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## FEDERAL COMMUNICATIONS COMMISSION

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**[ET Docket No. 18–295, GN Docket No. 17–183; FCC 24–125; FR ID 275890]**

## 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) expands unlicensed very low power (VLP) device operation to the entire 6 gigahertz (GHz) band (5.925–7.125 megahertz (MHz)). The VLP devices will operate with the same power levels and other technical and operational requirements that apply to VLP devices in the U–NII–5 (5.925–6.425 MHz) and U–NII–7(6.525–6.875 MHz) portions of the 6 GHz band. These technical and operational requirements are designed to prevent the licensed services that operate in the 6 GHz band from experiencing harmful interference. The Commission's actions will provide additional spectrum for high-throughput, low latency operations for these versatile portable devices.

**DATES:** This final rule is effective May 5, 2025.

**FOR FURTHER INFORMATION CONTACT:** Nicholas Oros of the Office of Engineering and Technology, at *Nicholas.Oros@fcc.gov* or 202–418–0636.

**SUPPLEMENTARY INFORMATION:** This is a summary of the Commission's *Third Report and Order,* in ET Docket No. 18–295, GN Docket No. 17–138, FCC 24–125, adopted on December 11, 2024, and released on December 13, 2024. The full text of this document is available for public inspection and can be downloaded at *https://docs.fcc.gov/public/attachments/FCC-24-125A1.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 rulemaking, 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 and policy changes contained in the *Third Report and Order* on small entities. The FRFA is set forth in Appendix B, *https://docs.fcc.gov/public/attachments/FCC-24-125A1.pdf.*

*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 *Third Report and Order* to Congress and the Government Accountability Office pursuant to 5 U.S.C. 801(a)(1)(A).

### Synopsis

#### Introduction

In 2020, the Commission adopted rules making unlicensed device access to 1200 megahertz across the 6 GHz band (5.925–7.125 GHz) more flexible, resulting in increased unlicensed device usage. These rules unleashed a torrent of new devices taking advantage of the newer Wi-Fi 6 and 6E standards to provide users across the U.S. with a better Wi-Fi user experience. More recently, in 2023, the Commission expanded 6 GHz band unlicensed use to permit an additional class of unlicensed access points—very low power (VLP) devices. VLP devices are intended to provide high data rate connections across short distances.

The Commission expands unlicensed VLP device operation to the entire 6 GHz band. This will provide additional spectrum for high-throughput, low latency operations for these versatile portable devices. Specifically, the Commission's actions pave the way for these devices to use the latest standards and to take advantage of larger channels across the 6 GHz band. The Commission expects that VLP devices will be instrumental in supporting cutting-edge applications, such as augmented and virtual reality and body-worn technologies, that will help businesses, enhance learning opportunities, advance healthcare opportunities, and bring new entertainment experiences. As the Commission expands the spectrum available for VLP devices, it adopts the same power levels and other technical and operational requirements that apply to VLP devices in the U–NII–5 and U–NII–7 portions of the 6 GHz band, which are designed to prevent the licensed services that operate in the 6 GHz band from experiencing harmful interference. In this way, the Commission facilitates more intensive use of its valuable spectrum resources, thereby enabling exciting new technologies to be deployed to American consumers, while ensuring that incumbent services are protected from harmful interference.

#### Background

The 6 GHz band has allocations for the Fixed Service, Mobile Service, and Fixed Satellite Service (FSS) across four sub-bands. These four sub-bands—which the Commission refers to as U–NII–5, U–NII–6, U–NII–7, and U–NII–8, respectively—are delineated based on the prevalence and characteristics of the incumbent licensed services that operate in each sub-band as denoted in table 1. Fixed microwave service licensees, specifically those operating point-to-point microwave links that support a variety of critical services provided by utilities, commercial and private entities, and public safety

agencies, are the largest user group in the 6 GHz band. These fixed microwave service licensees make significant use of the U–NII–5 and U–NII–7 bands, and also operate in relatively smaller numbers in the U–NII–8 band. The microwave links provide backhaul for commercial wireless providers (such as traffic between commercial wireless base stations and wireline networks), coordinate railroad train movements, control natural gas and oil pipelines, manage electric grids, as well as carry long-distance telephone calls.

TABLE 1—PREDOMINANT LICENSED USES OF THE 6 GIGAHERTZ BAND

| Sub-band | Frequency range (GHz) | Primary allocation | Predominant licensed services |
|---|---|---|---|
| U–NII–5 | 5.925–6.425 | Fixed | Fixed Microwave. |
| | | FSS | FSS (uplinks). |
| U–NII–6 | 6.425–6.525 | Mobile | Broadcast Auxiliary Service. |
| | | FSS | Cable Television Relay Service. |
| | | | FSS (uplinks). |
| U–NII–7 | 6.525–6.875 | Fixed | Fixed Microwave. |
| | | FSS | FSS (uplinks/downlinks). |
| U–NII–8 | 6.875–7.125 | Fixed | Fixed Microwave. |
| | | Mobile | Broadcast Auxiliary Service. |
| | | FSS | Cable Television Relay Service. |
| | | | FSS (uplinks/downlinks) (6.875–7.075 GHz only). |

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

The Fixed Satellite Service (FSS) is allocated in the Earth-to-space direction in all four sub-bands, except for the 7.075–7.125 GHz portion of the U–NII–8 band. FSS operations are heaviest in the U–NII–5 band, which is paired with the 3.7–4.2 GHz frequency band in the space-to-Earth direction to comprise the ''conventional C band.'' Predominant FSS uses of these frequencies include content distribution to television and radio broadcasters, including transportable antennas to cover live news and sports events, cable television and small master antenna systems, and telephone and data backhaul traffic. The 7.025–7.075 GHz portion of the U–NII–8 band also hosts feeder uplinks to Satellite Digital Audio Radio Service space stations. Additionally, portions of the UNII–7 and U–NII–8 bands are allocated for FSS space-to-Earth operations for Mobile-Satellite Service feeder links between 6.700 GHz and 7.075 GHz. In addition to these licensed incumbent services, an international footnote in the table of frequency allocations urges that the Commission takes ''all practicable steps'' to protect the radio astronomy service in the 6650–6675.2 MHz range from harmful interference. Finally, low-power unlicensed ultra-wideband (UWB) and wideband systems operate in the 6 GHz band under the Commission's part 15 rules. Like all other part 15 devices, UWB and wideband devices operate on a non-interference basis and must accept interference from and are not permitted to cause harmful interference to authorized stations.

On April 23, 2020, the Commission adopted a *Report and Order* (*6 GHz First Order*), 85 FR 31390 (May 26, 2020), that expanded unlicensed operations in the 6 GHz band (5.925–7.125 GHz). The *6 GHz First Order* adopted rules for two categories of unlicensed operations—standard-power operations and low-power indoor (LPI) operations. Standard-power access points and fixed client devices are limited to two portions of the 6 GHz band—the U–NII–5 band (5.925–6.425 GHz) and the U–NII–7 band (6.525–6.875 GHz)—and are required to operate under the control of an automated frequency coordination (AFC) system. Low-power indoor access points can operate across the entire 6 GHz band, but at lower power levels than standard power operations, and must incorporate a contention-based protocol. Client devices operate under the control of either a standard-power or low-power indoor access point and communicate using power levels that depend on the type of access point to which they are connected.

On November 1, 2023, the Commission released a *Second Report and Order,* 89 FR 874 (January 8, 2024), that allowed unlicensed very low power (VLP) devices to operate in the U–NII–5 and U–NII–7 portions of the 6 GHz band (*6 GHz Second Order*). The VLP devices are authorized to operate anywhere, indoors and outdoors, without being under the control of an AFC system. The VLP devices are limited to power levels that allow them to coexist with incumbent operations in the band: 14 decibel-milliwatts (dBm) equivalent isotropic radiated power (EIRP) and a −5 dBm/MHz EIRP power spectral density. VLP devices are also required to employ a transmit power control mechanism that has the capability to operate at least 6 dB below the −5 dBm/MHz EIRP power spectral density (PSD) level and must employ a contention-based protocol. VLP devices are prohibited from operating as part of a fixed outdoor infrastructure, such as poles or buildings. Also, VLP devices are required to prioritize operations above 6105 MHz prior to operating on frequencies between 5925 MHz and 6105 MHz to ensure that services below the U–NII–5 band are protected from potential harmful interference. In the *6 GHz Second Order,* the Commission required emissions from VLP devices in the U–NII–5 and U–NII–7 bands to comply with the transmission emission mask adopted in the *6 GHz First Order.* The power spectral density must be suppressed by 20 dB at one megahertz outside of an unlicensed device's channel edge, suppressed by 28 dB at one channel bandwidth from an unlicensed device's channel center, and suppressed by 40 dB at one and one-half

times the channel bandwidth away from an unlicensed device's channel center. At frequencies between one megahertz outside an unlicensed device's channel edge and one channel bandwidth from the center of the channel, the limits must be 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 must be linearly interpolated between the 28 dB and 40 dB suppression levels. Emissions removed from the channel center by more than one and one-half times the channel bandwidth, but within the U–NII–5 and U–NII–7 bands, must be suppressed by at least 40 dB. The Commission is adopting the same emission limits for VLP devices operating in the U–NII–6 and U–NII–8 bands. For emissions limits at the edge of the U–NII–5 and U–NII–8 bands, 6 GHz VLP devices must comply with 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). Consistent with the rules adopted in the *6 GHz Second Order* for LPI and standard power devices, VLP devices will be prohibited from operating in low flying aircraft and unmanned aircraft systems. For aircraft above 10,000 feet, VLP devices can operate across the 5.925–6.425 GHz band. The Commission will also continue to prohibit VLP devices from operating on oil platforms. Similarly, in the *6 GHz Second Order,* VLP devices will continue to be permitted to operate on boats.

In the *Second Further Notice of Proposed Rulemaking* (*6 GHz Second FNPRM*), 89 FR 14015 (February 26, 2024), adopted concurrently with the *6 GHz Second Order,* the Commission proposed to expand VLP operation to the U–NII–6 (6.425–6.525 GHz) and U–NII–8 (6.875–7.125 GHz) portions of the 6 GHz band, with no requirement that the devices be kept indoors or be under the control of an AFC system. The *6 GHz Second FNPRM* also proposed to permit VLP operation at higher power levels while under the control of a geofencing system. The geofencing system would utilize Commission databases to create exclusion zones to protect incumbent licensed services. In addition, because the current 6 GHz unlicensed rules prohibit direct communication between client devices, the *6 GHz Second FNPRM* sought comment on allowing such communications between client devices to 6 GHz unlicensed low-power indoor access points. In the *Third Report and Order,* the Commission only addresses the *6 GHz Second FNPRM* proposal to expand VLP operation to the U–NII–6 and U–NII–8 portions of the 6 GHz band while deferring the remaining issues to future Commission actions.

The Commission received comments from numerous parties in favor of allowing unlicensed VLP operations in the 6 GHz band, as well as from parties representing the interests of incumbent licensees raising concerns about potential harmful interference from the proposed unlicensed VLP operations in the U–NII–6 and U–NII–8 bands. In response to the *6 GHz Second FNPRM,* 6 GHz band unlicensed device proponents—including Apple, Broadcom, Google, Intel Corporation, Meta Platforms, Microsoft Corporation, Qualcomm, the Wi-Fi Alliance, the Wireless Broadband Alliance, the Japan Electronics and Information Technology Industries Association, and the Consumer Technology Association (CTA)—support the Commission's proposal for authorizing unlicensed VLP device operations across the 6 GHz band. They emphasize that such operations will support a host of immersive, real-time applications in areas such as healthcare, high accuracy location, advanced connectivity, innovative game experiences, and augmented reality/virtual-reality devices, among other uses. CTA points out that providing high-speed connections for some of the most advanced applications, including wearables and augmented and virtual reality (AR/VR), will help businesses, enhance learning opportunities, advance healthcare opportunities, and bring new entertainment experiences. Several commenters also assert that technical rules can be established to protect incumbent spectrum users from harmful interference. Apple, Broadcom, et al. submitted several technical studies to support their contention that VLP devices will not cause harmful interference to licensed incumbent users.

Commenters representing incumbent users express various concerns about the potential for harmful interference to their operations from unlicensed VLP operations. Commenting parties include the National Public Safety Telecommunications Council on behalf of public safety microwave incumbents, Sirius XM Radio, the National Association of Broadcasters (NAB) on behalf of local radio and television stations and broadcast networks, and the National Academy of Sciences' Committee on Radio Frequencies regarding radio astronomy observatories. In its comment, Electric Power Research Institute (EPRI) states that incumbent microwave operators will incur significant costs in trying to locate VLP interference sources if the protection scheme is ineffective in providing adequate protection. According to EPRI, ''VLP sources being outdoor and portable or vehicular mobile[ ] will make locating the offending device extremely difficult if not impossible.'' MEMA, The Vehicle Suppliers Association, also expressed interference concerns in its filing, pointing out that higher transmitting power in VLP devices could ''increase the potential for interference with vehicle safety systems communications.''

**Discussion**

The Commission adopts rules to permit VLP devices to operate across the U–NII–6 and U–NII–8 portions of the 6 GHz band at the same power levels the Commission adopted for VLP operations in the U–NII–5 and U–NII–7 bands: −5 dBm/MHz EIRP power spectral density (PSD) and 14 dBm EIRP. This will expand the spectrum available for VLP devices to 1200 megahertz, thereby permitting the use of up to seven 160-megahertz channels or three 320-megahertz channels. VLP devices will enable new innovative uses and will provide opportunities to enhance nascent applications, such as augmented reality/virtual reality, in-car connectivity, wearable on-body devices, healthcare monitoring, short-range mobile hotspots, high accuracy location and navigation, and automation. The rules the Commission is adopting are designed to support innovation to bring exciting new applications to market while protecting the important licensed services that operate in the U–NII–6 and U–NII–8 portions of the 6 GHz band from harmful interference. The Commission concludes that VLP operation at the power levels they are permitting will have an insignificant potential for causing harmful interference to licensed users of the band.

In expanding VLP operations to the U–NII–6 and U–NII–8 portions of the 6 GHz band, the Commission is adopting the same rules that it previously adopted for VLP devices operating in the U–NII–5 and U–NII–7 bands. For example, VLP devices in the U–NII–6 and U–NII–8 bands must operate at the same power levels, employ a contention-based protocol, and implement transmit power control.

**Protecting Mobile Services**

The U–NII–6 and U–NII–8 bands are used for electronic newsgathering (ENG) and other video broadcasting-related applications by licensees operating under the part 74 broadcast auxiliary services, part 78 Cable Television Relay Service, and part 101 Local Television Transmission Service. Additionally, Low Power Auxiliary Stations (*i.e.,* wireless microphones), which operate on an itinerant basis, are authorized to operate in the U–NII–8 band on a secondary basis for uses such as portable cameras, wireless microphones, cues, and backstage communications. The *6 GHz Second FNPRM* specifically requested information on three categories of mobile 6 GHz band equipment: (i) outdoor ENG central receive sites; (ii) outdoor ENG truck receivers (transmissions from portable cameras and microphones to a receiver on a truck); and (iii) low-power short range mobile devices. Commenters in response to the *6 GHz Second FNPRM* discussed the interference potential of VLP devices to outdoor ENG central receive sites and transmissions from portable cameras to outdoor ENG truck receivers. No commenters provided feedback regarding other types of mobile 6 GHz equipment or use scenarios, such as low-power short range mobile devices. Because no commenters have raised concerns or suggested other use cases, the Commission directs its examination of the potential for VLP devices to cause harmful interference to mobile applications to the three specific use cases discussed in the *6 GHz Second FNPRM.* As discussed in more detail below, the Commission concludes that there is an insignificant risk that VLP device operation in the U–NII–6 and U–NII–8 bands will cause harmful interference to licensed mobile operations for these use cases.

Limiting its discussion to these three use cases closely mirrors the approach the Commission followed when adopting rules to permit unlicensed 6 GHz band low-power indoor devices to operate in the U–NII–6 and U–NII–8 bands. For low-power indoor devices, the Commission considered three distinct use cases as representative of mobile use of those portions of the 6 GHz band: (i) an ENG truck transmitting to a central receive site; (ii) portable cameras transmitting to an outdoor ENG truck receiver; and (iii) portable cameras transmitting to an indoor receive site. These were the three use cases that were examined in an engineering study conducted by Alion (Alion Study) that was provided by NAB. The first two of these use cases are identical to the cases in the *6 GHz Second FNPRM,* while the *6 GHz Second FNPRM* discusses a slightly broader third case. Given the Commission's past approach to considering the interference potential of 6 GHz unlicensed devices to mobile operations, the Commission believes that discussing the three use cases raised in the *6 GHz Second FNPRM* adequately addresses mobile operations in the band.

**ENG Central Receive Sites**

The communications link between ENG trucks and a central receive site shares many of the characteristics of a fixed microwave link. Specifically, the link uses directional antennas to send signals between two fixed locations that are mostly above the local clutter. The *6 GHz Second FNPRM* proposed to permit VLP devices to operate in the U–NII–6 and U–NII–8 bands and sought comment on whether VLP devices could operate at up to −5 dBm/MHz EIRP PSD and 14 dBm EIRP in those bands while keeping the risk of harmful interference to ENG central receive sites to an insignificant level. The *6 GHz Second FNPRM* also sought comment on whether the same type of analysis discussed in the *6 GHz Second Order* showing an insignificant harmful interference risk to fixed microwave receive sites would be appropriate with respect to ENG central receive sites, or whether there are inherent differences between BAS/CARS operations as compared to fixed point-to-point operations that must be considered when analyzing the harmful interference risk, *e.g.,* differences in antenna beamwidth and gain, typical antenna heights or receive antenna locations.

NAB expresses concerns about potential interference to ENG central receive sites from VLP devices in the U–NII–6 and U–NII–8 bands. In making its comments, NAB considered a study filed by Apple, Broadcom, et al. on September 11, 2023, which found that VLP devices would not cause harmful interference to ENG central receive sites. NAB concedes that ''in a Monte Carlo analysis that relies on reasonable assumptions, some number, even a large number, of simulations might yield no degradation or interference to an ENG receiver,'' but states that Apple, Broadcom, et al.'s claim of absolutely no interference to ENG receivers, ever, is ''plainly and facially unreasonable.'' NAB states that ''*[m]any* hypothetical VLP transmitters located near [an] ENG receive antenna would certainly present signals exceeding −6 dB above the receiver noise floor,'' and argues as an example that the Washington, DC Old Post Office site considered in the Alion Study would have a received signal level 34 dB above the −6 dB interference-to-noise (I/N) criterion from a VLP device located 500 meters away. NAB disputes Apple, Broadcom, et al.'s claim that '' 'ENG links typically are configured to operate with a significantly higher signal-to-noise ratio than needed to successfully operate,' '' stating that this is ''unfounded and inaccurate'' because ''ENG links are not 'configured' to operate in some excessive or overengineered manner . . . and often operate within a few dB of failure.''

On June 28, 2024, Apple, Broadcom, and Meta submitted an additional study performed by RKF Engineering (RKF) on the potential for interference from VLP devices to ENG central receive sites in the 6 GHz band. RKF performed a Monte Carlo analysis with 100,000 iterations over the contiguous United States to investigate the likelihood of harmful interference to ENG central receiver sites from VLP devices in the U–NII–6 and U–NII–8 bands. A Monte Carlo simulation uses random sampling and statistical modeling to estimate mathematical functions and mimic the operations of complex systems. The simulation examined all 567 ENG central receive sites listed in the FCC's Universal Licensing System for the continental United States as a representative sample of all ENG central receive sites. RKF states that ''[t]he analysis demonstrates that the risk that VLP devices will cause exceedances of −6 dB I/N is extremely low,'' and is in fact ''lower than [in] other scenarios where the Commission has determined that sharing between 6 GHz [Radio Local Area Network (RLAN)] devices and incumbent licensees presented an 'insignificant' risk of harmful interference by the FCC's definition.'' It states that 95% of ENG receive sites ''had no exceedance over 100,000 simulation iterations,'' and that ''[t]he risk of harmful interference from VLP devices to [ENG receive sites] was exceedingly small with a 0.0001% average probability of an exceedance across all [ENG receive sites].''

On November 7, 2024, Apple, Broadcom, et al. submitted updated results for the June 28, 2024, study. NAB pointed out that it might be possible that the June 28, 2024, study had inverted the antenna pattern for the ENG central receive sites to have positive gain above the horizon instead of below the horizon. Apple, Broadcom, et al. agreed with NAB that the antenna pattern used in the June 28, 2024, study was incorrect and submitted new simulation results with the antenna

pattern correctly implemented. The revised simulation indicates the probability of exceeding −6 dB I/N across all ENG central receive sites was 0.0005%, which Apple, Broadcom, et al. contend is below what the Commission found to be acceptable for low-power indoor operation in the U–NII–6 and U–NII–8 bands. The revised simulation also indicates that the probability of exceeding −6 dB I/N for the ENG receive site with the highest probability of exceedance increased from 0.007% to 0.009%, which Apple, Broadcom, et al. point out is much lower than the 0.04% exceedance probability for the worst-case link in the San Francisco study that the Commission relied on in the *6 GHz Second Order.*

The Commission finds that the June 28, 2024, computer simulations based on Monte Carlo analysis submitted by Apple, Broadcom, and Meta, as corrected by the Apple, Broadcom, et al. November 7, 2024, filing, provides sufficient support for permitting VLP operation at up to −5 dBm/MHz EIRP power spectral density (PSD) and 14 dBm EIRP across the U–NII–6 and U–NII–8 portions of the 6 GHz band. Relying on this computer simulation is consistent with a directive the Commission made in a 2023 Policy Statement to follow a data-driven approach to spectrum management rather than placing dispositive weight on worst-case examples that may be rare or never occur in practice. Relying on Monte Carlo computer simulations is also consistent with the Commission's previous actions in adopting rules for unlicensed 6 GHz low-power indoor devices and for VLP devices in the U–NII–5 and U–NII–7 bands. For the low-power indoor device rules, the Commission characterized a Monte Carlo computer simulation submitted by CableLabs as ''the best evidence in the record of the impact that unlicensed low-power indoor devices will have on incumbent operations,'' and for the VLP rules the Commission found that Monte Carlo computer simulations submitted by Apple, Broadcom, et al. and by Apple provided sufficient support for permitting VLP operation in the U–NII–5 and U–NII–7 bands.

The Commission previously found that a well-designed computer simulation can simultaneously model many probabilistic factors that determine whether harmful interference may occur. In the case of ENG central receive sites in the U–NII–6 and U–NII–8 bands, these factors include VLP device location variability in relation to the ENG receiver, height of the VLP device, whether the VLP device is operating co-channel to the ENG receiver, the VLP power level, and the radio propagation environment. In examining the potential for harmful interference to occur to ENG central receive sites from VLP devices, the characteristics of the receivers and antennas must also be considered. ENG central receive sites use directional antennas typically located on tall towers or building rooftops, but unlike fixed microwave antennas their directivity may be variable to accommodate ENG signals from multiple directions. In addition, other factors that affect the potential for VLP devices to cause harmful interference include body loss, the use of transmit power control (TPC), and antenna polarization mismatch.

Based on Apple, Broadcom, and Meta's June 28, 2024, study, as corrected by the Apple, Broadcom, et al. November 7, 2024, filing, the Commission concludes that there is an insignificant risk of harmful interference occurring to ENG central receiver sites from VLP devices operating in the U–NII–6 and U–NII–8 bands. This simulation provides a detailed description of all the assumptions used in performing a Monte Carlo analysis to determine the likelihood of harmful interference to ENG central receive sites from VLP devices operating in the U–NII–6 and U–NII–8 bands. With the exception of certain assumptions specific to ENG central receive sites described below, it uses the same assumptions as the San Francisco simulation that the Commission relied upon in the *6 GHz Second Order* when it adopted rules for VLP devices in the U–NII–5 and U–NII–7 bands. It assumes a −5 dBm/MHz PSD VLP EIRP and a 14 dBm maximum EIRP, power reduction from TPC based on a Gaussian distribution with a 3 dB mean that is truncated at 0 dB and 6 dB, body loss based on a Gaussian distribution with a 4 dB mean that is truncated at 0 dB and 8 dB, and a VLP device height of 1.5 meters in 90% of cases with higher elevation (*e.g.,* on balconies) in 10% of cases. To determine the number of active VLP devices in each simulation iteration, the study used the same assumptions as for the San Francisco study regarding the percentage of people outdoors (6%), the percentage of people outdoors using VLP devices (25%), the percentage of VLP devices operating in unlicensed bands (90%), the percentage of those devices capable of using the 6 GHz band (50%), the percentage of the devices actually using the 6 GHz band (65%), and the percentage of devices actively transmitting at any instant (2%). Multiplying these percentages by the total United States population results in 29,661 active VLP devices for each iteration. The study also used the same propagation models previously specified by the Commission and used in prior studies, *i.e.,* free space path loss at distances less than 30 meters, WINNER II line-of-sight (LOS) at distances between 30 meters and 50 meters, WINNER II Combined LOS/non-LOS (NLOS) at distances between 50 meters and 1 kilometer, and Irregular Terrain Model (ITM) at distances greater than 1 kilometer.

Apple, Broadcom, and Meta's June 28, 2024, study used ENG receive site antenna information for the 567 receive sites listed in the Commission's Universal Licensing System (ULS), specifically, the center frequency, bandwidth, location, antenna height above ground, and maximum antenna gain. In analyzing the ULS data, RKF discovered that 99 of these sites had an apparently erroneous antenna height of exactly 6.1 meters listed when in fact the antenna height was much greater because it was mounted on a building or tall tower. RKF believed that it was more appropriate to perform the analysis by excluding the sites with apparently erroneous antenna height information, but also provided results showing the effect of including these sites. Apple, Broadcom, and Meta's June 2024 study uses the same parameters and assumptions as NAB's Alion Study for ENG central receive sites, specifically, Vislink ProScan III antenna patterns (azimuth and elevation), a 4 dB receiver noise figure, and a 1 dB feeder loss.

Apple, Broadcom, and Meta's June 28, 2024, study, as corrected by the Apple, Broadcom, et al. November 7, 2024, filing, shows that the average probability of exceeding the −6 dB I/N interference protection criterion in a given iteration is only 0.0005% per central receive site. Further, the study showed the worst-case probability for a single receive site to exceed this metric is only 0.009%. Based on the results of this study, which uses assumptions and parameters that are consistent with those the Commission previously accepted, the Commission finds that the risk of harmful interference to ENG central receive sites is insignificant. The Commission notes that these results showing an extremely low harmful interference likelihood are consistent with those of the September 11, 2023, study submitted by Apple, Broadcom, et al., which analyzed the potential for interference from VLP devices at two ENG central receive sites. The Commission recognizes the limitations of Apple, Broadcom, and Meta's latest analysis in that not every ENG central

receive site is listed in the ULS, but the Commission believes that the sample size is large enough to represent the harmful interference potential of VLP devices in the U–NII–6 and U–NII–8 bands. Regardless of whether the analysis includes or excludes the 99 receive sites listed in the ULS that have apparently incorrect height information, the Commission's conclusion is the same in that the likelihood that the −6 dB I/N ratio will be exceeded at ENG central receive sites is very low and presents only an insignificant harmful interference risk.

NAB takes issue with several aspects of Apple, Broadcom, and Meta's June 28, 2024, study. NAB faults the study for placing VLP devices at locations throughout the entire contiguous United States, which it notes includes locations more than 30 kilometers from ENG central receive sites. NAB claims that interference would not be possible at such distances. NAB also claims that the study does not include enough active VLP devices in each iteration. It points out that by using only approximately 30,000 VLP devices across the contiguous United States, it only evaluates potential interference from an average of one device in every 100 square miles. The Commission disagrees with NAB regarding the merit of its criticism. Apple, Broadcom, and Meta's June 28, 2024, study, as corrected by the Apple, Broadcom, et al. November 7, 2024, filing, provides I/N statistics at ENG central receive sites resulting from VLP operations. The Commission believes that the methodology employed, which randomly placed the active VLP devices based on population density, was appropriate for evaluating the potential interference environment to generate these I/N statistics. The study used appropriate assumptions to determine that 30,000 VLP devices will be transmitting at a time. As noted, active VLP devices were placed based on population density, and because the study accounts for receivers in densely populated areas, the number of active VLP devices near ENG central receive sites evaluated during each iteration is likely to be far higher than NAB's calculated average. The Commission agrees with Apple, Broadcom, et al. that the inclusion of VLP devices in the simulation that are distant from ENG central receive sites does not change the properly modeled density of VLP devices close to the ENG central receive sites, which is based on user density. Thus, NAB's argument does not reflect the nature of how VLP devices were actually placed for evaluation. Relatedly, the Commission also notes that the fact that many VLP devices will not be located within 30 kilometers of an ENG central receiver site reflects the reality that the majority of VLP devices active at any given time will not be operating near these locations.

The Commission disagrees with NAB's contention that a VLP device operating at 500 meters from the Old Post Office Building in Washington, DC would produce a received signal level that exceeds the −6 dB I/N threshold by 34 dB at an ENG receiver located there. The Commission reiterates that exceeding a −6 dB I/N does not constitute harmful interference, rather, if the probability of exceeding this level is extremely low, then the probability of actual harmful interference is insignificant. NAB does not describe how it calculated its result, but based on the magnitude the Commission believes that NAB used a methodology inconsistent with previous Commission orders, resulting in an unrealistically high I/N ratio. Its result appears to be consistent with the use of free-space propagation modeling, whereas the Commission previously rejected free-space propagation modeling at distances greater than 30 meters, stating that free space propagation has limited applicability beyond that distance because it ignores environmental clutter and over long distances can result in extremely conservative calculations that under predict the amount of actual path loss. The Commission found that the WINNER II model is more appropriate for distances between 30 meters and 1 kilometer because it accounts for obstructions from urban and suburban clutter, which the free space model does not. Also, NAB's stated value of −104 dBm/10 MHz for ENG receiver sensitivity appears to be too low. The Commission calculates that this level would be the thermal noise floor of a receiver with a 10 megahertz bandwidth, meaning it does not include the receiver noise figure. The Alion Study specifies that a receiver noise figure of 4 dB along with a line loss of 1 dB should be included in calculating potential interference to ENG receivers. Additionally, NAB failed to include other mitigating factors that the Commission previously found were appropriate, specifically, 3 dB for TPC, 4 dB for body loss, 3 dB for antenna polarization mismatch, and 5 dB for antenna pattern mismatch. Taking all these factors into account, the Commission calculates that the received signal strength in NAB's example would be −129 dBm, compared to a receiver noise floor of −100 dBm (including noise figure), significantly less than the −6 dB I/N metric.

In sum, Apple, Broadcom, and Meta's latest study performed in the same manner and using the same assumptions as previous studies (with the exception of those specific to ENG receivers) that the Commission found acceptable for permitting VLP devices in the U–NII–5 and U–NII–7 bands shows that the likelihood of VLP devices in the U–NII–6 and U–NII–8 bands exceeding −6 dB I/N at an ENG central receive site is extremely low. In addition, the Commission's calculations show that even in what NAB indicates would be a worst-case scenario, a VLP device would likely not exceed −6 dB I/N. Thus, the Commission concludes that the risk of harmful interference from VLP devices to ENG central receive sites in the U–NII–6 and U–NII–8 bands is insignificant. Because this interference risk is so low in the absence of any of the additional factors or mitigation measures suggested by Apple, Broadcom, et al. that could further reduce the likelihood of harmful interference (*i.e.,* that links have a significantly higher signal-to-noise ratio than needed to successfully operate, the locations of ENG trucks can be moved to get a better line of sight to a fixed receive site, and ENG power levels can be increased), the Commission does not address NAB's arguments on the validity of the Apple, Broadcom, et al.'s statements.

NAB's points regarding interference matters in other bands and outside the record of this proceeding do not add support to its claims of potential interference described here, and the Commission has adequately addressed those for purposes of this rulemaking. Specifically, NAB claims that it has repeatedly demonstrated that broadcasters have lost access to licensed spectrum in the 2.4 GHz band ''due to ruinous interference from unlicensed devices'' that ''has continued unabated for nearly 25 years.'' The Commission has previously concluded that the record in this proceeding ''contains no substantial evidence of harmful interference to broadcast operations in the 2.4 GHz band'' and noted the absence of interference complaints regarding the 2.4 GHz band. No commenter to this proceeding offers new information regarding such interference claims, and the Commission declines to revisit them on its own motion. NAB also contends that even when interference occurs among licensed users, such as alleged interference to private land mobile systems in spectrum bands shared with broadcast television stations, the

Commission has not consistently investigated or resolved these conflicts. NAB claims that rather than take action to resolve these longstanding interference problems, the Commission has demurred. According to NAB, this past FCC inaction raises concerns that if the risk of interference is not addressed now it will go unaddressed in the future. The Commission takes seriously its responsibility to prevent harmful interference from occurring. The Commission has concluded that permitting VLP devices to operate in the U–NII–6 and U–NII–8 bands will present an insignificant harmful interference risk to licensed mobile operations. Therefore, the Commission has adequately addressed NAB's interference concerns and NAB's allegations concerning the Commission's inaction regarding interference in other bands do not provide grounds to alter its course. Nonetheless, the Commission also remains committed to resolving harmful incidents in the unlikely possibility that they occur.

**ENG Truck Receivers**

Electronic newsgathering (ENG) trucks are generally situated near a news or sporting event and receive signals from hand-held cameras or other portable news gathering equipment. According to the Alion Study previously submitted by NAB, the ENG truck receive antenna may be omni-directional or sectoral with adjustable height from 5 to 50 feet and the signals may use various bandwidths between 3 and 20 megahertz. The *6 GHz Second FNPRM* proposed to permit VLP devices to operate in the U–NII–6 and U–NII–8 bands and sought comment on whether the devices can operate at up to −5 dBm/MHz EIRP PSD and 14 dBm EIRP while minimizing the risk of harmful interference to ENG truck receivers. The *6 GHz Second FNPRM* asked what is the appropriate metric for evaluating the harmful interference risk to an ENG truck receiver; if signal-to-interference-plus-noise ratio (SINR) is used as a metric what value or range of values should be used; and is there a connection between reliance on an I/N metric for evaluating ENG trucks connecting to a central receive site and evaluating the risk to a truck receiver based on SINR. The *6 GHz Second FNPRM* also requested information on the typical bandwidth and coding rates used by ENG truck receivers and how close a random VLP device can come to a ENG truck receiver under normal operating conditions.

According to Apple, Broadcom, et al., a SINR of 1 dB is necessary for the link between a camera and a portable ENG truck receiver to operate without harmful interference. As described in their comments, the parties base this claim on empirical SINR measurements that Broadcom previously submitted showing the level necessary to maintain an error-free video signal for different signal bandwidths, coding rates, and unlicensed device activity factors. These measurements show that there would be no audio or video defects with an SINR of at least 1 dB for an unlicensed device activity factor of 2% and a video signal of 10 megahertz bandwidth. Apple, Broadcom, et al. note that the *6 GHz First Order* relied on these Broadcom measurements in authorizing low-power indoor operations in the U–NII–6 and U–NII–8 bands. Apple, Broadcom, et al. claim that while the Commission, in the *6 GHz First Order,* discussed studies that apply a 10 dB SINR threshold for interference, it did not adopt this 10 dB SINR as an interference threshold. Instead, they note that the Commission observed that the Broadcom measurements found '' 'that for a 10% activity factor the [ENG] link required a signal-to-interference-plus-noise of between 2 and 9 dB.' '' Apple, Broadcom, et al. point out that the Commission has more recently determined that a more realistic 2% activity factor should be assumed for VLP devices. Therefore, they claim that Broadcom's measurements demonstrate that with a VLP duty cycle of 2%, the portable equipment to ENG truck receiver link only requires an SINR of 1 dB. Apple, Broadcom, et al. also suggest that assuming broadcasters would use a 10 megahertz bandwidth signal rather than an 8 megahertz bandwidth signal is more realistic as this would be more robust and support higher throughput. But, even with an 8 megahertz bandwidth, they state that the ENG Truck Receiver Studies show harmful interference is extremely unlikely because only a 7 dB SINR would be needed for a 2% activity factor and a SINR below 10 dB is only possible in a small area very close to the truck receiver and only when the truck receiver is not elevated.

Apple, Broadcom, et al. claim that the record demonstrates that VLP devices will not pose a significant interference risk to the link between mobile transmitters and ENG truck receivers. To support this claim, they refer to a set of related technical studies submitted by Broadcom and Apple, Broadcom, et al. (collectively, ''ENG Truck Receiver Studies''). The ENG Truck Receiver Studies use a link budget methodology to calculate the SINR for an ENG camera transmitting at a fixed location 94 meters from an ENG truck receiver receiving interference from a single VLP device. The ENG Truck Receiver Studies present plots of the variation of SINR with VLP device location within a 94-meter radius of the ENG truck receiver for truck antenna heights of 1.5, 2.5, 5, 10, and 15 meters. The ENG Truck Receiver Studies assume that a portable ENG camera transmits with either 20 dBm or 23 dBm of power from a fixed location 94 meters away from the ENG truck receiver and that the ENG truck receiver uses a 10 megahertz bandwidth, has a 4 dB noise figure, and uses the ITU–R F.1336–4 antenna pattern used in the Alion Study. The ENG Truck Receiver Studies use a free space propagation model, assume that the VLP device transmits at −5 dBm/MHz, 4 dB of body loss, a power reduction of 3 dB from transmit power control, an attenuation of 5 dB from the mismatch between the VLP device's antenna pattern and the ENG receiver, and a 3 dB loss from polarization mismatch between the VLP device antenna and truck receiver. Apple, Broadcom, et al. claim that the ENG Truck Receiver Studies show that a SINR below 1 dB only occurs when the VLP device is operating within a few meters of the ENG truck receiver and the ENG truck receiver antenna is located at the same height as the VLP device. Apple, Broadcom, et al. view such a scenario as unlikely because the receive antenna would likely be located on top of the truck or on a telescoping mast, and the VLP device would operate so close to the truck receiver that it could easily be observed and controlled. They claim that ''in every realistic scenario'' the SINR will be above 8 dB. They also point out that for antenna heights above 2.5 meters, the SINR is greater than 10 dB at all locations. According to Apple, Broadcom, et al., the results of the ENG Truck Receiver Studies are conservative because 94 meters is an unusually long distance for ENG transmissions, the ENG receiver would be elevated on a mast especially where the ENG transmitter is located so far from the receiver, and ENG transmitters commonly use an antenna with 3 dB of gain to transmit at 23 dBm instead of 20 dBm. Apple, Broadcom, et al. contend that if the ENG receiver is elevated to 5 meters, the SINR would be at least 15 dB for all locations at least one meter from the truck.

Apple, Broadcom, et al. also suggest that the Commission adopt a requirement that VLP devices operating in the U–NII–6 and U–NII–8 bands be required to employ a contention-based

protocol as is required for the U–NII–5 and U–NII–7 bands. They point out that the Commission previously acknowledged that the contention-based protocol will protect incumbents by '' 'avoid[ing] co-frequency interference with other services sharing the band.' '' According to Information Technology Industry Council, a VLP device that is near an ENG truck receiver will also be close enough to an ENG camera transmitter for the contention-based protocol to detect the signal and select an alternative channel.

NAB criticizes Broadcom for assuming both the VLP devices and ENG truck receiver are located at fixed locations with the ENG transmitter always 94 meters away from the truck receiver. According to NAB the purpose of using a radio link for ENG is to allow the camera transmitter to move in real time and a Monte Carlo simulation should consider a variety of possible scenarios. NAB also faults the ENG Truck Receiver Studies for assuming static line-of-sight conditions, claiming that the probability that the signals from both the ENG camera and the VLP device will be simultaneously faded is situation-dependent and that fades can be greater than 10 dB. NAB characterizes the 5 dB VLP/ENG antenna mismatch and 3 dB body loss used by Broadcom as ''unexplained and unjustified'' and claims that Apple, Broadcom, et al.'s measurements allow for less body loss 20 percent of the time. NAB claims that it was improper for Broadcom to include body loss, antenna mismatch, and polarization loss for the link between the VLP device and ENG truck receiver but not include these losses for the link between the ENG camera and ENG truck receiver.

NAB also criticizes Broadcom's use of SINR instead of a −6 dB I/N as has been used by the Commission. NAB explains that SINR may be appropriate for static conditions where the signal paths are well characterized and the systems well engineered, but both ENG and VLP operations are variable in time and location, which indicates the appropriate protection criteria is one that preserves the incumbent's noise floor. Regarding use of a 1 dB SINR threshold as an interference threshold, NAB states that Apple, Broadcom, et al. neither provide the assumed ENG link parameters (modulation type, error correction code, bandwidth, etc.), nor describe the bandwidth of the Wi-Fi interference. NAB believes that the 1 dB SINR threshold employed by Apple, Broadcom, et al. is not realistic based on bench measurements and decades of ENG field experience by broadcasters. NAB points to bench and field tests conducted by the Department of Defense and its contractors for the 2 GHz band that demonstrate a SINR threshold of 11.3 dB is needed to avoid harmful interference from a co-channel interferer with a 3.2 megahertz bandwidth. NAB suggest that because 6 GHz and 2 GHz ENG systems use identical modulation, coding, and bandwidth, this result is applicable to the 6 GHz band and that wider bandwidth Wi-Fi signals would have more interference potential. NAB also claims that these measurements indicate the duty cycle of the interfering signal has little effect because once a link is broken it requires a significant interference-free interval to reestablish.

According to NAB, for Apple, Broadcom, et al.'s claim that VLP devices will not pose a significant harmful interference risk to be viable, ''the following confluence of circumstances must hold as well: an atypically low height of the ENG receiving antenna; 4 dB of continuous body loss; antenna pattern and polarization mismatches of 5 dB and 3 dB; operation with continuous transmit power reduction; and static free-space conditions for both the ENG transmitter and VLP devices.'' NAB contends that for all of these conditions to be simultaneously true, a series of providential conditions would have to occur. NAB also points out that Broadcom's claims that VLP devices causing interference are likely to leave the area quickly ignore the fact that newsworthy events frequently transpire in proximity to crowds, meaning that ENG receivers can easily receive harmful interference from nearby VLP devices. Because VLP devices are not required to operate through an access point, there would not be any way to shut down operations if interference were to occur during breaking news event. NAB also explains that assertions that news gathering operations are opportunistic with respect to channel selection are incorrect and irrelevant because television stations in most markets have defined channel plans and VLP device operation is also opportunistic. The Society of Broadcast Engineers (SBE) states that the studies proffered by VLP supporters are flawed as demonstrated by NAB, in that they do not account for the full range of mobile BAS operations and rest on mere assumptions. SBE also points to comments of the Electric Power Research Institute (EPRI) which claim that real-world testing has shown results differing from those predicted by Monte Carlo simulations provided by VLP proponents and call for the models and inputs of the studies to be made public.

NAB claims that an ENG truck receiver with an antenna height of 15 meters would receive a signal from a VLP device located 100 meters distant that exceeds the −6 dB I/N criterion established by the Commission by more than 34 dB. For this ENG truck receiver and VLP device, NAB calculates that the desired-to-undesired (D/U) ratio would be 12 dB under static conditions for a signal from a camera transmitter located 4 meters from the truck receiver. According to NAB, this would leave the ENG receiver only 0.7 dB from failure under static conditions based on measurements showing a D/U ratio of 11.3 dB is required to achieve zero uncorrected errors. NAB claims that this 0.7 dB margin for a typical link configuration is unacceptably low because some configurations will fall short of the median value and the link will not close. NAB notes that in addition both transmitters are likely to be in motion, resulting in statistical fading due to multipath effects, which increase the likelihood of harmful interference.

Apple, Broadcom, et al. respond to NAB that there is no record support for NAB's claim that an 11.3 dB D/U ratio is required for error-free ENG operation, noting that NAB's citation is to an NAB conference related to the 2 GHz band. Apple, Broadcom, et al. fault NAB for failing to address the Broadcom measurement data that directly contradicts this claim and that the Commission relied on in the *6 GHz First Order.* Apple, Broadcom, et al. claim that the ENG Truck Receiver Studies employ a more conservative methodology than a Monte Carlo approach because they used an ENG transmitter 94 meters from the receiver while a Monte Carlo approach would have included a large number of shorter distances. Apple, Broadcom, et al. note that NAB raised the same objection regarding fading about a 2020 ENG study by Broadcom that it raises about the ENG Truck Receiver Studies and that the Commission rejected this contention in the *6 GHz First Order.* Apple, Broadcom, et al. also note that the assumption of 5 dB from the mismatch between the VLP device's antenna pattern and the ENG receiver and 4 dB for body loss that NAB criticizes are consistent with assumptions upon which the Commission has previously relied.

*Discussion.* The Commission concludes that VLP devices can operate without creating a significant risk of harmful interference to communication links between portable ENG transmitters and ENG truck receivers. The Commission bases this conclusion on

many factors, including the large power differential between portable ENG transmitters and VLP devices, the requirement that VLP devices employ a contention-based protocol, and the low probability that a VLP device will overlap the ENG signal in frequency because of the large amount of spectrum available for VLP operations. The results of the ENG Truck Receiver Studies provide additional support for the Commission's conclusion.

The consequences of the large power differential between ENG portable transmitters and VLP devices is illustrated by examining in detail the example provided by NAB of an ENG truck receiver with a 15 foot high antenna receiving signals from a VLP device located 100 meters away and an ENG portable camera transmitter located 4 meters away. This situation represents one of the worst potential interference cases because the VLP device is in the main beam of the ENG truck receiver antenna while the ENG portable camera transmitter is far below the antenna's main beam. According to the antenna pattern for an ENG truck receiver used in a Alion Study previously submitted by NAB, the antenna gain toward the VLP device would be 10.1 dB while the gain would be only −8.9 dB toward the ENG portable camera signal, assuming both transmitters are at a 1.5 meter height. This 19 dB difference in antenna gain is greater than the difference in propagation loss of 17.1 dB between the two locations using a free space path loss model, which illustrates that moving the VLP device closer to the truck receiver would not result in the VLP device's interference potential being appreciably worse.

In providing this example, NAB has considered only the antenna gain and propagation loss in calculating the received power from these two transmitters. In the *6 GHz First Order,* when the Commission examined a set of link budget examples provided by AT&T, it treated statistical quantities such as polarization loss and antenna discrimination using median or average values. As was done in the *6 GHz First Order,* the Commission believes that for a static link budget analysis it is appropriate to treat such statistical quantities using median values when calculating signal levels for NAB's example case. Using mean values for these parameters, the Commission evaluates the received signal power from the VLP device—operating at −5 dBm/MHz EIRP PSD and 14 dBM EIRP—at the ENG truck receiver to be −88.8 dBm. For the ENG camera transmitter, NAB used 20 dBm as the transmit power. As Apple, Broadcom, et al. point out, ENG camera transmitters commonly use antennas with 3 dB of gain which would increase the transmit EIRP to 23 dBm. This results in −57.6 dBm received signal power at the ENG truck receiver. The resulting D/U ratio is 31.2 dB, which greatly exceeds the 11.3 dB D/U ratio that NAB states is necessary to avoid harmful interference. Even if the ENG portable camera transmits with only 20 dBm of power, the resulting 28.2 dB D/U ratio would greatly exceed the 11.3 dB D/U ratio. Regarding NAB's concern that fading is likely to occur from the motion of the devices thereby increasing the interference likelihood, given that both the ENG transmitter and VLP device are likely to be stationary or possibly moving slowly and that the distances between transmitters and the receiver are less than 100 meters, the Commission expects that any fading that occurs would be mild and less than 10 dB in magnitude. These large D/U ratios indicate that even with that level of fading the D/U ratio would remain above 11.3 dB. This illustrates that VLP devices operating at the power level that the Commission is permitting under its rules are unlikely to cause harmful interference to this type of ENG operation. In addition, for this particular example, the signal from the VLP device is likely to experience more clutter loss than the signal from the ENG transmitter due to the greater distance, which suggests that the D/U ratio would be even greater.

The fact that the Commission is requiring the VLP devices to employ a contention-based protocol also lessens the risk that harmful interference will occur to ENG operations. For the scenarios discussed in both NAB's examples and the ENG Truck Receiver Studies, the portable ENG transmitter is likely to be within a relatively close distance to the truck receivers—*i.e.,* 100 meters or less. VLP devices that present a harmful interference risk are also likely to be within such a distance of the ENG truck receiver. Consequently, the VLP devices and portable ENG transmitters will operate in close proximity to each other. In such situations, the VLP device should be able to detect when a portable ENG transmitter is operating nearby on the same channel. Because the portable ENG transmitter operates continuously when sending a video signal, the Commission would expect that the contention-based protocol used by the VLP device will cause it to vacate the channel used by the portable ENG transmitter and thereby further lessen the potential for harmful interference to occur.

Because there is 1,200 megahertz of 6 GHz band spectrum available for VLP device operation under the rules adopted in the *Third Report and Order,* it is unlikely that a VLP device will transmit co-channel with a portable ENG camera transmitter. This provides additional protection against harmful interference occurring. For a VLP device using a 20 megahertz bandwidth, there is a 1.7% chance of channel overlap with an ENG transmitter operating in a 10 megahertz bandwidth. For VLP devices using a 160 megahertz bandwidth, the likelihood of channel overlap would be 11.8%.

The Commission is basing its conclusion that there is an insignificant risk of harmful interference occurring to ENG truck receivers from VLP operations on the factors discussed above: the power differential between VLP devices and portable ENG transmitters, the use of a contention-based protocol by VLP devices, and the large amount of spectrum available for VLP operations in the 6 GHz band. In addition to these factors, the Commission also recognizes that the ENG Truck Receiver Studies provide additional evidence to support this conclusion. Despite NAB and SBE's contentions, the Commission believes that the assumptions used in the ENG Truck Receiver Studies are appropriate. The 4 dB for body loss, 3 dB power reduction from transmit power control, 5 dB attenuation from the mismatch between the VLP device's antenna pattern and the ENG truck receiver, and 3 dB loss from polarization mismatch between the VLP device antenna and the ENG truck receiver are consistent with the assumptions that the Commission concluded were appropriate in the *6 GHz First Order* and/or the *6 GHz Second Order.* The Commission also believes that Broadcom was correct not to include these losses for the ENG camera to ENG truck receiver link. As shown in the pictures submitted by NAB, the portable ENG cameras use an external antenna that is not body worn and is located on the back of the camera that is at least half a foot from the operator's body. Because this antenna is located several wavelengths away from body, body loss is expected to be insignificant. As the vertical orientation of the antenna does not change as the camera operator moves, there is unlikely to be polarization loss. Antenna pattern mismatch is not a significant factor for large external antennas that have omni-directional patterns such as the camera antennas. The ENG Truck Receiver

Studies assume a receiver bandwidth, noise figure, and antenna pattern that were taken from the Alion Study previously submitted by NAB, which included an interference analysis for an ENG portable camera transmitting to an ENG truck receiver. In addition, contrary to NAB's contention, Broadcom does indicate the ENG camera's modulation, coding rates, and signal bandwidths used in its SINR measurement study. While Broadcom does not specify the unlicensed device signal bandwidth when conducting these measurements, the Commission presumes that the unlicensed device's signal fully overlaps the 8- or 10-megahertz ENG signals examined based on the 20-megahertz minimum Wi-Fi bandwidth.

In examining the ENG Truck Receiver Studies, the Commission appreciates that a 94-meter distance between the ENG portable camera transmitter and ENG truck receiver is at the outer range of what is likely to occur in practice. Given this large distance between the ENG portable camera transmitter and the ENG truck receiver, the Commission would expect that the ENG truck receiver would use an elevated antenna—at least 5 meters in height—in order to increase the available margin by elevating the signal path over any obstacles. At such a height, the ENG Truck Receiver Studies indicate that the SINR would be greater than 11 dB for VLP devices located anywhere within 94 meters of the ENG truck receiver when the camera is transmitting at 20 dBm and greater than 14 dB if the camera transmits at 23 dBm. When the ENG truck is being used to relay video signals to a central receive site, it would likely use a 15-meter antenna height to rise above any ground clutter and to achieve a line-of-sight link to the ENG central receive site, which would result in a SINR of over 23 dB. Even if a 2.5-meter antenna height were used, as would be the case for a receiver on the roof of the truck, the area where a VLP device would result in a SINR that is lower than 10 dB is small and the SINR remains above 8 dB everywhere for an ENG camera transmitting at 20 dBm.

The Commission cannot endorse use of an SINR of 1 dB as an indication of whether there is an insignificant risk of harmful interference occurring when examining the results of the ENG Truck Receiver Studies, as suggested by Apple, Broadcom, et al. According to the SINR measurements submitted by Broadcom, a 1 dB SINR is needed to ensure error-free video signals when a Wi-Fi device with a 2% activity factor when an 10 megahertz bandwidth video signal is used. While this appears to be a valid result for a static channel, the Commission agrees with NAB that fading may affect the signals received from the ENG transmitter and VLP device. No information submitted on the record addresses the extent of fading that may occur other than NAB's unsupported contention that such fading may be greater than 10 dB. Given that the portable ENG camera transmitter and body worn VLP devices are likely to be stationary or moving slowly and that the distances between transmitters and the receiver are less than 100 meters, the Commission expects that any fading that occurs would be mild and less than 10 dB in magnitude. Even with this level of fading the ENG Truck Receiver Studies supports the Commission's conclusion that there is an insignificant risk that harmful interference will occur to the ENG truck receivers. The ENG Truck Receiver Studies indicate that for an ENG truck receiver antenna elevation of at least 5 meters, the SINR remains above 11 dB when the ENG transmitter is transmitting at 20 dBm and the SINR is above 14 dB when the ENG transmitter is transmitting at 23 dBm. The Commission notes that an 11 dB SINR is only slightly lower than the 11.3 dB SINR at which NAB claims bench and field tests demonstrate to be the median threshold for no harmful interference. The SINR increases to at least 23 dB when the ENG truck receiver antenna is raised to 15 meters as would often occur for relaying a video signal to an ENG central receive site. While the ENG Truck Receiver Studies indicate the SINR can be as low as 8 dB if the ENG truck receiver height is only 2.5 meters, the Commission notes that NAB states that with robust modulation and coding the required SINR can be reduced to 7.3 dB. In addition, Apple, Broadcom, et al. show that the SINR will exceed 8 dB in every scenario examined and that SINRs of less than 11 dB are quite rare, providing an additional basis for the Commission's conclusion that the risk of harmful interference to mobile receivers is insignificant.

The Commission does not believe that the ENG Truck Receiver Studies' examination of the SINR produced by VLP devices instead of I/N is improper, as NAB suggests. In the *6 GHz First Order,* the Commission agreed with the technical study findings provided by CableLabs and Apple, Broadcom, et al. that examined the potential for interference from 6 GHz low-power indoor devices to ENG truck receivers, which used SINR as a measure of interference potential. It also adopted a −6 dB I/N ratio for use by the automated frequency coordination (AFC) systems that manage spectrum access by 6 GHz standard power access points. The Commission made the decision to use I/N for this purpose based on implementation simplicity and because it was used by most commenters in their analyses. In making this decision, the Commission clearly stated that it was not ''making a determination that any signal received with an I/N greater than −6 dB would constitute harmful interference.'' The Commission did not prohibit (or imply that it was prohibiting) the use of other signal quality measurements besides I/N as an indication as to whether harmful interference may occur. In examining a study that uses SINR, the Commission is not implying that any SINR below a particular level constitutes harmful interference.

The Commission agrees with NAB that a Monte Carlo simulation that considers a wide variety of situations would have been more informative than the approach employed by the ENG Truck Receiver Studies. The Commission acknowledges the limitations of the ENG Truck Receiver Studies in only considering one location for the ENG camera transmitter rather than examining more scenarios as could have been done in a Monte Carlo simulation. Despite this limitation, the Commission concludes the ENG Truck Receiver Studies provide additional support for concluding that there is an insignificant harmful interference risk to ENG receivers from VLP devices.

The Commission disagrees with SBE that the evidence to support VLP operations is flawed because the various studies submitted for the record do not account for the full range of mobile operations. As explained above, the Commission is limiting its discussion to three use cases—ENG central receive sites, ENG truck receivers, and low-power short range devices—consistent with the *6 GHz Second FNPRM* and the approach followed for low-power devices in the *6 GHz First Order.* As neither SBE nor any other commenters have suggested other use cases beyond these three cases, the Commission believes the approach the Commission is following is reasonable. The Commission also disagrees with SBE that the technical studies from Apple, Broadcom, et al. are flawed because EPRI claims real-world test have shown differing results from previous Monte Carlo simulations. The measurement studies that EPRI cites all claim that interference is occurring from unlicensed devices at particular fixed locations because the I/N ratio is greater

than −6 dB. Because Monte Carlo simulations are designed to examine the likelihood of interference occurring in general and the simulations have indicated that it is not impossible for an I/N over −6 dB to occur, the fact that there may exist locations where the I/N exceeds −6 dB does mean that the results differ from the Monte Carlo simulations. In addition, the Commission has not indicated that the occurrence of an I/N of greater the −6 dB indicates that harmful interference is occurring. The Commission also rejects EPRI's suggestion that the models and inputs of the Monte Carlo simulations be made publicly available for the same reasons the Commission rejected a similar request in the *6 GHz Second Order.* The Commission believes that Apple, Broadcom, et al. and Broadcom have provided sufficient information for knowledgeable engineers to understand the algorithms and models used in the technical studies they have submitted and find it noteworthy that no opponent of VLP expansion to U–NII–6 and U–NII–8 have conducted their own similar technical studies.

In reaching its conclusion that VLP devices will not present a significant risk of causing harmful interference to ENG truck receivers, the Commission is not relying on the opportunistic nature of ENG operations or on the assumption that VLP devices causing interference are likely to leave the areas quickly. Mobile ENG operations by broadcasters are conducted on a primary basis and licensees have the right to operate on any channel permitted by their license and are not expected to need to adjust their operating frequency to avoid VLP devices. The Commission also does not find that NAB's concern that there would be no way to shut down VLP devices that cause interference during a breaking news event provides justification for prohibiting VLP devices in the U–NII–6 and U–NII–8 bands because the record supports its conclusion that the risk of such harmful interference occurring would be insignificant. Because of the difference in power levels between the ENG operations and VLP devices, the use of a contention-based protocol by VLP devices, and the large amount of spectrum available for VLP operations, the Commission expects there to be an insignificant risk that harmful interference will occur to ENG truck receivers. This conclusion is further supported by the ENG Truck Receiver Studies.

**Low-Power Short Range Mobile Devices**

No commenters provided technical studies or described specific use cases for low-power short range mobile devices. Low-power short range mobile devices include portable cameras and microphones as well as Low-power Auxiliary Stations, which 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. While the Commission refers to these devices as low-power short range mobile devices, they operate at significantly higher power than VLP devices—portable ENG cameras typically operate at 20 dBm and Low-power Auxiliary Stations may operate at up 30 dBm. The *6 GHz Second FNPRM* suggested that these low-power short range mobile devices be protected by a combination of a required contention-based protocol and the low probability of a VLP device operating on the same channel in a nearby location. The Commission concludes that these measures will adequately protect low-power short range mobile devices from harmful interference from VLP devices.

The *6 GHz First Order* discussed a simulation submitted by Apple, Broadcom, et al. that simulated ENG equipment operating indoors within the U.S. House of Representatives chamber, a scenario which had been explored in the Alion Study submitted by NAB. To confirm that the energy sensing employed by the contention-based protocol in the 802.11 specification could be used to mitigate interference to indoor ENG receivers, the simulation calculated the received power level from ENG transmitters at 20 unlicensed access point locations operating within the U.S. House of Representatives chamber. The results of this simulation demonstrate that, even at the lowest ENG transmit power level, all unlicensed access points would detect the ENG signal at greater than the −62 dBm threshold used in the 802.11 specification and therefore not transmit co-channel with the ENG transmitters. While this simulation was limited to low-power ENG cameras and associated receivers, it should equally apply to other low-power short range mobile devices that operate with similar power levels and at similar distances. This simulation illustrates that unlicensed VLP devices using such a contention-based protocol have the capability to sense the energy from nearby low-power mobile devices and avoid using the same channel. In addition, for the same reasons as discussed above regarding ENG truck receivers, the 1200 megahertz of 6 GHz band spectrum available for VLP device operation makes it unlikely that even absent a contention-based protocol, these devices would transmit co-channel with low-power short range mobile devices.

**Reservation of Spectrum for ENG**

The Commission notes that NAB requests that the Commission ''adopt a 55 MHz carve-out at the top of the U–NII–8 band at which no VLP operations are permitted, at least until there is significant experience to determine such a carve-out is unnecessary.'' NAB has made similar requests previously in this proceeding, and in both instances the Commission chose not to adopt NAB's suggestion. In this case, NAB repeats prior concerns without providing any new information that addresses any changes in operational parameters. As the Commission has thoroughly addressed interference considerations related to VLP operations in the U–NII–6 and U–NII–8 bands herein and found that such operations will have an insignificant potential for causing harmful interference to ENG operations, it declines to adopt NAB's suggestion.

**Protecting Fixed Services**

The operational and technical characteristics of the limited number of fixed microwave links in the U–NII–6 and U–NII–8 bands are consistent with those in the U–NII–5 and U–NII–7 bands. Because the Commission is adopting identical technical rules for VLP operation in the U–NII–6 and U–NII–8 bands as apply in U–NII–5 and U–NII–7 bands, the Commission's conclusion in the *6 GHz Second Order* that VLP operations will not present a significant risk of harmful interference to fixed microwave links applies equally to the U–NII–6 and U–NII–7 bands.

Apple, Broadcom, et al. and the IEEE 802 LAN/MAN Standards Committee support this contention, suggesting that the previously conducted studies demonstrate that there will be no harmful interference to incumbent fixed microwave services in the U–NII–6 and U–NII–8 bands. AT&T raises concerns that the simulation studies the Commission previously relied upon remain unfiled and untested and contends it is poor public policy to rely on studies that have not been filed for public review. The Fixed Wireless Communications Coalition (FWCC) states that the record was insufficient to act on the proposals prior to the *6 GHz Second FNPRM* and remains insufficient to support Commission action because the comments ''were either non-substantive or rehashed information previously submitted [in] the record.'' Several microwave licensees and their representatives urge

the Commission to gain real-world experience or require testing with VLP devices before further liberalizing the rules. The American Petroleum Institute (API) raises several specific concerns regarding the technical studies that the Commission relied upon in its decision to permit VLP in the U–NII–5 and U–NII–7 bands. API claims that for the Houston area microwave link simulation (Houston Simulation) submitted by Apple, using an antenna based on the Commission's rules instead of the 44 dBi gain antenna with the ITU–R F.1245 pattern relied upon by Apple, would have resulted in more predicted interference. API also criticizes the Houston Simulation's use of 1.3 dB cable loss (*i.e.,* feeder loss) for microwave systems, claiming that most modern microwave systems utilize receivers with the radio directly connected to the antenna that may have less than 0.5 of coupling loss. Regarding the Commission's discussion of a link budget analysis submitted by Nokia, API suggest that the Commission should not have included a 2 dB feeder loss and that what API refers to as ''antenna polarization mismatch'' should have been 1.5 dB instead of 5 dB.

In responding to AT&T's previous request that the code for the simulation studies be publicly disclosed, the Commission in the *6 GHz Second Order* explained that both Apple, Broadcom, et al. and Apple provided sufficient information regarding their simulations. The Commission sees no reason to reconsider this finding or the Commission's reliance on these simulations in concluding that VLP devices will not result in a significant risk of harmful interference to fixed microwave receivers. The Commission also does not agree with FWCC's general contention about the sufficiency of the record to support its expansion of VLP operations to the U–NII–6 and U–NII–8 bands. Given that the VLP operations the Commission is now authorizing in the U–NII–6 and U–NII–8 bands are identical to what the Commission currently permits in the adjacent much larger U–NII–5 and U–NII–7 bands, the Commission sees no reason to pause its rulemaking for some unspecified time to gain experience with VLP devices as suggested by some of the microwave licensees.

Regarding API's concerns, the *6 GHz Second Order* explained that the Houston Simulation's use of the ITU–R F.1245 antenna pattern with a 44 dBi gain was appropriate because it represents an ''average'' antenna, which would provide a reasonable estimate of microwave link interference performance. The goal of a Monte Carlo simulation is to obtain overall statistics on the potential for harmful interference to occur to all microwave links. Hence, the Commission disagrees with API's contention that a pattern based strictly on what is permitted by its rules would be more appropriate, as this would likely result in a worst-case overprediction of harmful interference occurring rather than overall interference statistics. Regarding the Houston Simulation's 1.3 dB feeder loss, AT&T previously raised the same concern that some microwave radios are mounted directly to the antenna and have no feeder loss. The *6 GHz Second Order* explained that using 1.3 dB feeder loss was a reasonable approach as the simulation is designed to model the interference potential in general rather than explore the interference risk for a particular microwave receiver.

The Commission also does not agree with API's concerns regarding the Nokia link budget analysis. Contrary to API's contention, the 5 dB loss the Commission applied was for ''RLAN/FS antenna pattern mismatch between unlicensed devices and microwave receivers'' rather than for a polarization mismatch. This 5 dB value was used by the Commission in link budget analyses in the *6 GHz First Order* for analyzing potential interference from low-power indoor devices to microwave receivers and is based on the antenna patterns of typical indoor enterprise and consumer access points. In those analyses, the Commission applied a separate attenuation for polarization loss. The Commission also used a 2 dB feeder loss for the link budget analysis in the *6 GHz First Order*. The *6 GHz Second Order* explained that because the Nokia analysis is a link budget that assumes the same type of microwave antennas and that the VLP devices likely have similar antenna patterns to the low-power indoor devices, these assumptions are appropriate for examining the Nokia analysis. The Commission also notes that even after the Commission applied these adjustments for antenna pattern mismatch and feeder loss, Nokia's suggested VLP power would be −11 dBm/MHz EIRP, which is significantly lower than the −5 dBm/MHz EIRP limit the Commission adopted for VLP devices. As the Commission explained, a Monte Carlo analysis rather than a static link budget analysis is a more realistic indication of the potential for VLP devices to cause harmful interference. Hence, even if the Commission had not applied the 7 dB of adjustment to the Nokia analysis, it would not have changed its conclusion regarding the risk of harmful interference occurring to microwave receivers from VLP devices.

**Fixed-Satellite Service Uplinks**

In the *6 GHz First Order,* the Commission authorized standard power devices in the U–NII–5 and U–NII–7 portions of the 6 GHz band and low-power indoor unlicensed devices across the entire 6 GHz band. To protect FSS uplinks that operate in all except the upper fifty megahertz of the 6 GHz band, the Commission required outdoor standard power access points to limit their maximum EIRP above a 30 degree elevation angle to 21 dBm. However, the Commission determined no restrictions were necessary for low power indoor devices because of these device's relatively low EIRP as well as building attenuation due to the indoor operation. Similarly, in the *6 GHz Second Order,* the Commission determined that VLP devices operating in the U–NII–5 and U–NII–7 bands did not require any restrictions because VLP devices are limited to no more than 14 dBm. In the *6 GHz Second FNPRM,* the Commission proposed expanding VLP access to the entire 6 GHz band but made no specific proposal regarding protecting FSS Earth-to-space operations.

Sirius XM urges the Commission to prohibit outdoor VLP devices in the upper U–NII–8 band, as they may disrupt Satellite Digital Audio Radio Service (SDARS) operations. While SDARS is not a part of the FSS, its ground stations use a portion of the U–NII–8 band to transmit digital audio signals to Sirius XM's geostationary satellite constellation. Sirius XM points out that the only analysis provided by unlicensed proponents of interference to FSS receivers was a 2018 study conducted by RKF Engineering (2018 RKF Study) that addressed FSS, but not SDARS. According to Sirius XM, SDARS is different than FSS because it must deliver a reliable signal to consumer-grade antennas rather than the large high-gain antennas used by C-band FSS operations. Sirius XM previously criticized the assumptions used by the 2018 RKF Study and further calls into question a number of its assumptions. Specifically, Sirius points out that the 2018 RKF Study assumed a 2% outdoor use factor while more recent simulations have assumed a 6% outdoor use factor, that the Study used an estimate of 6 GHz band unlicensed devices that is far lower than more recent estimates of connected devices from Cisco, and that device activity factors have been trending higher due to increased video streaming. Sirius points out that the interference levels from VLP

devices would be 40 times higher than low-power indoor devices due to the lack of building attenuation. Sirius XM also cautions that once interference occurs to SDARS, there would not be a practical enforcement mechanism to resolve it. Sirius contends that the risk of harm to the valuable SDARS service outweighs the benefit of satisfying an undemonstrated need for more spectrum for outdoor VLP device use. Sirius XM renews its previous proposal that the Commission prescribe a maximum aggregate increase in the uplink noise floor and prohibit the manufacture, importation, and sale of additional unlicensed devices if a −23 dB I/N is exceeded. It also suggests that VLP devices be required to prioritize other parts of the 6 GHz spectrum outside of the SDARS uplink band.

Apple, Broadcom, et al. respond that Sirius XM presents no detailed analysis of the interference risk to its system, nor any concrete interference protection requirements. Apple, Broadcom, et al. contend that Sirus XM's satellites are no different from other 6 GHz FSS operations in that they receive aggregate interference over a large footprint and receive interference from numerous existing terrestrial licensees and that the record demonstrates these other devices contribute orders of magnitude more energy than unlicensed devices will. According to Apple, Broadcom, et al., high power 6 GHz licensees will continue to be the dominant interferers to Sirius XM's uplinks, not VLP devices. They point to the 2018 RKF Study on the potential for interference from standard-power devices operating at 4 Watts (36 dBm) and claim that interference from VLP devices would be even fainter than the −20 dB I/N predicted.

*Discussion.* The Commission believes that its previous conclusion that FSS uplinks in the U–NII–5 and U–NII–7 bands will not have a significant risk of experiencing harmful interference from VLP devices applies equally to FSS uplinks in the U–NII–6 and U–NII–8 bands, including to Sirius XM's SDARS system. This conclusion is based on the fact that VLP devices, which can operate with up to 14 dBm EIRP, will transmit with significantly less power than the 21 dBm power permitted above 30 degrees elevation for standard power access points. Sirius XM's SDARS operations in the U–NII–8 band have the same characteristics as 6 GHz FSS systems. As with 6 GHz band FSS systems, its satellites operate in geostationary orbits and have receive beams that cover the entire United States. Its satellites potentially receive interference from other licensed users that share the 6 GHz band just as 6 GHz FSS uplinks. As to Sirius XM's observation that the power received from outdoor VLP devices can be significantly higher than the power from low-power indoor devices due to the lack of building attenuation, the power from outdoor VLP devices would be significantly less than that of standard power access points, which its rules permit to operate outdoors and which the Commission previously found are unlikely to cause harmful interference to FSS receivers.

The Commission notes that Sirius XM has not produced any technical analysis regarding the Commission's proposal to permit U–NII–8 VLP operations. Instead, Sirius XM refers back to its previous critique of the 2018 RKF Study, which was available to the Commission prior to adopting the rules for 6 GHz band standard power and low-power indoor devices. The only new points regarding the 2018 RKF Study that Sirius XM now raises are that more recent technical studies regarding VLP devices filed by unlicensed proponents assume a 6% outdoor use factor instead of 2%, that Cisco recent estimates of connected devices are higher than the 2018 RKF Study, and that unlicensed device activity factors will continue to increase due to video downloads. The Commission notes that the 6% and 2% outdoor use factors to which Sirius refers have different meanings in the 2018 RKF Study than in the more recent VLP simulation Sirius references. The 2018 RKF Study assumed that 2% of the ''RLANs'' are outdoors while the Apple, Broadcom, at al. simulation of VLP use in San Francisco assumed 6% of the people were outdoors with 25% of those people using VLP devices and only 2% of those devices active at any given time. The two simulations also had different foci: The 2018 RKF Study simulated radio local area networks, including Wi-Fi access points, both indoor and outdoor across the entire United States while the Apple, Broadcom, at al. simulation only considered outdoor VLP use in San Francisco. Given the different meanings of these outdoor use factors, the Commission cannot directly compare whether the two simulations in fact represent a different level of outdoor device use. Because of the different scope of these two simulations, the Commission believes it was appropriate to use different methodologies for modeling the number of outdoor devices. The Cisco connected device data Sirius XM points to is for all internet-connected devices in general and not for 6 GHz VLP devices in particular. As for the contention regarding increasing device activity factor because of growing video activity on the internet, the Commission stated in the *6 GHz Second Order,* which was adopted in 2023, that assuming a 2% activity factor for VLP devices is reasonable for analytical purposes and the Commission sees no reason to reconsider this conclusion. Given the limited new technical information that has been presented, the Commission is not convinced that it should reconsider its conclusion as to the likelihood of interference occurring to FSS uplinks.

Sirius's concern about the lack of any practical enforcement mechanism if harmful interference were to occur also does not give the Commission reason to limit VLP access to the U–NII–8 band. The Commission is concluding, based on the currently available technical evidence, that there is an insignificant risk that harmful interference will occur to 6 GHz FSS systems and SDARS systems and thus there is no basis to prevent the introduction of an exciting new service to the public. As the demand for spectrum continues to grow, the Commission believes that it is in the public interest to continue to find ways to more intensively use the valuable spectrum resource, so long as the Commission also concludes that the evidence presented in the record shows the likelihood for harmful interference to remain insignificant.

Because the Commission has concluded that the likelihood of harmful interference occurring to Sirius XM's system from VLP devices is insignificant, it sees no reason to adopt an aggregate interference threshold as Sirius XM suggests. The Commission also does not find it appropriate to require VLP devices to prioritize operations in portions of the 6 GHz band outside of the SDARS uplink spectrum because the record does not support that Sirius XM will experience a harmful interference problem from VLP device operations.

**Fixed-Satellite Service Downlinks**

Portions of the U–NII–7 and U–NII–8 bands are allocated for FSS space-to-Earth (downlink) operations. However, no such earth stations are currently licensed in the U–NII–7 band. The U–NII–8 space-to-Earth allocation is limited to use by non-geostationary Mobile-Satellite Service feeder links. Globalstar operates earth station receive sites in the U–NII–8 band at Clifton, TX, Naalehu, HI, Wasilla, AK, Reno, NV, Sebring, FL, and Barrio of Las Palmas, Cabo Rojo, PR.

In the *6 GHz Second FNPRM,* the Commission sought comment on

whether any restrictions on VLP devices are necessary to protect space-to-Earth stations. The Commission recognized that VLP devices operate at significantly lower power spectral density levels than the geofenced VLP devices it also proposed to permit in the *6 GHz Second FNPRM;* therefore, it sought comment on how this difference impacts the analysis of potential harmful interference. Globalstar, the only stakeholder in the U–NII–8 band for FSS downlink transmission, expresses concern that a new class of higher-power, geofenced VLP devices could cause harmful interference and suggests that the geofencing system protect their earth stations. However, Globalstar does not address VLP operations of the type previously authorized in the U–NII–5 and U–NII–7 bands.

In the *6 GHz First Order,* the Commission concluded that the low probability of harmful interference to FSS space-to-Earth stations from low-power indoor devices in the U–NII–8 band was due to the indoor restriction and a transmit EIRP below 30 dBm. While a majority of VLP use cases are expected to be indoors, there will undoubtably be scenarios in which VLP operations occur outdoors. In these cases, VLP transmissions will still be attenuated by transmit power control (TPC) and body loss. Additionally, at 1.5 meters at which most VLP devices will be operated there will be significant clutter loss. These losses will bring the effective EIRP below that of a low-power access points effective EIRP. The Commission also notes that Globalstar has raised no interference concerns regarding VLP operation in U–NII–8 at the current VLP power levels. Therefore, the Commission concludes that no restrictions on VLP devices are necessary to protect FSS space-to-Earth operations.

**Protecting Passive Services**

The Committee on Radio Frequencies (CORF) expresses concerns about potential interference from VLP devices to the radio astronomy service and to the Earth Exploration Satellite Service (EESS) in the U–NII–6, U–NII–7, and U–NII–8 bands. 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. Remote sensing using the EESS, which CORF states is critical to weather prediction and the study of climate change and of the Earth in general, operates in the 6.425–7.250 GHz band, which includes all of the U–NII–6, U–NII–7, and U–NII–8 bands. CORF argues that the methodology the Commission used in the *6 GHz Second Order* to calculate VLP power limits in the U–NII–7 band by extrapolating the low-power indoor power limits was not appropriate in that the Commission failed to properly take into account differences between the two types of devices, including power levels and building entry loss. CORF requests that certain frequencies around the 6.65–6.6752 GHz band be made unavailable to VLP devices in areas close to radio astronomy sites, but suggests that these frequencies could be made available in areas where the spectrum is congested but are sufficiently removed from radio astronomy sites to avoid causing interference.

With regard to the EESS in the U–NII–6, U–NII–7, and U–NII–8 bands, CORF argues that a 14 dBm EIRP VLP device would exceed the ITU–R RS.2017 −166 dBW interference threshold in a 200 MHz bandwidth. It states that a single 14 dBm EIRP VLP device within a receiver's antenna beam and passband could result in a signal that exceeds the ITU–R RS.2017 threshold by as much as 33 dB. CORF further states that VLP devices in the U–NII–5 band would have a negligible effect on sensing operations in the bands where the EESS operates. As a result, CORF states that geofencing could be used with devices programmed to avoid the U–NII–6, U–NII–7, and U–NII–8 bands in oceanic zones, including in coastal waters, and non-geofenced usage could be restricted to the U–NII–5 band only.

*Discussion.* The Commission declines to restrict the frequencies that may be used by VLP devices in the U–NII–7 band to protect radio astronomy operations. That request is outside the scope of this Order, which addresses VLP operations in only the U–NII–6 and U–NII–8 bands. However, the Commission notes that in the *6 GHz Second Order* the Commission already considered and rejected CORF's request to prohibit use of certain frequencies by VLP devices to protect radio astronomy operations, stating that the interference potential for VLP devices in the U–NII–7 band is even lower than for low-power indoor devices that were already permitted to operate at higher power levels than those adopted for VLP devices. The Commission continues to believe that VLP devices in the U–NII–7 band are unlikely to interfere with radio astronomy operations, noting that CORF's analysis, in which it questioned the validity of extrapolating the low power indoor device power limit to determine the appropriate VLP device power limit, suggests a greater value for building entry loss (30 dB) than the Commission previously found to be appropriate (20.5 dB). Additionally, CORF failed to consider mitigating factors that reduce the potential for interference, including, 3 dB for the use of TPC, 4 dB for body loss, and 2% (17 dB) activity factor correction.

The Commission finds that it can permit VLP devices to operate in the U–NII–6 and U–NII–8 bands while protecting the EESS. In the *6 GHz Second Order,* the Commission permitted VLP devices to operate in the U–NII–7 band where the EESS also operates, subject to a prohibition on their use on oil platforms to protect ocean temperature sensing activities. The power levels the Commission are permitting for VLP devices in the U–NII–6 and U–NII–8 bands are the same as those the Commission permits for VLP devices in the U–NII–7 band, and as discussed below, the Commission is maintaining the prohibition on operation on oil platforms. Consequently, EESS operations in the U–NII–6 and U–NII–8 bands will be protected to the same extent that they are in the U–NII–7 band.

CORF's analysis of potential interference in the U–NII–6 and U–NII–8 bands overstates VLP device interference potential to the EESS. In particular, CORF's analysis fails to consider certain mitigating factors that the Commission previously found to be appropriate. When using the Commission's previously assumed factors of 5 dB for antenna pattern mismatch, 3 dB for antenna polarization loss, 20.5 dB for building entry loss, 3 dB for the use of TPC, and 4 dB for body loss, the Commission calculates a 4.2 dB protection margin. It should be noted that this calculation does not take into account clutter loss that can exist. Furthermore, given that EESS observation times are in the order of milliseconds while Wi-Fi transmissions are generally in the order of microseconds, the Commission believes that using the average power instead of peak power is appropriate. With a conservative 2% activity factor assumption (a 17 dB reduction), the protection margin evaluates to 21.2 dB.

Given the limited footprint of EESS satellites, the significant protection margin that exists, and that large numbers of VLP devices generally are not transmitting simultaneously on boats in an area, the Commission believes that continuing to allow VLP devices to operate on boats in the ocean will not result in any significant risk to EESS operations. For these same reasons, the Commission does not see a need to impose restrictions on VLP devices over large lakes and rivers, as CORF suggests. The Commission will continue to prohibit 6 GHz devices,

including VLP devices, from operating on oil platforms because oil platform locations tend to be concentrated in areas where the passive and active sensing of EESS operations are conducted.

**Technical Rules**

In the *6 GHz Second Order,* the Commission adopted rules that permitted VLP devices to operate in the U–NII–5 and U–NII–7 bands at power levels up to −5 dBm/MHz EIRP PSD and 14 dBm EIRP. The Commission determined that the risk of harmful interference to incumbent services in those bands was insignificant for VLP devices operating at that power level. As a natural outgrowth of that determination, in the *6 GHz Second FNPRM,* the Commission proposed to permit VLP devices to operate in the U–NII–6 and U–NII–8 bands without geofencing. In the *Third Report and Order,* the Commission is adopting this proposal.

Many of the proponents arguing to expand VLP operations to the U–NII–6 and U–NII–8 bands without geofencing suggest no changes to the technical rules governing VLP U–NII–5 and U–NII–7 operations. Several commenters, as discussed in more detail below, suggest modification to the rules that will apply to VLP operation throughout the 6 GHz band. To the extent that the Commission did not seek comment on those rule changes in the *6 GHz Second FNPRM,* the Commission is not able to consider applying them to U–NII–5 and U–NII–7 VLP operations. In addition, the Commission believes that having uniform rules that apply to all VLP operations will be of great benefit because it will make product development easier and lead to economies of scale that will reduce cost. For this reason, the Commission is adopting identical technical rules for VLP operations in the U–NII–6 and U–NII–8 bands as currently apply to such operations in the U–NII–5 and U–NII–7 bands.

However, the *6 GHz Second FNPRM* did seek comment on making several changes to the VLP rules. The Commission sought comment on any adjustment needed to the VLP device rules to adequately protect C–V2X operations in vehicles. The Commission also sought comment on relaxing the restrictions regarding VLP use on aircraft and on oil platforms and on providing additional flexibility for in-vehicle use. The Commission defers action on all of these *6 GHz Second FNPRM* proposals.

*VLP Power Levels.* The Wi-Fi Alliance and the IEEE 802 LAN/MAN Standards Committee support increasing the permitted power for VLP devices to 1 dBm/MHz with a total EIRP of 14 dBm without use of a geofencing system. IEEE 802 LAN/MAN Standards Committee states this would contribute to global harmonization of VLP devices and claims that this increased power spectral density for 20 and 40 megahertz wide channels would not cause any risk to incumbent services as these channel sizes may not be widely used. The Commission determined the power levels for VLP devices in the *6 GHz Second Order* based on an extensive record examining the potential for these devices to cause harmful interference to microwave receivers. No commenters submitted additional technical analysis examining interference to microwave receivers, and the simulation submitted by Apple, Broadcom, et al. of interference to ENG central receive sites assumed a VLP power of −5 dBm/MHz. Therefore, the record does not support adjusting the power for VLP device operations.

*Firmware Download.* AT&T suggests that all new unlicensed devices be required to accept mandatory firmware updates that alter their operating parameters, which will allow unlicensed performance to be changed in the future, enhancing efficiency and improving spectrum management. AT&T claims this would be consistent with the National Telecommunications and Information Administration's (NTIA) Commerce Spectrum Management Advisory Committee's recommendation that rules for unlicensed devices be designed to avoid creating obstacles to future reallocation of the band. APCO also supports requiring, wherever possible, that unlicensed devices be capable of modification through over-the-air firmware updates as the harm resulting from interference from unlicensed devices is potentially irreversible. Sirius XM also advocates that new unlicensed devices be capable of changing operating parameters through over-the-air firmware updates to address interference to its satellite radio system from unlicensed devices that are in the hands of consumers. Utilities Technology Council recommends that the Commission require all new unlicensed devices to accept mandatory firmware updates that alter their operating parameters to allow devices to be changed in the future for enhanced efficiency and improved spectrum management.

While AT&T and others assert that requiring unlicensed devices to be capable of firmware updates could have many benefits, such as permitting devices to adjust their operations to account for changing priorities in spectrum demand and evolving technology capabilities or to address interference issues, such a mandate could be complex and was not raised in the *6 GHz Second FNPRM.* Accordingly, 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 VLP devices in the U–NII–6 and U–NII–8 bands it does not believe such a mandate is necessary. Therefore, the Commission will not impose a firmware update mandate on VLP devices. However, the Commission notes that the vast majority of today's devices have capability for firmware updates as manufacturers routinely make changes and upgrades to correct bugs, enable more efficient operation, or add capabilities. Thus, even absent a Commission mandate, the Commission expect that most, if not all, VLP devices will have the ability to receive firmware updates, including updates to change a device's ability to transmit on certain frequencies, if such an update is necessary.

*Transmit Power Control (TPC).* The VLP rules require that VLP devices employ a TPC mechanism that has the capability to operate at least 6 dB below the maximum −5 dBm/MHz EIRP PSD. The Ultra Wide Band Alliance suggests that the Commission expand the TPC requirement beyond the 6 dB level. The Ultra Wide Band Alliance notes there are many benefits to using only the power required for a given link, such as reducing the area that could be impacted, increasing device density, and increasing the overall capacity of the band. While the Ultra Wide Band Alliance encourages the Commission to consider technical requirements for use of TPC that will ''encourage innovation in intelligent TPC as part of link adaptation schemes,'' it does not provide any concrete proposal on what specific TPC rules the Commission should require. Without a specific proposal, the Commission is unable to evaluate the merits of their request or the impact it would have on VLP operations.

**Benefits and Cost**

In the *6 GHz Second FNPRM,* the Commission sought comment on whether allowing VLP devices in the U–NII–6 and U–NII–8 bands will yield comparable benefits to those that stem from allowing VLP devices in the U–NII–5 and U–NII–7 bands in the *6 GHz Second Order.* The Commission tentatively concluded that at a

minimum the benefits would be in proportion to the amount of spectrum in the U–NII–6 and U–NII–8 bands relative to the amount of spectrum in the U–NII–5 and U–NII–7 bands. No commenter objected to this methodology so the Commission will estimate benefits on that basis.

The *6 GHz Second Order* found a lower bound of the benefit of opening the U–NII–5 and U–NII–7 bands to unlicensed use to be $2 billion. The Commission expects unlicensed uses in the U–NII–6 and U–NII–8 bands to be similar, but with less megahertz of spectrum involved compared to the U–NII–5 and U–NII–7 bands. To approximate a new lower bound of benefits, the Commission therefore multiplies the ratio of the sum of megahertz of spectrum in the U–NII–6 and U–NII–8 bands to the sum of megahertz of spectrum in the U–NII–5 and U–NII–7 MHz bands by $2 billion, resulting in $820 million of expected benefits. This lower bound also does not include any benefits that may come from creating a large contiguous band of spectrum for unlicensed use, which may allow greater speed and decreased latency. In any case, these benefits will be well in excess of the costs that the Commission estimates.

Because any changes to the design of VLP devices will be voluntary for device manufacturers, the rules that the Commission promulgates do not have net cost implications for the existing unlicensed device ecosystem. Manufacturers will change designs only if the additional revenue from taking advantage of the U–NII–6 and U–NII–8 bands outweighs the costs of redesign. And because the harmful interference risk to incumbent operators is insignificant and the Commission is not imposing any specific requirements on any incumbent operator, there are also no cost implications on them. Thus, by promulgating these rules to enable VLP devices to operate in the U–NII–6 and U–NII–8 portions of the 6 GHz band, significant economic benefits will be bestowed on the American public.

**Table of Frequency Allocations**

Finally, the Commission takes this opportunity to reinstate the text of international footnotes 5.458A and 5.458B in the Table of Frequency Allocations (Table), § 2.106 of its rules. This text was inadvertently removed when the Commission implemented formatting changes to accommodate the Office of the Federal Register's publication guidelines, even though the underlying citations to these footnotes continued to be printed in the graphical portion of the Table under both the International Table and the United States Table columns. Because this change is editorial and does not alter the substance of these pre-existing footnotes, the Commission finds good cause to conclude that notice and comment are not necessary for its adoption.

**Ordering Clauses**

Accordingly, *it is ordered,* pursuant to sections 2, 4(i), 302, and 303 of the Communications Act of 1934, as amended, 47 U.S.C. 152, 154(i), 302a, 303, the *Third Report and Order* is hereby *adopted*.

*It is further ordered* that the amendments of the Commission's rules as set forth in Appendix A of the *Third Report and Order* are adopted, effective 60 days from the date of publication in the **Federal Register**.

*It is further ordered* that the Office of the Secretary, shall send a copy of the *Third 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 Office of Managing Director, Performance Program Management, shall send a copy of the *Third Report and Order* in a report to be sent to Congress and the Government Accountability Office pursuant to the Congressional Review Act, 5 U.S.C. 801(a)(1)(A).

**List of Subjects**

*47 CFR Part 2*

Communications, Communications equipment, Radio, Satellites.

*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 2 and 15 as follows:

## PART 2—FREQUENCY ALLOCATIONS AND RADIO TREATY MATTERS; GENERAL RULES AND REGULATIONS

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

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

■ 2. Amend § 2.106 by adding paragraphs (b)(458)(i) and (ii) to read as follows:

**§ 2.106 Table of Frequency Allocations.**

* * * * *

(b) * * *

(458) * * *

(i) 5.458A In making assignments in the band 6700–7075 MHz to space stations of the fixed-satellite service, administrations are urged to take all practicable steps to protect spectral line observations of the radio astronomy service in the band 6650–6675.2 MHz from harmful interference from unwanted emissions.

(ii) 5.458B The space-to-Earth allocation to the fixed-satellite service in the band 6700–7075 MHz is limited to feeder links for non-geostationary satellite systems of the mobile-satellite service and is subject to coordination under No. 9.11A. The use of the band 6700–7075 MHz (space-to-Earth) by feeder links for non-geostationary satellite systems in the mobile-satellite service is not subject to No. 22.2.

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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 revising the definition of ''Very low power device'' to read as follows:

**§ 15.403 Definitions.**

* * * * *

*Very low power device.* For the purpose of this subpart, a device that operates in the 5.925–7.125 GHz band and has an integrated antenna. These devices do not need to operate under the control of an access point.

■ 5. Amend § 15.407 by revising paragraphs (a)(9) and (d)(10) to read as follows:

**§ 15.407 General technical requirements.**

(a) * * *

(9) For very low power devices operating in the 5.925–7.125 GHz band, the maximum power spectral density must not exceed −5 dBm e.i.r.p in any 1-megahertz band and the maximum e.i.r.p must not exceed 14 dBm.

* * * * *

(d) * * *

(10) Very low power devices operating in the 5.925–7.125 GHz band shall employ a transmit power control (TPC) mechanism. A very low power device is required to have the capability to operate at least 6 dB below the maximum EIRP PSD value of −5 dBm/MHz.

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