of an unlicensed device's channel edge, 28 dB at one channel bandwidth from an unlicensed device's channel center, and 40 dB at one and one-half times the channel bandwidth away from an unlicensed device's channel center. At frequencies between one megahertz outside an unlicensed device's channel edge and one channel bandwidth from the center of the channel, the limits are linearly

interpolated between the 20 dB and 28 dB suppression levels. At frequencies between one and one and one-half times an unlicensed device's channel bandwidth from the center of the channel, the limits are linearly interpolated between the 28 dB and 40 dB. 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, are to be suppressed by at least 40 dB.

Emission Limits outside of U-NII-5 and U-NII-8. As proposed in the *6 GHz Second FNPRM*, the Commission is adopting emission limits for GVP devices outside of the 6 GHz band that are identical to the emission limits adopted in the *6 GHz First Order* for standard-power and low power indoor devices and in the *6 GHz Second Order* for VLP devices. Specifically, the Commission is adopting a -27 dBm/MHz EIRP limit 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 apply this limit 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 already subject to an emission mask discussed in this document. The Commission notes that these limits are designed to protect cellular vehicle-to-everything (C-V2X) operations below and federal operations above the 6 GHz band. While the Commission previously determined that the -27 dBm/MHz limit was sufficient to ensure C-V2X operations were protected from harmful interference from U-NII devices operating in other bands, in the *6 GHz Second FNPRM*, the Commission sought comment on whether any adjustments are needed to the Commission's VLP device rules to adequately protect C-V2X operation in vehicles. The Commission is deferring consideration of adjusting the in-vehicle VLP device OOBE issue raised in the *6 GHz Second FNPRM* at this time, as potential adjustments to those limits are outside of the scope of this instant document, which is directed to authorizing GVP devices, and are more appropriately considered in a future proceeding.

Prior to adoption of the *6 GHz Second FNPRM,* NTIA filed comments directed at VLP operations that included a Department of Transportation study (*DoT Exhibit*) addressing C-V2X protection requirements in the 5.895-5.925 GHz Intelligent Transportation Systems (ITS) band in which C-V2X technology is used. ITS operators in this band transmit basic safety messages for crash-avoidance and require low-latency, harmful-interference-free operation. According to the *DoT Exhibit*, testing showed that if 6 GHz devices that comply with the -27 dBm/MHz OOBE limit were to operate inside of a motor

vehicle, the operational range of C-V2X receivers operating in the same vehicle would decrease by more than 50%. The *DoT Exhibit* claims that implementing both parts of a two-part compromise submitted by several VLP proponents, which would require VLP devices to prioritize operations to frequencies above 6.105 GHz and limit VLP OOBE below 5.925 GHz to -37 dBm/MHz, is necessary to protect C-V2X receivers.

The Commission notes that no commenter opposed adopting a GVP out-of-band emission (OOBE) limit below the U-NII-5 band and above the U-NII-8 band. The Wi-Fi Alliance contends that given the adequate protection afforded to C-V2X operations by the OOBE limit in place for other U-NII devices, there is no reason to subject GVP devices to more restrictive OOBE limits than for VLP devices. Qualcomm Incorporated (Qualcomm) claims that the Commission should adopt a more stringent OOBE level for VLP devices and that this level of protection should be extended to GVP devices. It contends that at the transmit power level of 21 dBm for GVP devices, Qualcomm's 6 GHz chipsets support an OOBE level of -38 dBm/MHz at the 5.925 GHz edge, which is already well below -37 dBm/MHz and would not require any transmit power reduction for unlicensed operations in the 320, 160, 80, 40, or 20 megahertz-wide Wi-Fi channels closest to the 5.925 GHz band edge. Thus, Qualcomm claims that "there is no technical obstacle to 6 GHz VLP unlicensed devices complying with a -37 dBm/MHz OOBE level that is needed to protect C-V2X operation in the 5.9 GHz band from harmful interference." It requests that the Commission maintain the 6.105 GHz prioritization rule, which can be relaxed to 6.0 GHz, and at the same time adopt a more stringent OOBE limit at the bottom edge of the U-NII-5 band.

The 5G Automotive Association (5GAA) asserts that the Commission's -27 dBm/MHz VLP, and by extension the proposed GVP, OOBE limit is insufficient. According to 5GAA, DOT testing shows that when one or more VLP devices are in close proximity (i.e., inside a vehicle), their respective OOBE reduces the range at which C-V2X devices can effectively communicate by more than 50%, particularly in non-line-of-sight scenarios. It claims that the U-NII interference from adjacent channels could reduce the ideal 300-meter range for safety applications to as little as 25 meters, thus diminishing driver response time and impacting critical safety alerts. Therefore, 5GAA proposes an OOBE no less restrictive than -37 dBm/MHz. 5GAA also challenges the Commission's conclusion that more stringent protection is not required as C-V2X devices are already designed to coexist with one another. It explains that this

misconstrues the system in place that coordinates with other C-V2X devices, which is not true for VLP devices because they operate outside the C-V2X system. Additionally, it claims that VLP devices can operate with higher duty cycles over a several-second period in which critical C-V2X messages need to be successfully transmitted. The Alliance for Automotive Innovation claims that in addition to prioritizing VLP operation frequencies above 6105 MHz, the Commission should adopt the -37 dBm/MHz OOBE limit for VLP devices. It contends that this limit has been agreed to by stakeholders in the unlicensed and C-V2X industries. It also claims that ongoing DOT testing is being done to assess the interference risks presented by mobile VLP devices in the lower U-NII-5 band. 5GAA has filed several slides that it claims are from a presentation given by DOT about U-NII-5 band test results.

The Association of State Highway and Transportation Officials (ASHTO) et al. echoes the overall sentiment of the automotive industry and opines that while a prioritization rule helps to mitigate the potential for harmful interference, the Commission has acknowledged that many VLP devices will still operate on the lowermost channels. While ASHTO et al. make no specific request regarding GVP devices, they do however request that the Commission adopt a -37 dBm/MHz OOBE limit for VLP devices, which will provide C-V2X safety operations much-needed protection. They claim that this OOBE limit can be achieved without lowering in-band VLP transmit power and that VLP devices comply with an European Union -45 dBm/MHz OOBE limit without impacting their transmit power.

The Commission declines to adopt a general GVP OOBE limit lower than what it originally proposed in the *6 GHz Second FNPRM*—e.g., -37 dBm/MHz. In particular, the Commission cannot rely on the testing scenario in the *DOT Exhibit* filed by NTIA and DOT on October 10, 2023, as a basis for a real-world interference analysis. The *DOT Exhibit* analysis included operations from devices in the U-NII-4 band and is intended to extrapolate its findings to the U-NII-5 band. In its analysis, DOT selected operational parameters from channel 171 (5855 MHz) and applied them in a manner intended to represent a channel whose OOBE it claimed could potentially interfere with CV2X channel 183 (5915 MHz). However, this analysis is not persuasive because U-NII-4 devices have different operational parameters than U-NII-5 GVP devices. Operational parameters for U-NII-4 devices include a maximum of 36 dBm EIRP for 40 MHz channels and when spanning the bands of U-NII-3 and U-NII-4 or utilizing concatenated channels to create an 80 MHz channel this power limit is not raised. In addition, devices

operating in the U-NII-4 band are only permitted to operate indoors and must not be housed in a weatherized enclosure. Therefore, a device configured in the manner in which it was configured in the *DOT Exhibit* could not exist under the Commission's current rules. Likewise, there are operational differences for GVP devices that do not apply to U-NII-4 Channel 171. For instance, the power limit the Commission is adopting for U-NII-5 GVP devices is lower than those permitted for U-NII-4 devices. In fact, the maximum EIRP limit that the Commission adopts today for GVP devices is 12 dB lower than those permitted for a U-NII-4 access point. In addition, devices authorized to operate under U-NII-5 rules must suppress emission by as much as 40 dB outside of its intended operating channel, as opposed to a U-NII-4 device where no such in-band channel emission mask is required by the Commission's rules. The Commission notes that the use cases and the resultant rules of the UNII-4 and UNII-5 bands were derived for different purposes. Each rule set is uniquely defined and not intended for substitution or cross-application.

The *DOT Exhibit* also used a 70% duty cycle for the unlicensed devices. However, with the current proposed uses of unlicensed devices in the 6 GHz band, GVP devices will utilize wide channels up to 320 MHz, as opposed to the 80 MHz channel the *DOT Exhibit* intended to model. Assuming that the 80 MHz wide channel selection was appropriate, the Commission notes that wider channels (i.e. channels exceeding 20 MHz) and channels with more advanced modulations schemes tend to transfer larger amounts of data faster. Thus, the resultant duty cycle is typically lower than for narrower channels or for legacy technology with less advanced modulation schemes. Because the commenters advocating for a lower OOBE limit rely on the *DOT Exhibit* as evidence for their arguments, their arguments are not persuasive. The Commission cannot express an opinion about the more recent DOT testing that 5GAA references because the two slides they provide summarizing the testing do not provide adequate technical details for us to reach any conclusion. The Commission also notes that the Wi-Fi channel plan starts at 5.945 GHz, which provides a 20 megahertz-wide guard band to the edge of the U-NII-5 band, thereby providing additional protection to C-V2X operations. In addition, the requirement to prioritize operations above 6.105 GHz, noted in this document, will minimize the number of devices operating near the lower portion of the 6 GHz band closest to C-V2X operations. Thus, based on the record, the Commission remains unconvinced that a more stringent OOBE limit for GVP U-NII-5 devices is necessary to protect

ITS services in the adjacent band. As such, the Commission is extending the -27 dBm/ MHz OOBE limit currently applied for VLP, standard-power, and low power indoor devices to GVP devices.

Prioritization of operations over 6.105 GHz. To provide protection from harmful interference to C-V2X operations below 5.925 GHz, in the *6 GHz Second FNPRM*, the Commission proposed to impose a channel prioritization requirement on GVP devices. The Commission reasoned that because GVP devices could be mobile and potentially used near C-V2X receivers, it proposed to require GVP devices to prioritize spectrum above 6.105 GHz. This prioritization requirement was part of a compromise proposal between the auto industry, chip manufacturers, and technology aggregators, whereby it was claimed that prioritizing channels above 6.105 GHz will reduce the likelihood of VLP devices operating adjacent to the ITS band when VLP devices are used in vehicles. The Commission adopted this prioritization suggestion for VLP devices in the *6 GHz Second Order* to protect ITS operations below the U-NII-5 band from harmful interference.

Several commenters generally support adopting this prioritization requirement for GVP devices, while no commenters opposed imposing this requirement. Qualcomm initially supported the prioritization of operations over 6.105 GHz but in a more recent filing has proposed lowering this threshold. Qualcomm now contends that lowering the prioritization threshold from 6.105 GHz to 6.0 GHz is feasible, would continue to protect CV2X reception, and would provide additional channels to be used when a GVP device first select an operating channel in accordance with the prioritization rule.

The Commission finds that its original analysis supporting such prioritization for VLP devices applies equally to GVP devices for the same underlying reasons. Prioritizing channels for operations above 6.105 GHz provides an additional layer of protection for both in-vehicle and out-of-vehicle devices by helping to reduce congestion in the lower portion of the band. This approach also enhances protection for adjacent band devices by statistically increasing the average spectral separation from the CV2X channels, thereby reducing the likelihood of harmful interference. At the same time, it avoids the unnecessary exclusion of valuable 6 GHz spectrum from potential use. The combination of existing out-of-band emission (OOBE) limits, channel mask requirements, and the prioritization of operations above 6.105 GHz constitutes a comprehensive framework of technical restrictions. Collectively, these measures are expected to provide sufficient protection and mitigate the potential for harmful interference into

CV2X receivers operating in adjacent bands. As previously noted, these restrictions were adopted for VLP devices out of an abundance of caution to ensure that safety of life services below the U-NII-5 band are protected from harmful interference. Therefore, the Commission is requiring GVP devices to prioritize operations on frequencies above 6.105 GHz prior to operating on frequencies between 5.925 GHz and 6.105 GHz.

The Commission sets 6.105 GHz as the breakpoint for prioritization rather than use 6.0 GHz, as Qualcomm suggests. No commenters other than Qualcomm suggest using 6.0 GHz for this purpose and Qualcomm has provided no technical data supporting its position. Given the lack of justification for adopting a different prioritization scheme for GVP devices than for VLP devices, the Commission sees no reason to adopt a different rule for GVP devices.

GVP Device Registration. In the *6 GHz First Order*, the Commission defined specific information that standard-power access points are required to provide when registering with an AFC system. These parameters include geographic coordinates (latitude and longitude referenced to North American Datum 1983 (NAD 83)), antenna height above ground level, FCC identifier (FCC ID), and unique manufacturer's serial number. The AFC system requires an access point's latitude and longitude coordinates and antenna height above ground to determine which frequencies are available at the access point's location. The AFC system also uses the FCC ID and the access point's serial number to verify that the device is authorized for 6 GHz band operations and, if necessary, to address any interference concerns. Consistent with the requirements set forth for standard-power devices operating under the control of an AFC system, the Commission will impose similar requirements for GVP devices to register with a geofencing system when requesting exclusion zones. To register, a GVP access point will be required to provide the geofencing system with the access point's FCC ID and either its unique manufacturer's serial number or its model name/number or other information sufficient to uniquely identify the device manufacturer and model. Although the access point's FCC ID, serial number, model name/number, or other information uniquely identifying the device manufacturer and model are not required to calculate exclusion zones, geofencing systems will use the information for two purposes. First, the information will be used to authenticate the access point to ensure that no unauthorized devices are operating in the band. Geofencing systems will verify the device's FCC ID by accessing the

Commission's Equipment Authorization System (EAS) database. Second, the information will be used for interference mitigation and enforcement purposes to investigate the source if harmful interference were to occur. During the registration process, GVP access points are required to provide sufficient information necessary for geofencing systems to assign exclusion zones for initial operation.

Consistent with the requirements for AFC systems, the Commission will require geofencing systems to store registered information in a secure database until a GVP access point ceases operation, which the Commission will define as a VLP access point not contacting the geofencing system to verify exclusion zone information for more than three months. In addition, since GVP access points will be in motion, they may need to download additional exclusion zone information, and they are required to contact the geofencing system daily to obtain any updated exclusion zones. As a result, new information will get updated in the geofencing systems' databases on at least a daily basis, which alleviates the need to store registered information for longer than three months. To ensure users' privacy, the geofencing system will use the registered data only to protect incumbents and for potential interference mitigation.

In previous filings, several parties voiced privacy concerns related to device registration in the AFC system, stating that registration requirements would compromise user privacy. The Commission will require that GVP access points provide geofencing systems with only the information necessary to receive its geofenced area of operation. A GVP access point will obtain exclusion zones for the area in which it is located from the geofencing system that will enable it to determine the frequencies on which it may operate and the power level it may transmit at. The exclusion zones may be downloaded for areas with varying levels of geographic granularity, including but not limited to: polygons with specified vertices, a circle of specified radius centered at a point, or a broader region up to and including entire states. Consequently, the GVP access point will not need to provide its specific latitude and longitude to download the exclusion zones and will not need to continuously provide its coordinates to the geofencing system as it moves. The Commission believes this approach will provide greater flexibility in implementing the geofencing system without raising any potential privacy concerns.

Security Issues. In the *6 GHz Second FNPRM*, the Commission proposed to require that GVP access points and geofencing systems incorporate adequate security measures. While the Commission received no comments in response to these security proposals, previous security requirements adopted for

AFC standard power access points received strong support. Reliable and secure communication between any GVP devices and associated geofencing systems are essential for successful GVP operations and incumbents' protection. Consistent with the Commission's previous actions and the proposal in the *6 GHz Second FNPRM*, the Commission will require that GVP access points and geofencing systems employ protocols and procedures to ensure that all communications and interactions between the access points and the geofencing system are accurate and secure and that unauthorized parties cannot access or alter the exclusion zones sent to an access point. These security measures must (1) prevent GVP access points from accessing geofencing systems 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 or unauthorized interception of data. Additionally, geofencing systems must incorporate security measures to protect against unauthorized data input or alteration of stored data (e.g., database information and the list of excluded/ available frequencies) and to protect the communication link between the geofencing system and Commission databases. The Commission will also require that geofencing systems and/or associated GVP access points establish communications authentication procedures for communications between GVP access points and GVP client devices. The Commission does not mandate specific security models. Instead, the Commission will require GVP device manufacturers and geofencing system operators to demonstrate that their systems contain the necessary communication and information security features during the device certification and geofencing system approval processes.

International Borders. In the *6 GHz Second FNPRM*, the Commission proposed that GVP operations would have to comply with international agreements with Canada and Mexico. No commenters addressed this proposal. As is the case for AFC systems, the Commission will require the geofencing systems to implement the terms of international agreements with Canada and Mexico by protecting microwave operations in Canada and Mexico near the United States border.

Restrictions on GVP device use on airplanes. In the *6 GHz Second FNPRM* the Commission sought comment on permitting GVP devices to be more generally used onboard commercial and general aviation aircraft. Additionally, the Commission sought comment on whether it should permit GVP

devices to operate across all flight phases, whether GVP devices could be permitted to operate only when above 10,000 feet, and whether to permit GVP devices to operate on aircraft at all. Apple, Broadcom et al. note that while the Commission banned standard-power access points from operating on any moving vehicle including aircraft, "the Commission's geofencing proposal . . . is explicitly designed to be simple enough to facilitate mobile operations without imposing unnecessary device or . . . system complexity." Furthermore, they claim that "[p]ortability is the key feature for the [GVP] device class."

The Commission will prohibit GVP device use on board any aircraft. While the Commission recognizes that unlicensed GVP proponents want to expand the opportunity for unlicensed connectivity on aircraft, the Commission notes that it already authorized VLP devices to operate on aircraft above 10,000 feet in the U-NII-5 band. The Commission finds there are logistical issues that would prevent GVP devices from adequately operating while in compliance with the geofencing requirements. For example, GVP devices in aircraft would likely be unable to check their location and verify they are not operating in an exclusion zone. While most fixed links are directed to the horizon and below and would not be impacted by GVP operations in aircraft at high altitudes, the Commission recognizes there are some links that are configured to point above the horizon to establish links to sites at higher elevation. In these scenarios, a GVP device operating on an aircraft that is unable to update its location could transmit while in the main beam of a microwave link. Therefore, the Commission will prohibit the use of GVP devices on aircraft.

In the *6 GHz Second FNPRM,* the Commission noted that VLP devices mounted on an unmanned aircraft system (UAS) could pose more than an insignificant harmful interference risk, given the potential for a UAS to fly almost anywhere and have a clear line-of-sight to a microwave receiver. The Commission also recognized that an exclusion zone for UAS usage would be much larger than for general usage because a UAS flies at a higher altitude than the 1.5 meters that the Commission proposed that geofencing systems would assume in calculating exclusion zones. Nonetheless, the Commission sought comment on whether there are operational limitations or guidelines that it could adopt to permit VLP devices to operate mounted on a UAS. API, the only commenter to address GVP UAS use, recommends prohibiting GVP use on UAS regardless of their operating altitude. The Commission will not permit GVP use on UAS. Because UAS may fly at altitudes exceeding the 10-meter height that the Commission

is mandating geofencing systems assume in calculating exclusion zones, the Commission believes such use will present a harmful interference risk.

Mandatory firmware updates. AT&T contends that the Commission should mandate that "all new unlicensed devices be required to accept mandatory firmware updates that alter operating parameters." AT&T points to a statement by the R St. Institute that "'once spectrum is designated for unlicensed use, it cannot be reallocated as the most productive use of particular bands changes.'" AT&T claims that its proposal is consistent with NTIA Commerce Spectrum Management Advisory Committee's (CSMAC) views, which recommended that "'[a]ccess to new unlicensed bands should generally be conditioned in ways that reserve the flexibility to reallocate a band in the future or to change its operating rules.'" APCO International states that the Commission should, wherever possible, require unlicensed devices and systems to have capability to modify system parameters through over-the-air firmware updates.

In reply, Apple, Broadcom et. al. maintain that mandatory firmware updates are "unnecessary, would impose substantial costs on manufacturers, and could undermine the cybersecurity of consumer devices." They contend that "a change to a device's firmware could require a manufacturer to seek recertification," which "is a lengthy process and therefore should not be approached lightly." They state that "rather than maximizing spectrum efficiency, . . . a mandate that every unlicensed device must permit over-the-air . . . firmware updates that can change the device's core radio functions would create a serious security risk." Apple, Broadcom et. al. claim that such a change would "require[] manufacturers to build in a pathway that a threat actor could exploit to remotely increase unlicensed devices' power levels or frequency ranges across the country."

In the *6 GHz Third Order*, the Commission declined to impose a mandatory firmware update for VLP devices because of its conclusion that there is an insignificant risk that harmful interference would occur due to VLP device operations. The Commission noted that the vast majority of devices have the inherent capability for firmware updates as manufacturers regularly make changes and upgrades to correct bugs, enable more efficient operation, or add capabilities. The Commission believes that this same rationale applies to GVP devices. As the Commission noted in the *6 GHz Third Order*, such a mandate could be complex and was not raised in the *6 GHz Second FNPRM*, and therefore, the Commission does

not have a record to explore such a mandate. Given the Commission's conclusion that there is an insignificant risk that harmful interference will occur due to the operation of GVP devices in the U-NII-5 and U-NII-7 bands, the Commission does not believe that such a mandate is necessary. A firmware mandate is even less necessary for GVP devices than for VLP devices because GVP devices will be under the supervision of geofencing systems. The geofencing systems will be able to adjust the operating frequencies and exclusion zone calculations if required by future rule changes or to respond in the event of a harmful interference incident. Additionally, manufacturers typically design devices to support firmware updates, even in the absence of a mandate. These updates are commonly used to correct software issues, improve performance, or modify device behavior. Given these factors, the Commission does not see a compelling reason to impose a firmware or software update mandate. No evidence has been presented to justify such a requirement and imposing one would amount to an unnecessary regulatory burden. Therefore, the Commission declines to mandate automatic over-the-air firmware updates for GVP devices.

Enforcement instructions. The National Public Safety Telecommunications Council (NPSTC) states that "it is imperative that 6 GHz licensees have a viable mechanism to report and expeditiously resolve any . . . harmful interference to critical microwave links." It notes that several AFC systems have committed to establish a "'centralized means to receive and address complaints regarding purported harmful interference from AFC-authorized unlicensed operations.'" NTPSC contends that even if these recommended procedures are used, they would only apply to AFC-controlled 6 GHz devices and are concerned that this is not a comprehensive approach. If harmful interference does occur, NPSTC is unclear how the interference source will be determined, i.e., whether it is from a standard-power, low power indoor, VLP, or a GVP device. It claims that licensed stakeholders in the 6 GHz band need a viable means to report and expeditiously resolve harmful interference regardless of the 6 GHz unlicensed device involved.

NPSTC indicates that past enforcement cases show that the Commission's established procedures for resolving interference issues are not as expeditious as it would prefer. As an example, it refers to an ongoing interference case involving an unlicensed device interfering with a commercial wireless system that took almost a year to address. NPSTC recommends that "the Commission put in place a more

expeditious and effective process to resolve any harmful interference."

In reply, Apple, Broadcom et al. view the Commission's current enforcement and reporting mechanisms as proven to be sufficient as evidenced by the operation of millions of unlicensed consumer devices in the 6 GHz band, beginning in 2020, without any evidence of harmful interference to licensed users. They state that "unlicensed devices have also operated in other bands with sensitive users, such as the 5 GHz band, without the need for special enforcement rules." They believe that the Commission has enforcement requirements in place and that "any additional enforcement requirements would be superfluous to the Commission's current enforcement authority."

The Commission finds that in a general sense, and as it applies to 6 GHz devices, the Commission has a long history of performing interference analyses and using such analyses in carefully crafting part 15 rules to protect incumbent systems. These analyses have demonstrated that the likelihood of a 6 GHz unlicensed device causing harmful interference is insignificant, based on the technical rules that the Commission has adopted. As 6 GHz devices are unlicensed, the Commission notes that § 15.5(b) of the Commission's rules provides that "[o]peration of an intentional, unintentional, or incidental radiator is subject to the condition[] that no harmful interference is caused." In the unlikely event that harmful interference does occur due to 6 GHz device operations, § 15.5(c) of the Commission's rules provides that "[t]he operator of a radio frequency device shall be required to cease operating the device upon notification by a Commission representative that the device is causing harmful interference," even if the device was properly certified and configured, and that "[o]peration shall not resume until the condition causing the harmful interference has been corrected." The Commission recognizes the Enforcement Bureau's efforts and reiterates that the Commission does not promise a zero chance of interference. As Apple, Broadcom et al. point out, unlicensed devices have operated in many bands without the requirement to include additional enforcement protections. As it pertains to low power indoor and VLP devices, the Commission believes that the rules that it has adopted are sufficient to adequately protect incumbent users from harmful interference.

Because these enforcement and compliance mechanisms are applicable to GVP devices, the Commission is adopting provisions to enable harmful interference that occurs from the operation of GVP devices to be mitigated. In the *6 GHz Second FNPRM,* the Commission recognized a need for geofenced

systems to seamlessly coordinate enforcement requests and database updates. In that respect, it proposed several enforcement-related rules concerning data updates and enforcement instructions. The Commission is adopting these proposals. That is, the following rules that are consistent with the rules for AFC systems will apply to geofencing systems. The Commission requires geofencing systems to ensure that their databases contain the information required by the Commission's rules, including frequency-specific exclusion zones and GVP access point's authorization parameters. The Commission also requires the geofenced systems to 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. In addition, the Commission requires geofencing systems to establish and follow protocols to comply with enforcement instructions from the Commission, including discontinuing GVP access point operations on specified frequencies in designated geographic areas and predetermined exclusion zones. The Commission also requires geofencing systems to comply with its instructions to adjust exclusion zones, if necessary, to more accurately reflect the harmful interference potential.

As for NPSTC's request that the Commission put in place a more expeditious and effective process to resolve any harmful interference, this appears to be directed at the Commission's enforcement procedures in general rather than specifically at 6 GHz unlicensed GVP operations. The example case that NPSTC refers to as "interference from an unlicensed device to a licensed commercial wireless system" does not involve someone operating an unlicensed part 15 device in accordance with the Commission's rules that causes interference to a licensed receiver. Instead, it involves someone operating a device in violation of the Commission's rules which causes harmful interference to a licensed radio receiver. While the operator of the interfering radio equipment in that case did not have a license to transmit in the frequency band at issue and in that sense was "unlicensed," that operator was not operating an unlicensed part 15 device in compliance with the Commission's rules such as would be the case for GVP devices. To the extent that NPSTC's concerns are that the Commission's enforcement rules and procedures are not sufficiently expeditious, this involves addressing issues more far reaching than the scope of the FCC's proceeding.

Definitions of GVP Access Points and Client Devices. In the *6 GHz Second FNPRM*, the Commission proposed to define a GVP 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. The *6 GHz Second FNPRM* explained 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 GVP devices cannot be easily modified to increase their EIRP. No commenters addressed this proposed definition. This definition is a straightforward description of a GVP access point. Other than adjusting the frequency range to account for the fact that the Commission is not permitting GVP devices to operate in the U-NII-6 or U-NII-8 bands, the Commission sees no reason to modify this definition, which the Commission shall incorporate into its rules.

The *6 GHz Second FNPRM* did not propose a definition of GVP client devices, and no commenters have suggested such a definition. However, the *6 GHz Second FNPRM* noted that client devices that operate under the control of a GVP access point 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. The Commission's rules currently define a client device as "[a] U-NII device whose transmissions are generally under the control of an access point and is not capable of initiating a network." This definition currently applies to client devices that operate under the control of either standard-power or LPI access points. This definition, by its current wording, will also apply to client devices that operate under the control of a GVP access point. Therefore, the Commission sees no need to adopt an additional definition that explicitly defines a GVP client device. All client devices will be restricted to transmitting at power levels no more than 6 dB less than the level at which the controlling access point is authorized to operate, whether that access point is a standard-power, low power indoor, or GVP access point.

Benefits and Costs

In the *6 GHz Second FNPRM*, the Commission sought comment on the benefits and costs of its proposals for implementing GVP devices in the 6 GHz band. The Commission did not receive any comments that included economic benefit or cost estimates for GVP devices.

Benefit estimates from rules the Commission previously adopted in the FCC's proceeding have been substantial. One report estimates that opening the 6 GHz band to unlicensed use has produced $870

billion in economic value in 2023 and 2024 together, and that this total benefit will increase to $1.2 trillion by 2027. In the *6GHz Second Order*, the Commission conservatively estimated benefits from permitting VLP devices to operate in the U-NII-5 and U-NII-7 bands to be $2 billion. In the *6 GHz Third Order*, the Commission conservatively estimated benefits from opening the U-NII-6 and U-NII-8 bands to VLP devices would be $820 million.

Consistent with previous experience in the FCC's proceeding, the Commission anticipates that the rules permitting GVP devices to operate in the U-NII-5 and U-NII-7 portions of the 6 GHz band will yield substantial benefits. The higher power GVP devices will enable increased data rates and greater range for current VLP applications. While geofencing will limit GVP operating areas, even a 5% improvement in economic value derived from these devices relative to the Commission's estimated benefits for VLP in the U-NII-5 and U-NII-7 portions of the 6 GHz band would result in $100 million in additional benefits over a five-year period, or on average, annual benefits of $20 million. The Commission believes this estimate to be conservative because higher data rates and range will not only enhance existing VLP applications, but also create opportunities for new applications, including augmented reality/virtual reality, short-range hotspots, automation processes, and indoor location and navigation. The expanded opportunities presented by these new GVP applications have the potential to yield benefits comparable to the benefits from existing VLP devices already operating within areas that may be subject to geofencing. Thus, GVP use may yield benefits much higher than $100 million over a longer time horizon.

The Commission anticipates that the rules its promulgating will impose no additional costs on the public. While manufacturers and users may incur costs in setting up the new GVP ecosystem, these costs will be voluntarily incurred and thus will not result in a private cost without a countervailing private benefit. This would include any costs for switching to new devices or developing and maintaining the geofencing systems. 6 GHz band users will be protected from harmful interference by the geofencing system, so there will be no costs imposed on other 6 GHz band users. The Commission therefore concludes that permitting GVP devices to operate in the 6 GHz band will yield substantial economic benefits to the American public.

ORDERING CLAUSES

IT IS ORDERED that, 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, 303, the Order IS HEREBY ADOPTED.

IT IS FURTHER ORDERED that the *Fourth Report and Order* SHALL BE EFFECTIVE 60 days after publication in the Federal Register.

IT IS FURTHER ORDERED that the Commission's Office of the Secretary SHALL SEND a copy of the *Fourth Report and Order*, including the Final Regulatory Flexibility Analysis, to the Chief Counsel for Advocacy of the Small Business Administration.

IT IS FURTHER ORDERED that the Commission SHALL SEND a copy of the *Fourth Report and Order* in a report to be sent to Congress and the Government Accountability Office pursuant to the Congressional Review Act, see 5 U.S.C. 801(a)(1)(A).

List of Subjects

47 CFR Part 0

Authority delegations (Government agencies), Communications, Telecommunications.

47 CFR Part 15

Communications equipment, Radio.

Federal Communications Commission.

Marlene Dortch,
Secretary.

Final Rules

For the reasons discussed in the preamble, the Federal Communications Commission amends 47 CFR parts 0 and 15 as follows:

PART 0 – COMMISSION ORGANIZATION

1. The authority citation for part 0 continues to read as follows:

Authority: 47 U.S.C. 151, 154(i), 154(j), 155, 225, 409, and 1754, unless otherwise noted.

2. Amend § 0.241 by revising paragraph (k) to read as follows:

§ 0.241 Authority delegated.

* * * * *

(k) The Chief of the Office of Engineering and Technology is delegated authority to administer the Automated Frequency Coordination (AFC) systems, AFC system operator functions, geofencing systems, and geofencing system operator functions set forth in subpart E of part 15 of this chapter. The Chief is delegated authority to develop specific methods that will be used to designate AFC system and geofencing system operators; to designate AFC system and geofencing system operators; to develop procedures that these AFC system and geofencing system operators will use to ensure compliance with the requirements for AFC system and geofencing system operations; to make determinations regarding the continued acceptability of individual AFC system and geofencing system operators; and to perform other functions as needed to administer the AFC and geofencing systems.

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PART 15 – RADIO FREQUENCY DEVICES

3. 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.

4. Amend § 15.403 by adding the definitions of "Geofenced variable power access point," "Geofencing," and "Geofencing system" in alphabetical order, to read as follows:

§ 15.403 Definitions.

* * * * *

Geofenced variable power access point. For the purpose of this subpart, an access point that operates in the 5.925–6.425 GHz and 6.525 -6.875 GHz bands, 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 geofenced variable power access points and associated devices are not permitted to operate on frequencies specified by the geofencing system; and inclusions zones within which such devices are permitted to operate on frequencies specified by the geofencing system.

Geofencing system. A system that automatically determines frequency specific zones where geofenced variable power access points are either permitted to operate or not permitted to operate in the 5.925-6.425 GHz and 6.525-6.875 GHz bands.

* * * * *

5. Amend § 15.407 by:

a. Redesignating paragraphs (a)(7) and (8) as paragraphs (a)(8)(i) and (ii);

b. Adding a new paragraph (a)(7);

c. Revising newly redesignated paragraph (a)(8) and paragraphs (a)(10), (d)(1)(i) and (iv), and (d)(3) and (5);

d. Removing and reserving paragraph (d)(7);

e. Revising paragraphs (d)(8) through (10), (k)(3), and (k)(7)(iii);

f. Redesignating paragraphs (l), (m), and (n) as paragraphs (n), (o), and (p);

g. Adding new paragraphs (l) and (m); and

h. Revising newly redesignated paragraphs (n), (o), and (p).

The revisions and additions read as follows:

§ 15.407 General technical requirements.

(a) * * *

(7) For a geofenced variable power access point operating in the 5.925–6.425 GHz or 6.525–6.875 GHz band, the maximum power spectral density must not exceed 11 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 24 dBm.

(8)(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, 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 variable power access point 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, the maximum e.i.r.p. over the frequency band of operation must not exceed 18 dBm, and the device must limit its power to no more than 6 dB below its associated geofenced variable power access point's authorized transmit power.

* * * * *

(10) Access points operating under the provisions of paragraphs (a)(5), (6), (7) and (9) of this section must employ a permanently attached integrated antenna.

* * * * *

(d) * * *

(1) * * *

(i) *Oil platforms.* Standard power access points, fixed client devices, geofenced variable power access points, very low power devices, and low-power indoor access points in the 5.925-7.125 GHz band are prohibited from operating on oil platforms.

* * * * *

(iv) *Aircraft.* Standard power access points, fixed client devices, geofenced variable power access points, very low power devices, and low-power indoor access points in the 5.925-7.125 GHz band are prohibited from operating on aircraft, except that very low power devices and low-power indoor access points are permitted to operate in the 5.925-6.425 GHz bands in large aircraft while flying above 10,000 feet.

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(3) Transmitters operating under the provisions of paragraphs (a)(5) and (6) and (a)(8)(ii) of this section are limited to indoor locations.

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(5)(i) In the 5.925–7.125 GHz band, client devices must operate under the control of a standard power access point, indoor access point, subordinate device, or geofenced variable power access point; Subordinate devices must operate under the control of an indoor access point.

(ii) Access points and subordinate devices may connect to other access points or subordinate devices.

(iii) Fixed client devices may only connect to a standard power access point.

(iv) 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.

(v) Client devices are prohibited from connecting directly to another client device, except that client devices under the control of the same geofenced variable power access point may communicate directly with each other using the same frequency they are using to communicate with the geofenced variable power access point.

* * * * *

(8) Very low power devices, geofenced variable power access points, and clients operating under the control of a geofenced variable power access point may not be installed on fixed outdoor infrastructure. Such devices may not be mounted on outdoor structures, such as buildings or poles.

(9) Geofenced variable power access points 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) Geofenced variable power access points and very low power devices operating in the 5.925-7.125 GHz band shall employ a transmit power control (TPC) mechanism with the capability to operate at least 6 dB below the device's maximum e.i.r.p. PSD value.

* * * * *

(k) * * *

(3) An AFC system must obtain information on protected services within the 5.925-6.425 GHz and 6.525-6.875 GHz bands from Commission databases and use that information to determine frequency availability for standard power access points and fixed client devices. Based on the criteria specified in paragraph (n) of this section, an AFC system must establish location and frequency-based exclusion zones (both co-channel and adjacent channel) around fixed microwave receivers operating in the 5.925-6.425 GHz and 6.525-6.875 GHz bands. Individual standard power access points and fixed client devices must not operate co-channel to fixed microwave system frequencies within co-channel exclusion zones, or on adjacent channel frequencies within adjacent channel exclusion zones.

* * * * *

(7) * * *

(iii) Providing standard power access points and fixed client devices with the permissible frequencies and the maximum permissible power in each frequency range at their locations using propagation models and interference protection criteria defined in paragraph (n) of this section.

* * * * *

(l) *Geofencing system*. (1) A geofencing system must obtain information on protected services within the 5.925–6.425 GHz and 6.525–6.875 GHz bands from Commission databases and use that information to determine frequency specific zones for geofenced variable power access points and provide that information to those devices. These zones must be determined for specified frequencies based on the propagation models and protection criteria specified in paragraph (n) of this section.

(i) The zones can be determined as exclusion zones specifying frequencies on which and locations where geofenced variable power devices are not permitted to operate or inclusion zones specifying frequencies on which and locations where geofenced variable power devices are permitted to operate.

(ii) The geofencing system must assume that geofenced variable power devices are at a height of 10 meters when determining exclusion zones.

(iii) The geofencing system must access the Commission’s licensing databases and update the

frequency-specific 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 must establish exclusion or inclusion zones to prevent geofenced variable power access point operations between 6.525-6.875 GHz on the oceans beyond the United States territorial sea as defined in 33 CFR 2.22(a)(1).

(3) The geofencing system must ensure that all communications and interactions between the geofencing system and the geofenced variable 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 or any information it provides to geofenced variable power access points. Additionally, the geofencing system must incorporate security measures to protect against unauthorized data input or alteration of stored data.

(4) A geofencing system must verify the validity of the FCC identifier (FCC ID) of any geofenced variable power access point seeking access to its services prior to authorizing the access point to begin operation. A list of geofenced variable power access points with valid FCC IDs and the FCC IDs of those devices must be obtained from the Commission's Equipment Authorization System.

(5) A geofencing system must implement the terms of international agreements with Mexico and Canada.

(6) With regard to enforcement instruction *and* data accuracy, each geofencing system must:

(i) Ensure that a regularly updated geofencing system database that contains the information described in this section, including frequency-specific exclusion or inclusion zones and geofenced variable 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 discontinuing geofenced variable power access point operations on specified frequencies in designated geographic areas and predetermined exclusion zones.

(iv) Comply with instructions from the Commission to adjust frequency-specific exclusion or

inclusion zones to more accurately reflect the potential for harmful interference.

(7) A geofencing system operator must provide continuous service to all geofenced variable power access points for which it has agreed 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 location and frequency-specific update information.

(8) 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.

(m) *Geofenced variable power access point requirements*. (1) A geofenced variable power access point must register with and be authorized by a geofencing system prior to the geofenced variable power access point's initial service transmission. At registration the geofenced variable power access point must provide its FCC identifier (FCC ID) and either its unique manufacturer's serial number or its model name/number or other information sufficient to uniquely identify the device manufacturer and model.

(2) Geofenced variable power access point device geo-location capability:

(i) A geofenced variable power access point must include an internal geo-location capability to automatically determine the geofenced variable power access point's geographic coordinates and location uncertainty (in meters), with a 95% confidence level. The geofenced variable power access point must use such coordinates and location uncertainty when comparing the device's specific location to frequency-specific information for its location obtained from the geofencing system.

(ii) Geofenced variable power access point equipment authorization applicants must provide an attestation describing the geo-location method used, that method's accuracy, and the location uncertainty accuracy.

(3) A geofenced variable power access point must access a geofencing system to obtain frequency-specific information (i.e., exclusion zones or inclusion zones) for the area in which it is operating or intends to operate (e.g., within a specific point radius or within specific boundaries) prior to transmitting. If the geofenced variable power access point moves beyond those boundaries, it

must obtain additional frequency-specific information for the new area and adjust its operating frequency, if necessary, prior to operating in this new area. If the geofenced variable power access point does not obtain frequency specific information for the area in which it is currently located, it may not transmit. The geofenced variable power access point must obtain updated frequency-specific information from the geofencing system at least once per day. If the geofenced variable power access point fails to obtain the updated frequency specific information on any given day, the geofenced variable 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 information for its location.

(4) A geofenced variable power access point must determine its location and avoid transmitting on frequencies that are not available in accordance with the frequency-specific information for its location obtained from the geofencing system. The geofenced variable power access point may not permit a client device operating under its control to transmit on frequencies that are not available to the geofenced variable power access point. The geofenced variable power access point must determine its location frequently enough to ensure that it can adjust its operating frequency, including ceasing operation, within one second after any portion of the access point's location uncertainty region crosses into an area in which its current operating frequency is prohibited.

(5) A geofenced variable power access point must incorporate adequate security measures to prevent it from accessing geofencing systems not approved by the FCC, 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 the geofenced variable power access point and geofencing systems and between the geofenced variable power access point and a client device operating under its control are secure to prevent corruption or unauthorized interception of data.

(n) *Incumbent protection by AFC and geofencing systems: Fixed microwave services*--(1) *Propagation models*. Propagation models to determine the appropriate separation distance between a standard power access point, a fixed client device, or geofenced variable power access point and an incumbent fixed

microwave service receiver. For a separation distance:

(i) Up to 30 meters, the AFC system and geofencing system must use the free space path-loss model.

(ii) More than 30 meters and up to and including one kilometer, the AFC system and geofencing system must use the Wireless World Initiative New Radio phase II (WINNER II) model. The AFC system or 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 is available. For evaluating paths where such data is not available, the AFC system and 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:

Equation 1 to Paragraph (n)(1)(ii)

Path-loss (L) = Σ_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.

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 AFC system and geofencing system will use the correct WINNER II parameters to match the morphology of the path between a standard power access point or geofenced variable power access point and a fixed microwave receiver (i.e., Urban, Suburban, or Rural).

(iii) More than one kilometer, the AFC system and 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 AFC system and 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 AFC system and 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 AFC system and geofencing system must use 1 arc-second digital elevation terrain data and, for locations where such data is not available, the most granular available digital elevation terrain data.

(2) *Interference protection criteria*. (i) The AFC system and geofencing system must use −6 dB I/N as the interference protection criteria in determining the size of the co-channel zone where I (interference) is the co-channel signal from the standard power access point, geofenced variable 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.

(ii) The AFC system must use −6 dB I/N as the interference protection criteria in determining the size of the adjacent channel 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 zone must be calculated based on the emissions requirements of paragraph (b)(7) of this section.

(3) *Body loss*. 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.

(o) *Incumbent protection by AFC and geofencing systems: Radio astronomy services.* The AFC system and geofencing system must enforce a zone 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. The zone sizes are based on the radio line-of-sight and determined using 4⁄3 earth curvature and the following formula:

Equation 2 to Paragraph (o)

dkm_los = 4.12 * (sqrt(Htx) + sqrt(Hrx))

Where:

Htx is the height of the unlicensed standard power access point or fixed client device.

Hrx is the height of the radio astronomy antenna in meters above ground level.

Htx is 10 meters for an unlicensed geofenced variable power access point.

Coordinate locations of the radio observatories are listed in § 2.106(c)(131) and (385) of this chapter.

(p) *Incumbent protection of fixed satellite services.* Standard power access points and fixed client devices located outdoors must limit their maximum e.i.r.p. at any elevation angle above 30 degrees as measured from the horizon to 21 dBm (125 mW) to protect fixed satellite services.

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