

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

In the Matter of
Amendment of Part 15 of the Commission's
Rules To Establish Regulations for Tank Level
Probing Radars in the Frequency Band
77-81 GHz
Amendment of Part 15 of the Commission's
Rules To Establish Regulations for Level Probing
Radars and Tank Level Probing Radars in the
Frequency Bands 5.925-7.250 GHz,
24.05-29.00 GHz and 75-85 GHz
Ohmart/VEGA Corp., Request for Waiver of
Section 15.252 to Permit Marketing of Level
Probing Radars in the 26 GHz Band

ET Docket No. 10-23

ET Docket No. 10-27

REPORT AND ORDER and ORDER

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I. INTRODUCTION

1. By this action, we modify Part 15 of our rules for level probing radars (LPRs) operating on an unlicensed basis in the 5.925-7.250 GHz, 24.05-29.00 GHz, and 75-85 GHz bands to revise our measurement procedures to provide more accurate and repeatable measurement protocols for these devices. LPR devices are low-power radars that measure the level (relative height) of various substances in man-made or natural containments. In open-air environments, LPR devices may be used to measure levels of substances such as water basin levels or coal piles. An LPR device that is installed inside an enclosure, which could be filled with liquids or granulates, is commonly referred to as a tank level probing radar (TLPR). LPR (including TLPR) devices can provide accurate and reliable target resolution to identify water levels in rivers and dams or critical levels of materials such as fuel or sewer-treated waste, reducing overflow and spillage and minimizing exposure of maintenance personnel in the case of high risk substances.¹

2. LPR devices have operated for years under the general technical standards for intentional radiators in Section 15.209 of the Commission’s rules, primarily inside metal or concrete tanks which substantially attenuate radio frequency energy from the LPR antenna.² Although we will continue to certify LPR under this rule, manufacturers have had a difficult time demonstrating compliance with the rule’s low emission limits for certain types of level-measuring applications in fiberglass or polyethylene (plastic) tanks or in open air. Such difficulty occurs because reflections off of the surfaces being measured attenuate inconsistently due to devices’ orientation and the material being measured, the physical shape of which can change continuously depending on the material and circumstances. Thus, it is difficult to make a measurement that will validly apply to all installations of a given LPR device when measuring LPR emissions *in situ* for certification purposes. The amended rules adopted in this Report and Order would establish a comprehensive and consistent approach that would provide simplicity and predictability for authorizing LPRs for level-measuring applications in any type of tank or open-air environments, in the following frequency bands: 5.925-7.250 GHz, 24.05-29.00 GHz, and 75-85 GHz.³ Certification of LPR equipment under the new rules will require measuring emissions in the main beam of the LPR antenna, while adjusting the emission limits in Part 15 for devices so measured to account for the significant attenuation that occurs upon reflection of those emissions. These emission limits will protect any nearby receivers from encountering any increase in interfering signal levels. The new rules will benefit the public and industry by improving the accuracy and reliability of these measuring tools, and providing needed flexibility and cost savings for LPR device manufacturers which should in turn make them more

¹ Over-filling of plant equipment can damage machinery, threaten workers’ safety, and cause environmental damage. Under-filling of equipment such as rock crushers or lubricant reservoirs can result in machinery running empty or dry, leading to severe product or machinery damage and collateral worker injury.

² 47 C.F.R. § 15.209. This rule section permits any type of unlicensed intentional radiator to operate in any frequency band, other than “restricted” bands identified in 47 C.F.R. § 15.205(a), as long as it complies with the general radiated emission limit and associated technical provisions.

³ Consistent with 47 C.F.R. § 15.215(a), the regulations adopted herein in new Section 15.256 “...provide alternatives to the general radiated emission limits for intentional radiators operating in specified frequency bands.”

available to users, without causing harmful interference to authorized services. To the extent practicable, these amended rules harmonize our technical rules for LPR devices with similar European standards, thus improving the competitiveness of U.S. manufacturers in the global economy.

3. In the Order, we also dismiss as moot a request by VEGA Americas, Inc. (formerly Ohmart/VEGA Corporation) (VEGA)⁴ to waive the use restrictions in Section 15.252 so that it can operate an LPR device in the 26 GHz band.⁵

II. BACKGROUND

4. Traditionally, measuring the level of various materials is accomplished using a variety of mechanical devices such as differential-pressure tools, air bubblers, and displacers. In contrast, LPRs take such measurements with technology-based tools that employ radio frequency (RF) signals. More specifically, LPR devices are downward-looking low-power transceivers that can operate either inside a tank (or similar enclosure) or in an open-air environment, *e.g.*, mounted under a bridge to measure water levels in a basin/river or under a roof structure to measure mounds of granulates such as coal. An LPR device is typically mounted at the top of an enclosure or on a support rail and emits RF signals from an antenna aimed downwards at the surface of the substance below. The device measures or calculates the time delay between the transmitted signal and the return echo reflected off the surface of the substance being measured to determine the substance's level.

5. Most LPR devices on the U.S. market currently operate on an unlicensed basis at 6 GHz, 24 GHz, or 26 GHz under the Section 15.209 general emission limits for intentional radiators. LPR devices operate at different frequency bands according to the type of substance being measured and the installation. For example, LPR devices operating in the 6 GHz frequency range are often used for applications where the substance to be measured may have high dust content or severe foaming characteristics; because the dust or foam is made up of relatively large particles, these substances tend to scatter a higher frequency signal. A relatively low frequency, therefore, is necessary to penetrate the surface below. LPR devices operating in the 24-26 GHz frequency range can accommodate a wide variety of applications but are less effective on foam, turbulent materials, or substances that tend to generate condensation or dust. LPR devices operating at even higher frequencies, *i.e.*, above 30 GHz in the "millimeter wave" spectrum,⁶ could be very effective in applications where access is limited because they can employ smaller antennas.⁷ Smaller antennas can accommodate existing small connection flanges more easily, enabling the radar to be installed in tighter spaces and in smaller enclosures than is possible with LPR devices operating at lower frequencies.⁸

6. Existing technology typically uses either traditional pulsed modulation techniques or frequency-modulated continuous waves (FMCW), typically producing bandwidths greater than or equal to 50 megahertz. With a pulsed-modulated LPR, short duration pulses are transmitted toward the target, and the target distance is calculated using the pulse transit time. With an FMCW-modulated LPR, a continuous frequency-modulated signal is transmitted, and the frequency difference caused by the time

⁴ See VEGA's request for waiver, Public Notice DA 10-128, ET Docket No. 10-27 (rel. Jan. 26, 2010).

⁵ 47 C.F.R. § 15.252.

⁶ The term "millimeter wave" arises from the fact that the wavelength of radio signals operating on frequencies between 30 GHz and 300 GHz ranges from 10 millimeters to 1 millimeter, respectively.

⁷ Part 15 rules do not currently permit unlicensed operation above 38.6 GHz, except in certain specific frequency bands. See 47 C.F.R. §§ 15.205(a), 15.253, 15.255 and 15.257.

⁸ As the frequency increases, the wavelength decreases and antennas operating at higher frequencies in most cases are physically smaller than those operating at lower frequencies.

delay between transmission and reception indicates the target distance. To conserve power, LPR devices operate with a low duty cycle: 20 percent or below for FMCW and much lower for pulsed LPR emissions. LPR devices do not communicate with one another, and there is minimal likelihood that two or more devices will emit simultaneously within close proximity of one another.

7. To date, the Commission has authorized LPR devices primarily for use in enclosed tanks upon demonstration of compliance with Section 15.209 of the rules, which specifies an average Equivalent Isotropic Radiated Power (EIRP) limit of -41.3 dBm for operations above 960 MHz.⁹ In addition, Section 15.35(b) of the rules sets a peak limit at 20 dB above the average limit, *e.g.*, a peak EIRP limit of -21.3 dBm.¹⁰ For pulsed signals, it may be necessary to take into account the limitation of the measurement instrumentation to determine the total peak power level, through the use of a pulse desensitization correction factor (PDCF).¹¹ Therefore, pulsed LPR devices often must reduce their peak power output in order to comply with the peak emission limit in Section 15.209 and thus may sacrifice the precision and accuracy required by certain applications. LPR devices using other modulation techniques, *e.g.*, FMCW, also need wider bandwidth in certain frequency ranges (*e.g.*, above 40 GHz frequency range) to achieve higher measurement precision.

8. Because some LPR devices need higher power within their main antenna beam and wider bandwidth than permitted under Section 15.209 to achieve performance objectives for certain level-measuring applications, LPR manufacturers also have considered whether they could operate under other Part 15 rules applicable to wideband devices, *i.e.*, those employing a bandwidth greater than 10 megahertz. Those rules allow higher peak-to-average power ratios than are permitted by Section 15.35(b) and specify a power limit in terms of power spectral density rather than total peak power, thus eliminating the need to apply a PDCF.¹² Section 15.250 permits operation in the 5.925-7.250 GHz band but prohibits “fixed outdoor infrastructure.”¹³ Section 15.252 only permits operation of radars mounted in terrestrial transportation vehicles in the 16.2-17.7 GHz and 23.12-29.0 GHz bands.¹⁴ Because of these various frequency and operational restrictions, LPR devices currently cannot be certified to operate under either of these alternative wideband rules without grant of a waiver.

9. On January 14, 2010, the Commission adopted the *Notice and Order* in this proceeding.¹⁵ The *Notice and Order* proposed to modify Part 15 of the rules to allow the restricted 77-81 GHz

⁹ 47 C.F.R. § 15.209.

¹⁰ 47 C.F.R. § 15.35(b).

¹¹ *Amendment of Part 15 of the Commission’s Rules To Establish Regulations for Tank Level Probing Radars in the Frequency Band 77-81 GHz and Amendment of Part 15 of the Commission’s Rules To Establish Regulations for Level Probing Radars and Tank Level Probing Radars in the Frequency Bands 5.925-7.250 GHz, 24.05-29.00 GHz and 75-85 GHz, Further Notice of Proposed Rulemaking*, ET Docket 10-23, 27 FCC Rcd 3660, 3666-67, para. 7 (2012) (*FNPRM*). A PDCF is an adjustment factor that must be added to the indicated value of a pulsed emission on a spectrum analyzer when the emission bandwidth of the pulse exceeds the resolution bandwidth of the analyzer.

¹² Wideband devices are required to comply with a peak limit based on power density in a specific bandwidth, not a total peak limit over their entire operating frequency range. Both Sections 15.250 and 15.252 permit a maximum peak emission limit of 0 dBm as measured in a 50-megahertz resolution bandwidth. 47 C.F.R. §§ 15.250 and 15.252.

¹³ 47 C.F.R. § 15.250.

¹⁴ 47 C.F.R. § 15.252.

¹⁵ *See Amendment of Part 15 of the Commission’s Rules To Establish Regulations for Tank Level Probing Radars in the Frequency Band 77-81 GHz, Notice of Proposed Rulemaking and Order*, ET Docket Nos. 10-23, 06-216 and 07-96, 25 FCC Rcd 601 (2010) (*Notice and Order*).

frequency band¹⁶ to be used on an unlicensed basis for the operation of LPR equipment installed inside closed storage tanks made of metal, concrete, or other material with similar attenuating characteristics and also sought comment on whether to allow TLPR operation on an unlicensed basis in the 75-85 GHz band.¹⁷ The *Notice and Order* also granted conditional waivers of the restriction in Section 15.205(a) that bars intentional radiators in the 77-81 GHz restricted band to Siemens, VEGA, and any other responsible party¹⁸ that can meet the waiver conditions specified in that decision.¹⁹ Under the terms of the waivers, these parties could employ TLPR devices in this band if installed inside tanks with high attenuation characteristics (e.g., metal and concrete tanks), pending the conclusion of the concurrently initiated rulemaking.

10. Since the adoption of the *Notice and Order*, the Commission received an additional waiver request (disposed herein), as well as some inquiries, regarding outdoor use on additional frequencies under existing Part 15 rules.²⁰ To address the apparent need for a comprehensive and consistent approach to LPR devices, on March 26, 2012, the Commission adopted a *Further Notice of Proposed Rule Making (FNPRM)* in this proceeding, proposing a set of common technical rules for the operation of LPRs in any type of tanks (i.e., with low RF attenuation characteristics such as fiberglass, or high RF attenuation characteristics such as metal) as well as in open-air environments in the following frequency bands: 5.925-7.250 GHz, 24.05-29.00 GHz, and 75-85 GHz.²¹ In the *FNPRM*, the Commission made new proposals that treat LPR and TLPR devices the same with respect to emission limits and frequency bands of operation without any additional installation limitations.²² That is, a level measuring radar that complies with our proposed rules would be able to be used in any application, whether outdoors in the open or inside any type of enclosure.²³ In adopting the *FNPRM*, the Commission held in abeyance

¹⁶ “Restricted” bands are frequency bands where unlicensed devices are not allowed to intentionally radiate energy and may only emit spurious emissions. These bands are usually used by licensed services for safety-of-life communications or for radio operations that use very low received levels, e.g., satellite downlinks or by critical and sensitive federal services. The restricted bands are listed in 47 C.F.R. § 15.205(a).

¹⁷ *Notice and Order, supra* at 606-07, para. 14.

¹⁸ In this context, the “responsible party” is the party responsible for demonstrating that the communications equipment at issue complies with the Commission’s technical requirements. Section 2.909 of the Commission’s rules specifies the responsible party under various circumstances. 47 C.F.R. § 2.909.

¹⁹ *Notice and Order, supra* at 614-15, para. 41. The Commission has only granted one certification based on the waiver terms in this *Order* to Siemens Milltronics Process Instruments (Siemens), FCC ID No. NJA-LR560, granted on Dec. 23, 2010. There are no pending requests for certification under the terms of this waiver. Because the rules we adopt here are less stringent than the waiver terms, Siemens may continue to operate its device under the waiver for the life of the device, or submit a new application to certify the device under the new rules in Section 15.256.

²⁰ On January 26, 2010, the Commission placed on public notice a request for waiver of Section 15.252(a) of the Commission’s rules filed by VEGA to permit certification of LPR devices installed at fixed locations at outdoor sites as well as inside storage tanks in the 24.6-27 GHz frequency band. See Public Notice DA 10-128, ET Docket No. 10-27 (rel. Jan. 26, 2010). (VEGA amended this request on April 26, 2012 to ask only for certification of LPR devices that would comply with the *FNPRM* proposals, pending the adoption of the LPR rules.)

²¹ *Amendment of Part 15 of the Commission’s Rules To Establish Regulations for Tank Level Probing Radars in the Frequency Band 77-81 GHz and Amendment of Part 15 of the Commission’s Rules To Establish Regulations for Level Probing Radars and Tank Level Probing Radars in the Frequency Bands 5.925-7.250 GHz, 24.05-29.00 GHz and 75-85 GHz, Further Notice of Proposed Rulemaking*, ET Docket 10-23, 27 FCC Rcd 3660 (2012) (*FNPRM*).

²² *Id.*, at 3666-67, para. 15.

²³ There is a growing trend towards using plastic or fiberglass tanks. *FNPRM, supra* at 3672, n. 65. These tank materials provide very little RF attenuation characteristics and would be equivalent, or nearly so, to operating the radar in open air. See *Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Level Probing Radar (LPR) Equipment Operating in the frequency bands 6 GHz to 8,5 GHz, 24,05 GHz to 26,5 GHz, 57 GHz to 64 GHz and 75 GHz to 85 GHz; Part 1: Technical characteristics and test methods*, European (continued....)

all waiver requests regarding LPR operations pending final action in this rulemaking proceeding.²⁴

11. The *FNPRM*'s technical and operational proposals were based in large part on measurements and analytical work conducted in support of the European Telecommunications Standards Institute (ETSI) LPR Technical Standard for LPR devices.²⁵ This standard is based on the research, modeling and recommendations provided by the Electronic Communications Committee (ECC) within the European Conference of Postal and Telecommunications Administrations (CEPT) in ECC Report 139, a study of the co-existence of LPR devices with various authorized services in the 6-8.5 GHz, 24.05-26.5 GHz, 57-64 GHz, and 75-85 GHz and adjacent frequency bands.²⁶

12. Fourteen parties filed comments and nine parties filed replies in response to the *FNPRM*. The majority of commenters support the *FNPRM* proposals. Some TLPR manufacturers request variations to the proposed rules, primarily to accommodate TLPR devices inside enclosures with high RF attenuation characteristics.²⁷ Radio astronomy interests request a distance separation from radio astronomy sites and a public database (or list) of LPR installations.²⁸ Some commenters propose additional technical restrictions on LPR devices.²⁹ A list of commenting parties is included in Appendix B.

III. REPORT AND ORDER

13. In this Report and Order, we adopt a comprehensive set of technical and operational rules for authorizing LPR devices operating on an unlicensed basis in the 5.925-7.250 GHz, 24.05-29.00 GHz, and 75-85 GHz in any RF level-measuring application, whether in an open-air environment or inside any type of enclosure. New Section 15.256 will allow for the introduction of more diverse applications of LPR in several frequency bands and improve the accuracy and reliability of these level-measuring tools beyond what is achievable under Section 15.209. The new rules will also help to streamline equipment development and certification of LPR devices, allowing manufacturers to take advantage of economies of scale by marketing the same LPR device for a variety of RF level-measuring applications, as well as provide a simplified method for measuring the radiated emissions from these devices.

14. Our action here addresses a significant obstacle to authorizing LPR devices under our current rules, namely, the difficulty of obtaining repeatable and accurate radiated emission measurements. Unlike most Part 15 devices that operate with the emitter/transmitter pointing horizontally, LPR devices must operate in a downward-pointing position such that their emissions are directed toward the substance to be measured located below. Our current rules are designed for devices with horizontal emitters or transmitters, and require measuring radiated emissions at a 3-meter horizontal distance from the radiating

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Telecommunications Standards Institute (ETSI) European Norm (EN) 302 729-1 V1.1.2 (2011-05), (ETSI LPR Technical Standard) at p. 57, Appendix G3.

²⁴ *FNPRM*, *supra* at 3664, para. 9.

²⁵ See *Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Level Probing Radar (LPR) Equipment Operating in the frequency bands 6 GHz to 8,5 GHz, 24,05 GHz to 26,5 GHz, 57 GHz to 64 GHz and 75 GHz to 85 GHz; Part 1: Technical characteristics and test methods*, European Telecommunications Standards Institute (ETSI) European Norm (EN) 302 729-1 V1.1.2 (2011-05), (ETSI LPR Technical Standard).

²⁶ See *Impact Of Level Probing Radars Using Ultra-Wideband Technology On Radiocommunications Services*, ECC Report 139 (Feb. 2010).

²⁷ Comments of Emerson, Krohne and Siemens.

²⁸ Comments of NRAO and CORF.

²⁹ Comments of Delphi, EIBASS and O3b.

source, with the radiating source pointed directly at the measurement antenna (boresighted),³⁰ while varying the measurement antenna height from 1 meter to 4 meters to obtain worst-case emissions.³¹ This compliance measurement practice does not yield repeatable results when LPR emissions are measured *in situ*, *i.e.*, with the radar pointing down toward a representative substance.³² This difficulty arises because the current measurement procedures are optimized for directly measuring device emissions,³³ whereas *in situ* measurements for LPRs would essentially only measure reflected emissions, which can vary erratically, depending on the nature of the surface at the precise moment(s) of measurement.³⁴ To obtain repeatable and accurate emission test results, manufacturers can measure LPR emissions directly in the main beam of the antenna for certification compliance purposes. However, when so measured, the general emission limit in Section 15.209 constrains LPR emissions to such a low level that the device cannot be used for most high-precision, high-accuracy applications, such as measuring volatile liquids inside non-corrosive fiberglass tanks or water level in rivers, for which LPR devices need higher power than a main-beam measurement permits under our current rules to achieve the necessary precision in these applications. The Part 15 rules that permit higher power for similar wideband devices, such as Sections 15.250 and 15.252, contain frequency and operational restrictions which preclude the certification of LPR devices absent a waiver, which some LPR manufacturers have sought.³⁵

15. Due to the normal operating condition of an LPR where it radiates in a downward direction, potential victims of interference from LPRs are unlikely to be located in the main beam and subject to the maximum radiated power from the device. Rather, it is the reflected emissions from LPRs - which will be lower than the main-beam emissions - that present the greatest potential for harmful interference.³⁶ Because of this, and the difficulty in measuring reflected emissions discussed above, we are amending Part 15 to add new Section 15.256 to increase the (main-beam) emissions limit for LPRs to a level that will still ensure that the reflected emissions remain within the maximum permitted level. This will allow LPR devices to achieve better accuracy in certain applications while not increasing the potential of causing harmful interference to other devices. We also are requiring that all spurious or

³⁰ Antenna boresight is the axis of maximum gain (maximum radiated power) of a directional antenna. *FNPRM, supra* at 3665, para. 11 and n. 31.

³¹ *FNPRM, supra* at 3666, para. 14.

³² 47 C.F.R. § 15.31(d) requires that “[f]ield strength measurements shall be made, to the extent possible, on an open field site.” However, the rules also allow these devices to be measured *in situ*, “[i]n the case of equipment for which measurements can be performed only at the installation site,” with the device tested in its normal operating position in an actual installation. 47 C.F.R. § 15.31(d). For LPRs, testing *in situ* would position the antenna pointed down toward a representative substance, instead of pointing directly at the measurement antenna. Thus, the measurement antenna would only capture any emission that is reflected off of the representative substance or the ground surface.

³³ Measurement of *direct* emissions requires the antenna of the device under test be pointed directly at the measurement antenna (boresighted). Because the LPR device is typically installed in a downward position, measuring the LPR emissions *in situ* would not have the LPR device pointed directly at the measurement antenna.

³⁴ This is because the patterns of reflected emissions tend to vary based on the irregularity of the surface of the material below, and are therefore difficult to measure consistently, propagation losses in the higher frequency bands are significant, and it is not always practical to create a test bed that is representative of all of the substances that an LPR will measure, making it difficult to determine the worst-case reflectivity factor. In addition, the current measurement procedure does not consider any potential emissions that may radiate from the top of an LPR device.

³⁵ 47 C.F.R. §§ 15.250 and 15.252. *See supra* para. 8.

³⁶ All radio signals attenuate as they travel in space away from the transmitter. Free-space propagation loss is a function of both the distance traveled and the frequency of the signal. Reflected waves are lower in amplitude than direct waves because of the additional losses they experience (through absorption, scattering, etc.) in addition to the distance traveled.

unwanted emissions from LPR devices not exceed the general emission limits in Section 15.209.³⁷ Measuring a main beam emission limit rather than measuring reflected emissions will make certification measurements simpler, repeatable and more reliable, and allow certified LPR devices to be used either in tanks or in open-air environments without increasing interference to any authorized services. LPRs will have the higher power and bandwidth needed without manufacturers having to request waivers of operational restrictions in Sections 15.250 and 15.252 for similar wideband devices as they have in the past. To further protect authorized services operating in the same and adjacent frequency bands, we will (1) require the LPR antenna to be dedicated or integrated as part of the transmitter and installed in a downward position; (2) limit installations of LPR devices to fixed locations; and (3) prohibit hand-held applications of LPR and the marketing of LPR devices to residential consumers.³⁸ The final rules are set forth in Appendix D.

16. We will continue to permit certification of LPR devices under the provisions of Section 15.209 of our rules as unlicensed intentional radiators. Certification of LPRs under Section 15.209 provides an alternative for those manufacturers who may not need higher power or who want to operate in frequency bands that are not covered by the new LPR rules. We are modifying Section 15.31 of the rules to provide compliance testing guidance for those manufacturers who choose to certify LPR under Section 15.209.

A. Certification under Section 15.209

17. In the *FNPRM*, the Commission observed that some TLPR devices have been certified under Section 15.209 of our rules.³⁹ The Measurement, Control & Automation Association (MCAA) requests that we continue to provide an option to certify LPR under the much lower general emission limits of Section 15.209. MCAA states that because some LPR devices need to use wider bandwidth to achieve precision measurements, it requests that LPRs be allowed to operate in any frequency range that does not contain a restricted band as permitted by Section 15.209.⁴⁰ MCAA is concerned about the 6 GHz frequency range because the proposed LPR rules would allow operation only in the 5.925-7.250 GHz band, whereas under Section 15.209 any unlicensed device could operate from 5.460-7.250 GHz. MCAA also asserts that many of the metal and concrete tanks come with an existing opening for an LPR antenna, but the opening is often too small to accommodate an antenna big enough to meet the antenna specifications as proposed in the *FNPRM*.⁴¹

18. We will continue to certify LPRs under Section 15.209. Although the new LPR rules are intended to simplify measurement procedures and permit certification of LPR devices that could be used both in any type of tank and outdoors in specific frequency bands, including the restricted band 75-85 GHz, we recognize that the new rules' frequency and technical requirements may limit options for some applications. LPR certified under Section 15.209 may operate in any non-restricted band at much lower emission limits than permitted under the new LPR rule and, except as discussed below, would demonstrate compliance by measuring their worst-case emissions in the main beam of the antenna; peak emissions for pulsed LPRs may be reduced further because the rules require that peak power output use a

³⁷ The measurement procedure for unwanted emissions would also utilize elevation and azimuth measurement scans to determine the location at which these unwanted emissions are maximized; it is possible that the source of the worst-case unwanted emissions from a device may be its control circuitry and/or RF leakage from its enclosure, rather than the device's transmitter circuitry and antenna.

³⁸ A "dedicated" antenna is an integrated antenna that is part of the main transmitter unit and cannot be replaced with another antenna with different gain characteristics.

³⁹ *FNPRM*, *supra* at 3674, para. 36.

⁴⁰ MCAA comments at 3. This is presumably due to the fact that some LPR designs take advantage of higher power to provide higher precision whereas some other designs take advantage of wider bandwidth to achieve such results.

⁴¹ MCAA comments at 2-3.

pulse desensitization correction factor (PDCF).⁴² We observe that legacy LPR operations certified under Section 15.209 have primarily operated in enclosed tanks with high attenuation levels and have not caused harmful interference over the years, but manufacturers have had difficulty in demonstrating compliance with Section 15.209 for other types of applications (*e.g.*, open-air operation).⁴³

19. While TLPRs are currently receiving certification under Section 15.209 using *in situ* measurement procedures,⁴⁴ we will provide specific measurement guidelines for certifying LPRs that are intended for installation inside enclosed tanks made of metal or concrete to promote consistency and repeatability.⁴⁵ Some manufacturers who have operated LPRs inside metallic and concrete tanks for many years request that, for these uses, they continue to be permitted to demonstrate compliance with the Section 15.209 general emission limits by measuring radiated emissions outside a representative test tank with the LPR installed inside, as they have in the past.⁴⁶ These parties point out that a tank wall made of metal or concrete provides a substantial RF shield, and they request that LPRs intended for this type of application not be subject to any further restriction on antenna beamwidth or main-beam emission limits, as long as emissions measured at 3 meters outside of the tank meet the general emission limit as currently required by Section 15.209.⁴⁷

20. We find that there is good reason for providing specific measurement procedures that allow more flexibility for certifying, under Section 15.209, LPRs intended for installation inside enclosures made of metal or concrete. At the same time, the rules will continue to permit manufacturers to demonstrate compliance with the Section 15.209 general emission limits as they have in the past, by measuring radiated emissions outside a representative enclosure with the LPR installed inside. As we observed in the *Notice and Order*, TLPR emissions outside of enclosed tanks with very high RF attenuation characteristics, *e.g.*, steel or concrete, will likely be minimal when considering the enclosure's attenuation coefficient in addition to the absorption characteristics of the target material (liquid or solid), and thus, any reflected signal will be mostly contained within the tank.⁴⁸ Because metal and concrete

⁴² Besides the very low emission limit (*i.e.*, -41.3 dBm EIRP), operation under the provisions of Section 15.209 requires compliance with the 20-dB peak-to-average ratio requirement and the pulse operation restrictions of Section 15.35(b) and (c), *inter alia*; however, it allows intentional emissions in any non-restricted frequencies, including the 5.460-7.250 GHz band. *See supra* n. 2.

⁴³ We also note that those TLPR devices now operating under waiver may continue to do so provided they continue to meet the terms of their respective waivers. *See, e.g.*, Krohne model BM702 operating at 8.5-9.9 GHz at http://www.krohne.com/html/dlc/MA_BM702_e_72.pdf. Krohne TLPR operation inside steel tanks in this band is pursuant to a waiver of the 9-9.2 GHz and 9.3-9.5 GHz restricted bands of Section 15.205(a) issued in 2001 on delegated authority by the FCC's Office of Engineering and Technology, with concurrence of the National Telecommunication Information Administration (NTIA).

⁴⁴ In accordance with 47 C.F.R. § 2.947(a)(3), "any measurement procedure acceptable to the Commission may be used to prepare data".

⁴⁵ The Commission's Laboratory will establish measurement guidelines for LPR and TLPR devices following the adoption of this Report and Order.

⁴⁶ Comments of Krohne at 2, Emerson at 2 and Siemens at 2.

⁴⁷ Krohne states that the RF environment around a tank with high RF attenuation characteristics is unique and deserves to be considered separately from other LPR applications. Krohne comments at 4. Krohne does specify that its recommendations and requests are only for metallic tanks. Krohne comments at fn. 2. Emerson states that metallic tanks effectively shield radio frequency; therefore Emerson argues that the emission limit of Section 15.209 is easily complied with, even if the radar by itself would not pass the proposed rules for LPR. Emerson comments at 2. MCAA requests that we not specify a restriction on the antenna beamwidth for LPR intended to be installed inside tanks made of metal or concrete that would provide enough attenuation to eliminate the effects of the beamwidth exterior to the tank. MCAA comments at 2-3.

⁴⁸ *Notice and Order* at 605, para. 11.

enclosures provide substantial RF attenuation, the power in the main beam of the antenna installed within such tanks can be increased beyond the limits required for unenclosed devices, thus permitting better measurement performance in LPR applications⁴⁹ (e.g., higher power may permit the LPR to better focus and receive accurate echoes from the substance to be measured below the LPR), but the potential for harmful interference is significantly diminished because the signal can be substantially attenuated by the enclosure itself. We also note that this addresses MCAA's concerns regarding the difficulties of accommodating some antennas in existing openings of some metal and concrete tanks. Because other materials do not provide the same attenuation,⁵⁰ we limit these measurement procedures to LPR devices intended to be used only in completely enclosed metal or concrete tanks.⁵¹ We are modifying Section 15.31 of the rules to provide compliance testing guidance for those manufacturers who choose to certify LPR under Section 15.209. The final rules are found in Appendix D.

B. New Section 15.256

1. Frequency Bands of Operation

21. As discussed above, most LPR devices on the U.S. market currently operate on an unlicensed basis in frequencies around 6 GHz, 24 GHz, or 26 GHz under the general emission limits of Section 15.209 of the Commission's rules. These operating frequency ranges are chosen by the different LPR manufacturers to accommodate various level-measuring applications.⁵² As we proposed in the *FNPRM*, we will allow LPR devices certified under new technical rules we adopt herein to operate both in any type of enclosure and in open air, in the following frequency bands: 5.925-7.250 GHz,⁵³ 24.05-29.00 GHz,⁵⁴ and 75-85 GHz.⁵⁵ As discussed below, the new rules address the specific spectrum

⁴⁹ As an example of improved performance, the use of higher power may permit the LPR to better focus and receive accurate echoes from the substance to be measured below the LPR.

⁵⁰ ETSI found that a tank made of concrete provides approximately 35 dB attenuation around 20 GHz, whereas a tank made of fiberglass or polyethylene (plastic) provides less than 5 dB in the same frequency range. See *Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Level Probing Radar (LPR) Equipment Operating in the frequency bands 6 GHz to 8,5 GHz, 24,05 GHz to 26,5 GHz, 57 GHz to 64 GHz and 75 GHz to 85 GHz; Part 1: Technical characteristics and test methods*, European Telecommunications Standards Institute (ETSI) European Norm (EN) 302 729-1 V1.1.2 (2011-05), (ETSI LPR Technical Standard) at p. 57, Annex G. ETSI has adopted a specific standard for TLPR devices inside high-attenuation tanks. See *Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Equipment for Detection and Movement; Tanks Level Probing Radar (TLPR) operating in the frequency bands 5,8 GHz, 10 GHz, 25 GHz, 61 GHz and 77 GHz; Part 1: Technical characteristics and test methods*, European Telecommunications Standards Institute (ETSI) European Norm (EN) 302 372-1 V1.2.1 (02-2011) (ETSI TLPR Technical Standard). The *FNPRM* did not propose the emission levels in the ETSI TLPR Technical Standard; rather, its proposals follow the ETSI LPR Technical Standard in order to provide one set of comprehensive requirements for all LPRs, including TLPRs.

⁵¹ The Commission's Office of Engineering and Technology Laboratory will publish guidance for LPR measurements for devices designed for use inside metallic and concrete enclosures.

⁵² See *supra* para. 5.

⁵³ The Commission currently authorizes LPR devices operating near 6 GHz under Section 15.209 in this frequency band. See, e.g., Siemens VEGA model Sitrans LR300IQ300, FCC ID No. NJA-1Q300; Endress+Hauser model FMR5X, FCC ID No. LCGFMR5XC.

⁵⁴ The Commission currently authorizes LPR devices operating in the 24-26 GHz frequency range under Section 15.209 in this frequency band. See e.g., VEGA model VEGAPULS40, FCC ID No. MOIPULS40; Siemens model Sitrans LR400, FCC ID No. NJA-LR400; Endress+Hauser model FMR240, FCC ID No. LCGFMR2.

⁵⁵ We note that these frequencies are slightly different than those adopted by ETSI and also that in the U.S. there are several "restricted" bands in some portions of the ETSI LPR lower frequency range. For instance, ETSI/ECC permits LPR devices in the 6-8.5 GHz frequency range, but in the U.S., the 7.25-7.75 GHz and 8.025-8.5 GHz bands

(continued....)

needs and restrictions in the U.S., and to the extent practicable, harmonize our technical rules for LPR devices with similar European standards.⁵⁶

a. 5.925-7.250 GHz frequency band

22. The Commission authorizes unlicensed wideband transmitter operation within the 5.925-7.250 GHz band under Section 15.250 of its rules.⁵⁷ LPR devices seeking higher power and wider bandwidths than provided therein in order to improve their performance cannot be authorized under this rule absent a waiver of certain usage restrictions in the rule. In this band, licensed users include non-Federal fixed, fixed satellite, and mobile services from 5.925 GHz to 7.125 GHz; and Federal fixed and space research services (deep space & Earth-to-space) from 7.125 GHz to 7.250 GHz.⁵⁸ Part 15 transmitters operating in this band are prohibited from being used in toys or operating on board an aircraft or satellite. They cannot utilize fixed outdoor infrastructure, including outdoor-mounted transmit antennas, to establish a wide area communications network.⁵⁹ The Commission observed in the *FNPRM* that it would consider LPR operation in the 5.925-7.250 GHz band, including permitting limited fixed outdoor installations, consistent with the intent underlying the usage restrictions in Section 15.250, because in this regard, LPRs are single, *i.e.*, relatively isolated, transmitters whose individual operations outdoors would not result in the establishment of a local area network of transmitters.⁶⁰

23. Sutron, an LPR manufacturer with products intended for waterway-level measurement, requests that the LPR rules allow operation in the 5.650-7.250 GHz band, a band slightly wider than what was proposed in the *FNPRM* (*i.e.*, 5.925-7.250 GHz). Sutron states that this wider frequency band would provide a usable bandwidth of 1.6 gigahertz instead of 1.3 gigahertz, which would enable its products to achieve the specific performance goals required by some of its customers. Sutron notes that the requested additional bandwidth does not include any restricted bands listed in Section 15.205(a) of the rules.⁶¹ Krohne America Inc. (Krohne) supports Sutron but only for TLPRs inside metal tanks and suggests

(Continued from previous page) _____

are restricted, where the Federal Government operates critical and sensitive services such as fixed microwave, fixed satellite, and meteorological satellite services. 47 C.F.R. § 2.106.

⁵⁶ ETSI permits TLPR and LPR devices to operate in several frequency bands that we did not propose in the *FNPRM*. For example, ETSI permits operation of TLPR devices inside tanks made of steel or concrete or other material of comparable RF attenuation in the 4.5-7 GHz and 8.5-10.6 GHz bands and LPR (including TLPR) devices in the 57-64 GHz band. *See* ETSI TLPR Technical Standard at p. 20; ETSI LPR Technical Standard at p. 24. We took a different approach in the *FNPRM* by proposing that each authorized band be available for both LPR and TLPR applications.

⁵⁷ 47 C.F.R. § 15.250.

⁵⁸ 47 C.F.R. § 2.106.

⁵⁹ 47 C.F.R. § 15.250(c). This rule prohibits fixed outdoor infrastructure to avoid the establishment of wide-area networks of devices seeking to operate under this section. *See Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, Second Report and Order and Second Memorandum Opinion and Order*, ET Docket No. 98-153, 19 FCC Red 24558, 24571, para. 27 (2004) (*WideBand Order*).

⁶⁰ *FNPRM*, *supra* at 3664, n.23 and 3668, para. 20. No commenter disputes the Commission's conclusion that LPRs will not operate as local area networks of transmitters. While there may be multiple LPRs installed at a single site, each device would be pointed at and computing readings from its particular target (coal or gravel piles, waterways at a specific location, etc.) to perform the level measurement and would not be communicating with the other LPRs at the same site. We note that EIBASS disputes as unfounded the Commission's observation at para. 20 of the *FNPRM* that it would not expect dense deployment of transmitters at an individual site (EIBASS comments at 2). However, given the absence of networking and the manner of operation of LPR devices, there is no reason to believe such proliferation would occur, and EIBASS provides no concrete suggestion otherwise.

⁶¹ *See* Sutron comments at 3.

extending the 5925-7250 MHz band to 5460-7250 MHz band.⁶² MCAA in reply comments states that the proposed bandwidth at 5925-7250 MHz is acceptable to the industry as long as Section 15.209 certification on in-tank units remains available.⁶³

24. We decline to expand the frequency band for LPR devices under the new rules at this time. First, the technical and operational requirements that we are adopting under the new rules are based on analytical work that encompasses frequencies from 6.0-8.5 GHz for LPR operations;⁶⁴ therefore, we find that compatibility of these limits with authorized services below 6 GHz has not been studied.⁶⁵ Neither Sutron nor any other commenter provided technical analyses or studies to support compatibility of LPR operating at the proposed higher emission limit with incumbent operations below 5.925 GHz. Although Sutron argues that greater bandwidth would yield greater level measurement resolution,⁶⁶ neither it nor any other party indicated with any specificity, much less demonstrated, how permitting a higher resolution than that which can be attained under the rules we are adopting herein would further the public interest. We conclude that, without further analyses, it would be imprudent to permit a wider bandwidth than what we proposed in the *FNPRM* and to expose incumbent services unnecessarily to additional radio noise. Further, the Commission and the NTIA are involved in active discussions relating to the 5.850-5.925 GHz bands.⁶⁷ Pending the outcome of these activities, we find that LPR devices should be confined to the 5.925-7.250 GHz band when operating at the higher emission limit we are adopting herein for LPR devices. Manufacturers requiring wider bandwidth than permitted under new Section 15.256 may seek authorization, as we discussed above, by demonstrating compliance under Section 15.209.

b. 24.05-29.0 GHz frequency band

25. In the *FNPRM*, the Commission proposed to permit LPR operation in the 24.05-29.00 GHz band to provide expanded flexibility for optimizing LPR applications and to enhance global marketing opportunities by more closely harmonizing with ETSI in this frequency range. Currently, the Commission authorizes unlicensed wideband operation in the 23.12-29.0 GHz band under Section 15.252

⁶² Krohne comments at 3-5 and n. 2.

⁶³ MCAA reply comments at 3.

⁶⁴ The analysis conducted by the ECC to support the ETSI Technical Standard for LPR devices calculate main-beam emission limits.

⁶⁵ Incumbent services (fixed satellites, mobile and fixed services) between 5.925 GHz and 6 GHz in the U.S. are the same as those above 6 GHz (up to 6.425 GHz). Incumbent services below 5.925 GHz are different than those above 5.925 GHz, and ECC's analysis would not pertain to the protection of those services. *See* 47 C.F.R. § 2.106.

⁶⁶ Technically, either wider bandwidth or higher power, or both, would provide higher level-measurement accuracy and resolution, depending on the design of the LPR. Sutron's equipment design appears to need wider bandwidth.

⁶⁷ Section 6406(b)(1) of the Middle Class Tax Relief and Job Creation Act of 2012 (Tax Relief Act) requires the Assistant Secretary of Commerce for Communications and Information (*i.e.*, the NTIA Administrator), in consultation with the Department of Defense (DoD) and other impacted agencies, to conduct a study evaluating known and proposed spectrum-sharing technologies and the risk to federal users if the FCC allows Unlicensed-National Information Infrastructure (U-NII) devices to operate in the 5.350-5.470 MHz and 5850-5.925 GHz bands. *See* Pub. Law No. 112-96, § 6406(b)(1), 126 Stat. 156 at 231 (Feb. 22, 2012). NTIA published the results of its initial study in a report (NTIA 5 GHz Report) on both these bands on January 25, 2013. *See* Department of Commerce, "Evaluation of the 5350-5470 MHz and 5850-5925 MHz Bands Pursuant to Section 6406(b) of the Middle Class Tax Relief and Job Creation Act of 2012," available at http://www.ntia.doc.gov/files/ntia/publications/ntia_5_ghz_report_01-25-2013.pdf. The Tax Relief Act also requires the Commission to begin a proceeding to modify 47 C.F.R. Part 15 to allow unlicensed U-NII devices to operate in the 5.35-5.47 GHz band no later than 1 year after the date of the enactment of the Act. *See Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band, Notice of Proposed Rule Making*, ET Docket No. 13-49, 28 FCC Rcd 8864 (2013).

of its rules.⁶⁸ LPR devices seeking higher power and wider bandwidths to improve their performance cannot be authorized under this rule absent a waiver of certain usage restrictions in the rule. While some LPRs currently operate in this band, their utility is limited by the restrictions of Section 15.252. This band is shared between Federal and non-Federal services. Authorized licensed operations include radiolocation, Earth exploration satellite service (EESS) (active), amateur, fixed, inter-satellite, radionavigation, radiolocation satellite (Earth-to-space), fixed satellite (Earth-to-space), mobile, standard frequency and time signal satellite (Earth-to-space), space research (space-to-Earth), and EESS (space-to-Earth) services. Unlicensed transmitters operating in the 23.12-29.0 GHz band subject to this rule must be mounted on vehicles and cannot be used in aviation applications.⁶⁹ Finally, in the *FNPRM*, the Commission observed that the proposed frequency band is wider than that which ETSI has adopted;⁷⁰ however, it believed that the risk of interference to incumbent authorized services from LPR devices will be no greater than it is from Part 15 vehicular radars currently operating in this band because LPR devices operate in a fixed downward-looking position, and because there have been no interference complaints related to the operation of these Part 15 radars, which unlike LPRs do not always operate in a downward position.⁷¹ There were no comments related to our proposals in this band, and for the reasons stated above, we will allow LPRs to operate within the 24.05-29 GHz frequency band at the radiated emission limits under new Section 15.256.

c. 75-85 GHz frequency band

26. Apart from a handful of specified frequency bands, spectrum above 38.6 GHz, including most of the 75-85 GHz band,⁷² is designated as “restricted” in Section 15.205 of the rules.⁷³ Unless expressly permitted by rule or waiver, unlicensed devices are not allowed to intentionally radiate energy into a restricted band, in order to protect sensitive radio services from harmful interference.⁷⁴ The Commission has permitted unlicensed operation within specific frequency bands above 38.6 GHz, *i.e.*, 46.7-46.9 GHz, 57-64 GHz, 76-77 GHz, and 92-95 GHz.⁷⁵

27. The 75-85 GHz band is shared between Federal and non-Federal services. Authorized operations in this band currently include radio astronomy, fixed/mobile/fixed satellite, mobile satellite, broadcast and broadcast satellite, radiolocation, space research (space-to-Earth), amateur and amateur satellite services.⁷⁶ In addition, unlicensed vehicular radars are currently permitted to operate in the 76-77 GHz band.⁷⁷ In the *FNPRM*, the Commission observed that the services in this band typically

⁶⁸ 47 C.F.R. § 15.252.

⁶⁹ Unlicensed devices authorized in this band under the general limits of 47 C.F.R. § 15.209 are not subject to these restrictions, except that they may not operate at all in the 23.6-24.0 GHz restricted band (*see* 47 C.F.R. § 15.205).

⁷⁰ The ETSI LPR standard specifies LPR operation in the 24.05-26.5 GHz band.

⁷¹ *FNPRM*, *supra* at 3668, para. 21.

⁷² The Commission opened the 76-77 GHz band to unlicensed vehicular radars in 1995 in *Amendment of Parts 2, 15 and 97 of the Commission’s Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications, First Report and Order and Second Notice of Proposed Rule Making*, ET Docket 94-124, 11 FCC Rcd 4481 (1996).

⁷³ 47 C.F.R. § 15.205(a).

⁷⁴ *See Revision of the Rules Regarding Operation of Radio Frequency Devices Without an Individual License, First Report and Order*, GEN Docket 87-389, 4 FCC Rcd 3493 (1989). *See also* 47 C.F.R. § 15.205(a).

⁷⁵ *See* 47 C.F.R. §§ 15.253, 15.255 and 15.257. The 57-64 GHz band is open to most types of unlicensed operations, while the 46.7-46.9 GHz and 76-77 GHz bands are limited to unlicensed vehicular radars, and operation within the 92-95 GHz band is limited to indoor applications.

⁷⁶ 47 C.F.R. § 2.106.

⁷⁷ 47 C.F.R. § 15.253.

employ highly directional antennas to overcome the relatively higher propagation loss that occurs at these frequencies.⁷⁸ The Commission stated its belief that LPR operation in the 75-85 GHz band would not adversely affect incumbent authorized users, because this band is currently sparsely used and the propagation losses are significant at these frequencies, making harmful interference unlikely beyond a short distance from the LPR device.⁷⁹

28. CORF notes that RAS has primary allocations at 76-77.5 GHz and 78-85 GHz and does not oppose sharing these bands with LPRs provided the Commission adopts certain protections designed to ensure that RAS can operate in the interference-free environment that the service requires for picking up extremely weak signals.⁸⁰

29. Delphi Automotive (Delphi) reminds us that the European Union (EU) has authorized the entire 77-81 GHz band for short-range vehicle radar applications and urges us to take automotive radar into account when considering TLPR/LPR operations in this band.⁸¹ We observe that the Commission has authorized vehicular radar operation, including Foreign Object Debris (FOD) detection fixed radar operations at airports, in the 76-77 GHz band under its Part 15 unlicensed rules;⁸² and a rulemaking petition is now pending asking that we permit unlicensed vehicular radars to operate in the 77-81 GHz band as well.⁸³ We further note that the Commission has modified Section 90.103 of the rules to permit the certification, licensing and use of FOD detection radars in the 78-81 GHz band.⁸⁴ We find that FOD radars and LPR devices would most likely not operate in the same geographical location, because the FOD radars are only authorized to operate at airports whereas LPR typically operate in industrial or remote areas. However, as discussed above, even if they were co-located, at these frequencies, the potential for harmful interference to FOD radars from LPR is extremely unlikely, given the substantial free-space propagation losses and the extremely narrow beamwidths of the FOD radar.⁸⁵ As for spectrum sharing between vehicular radars and LPR, we believe that LPR devices will be able to co-exist successfully with vehicular radars because the LPR is installed in a downward-looking position at fixed locations and the main-beam emission limits have been carefully calculated to avoid harmful interference to other radio services. We further find that the extreme propagation losses of radio signals at these

⁷⁸ *FNPRM, supra* at 3669, para. 23. There is approximately 58 dB of free space attenuation at 3 meters for a 6 GHz signal and 80 dB of free space attenuation at 3 meters for an 80 GHz signal. Free space path loss (FSPL) is calculated according to the formula $FSPL = 20 \log F(\text{GHz}) + 20 \log D(\text{m}) + 32.5$, with frequency F in GHz and distance D in meters. *FNPRM, supra* at 3669, n.51.

⁷⁹ See *FNPRM, supra* at 3669, para. 23 and n.55 (observing that the wavelength of an LPR device operating at 75 GHz is 4 millimeters, and the free space path loss at this frequency is approximately 79.5 dB at a distance of 3 meters (*i.e.*, 750 wavelengths away) from the transmitter).

⁸⁰ CORF comments at 1-3.

⁸¹ Delphi comments at 3.

⁸² See *Amendment of Sections 15.35 and 15.253 of the Commission's Rules Regarding Operation of Radar Systems in the 76-77 GHz Band, and Amendment of Section 15.253 of the Commission's Rules to Permit Fixed Use of Radar in the 76-77 GHz Band*, ET Docket Nos. 11-90 and 10-28, *Report and Order*, 27 FCC Rcd 7880 (2012).

⁸³ See Petition for Rulemaking filed by Robert Bosch, LLC. Filed on April 16, 2012 in *Amendment of Part 15 of the Commission's Rules to Permit the Operation of Vehicular Radar Systems in the 77-81 GHz*, RM-11666, DA 12-1139.

⁸⁴ *Amendment of the Commission's Rules to Permit Radiolocation Operations in the 78-81 GHz Band, and Request by the Trex Enterprises Corporation for Waiver of Section 90.103(b) of the Commission's Rules*, WT Docket No. 11-202, *Report and Order*, 28 FCC Rcd 10423 (2013) (*Part 90 FOD Order*).

⁸⁵ A FOD radar operating in the 78-81 GHz band under Part 90 of the rules typically has a 1 degree (elevation) x 0.4 degree (azimuth) antenna beamwidth. See *Part 90 FOD Order* at para. 11, n. 37.

frequencies would mitigate any potential harmful interference beyond a very short distance from the LPR device, as noted above.

30. Accordingly, we will allow LPR to operate within the 75-85 GHz frequency band, at the radiated emission limits specified in new Section 15.256 discussed below. To permit LPR operation in the 75-85 GHz band, we also modify Section 15.205 of the rules to remove the prohibition on intentional emissions in this band for LPR devices authorized under the new rules.⁸⁶

2. Technical Requirements

31. To maintain the existing interference protection criteria to authorized services in the frequency bands covered by new Section 15.256 for LPR operations, the *FNPRM* invited comment on establishing requirements for the following interdependent parameters: main-beam radiated emission limits,⁸⁷ antenna beamwidth,⁸⁸ and antenna side-lobe gain.⁸⁹ Main-beam emissions must be measured with the LPR antennas “boresighted” to produce the maximum realizable antenna coupling.⁹⁰ The main-beam emission limits we adopt will allow an LPR device to operate at higher peak levels than Part 15 currently permits⁹¹ but would continue to provide the same level of interference protection to authorized services as any other Part 15 device operating under the general emission limits,⁹² provided that the LPR antenna always maintains a downward position and utilizes a relatively narrow beamwidth.⁹³ Because the LPR is always pointing downward and direct emissions from the LPR antenna are focused by a narrow beamwidth toward the substance being measured, it is unlikely that emissions reflected from this material or from the ground surface would cause interference to a potential victim receiver located at any height relative to the LPR due to the significant attenuation of the reflected signal.

32. The technical and operational requirements proposed in the *FNPRM* and discussed below are based on analytical work performed by the ECC in support of the ETSI Technical Standard for LPR devices.⁹⁴ This standard specifies compliance measurements based on main-beam emission limits. To

⁸⁶ 47 C.F.R. § 15.205.

⁸⁷ *FNPRM*, *supra* at 3669-72, paras. 24-28.

⁸⁸ *Id.* at 3672, para. 29.

⁸⁹ *Id.* at 3672, para. 30.

⁹⁰ Antenna boresight is the axis of maximum gain (maximum radiated power) of a directional antenna. The LPR transmitter antenna would be pointed directly at the measurement antenna, which would receive and measure the maximum radiated power.

⁹¹ Sections 15.209 and 15.35(b) impose a total peak limit of -21.3 dBm for operation of Part 15 devices above 960 MHz. 47 C.F.R. §§ 15.209 and 15.35(b). Sections 15.250 and 15.252 impose a peak limit of 0 dBm in a 50-megahertz bandwidth for Part 15 devices operating in the 5.925-7.250 GHz, 16.2-17.7 GHz and 23.12-29.00 GHz frequency bands. 47 C.F.R. §§ 15.250 and 15.252. The ECC LPR peak emission limits are +7 dBm for LPR devices operating in the 5.925-7.250 GHz band, +26 dBm for LPR devices operating in the 24.05-29.00 GHz band and +34 dBm for LPR devices operating in the 75-85 GHz band, as measured in a 50-megahertz resolution bandwidth. The limits differ for each frequency band because the modeling took into account the frequency-dependent propagation loss characteristics in each band.

⁹² The Part 15 rules specify an average emission limit of -41.3 dBm from Part 15 devices operating above 960 MHz, as the minimum protection to authorized services. The ECC modeling provides for an equivalent main-beam average emission limit of -33 dBm in the 5.925-7.250 GHz band, -14 dBm for LPR devices operating in the 24.05-29.00 GHz band, and -3 dBm for LPR devices operating in the 75-85 GHz band, as measured in a 1-megahertz resolution bandwidth. The limits again differ for each frequency band because the modeling took into account the frequency-dependent propagation loss characteristics in each band.

⁹³ “Beamwidth” refers to the angle between the half-power points (*i.e.*, the -3 dB points) of the main lobe of an antenna, when referenced to the maximum power of the main lobe. Beamwidth is usually expressed in degrees.

⁹⁴ *See supra* para. 11; *FNPRM*, *supra* at 3667, para. 16.

determine the maximum allowable radiated emission limits for LPR devices operating in each authorized frequency band, the ECC studied the interference potential of an LPR by taking into account reflected emissions within a hemispherical boundary around the LPR device. The ECC assumed a worst-case material reflectivity coefficient and determined the main-beam emission level that correlates to the appropriate reflected emission level. We find that the analytical work of ETSI/ECC provides a reliable correlation between main-beam emissions and emissions at 3 meters from the LPR that is sufficiently conservative to conclude that the use of a main-beam emission limit rather than limits based on reflected emissions will not create a greater interference potential, thus providing strong support for the approach we are taking here. Moreover, a main-beam emission limit would represent a more realistic evaluation of interference potential and permit higher power, thus increasing the accuracy and utility of LPRs. At the same time, it will simplify compliance measurements of LPR emissions, because emissions from the LPR would be measured directly in the main beam of the antenna where maximum emissions are found, thus avoiding the measurement of reflected emissions that can be highly variable due to the variable site-related factors involved with *in situ* testing.⁹⁵ Under this approach, certification measurements will be simpler, repeatable and more reliable. Accordingly, we amend the rules to require that LPR radiated emissions be measured in the main beam of the LPR antenna.⁹⁶ We note that no party opposes the use of main-beam emission measurement or the general measurement principles in the FNPRM proposed rules.⁹⁷

a. Radiated Emission Limits

33. In the *FNPRM*, the Commission proposed radiated emission limits that are listed in Table 1 below.⁹⁸ These limits are based on the results of the ECC's mathematical modeling and supported by measurement data,⁹⁹ which show that if the LPR complies with the main-beam (boresight) emission limits specified in the second and third columns of Table 1, all emissions, including antenna back-lobe and side-lobe emissions and worst-case reflections from the target material, will also comply with the existing average emission limit specified in Section 15.209 for devices operating above 960 MHz, shown in the table's fourth column.¹⁰⁰ The main-beam emission limits vary with frequency bands because the mathematical model accounts for the frequency-dependent propagation loss

⁹⁵ ECC Report 139 at p. 2 and p. 11.

⁹⁶ The Commission's Office of Engineering and Technology (OET) will publish guidance for LPR measurements for devices designed to operate under new Section 15.256.

⁹⁷ With respect to the measurement principles proposed in the *FNPRM*, we are clarifying step (6) of proposed Section 15.256(j) in the *FNPRM* as follows: "... (6) compliance measurements for minimum emission bandwidth of frequency-agile LPR devices shall be performed with any related frequency sweep, step, or hop function activated." This provision is intended to apply only to minimum bandwidth measurements, and not to other measurements such as power level measurements, as originally requested by the LPR industry (*see* MCAA Notes on Rulemaking filed Jan 31 2011). This provision is necessary for minimum emission bandwidth measurements because it is very difficult to get accurate emission bandwidth measurements if the frequencies are not properly activated while doing such measurements. The clarified provision is found in Appendix B, Section 15.256(l)(6).

⁹⁸ *FNPRM, supra* at 3670, para. 24.

⁹⁹ ECC Report 139 at Annex 4.

¹⁰⁰ *FNPRM, supra* at 3670, para. 24. We note that the ETSI equivalent average reflected emission level in the 5.925-7.250 GHz band (used to derive the average and peak main-beam limits) – which we are adopting here for those who seek certification of LPR devices under the provisions of new Section 15.256 – is more stringent than the -41.3 dBm EIRP limit that applies to certification under Section 15.209; for Section 15.256 certifications, we nevertheless employ the stricter limit to harmonize with Europe on the derived main-beam limits for this frequency range. We note also that in our rules, the limits at these frequencies for some UWB devices are also more stringent than Section 15.209. *See e.g.*, 47 C.F.R. §§ 15.510(c)(4) and 15.515(d).

characteristics associated with each band.¹⁰¹ The Commission stated that because the emission limits for main-beam emissions were derived by mathematically correlating the reflected emissions from an LPR with the existing Part 15 average emission limit for devices operating above 960 MHz, it expected that the LPR main-beam emission limits would maintain the existing level of interference protection to incumbent radio services.¹⁰² The Commission further noted that harmonization of its emission limits with the ETSI limits is desirable because it could serve to expand global marketing opportunities for U.S. manufacturers.¹⁰³

Table 1 – LPR Emission Limits

Frequency Band (GHz)	Average Emission Limit (EIRP in dBm/MHz) as measured boresight (main beam) (Note 2)	Peak Emission Limit (EIRP in dBm measured in 50 MHz) as measured boresight (main beam) (Note 2)	Equivalent Average Reflected Emissions if measured <i>in situ</i> (EIRP in dBm/MHz) (Note 3)
5.925-7.250	-33	+7	-55
24.05-29.00	-14	+26	-41.3
75-85	-3	+34	-41.3

Notes: 1. Minimum bandwidth at the -10 dB points is 50 megahertz.

2. All emission limits defined herein are based on boresight measurements (*i.e.*, measurements performed within the main beam of an LPR antenna).

3. Equivalent reflected emissions include antenna back-lobe and side-lobe emissions and worst-case reflections from material being measured.

34. We are adopting distinct radiated emission limits for LPR devices operating in each of the frequency bands, as set forth in Table 1 above. As discussed above, the emission limits for main-beam emissions were derived by mathematically correlating the reflected emissions from an LPR with the existing Part 15 average emission limit at -41.3 dBm EIRP for devices operating above 960 MHz—or lower levels (at -55 dBm EIRP for frequencies below 8.5 GHz).¹⁰⁴ The LPR main-beam emission limits therefore would maintain the existing level of interference protection to incumbent radio services.

¹⁰¹ Higher frequencies have more associated propagation losses. For example, there are approximately 58 dB of free space path loss at 3 meters for a 6 GHz signal versus 80 dB for an 80 GHz signal.

¹⁰² ETSI/ECC calculated through mathematical modeling the amount of main-beam emissions of a downward-pointing antenna that would limit reflected emissions to 500 μ V/m at a distance of 3 meters from the source, which is equivalent to an EIRP level of -41.3 dBm (this is the same as the Part 15 existing average emission limit.) Its mathematical modeling took into account reflected emissions in the vertical plane above the LPR device—as in the case of an open-air LPR installation over water—as well as reflected emissions in the horizontal plane around the LPR device with a worst-case scenario of material reflectivity coefficient. ETSI/ECC determined that because the LPR is always pointing downward, only reflected emissions would be seen by a potential victim receiver of an authorized radio service located overhead (*e.g.*, a satellite receiver) or horizontally relative to the LPR transmitting source.

¹⁰³ *FNPRM, supra* at 3670, para. 24.

¹⁰⁴ In order to derive the main-beam emission limit for each of the LPR operating frequency bands, ECC modeling uses -41.3 dBm EIRP (the same level as the general emission limit in Section 15.209 of the Commission's rules) as equivalent reflected emission levels for frequencies higher than 8.5 GHz. For frequencies below 8.5 GHz, ECC modeling uses the lower value of -55 dBm EIRP to account for lesser propagation losses and different incumbent services.

As the Commission tentatively concluded in the *FNPRM*, the LPR emission limits for each of the specified operating frequency bands as measured in the main beam of the LPR antenna will adequately protect against harmful interference to incumbent authorized services in any of the proposed frequency bands, based on several factors.¹⁰⁵ First, LPR devices will be required to utilize downward-focused narrow-beam transmit antennas, which are also needed to optimize level-measuring performance; therefore, the only LPR emissions likely to be incident on an incumbent receiver within proximity will be reflected from the target material and thus significantly attenuated. Second, the LPR emission limits are consistent with the results expected from application of the existing limits in radiated *in situ* measurements and therefore will maintain the existing level of protection afforded to incumbent authorized services under existing rules and their attendant measurement procedures.¹⁰⁶ Third, as the operating frequency increases, the propagation path loss also increases as a result of the increased attenuating effects on radio waves from intervening objects and atmospheric conditions, and we account for this by varying the permitted radiated emission limit for each frequency band. None of the commenters took issue with any of these factors or with the conclusion that the proposed limits will provide adequate protection against harmful interference. Moreover, our adoption of several operational restrictions, discussed below, in addition to these emission limits, provides further assurance that authorized services will not be subject to harmful interference.

35. The Engineers for the Integrity of Broadcast Auxiliary Services Spectrum (EIBASS) argue that, for LPRs operating in the 6 GHz frequency range, an increase from the existing peak EIRP of -21.3 dBm allowed in Sections 15.209 and 15.35(b)¹⁰⁷ to the proposed +7 dBm would be a potential co-channel interference threat to TV Broadcast Auxiliary Service (BAS) service in the 6.425-6.525 GHz and 6.875-7.125 GHz frequency bands.¹⁰⁸ EIBASS contends that, while the 6.425-6.525 GHz TV BAS operations are mobile only, the primary use of the 6.875-7.125 GHz TV BAS band is for fixed, point-to-point links, including studio-to-transmitters link (STL) paths that demand the highest level of interference protection.¹⁰⁹ EIBASS is also concerned about allowing LPRs to operate outdoors in these bands despite the restriction against “fixed outdoor infrastructure” for 6 GHz wideband devices operating under Section 15.250(c).¹¹⁰ EIBASS states that there is no basis for the Commission to assume that only one high-power outdoor LPR device would be employed at a particular site.¹¹¹ In reply, MCAA argues that TV BAS STL links are installed high off the ground and use highly directional receive antennas, making received interference from LPRs highly unlikely. It further contends that no 6 GHz authorized users – including those operating TV BAS STLs -- have received interference from Part 15 devices operating under Section 15.250 and using the same general modulation techniques as LPR devices.¹¹²

36. We agree with MCAA that because STL links are installed high off the ground with highly directional receive antennas, received interference from LPRs that point downward toward the measured substance is highly unlikely. We do not believe that EIBASS is correct in comparing LPR

¹⁰⁵ *FNPRM*, *supra* at 3671, para. 26.

¹⁰⁶ See 47 C.F.R. §§ 15.250(d)(1), 15.252(b)(1) & (2), 15.509(d), 15.510(d)(3), 15.511(c), 15.513(d), 15.515(d), 15.517(c), and 15.519(c).

¹⁰⁷ 47 C.F.R. §§ 15.209 and 15.35(b).

¹⁰⁸ EIBASS comments at para. 1.

¹⁰⁹ *Id.*

¹¹⁰ *Id.*, at para. 3. Section 47 C.F.R. § 15.250(c) prohibits fixed outdoor infrastructure to avoid the establishment of wide-area networks of devices seeking to operate under this section. See *Wide-Band Order*, 19 FCC Rcd 24558, 24571, para 27 (2004).

¹¹¹ *Id.*

¹¹² MCAA reply comments at 8.

devices to other unlicensed narrowband Part 15 devices that operate under Sections 15.209 and 15.35(b) of our rules because LPR devices are wideband devices that are more similar to unlicensed devices operating under Section 15.250 of the rules.¹¹³ While it is true that the proposed main-beam peak emission limit for LPR is 7 dB higher than the peak emission limit in Section 15.250, *i.e.*, 0 dBm peak EIRP,¹¹⁴ with the LPR antenna pointing down toward the substance being measured, only *reflected* emissions (which typically are already attenuated from the direct emission levels) would be expected.¹¹⁵ Because of reflection losses, LPR emission levels are therefore lower than other unlicensed wideband devices operating in the same frequency range. Further, because STL antennas are also directional in nature, there are additional antenna losses in the potential STL victim receive antenna, unless the LPR emissions are in the STL antenna main beam, which is a highly unlikely circumstance. We further note that the number used to derive the LPR equivalent main-beam emission limit at 6 GHz is actually 14 dB lower (at -55 dBm EIRP) than the average emission limit in Section 15.250 (at -41.3 dBm EIRP)¹¹⁶ for Part 15 devices operating in the same bands as STLs.¹¹⁷ Therefore, in the 6 GHz frequency range, the proposed main-beam emission limit is constraining any potential reflected emissions from an LPR to a level lower than the existing interference protection level for authorized services from unlicensed devices, resulting in a 14 dB additional interference protection margin for authorized services as compared to that provided by other Part 15 devices. Furthermore, as MCAA observes, there has not been any case of harmful interference to STL links from other Part 15 devices that currently operate in the same frequency band (devices that do not even have the interference-avoiding characteristic of being pointed downward).¹¹⁸ We further note that LPR devices are not by their nature used to establish local or wide area networks¹¹⁹ because LPRs are designed to measure the level of a substance at a single, circumscribed

¹¹³ 47 C.F.R. § 15.250. This section covers unlicensed wideband devices operating within the 5.925-7.250 GHz band with operating bandwidths at least 50 MHz. LPR devices typically have bandwidths exceeding 50 MHz. The Commission has recognized that the peak emission limit specified in 47 C.F.R. § 15.35(b) was established based on the operation of narrowband transmission systems and may unfairly penalize some wideband operations, effectively prohibiting the operation of these devices, and has stated that this existing limit on the total peak power level is not well suited to measure the operation of, or represent the interference potential of, transmitters that employ extremely wide bandwidths. *See Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, Second Report and Order and Second Memorandum Opinion and Order*, ET Docket No. 98-153, 19 FCC Rcd 24566, 24558, para. 17 (2004) (*UWB Second Order and Second MO&O*).

¹¹⁴ 47 C.F.R. § 15.250(d)(3).

¹¹⁵ Due to the operating nature of LPR devices, their emissions sustain several losses before they can reach a potential victim receiver. An LPR antenna is typically mounted at least 3 meters above the material it is intended to measure, pointing down toward that material. Free-space path loss (FSPL) from the LPR antenna to the measured material in the 5.925-7.250 GHz band is approximately 58 dB. Worst-case reflection losses calculated by ETSI/ECC studies add another 22 dB. Therefore, peak reflected emissions that could reach a potential STL victim receiver in this receiver's antenna main beam would be attenuated by 80 dB, from the proposed +7dBm peak EIRP to -73 dBm peak EIRP.

¹¹⁶ The -41.3 dBm EIRP average emission limit in Section 15.250 is the same as the general emission limit in Section 15.209. 47 C.F.R. §§ 15.250 and 15.209. This limit is generally used as interference protection criteria for authorized radio services from unlicensed operations.

¹¹⁷ *See* Table 1, fourth column, above. ETSI/ECC calculations for LPR main-beam emission limits in the 6 GHz frequency range are based on maintaining a -55 dBm EIRP reflected emission level within a 3-meter hemispherical boundary around the LPR antenna. *See Impact Of Level Probing Radars Using Ultra-Wideband Technology On Radiocommunications Services*, ECC Report 139, at 19-20 (Feb. 2010).

¹¹⁸ *See, e.g.*, Zebra Technologies Corporation Model UWT1100, FCC Identifier XWX-UWT1100; TDC Acquisition Holdings, Inc. Model PLUS-0309, FCC Identifier NUF-PLUS-0309; Ubisense Ltd. Model UbiTagV2.3, FCC Identifier SEAMOD23.

¹¹⁹ The basis of the prohibition of outdoor fixed structure in Section 15.250(c) is to prevent devices operating in the 5.925-7.250 GHz band to establish wide-area networks. 47 C.F.R. § 15.250(c).

site (e.g., a pile of coal or gravel, or water in a tank or under a bridge).

37. *Aggregate emissions of LPR devices.* CORF notes that there are important Earth Exploration-Satellite Service (EESS) passive observations made in the primary allocated bands at 22.21-22.5 GHz and 23.6-24.0 GHz, and urges us to consider aggregate emission limits for LPRs to avoid the impact of interference from multiple LPR devices on EESS activities in these bands.¹²⁰ O3b Limited (O3b) is also concerned about potential interference to its non-geosynchronous orbit (non-GSO) satellites operating in the 26 GHz band from aggregate operation of LPRs raising the noise floor. O3b requests that we require LPR to adhere to Section 15.5 non-interference rules.¹²¹

38. We observe that in calculating the LPR main-beam emission limits, the ECC Report 139 did take into account the co-existence between LPRs and EESS operating in the EESS allocated frequencies. ECC simulations show that in the most critical scenarios, there are wide margins of safety against harmful interference to EESS, even when using a very conservative number for the possible future growth of LPR devices in the long-term. CORF did not dispute these ECC analyses.¹²² We therefore find that there would be minimal or no effect on EESS or non-GSO satellite services from LPRs operating in the 24-26 GHz frequency range, and thus we do not adopt aggregate emission limits for LPR in these bands. We also observe that LPR, as all unlicensed devices operating under Part 15 of the Commission rules, are subject to the non-interference rules in Section 15.5.

39. *Unwanted (harmonic and spurious) emissions of LPR devices.* In the *FNPRM*, the Commission proposed that LPR unwanted emissions for LPRs operating in any of the specified operating frequency bands be suppressed to below -41.3 dBm EIRP.¹²³ Hach, a manufacturer for LPRs operating in the 26 GHz frequency range, states that establishing a limit for harmonic emissions at an average power spectral density of 20 dB below the fundamental emissions would bring our rules in line with ETSI and help manufacturers take advantage of economies of scale.¹²⁴ In reply, MCAA contends that a 20-dB difference between harmonic and fundamental emission limits would relax the limits for LPRs operating in the 26-GHz band, such as the Hach equipment, as well as for LPRs operating in the 80-GHz range, but would subject those LPRs operating in the 6-GHz frequency range to more stringent standards.¹²⁵ Although MCAA states that it does not oppose the Hach proposal, it asserts that the proposal needs further study.¹²⁶

40. We note that similar Part 15 equipment operating under Section 15.250 in the 5.925-7.250 GHz band and under Section 15.252 in the 23.12-29 GHz band are subject to unwanted

¹²⁰ CORF comments at 4.

¹²¹ O3b reply comments at 2. *See also* 47 C.F.R. § 15.5. Under these rules, all unlicensed devices operating under Part 15 are subject to the condition that they not cause harmful interference and that they cease operation if they do cause such interference.

¹²² ECC Report 139, at 35-38. ECC noted that although the data from ETSI Technical Report 102 601 regarding LPR market growth up to 2015 indicate a maximum expected LPR density per km² of 0.00238, ECC decided to use a very conservative figure of 0.005 in calculating the interference scenario for worst-case vertical LPR emissions in ECC Report 139, and a good interference safety margin was still found.

¹²³ *FNPRM*, *supra* at 3667, para.16. This means that for LPRs operating in the 26 GHz range at the maximum average emission limit of -14 dBm EIRP must suppress their unwanted emissions by 27.3 dB.

¹²⁴ Hach comments at 8; Hach reply comments at 2.

¹²⁵ MCAA reply comments at 3-4. Using a 20-dB difference, the unwanted emission limit would be -53 dBm EIRP for LPRs operating in the 6 GHz range, -34 dBm EIRP for LPRs operating in the 26 GHz range, and -23 dBm EIRP for LPRs operating in the 80 GHz range. The Commission has proposed to limit all LPR unwanted emissions to less than -41.3 dBm EIRP, the same as the general emission limit in Section 15.209 of the rules. 47 C.F.R. § 15.209.

¹²⁶ MCAA reply comments at 4.

emission limits that are much more stringent than what we proposed for LPR devices,¹²⁷ because we expect that LPRs will have a low interference potential as they operate in a fixed downward position. However, we do not believe that LPR unwanted emissions should be allowed to be as high as -34 dBm EIRP as Hach requests for LPRs operating in the 26 GHz frequency range, because as we discussed above our goal is to maintain the existing interference protection criteria (*i.e.*, the Part 15 general limit of less than -41.3 dBm EIRP) to authorized services from LPR's unwanted emissions.¹²⁸ Further, the same principle of establishing an unwanted emissions limit at 20 dB below the fundamental limit would allow unwanted emissions from LPRs operating in the 80 GHz range to be as high as -23 dBm EIRP.¹²⁹ We find that the -41.3 dBm EIRP general emission limit of Section 15.209 is appropriate so as to constrain any LPR unwanted emissions to the existing level of interference protection for incumbent users of the spectrum and Hach has not presented evidence that this is an inappropriately strict level for Part 15 devices in general or for LPRs in particular. We therefore deny Hach's request for LPR unwanted emissions to be 20 dB below the fundamental emissions.

a. Antenna Requirements

41. An antenna converts electrical signals traveling along a transmission line into electromagnetic energy that is radiated into the environment. Antennas such as those used in LPR devices are directional, in that the energy being transmitted is concentrated into one direction. If the gain characteristics of the antenna are plotted, a pattern is formed that consists of a single main lobe in the direction in which the majority of the energy is transmitted. In addition to the main lobe, there are multiple side lobes in undesired directions. The magnitude of the main lobe is called the gain of the antenna, and is compared to the magnitude of an isotropic antenna that transmits energy equally in every direction. Because an antenna can only focus energy, but cannot create additional energy, a higher gain (more energy) in the main lobe of the antenna can be realized only when the beamwidth of the main lobe is narrowed, accordingly reducing the gain in the side lobes (lessening the energy in other directions). In other words, the beamwidth, main-beam gain, and side-lobe gain of the antenna are all interdependent. Since we are specifying a maximum antenna beamwidth, for any given antenna, there is necessarily a minimum antenna gain that corresponds to the maximum beamwidth and a corresponding maximum side-lobe gain as well.

(i) Antenna Beamwidth

42. In the *FNPRM*, the Commission proposed an antenna beamwidth no greater than 12 degrees for frequencies below 57 GHz and no greater than 8 degrees in the 75-85 GHz bands.¹³⁰ Because the main source of the scattering of LPR emissions is the interaction with the surface being measured, the proposed maximum antenna beamwidth for LPRs was restricted to limit emission

¹²⁷ See 47 C.F.R. §§ 15.250(d)(1) and Section 15.252(b)(2). For example, Part 15 devices operating in the 5.925-7.250 GHz band under Section 15.250 must suppress unwanted emissions to less than the following EIRP levels: -75.3 dBm in the 960-1610 MHz band, -63.3 dBm in the 1610-1990 MHz band, -61.3 dBm in the 1990-3100 MHz band, -51.3 dBm in the 3100-5925 MHz band, -51.3 dBm in the 7250-10600 MHz band, and -61.3 dBm above 10600 MHz. All of these levels are at least 10 dB more stringent than what we are proposing for LPR unwanted emissions.

¹²⁸ For LPRs operating in the 24.05-29 GHz band, the fundamental emission limit proposed in the *FNPRM* and adopted herein is -14 dBm EIRP. Thus, with Hach's proposal for a 20-dB difference, the unwanted emissions would only be suppressed to less than -34 dBm EIRP, which is higher than the Part 15 interference criteria of -41.3 dBm EIRP.

¹²⁹ For LPRs operating in the 75-85 GHz band, the fundamental emission limit proposed in the *FNPRM* and adopted herein is -3 dBm EIRP. Thus, with Hach's proposal for a 20-dB difference, the unwanted emissions would only be suppressed to less than -23 dBm EIRP, which is higher than the Part 15 interference protection criteria of -41.3 dBm EIRP.

¹³⁰ *FNPRM*, *supra* at 3672, para. 29; ECC Report 139 at p. 3.

scattering in order to control the interference potential of LPRs to other radio services.¹³¹ The Commission also observed that maintaining a narrow antenna beamwidth could enhance LPR performance because a narrower beam reduces false echoes from objects other than the desired target material.¹³²

43. In its comments, Sutron requests that the proposed antenna beamwidth of 12 degrees be changed to permit an antenna beamwidth of 35 degrees, which is 23 degrees wider.¹³³ Sutron states that because a narrower beamwidth would result in a physically larger antenna, the size of a 6 GHz antenna with a 12 degrees beamwidth would be 10x12 inches for the aperture opening and a length of 28 inches. It contends that such an antenna in an open outdoor environment will increase the cost to support the antenna structure in windy conditions or under heavy snow loading. Sutron states that it has performed an actual antenna test to show that the horizontal emissions of its LPR device are less than the equivalent proposed horizontal emission level for LPRs operating in this frequency band¹³⁴ and argues that the horizontal emissions it measured are too low to constitute a threat to spectrum incumbents.¹³⁵

44. We are adopting our proposed antenna beamwidth limitations of no greater than 12 degrees for frequencies below 57 GHz and no greater than 8 degrees in the 75-85 GHz bands. First, the antenna beamwidth limits proposed in the *FNPRM* were designed to be consistent with the proposed main-beam emission limits, which in turn were based on ETSI standards.¹³⁶ As noted above, harmonization of our emission limits with the ETSI limits serves to expand global marketing opportunities for U.S. manufacturers. We conclude that any benefits that might result from Sutron's proposed beamwidth limits would be outweighed by the potential benefits of harmonization with European standards. Moreover, we note that a wider main beam could result in greater reflected emissions, and increase the potential for harmful interference to other spectrum users. We further observe that other waterways level-measuring LPR manufacturers such as Hach state in their comments that their devices use planar antennas which have outer dimensions much smaller than a horn antenna, are less obtrusive and less susceptible to vandalism and can still meet the proposed rule for antenna beamwidth.¹³⁷ In addition, we do not find Sutron's argument about wind/snow effects on the LPR antenna compelling, because this problem could be addressed by judiciously choosing an installation location that would shield the LPR antenna from weather conditions. Accordingly, we deny Sutron's request to increase the antenna beamwidth limit to 35 degrees.

(ii) Antenna Side-Lobe Gain

45. In the *FNPRM*, the Commission proposed a fixed side-lobe gain limit of -10 dBi for off-axis angles greater than 60 degrees.¹³⁸ The Commission also sought comment on the necessity of establishing limits on the gain of the antenna in the side lobe region and off-axis angles.¹³⁹

¹³¹ ETSI LPR Standard at Section 7.4.1, p. 29.

¹³² *FNPRM, supra* at 3672, para. 29.

¹³³ A wider antenna beamwidth would allow more emission scattering horizontally.

¹³⁴ For the 5.925-7.250 GHz band, the expected equivalent horizontal emissions, which include antenna back-lobe and side-lobe emissions and worst-case reflections from the material being measured, is -55 dBm EIRP. ECC Report 139 at p. 3, ETSI LPR Technical Standard at p. 26, *FNPRM, supra* at para. 24.

¹³⁵ Sutron comments at 2-3.

¹³⁶ *FNPRM, supra* at 3672, para. 29. *See also* ECC Report 139 at p. 11, ETSI LPR Technical Standard at p. 29.

¹³⁷ Hach comments at 6.

¹³⁸ *FNPRM, supra* at 3672, para. 30.

¹³⁹ *Id.*

46. Delphi, a mobile electronics and vehicle radar manufacturer, takes issue with the proposed fixed side lobe gain limit. It contends that an inefficient antenna could allow side lobe emissions to exceed the intended general emission limit (*i.e.*, -41.3 dBm EIRP in 75-85 GHz band, the same as the general 15.209 emission limit) and yet still comply with the proposed fixed -10 dBi gain.¹⁴⁰ Delphi recommends that we specify antenna side lobe emission limits and require that these emissions be verified by measuring the ratio of main lobe gain to side lobe gain or tested at the system level if it is determined that side lobe emission levels can be accurately measured.¹⁴¹

47. In reply, MCAA argues that Delphi's analysis using 10% antenna efficiency is unrealistic. MCAA contends that for a given beamwidth, and holding all other properties constant, the gain of an antenna (as a numeric value) is directly proportional to its efficiency.¹⁴² MCAA further observes that, in the 77-81 GHz band that Europe has authorized for short-range automotive radar applications, radio wave propagation is subject to both high free-space attenuation¹⁴³ and high attenuation from terrain and ground clutter.¹⁴⁴ MCAA states however that it has no objection to the Commission's measuring the side-lobe gain as part of the certification, so long as the measurement ascertains gain, rather than side-lobe emissions.¹⁴⁵

48. We agree with Delphi that, in some cases, an LPR operating at the maximum main-beam power as proposed in the *FNPRM* could have side-lobe emissions that exceed the -41.3 dBm EIRP interference protection criteria in Section 15.209, depending on the efficiency of the antenna used and the power at which the LPR is operated. The Commission noted in the *FNPRM* that it did not intend any rule revisions adopted in this proceeding to permit the gain of any LPR side lobe to exceed the EIRP limit in Section 15.209.¹⁴⁶ Therefore, we will modify the side-lobe gain limits from those proposed in the *FNPRM*.¹⁴⁷ We note that antenna side-lobe gains correlate to main-beam gains; as the antenna main-beam gain varies, the side-lobe gain also varies. Therefore, to ensure that LPRs provide the same interference protection to authorized radio services as other Part 15 devices (*i.e.*, maintain the general -41.3 dBm EIRP limit from Section 15.209 on horizontal transmissions from LPRs), we adopt a side-lobe gain limits *relative* to the main-lobe gain,¹⁴⁸ as shown in Table 3 below. The calculations for these limits are found in Appendix C.

¹⁴⁰ Delphi calculates that for an LPR operating in the 75-85 GHz band with the required 8 degrees maximum beamwidth, a 10% efficient antenna could allow a resulting side lobe emission of -32 dBm EIRP, which would be 10 dB above the intended general emission limit of -41.3 dBm EIRP, while still complying with the required fixed antenna side lobe gain of -10 dBi.

¹⁴¹ Delphi comments at 2.

¹⁴² MCAA states that by redoing Delphi's calculation, but with a more realistic low-value antenna efficiency of 60%, its calculations instead yield a side lobe emission of just 1.5 dB above the emission limit of -41.3 dBm EIRP.

¹⁴³ There is approximately 80 dB of free space attenuation at 3 meters for an 80 GHz signal. See *FNPRM*, 27 FCC Rcd at 3669 n.51.

¹⁴⁴ MCAA reply comments at 6.

¹⁴⁵ *Id.*

¹⁴⁶ *FNPRM*, *supra* at 3670, para. 25.

¹⁴⁷ ECC Report 139 at p. 12. We note that although ECC uses the fixed -10 dBi antenna side lobe gain as an initial reference value in the simulations in ECC Report 139, it states that the eventual ETSI harmonized standard for LPRs may establish a different value for side-lobe gain based on further practical measurement results.

¹⁴⁸ If an antenna has a low main-beam gain because of losses due to inefficiency and the input power to the antenna is increased to compensate for the loss and to attain the maximum main beam EIRP, the specified side-lobe EIRP gain limit relative to the main beam gain has been calculated to ensure that side-lobe power is always suppressed to less than the general emission limit of Section 15.209 (*i.e.*, less than -41.3 dBm EIRP), even if the main beam gain is increased up to the maximum main-beam limit. See *infra* Appendix C.

Table 3 – Side Lobe Gain Limit Relative to Main Beam Gain Limit

Frequency Range (GHz)	Antenna Side Lobe Gain Limit Relative to Main Beam Gain (dB)
5.925-7.250	-22
24.05-29.00	-27
75-85	-38

b. Automatic Power Control

49. In the *FNPRM*, the Commission noted that as a consequence of its proposed main-beam emission limits, all reflected emissions from the LPR device will be kept at or below the Section 15.209 general emission limits, and thus it did not propose to adopt automatic power control (APC) requirements for LPR devices. The Commission sought technical analyses from parties advocating a requirement for APC to show the inadequacy of the emission limit in Section 15.209.¹⁴⁹ No party provided comments on APC. Accordingly, we do not adopt APC requirements for LPR devices.

3. Other Requirements

b. Operational and Marketing Restrictions

50. In the *FNPRM*, the Commission proposed, for LPR devices authorized under the higher emission limits in the new rule, that the antenna of an LPR device be dedicated or integrated as part of the transmitter and professionally installed in a downward position; to limit installations of LPR devices to fixed locations; to prohibit hand-held applications of LPR devices; and to prohibit the marketing of LPR devices to residential consumers. It stated that these restrictions are intended to protect incumbent authorized services operating in the same and adjacent frequency bands from potential harmful interference from LPRs.¹⁵⁰ As we discuss below, we will require the antenna of an LPR device to be dedicated or integrated as part of the transmitter; limit installations of LPR devices to fixed locations; prohibit hand-held applications of LPR devices; and prohibit the marketing of LPR devices to residential consumers. A requirement for professional installation appears unnecessary as we are requiring LPRs to be installed in a downward position and LPRs would not function correctly if they are not pointed down toward the substance to be measured. Accordingly, we are not adopting a requirement for professional installation.

51. CORF specifically supports the proposals that the LPR antenna be dedicated or integrated as part of the transmitter and professionally installed in a downward position; to limit installations of LPR devices to fixed locations; to prohibit hand-held applications of LPR devices; and to prohibit the marketing of LPR devices to residential consumers.¹⁵¹ EIBASS argues that the proposed requirement for “professional installation” is meaningless unless there is a requirement for LPRs operating at 6.6 GHz under the higher emission limits to produce upon FCC request a record showing the qualifications of the person making the installation and when the installation took place.¹⁵² EIBASS also recommends that LPRs operating in the 6 GHz frequency range include a built-in circuit that would not allow the LPR to

¹⁴⁹ *FNPRM*, *supra* at 3672, para. 31.

¹⁵⁰ *Id.*, at 3673, para. 34.

¹⁵¹ CORF comments at 4; *see also* NRAO reply comments at 2.

¹⁵² EIBASS comments at para. 7. EIBASS recommends that to meet such qualifications, the “professional” installer of LPRs should be a person holding certification from either the Society of Broadcast Engineers (SBE) at the broadcast engineer level or higher, or the National Association of Radio and Television Engineers (NARTE) as an Electromagnetic Compatibility (EMC) engineer, or be registered as a Professional Engineer (PE). *Id.*, at para. 6.

transmit if the transmitting antenna is not within ± 10 degrees of straight downwards.¹⁵³

52. We conclude that the LPR antenna must be dedicated or integrated as part of the transmitter. We do so because, as we explain above, antennas used in LPR devices must satisfy the requirements for main-beam radiated emissions, beamwidth and side-lobe gain, which are interdependent, to demonstrate compliance with new Section 15.256. By requiring a dedicated or integrated antenna as part of the transmitter, we will ensure that the LPR when operated will meet the emission limits necessary to protect authorized users. We also conclude that there is no need to adopt a rule to require professional installation of LPR. We observe that the Commission has not adopted a specific definition for “professional installation” in any of our rules for unlicensed devices but has rather left it to be assessed on a case-by-case basis as a certification grant condition.¹⁵⁴ Here, LPR devices are commercial products intended to measure industrial types of materials such as coal, gravel, sand piles or waterways such as rivers or dams, and the rules we adopt herein prohibit their marketing to residential consumers. We also find that the installation of these devices is relatively simple, and because they are commercial products, they will typically be handled by people with product knowledge, unlike many Part 15 devices that have consumer-oriented applications. Further, we are prohibiting the marketing of LPR devices to residential consumers. We therefore find that the operational and marketing restrictions placed on LPR devices are sufficient to avoid harmful interference to authorized radio services without imposing the requirement for professional installation on LPR devices. We also observe that by its operating nature, an LPR device must be directed toward the substance being measured; the device would not operate correctly if there are too many false echoes caused by reflections from various neighboring physical objects. Thus, installation errors or unintentional misuse of the product will require correction to operate effectively and would need no additional hardware or software safeguard. We are also requiring in the rules adopted herein that LPRs be installed in a downward position. However, we find that additionally requiring built-in circuits to prevent transmission in case of installation errors as recommended by EIBASS an unnecessary cost without correlating benefits.

53. EIBASS also states that while some LPRs appear large enough to make hand-held or mobile applications unlikely, others are clearly small enough to be operated as a non-fixed device, and violation of the hand-held restriction in the LPR rules could cause interference to a TV station’s studio-to-transmitter links (STL).¹⁵⁵ EIBASS therefore recommends that LPRs operating in the 6 GHz frequency range include a built-in circuit to ensure that the LPR is stationary (*i.e.*, it would detect motion if the LPR device is used in a hand-held fashion).¹⁵⁶

54. We conclude that LPR devices should only be operated when installed in fixed locations, and thus we will prohibit hand-held and mobile applications to prevent interference to authorized services in the same or adjacent frequency bands. The record supports this conclusion. YSI Incorporated (YSI) urges us to confirm that “fixed” also means temporary fixed installations, to allow users the flexibility to operate an LPR at different locations to meet diverse measurement needs, without requiring it to remain permanently at a specific fixed location.¹⁵⁷ We clarify that an LPR may be temporarily affixed to a structure, so long as it operates only when at a fixed location as required by the rules. We are prohibiting hand-held applications since these could increase the potential for harmful interference to authorized radio services; they could easily be moved, operated while in motion, or operated when not pointed straight downward. The same concerns apply to operating an LPR while it is moving (*e.g.*, while being transported inside a tanker truck), and the rules will prohibit such use. Because we believe that misuse of

¹⁵³ *Id.*, at para. 4.

¹⁵⁴ *See e.g.*, 47 C.F.R. §§ 15.203, 15.231, 15.247 and 15.711.

¹⁵⁵ EIBASS comments at para 5.

¹⁵⁶ *Id.*, at para. 4.

¹⁵⁷ YSI comments at 3-4.

an LPR will render it ineffective and thus is quite unlikely to be pursued or to occur, we find that requiring built-in circuits to detect motion as recommended by EIBASS is an unnecessary cost without sufficient correlating benefits.¹⁵⁸

55. EIBASS also argues that the Commission lacks jurisdiction when it comes to the advertisement of Part 15 devices that are already approved, and submits that the Commission's authority ends after a device has obtained certification. EIBASS contends that even if the manufacturer of the Part 15 device complies with the marketing requirement and sells only to industrial users, the manufacturer has no control over second-tier distributors. EIBASS is therefore concerned about expanded commercial use that does not comply with the marketing restrictions for LPR.¹⁵⁹

56. We disagree with EIBASS' assertion that the Commission lacks authority to prohibit marketing of LPR devices to certain types of customers or for certain types of applications. We note that Congress granted the Commission authority to regulate the marketing, offering for sale, sale or use of RF devices in Section 302 of the Communications Act,¹⁶⁰ and the Commission implemented that authority in Section 2.803 of its rules.¹⁶¹ Further, as an unlicensed Part 15 device, an LPR is subject to the provisions of Section 15.5 of the rules, which require the user of a transmitter that causes interference to authorized radio communications to stop operating the transmitter or correct the problem causing the interference.¹⁶² The Commission has the authority to investigate Part 2 and Part 15 violations and take action accordingly, including imposing fines and penalties through its Enforcement Bureau's actions.¹⁶³ Therefore, the rules provide several safeguards against the improper use of an LPR (*e.g.*, using it for hand-held applications), that could result in harmful interference to authorized spectrum services.

a. Equipment Certification

57. In the *FNPRM*, we proposed to permit Telecommunications Certification Bodies (TCBs) to certify LPR devices operating under the proposed rules.¹⁶⁴ We noted that the *FNPRM* proposals specify direct measurement of emissions within the main beam of the LPR antenna and are consistent with compliance measurement methodologies currently used by TCBs with other types of unlicensed

¹⁵⁸ EIBASS contends that the *FNPRM* cost-benefit analysis fails to consider the costs to incumbent TV BAS licensees in tracking down harmful interference caused by unlicensed high power LPRs. However, EIBASS concedes that tracking down interference from a stationary, continuously radiating IX source is far easier than trying to locate interference from a mobile or intermittently transmitting device. EIBASS comments at para. 11. We do not anticipate that BAS licensees will incur costs to investigate interference from LPR because, as we discuss above, we do not anticipate that LPRs will cause harmful interference to BAS.

¹⁵⁹ *Id.* at para. 9-10.

¹⁶⁰ 47 U.S.C. § 302a. Section 302 of the Communications Act of 1934, as amended, states that the Commission may, consistent with the public interest, convenience, and necessity, make reasonable regulations governing the interference potential of devices which in their operation are capable of emitting RF energy by radiation, conduction, or other means in sufficient degree to cause harmful interference to radio communications. 47 U.S.C. § 302a(a). It further states that no person shall manufacture, import, sell, offer for sale, or ship devices or home electronic equipment and systems, or use devices, which fail to comply with regulations promulgated under this section. This provision of the law is intended to prevent devices that could cause harmful interference to radio communications from reaching the marketplace or being operated. 47 U.S.C. § 302a(b).

¹⁶¹ 47 C.F.R. § 2.803.

¹⁶² 47 C.F.R. § 15.5.

¹⁶³ *See* 47 U.S.C. §§ 501-503, 510.

¹⁶⁴ *FNPRM*, *supra* at 3672-3673, para. 35. TCBs are accredited third-party product certification bodies authorized to issue a grant of certification for certain products in lieu of a traditional grant issued by the Commission. 47 C.F.R. §§ 2.1031-2.1060.

transmitters.¹⁶⁵ We continue to hold this view, and we will allow LPR equipment certification by TCBs in addition to the Commission. We note that no comment was received on this proposal.

58. In the *FNPRM*, the Commission recognized that, currently, a certified TLPR device could be approved to operate under other conditions, *e.g.*, outdoor installations in open-air environments, in an enclosure with low RF attenuation characteristics, or with higher power. To allow previously-certified devices to take advantage of any changes proposed in the *FNPRM* and adopted in this *Order*, the Commission proposed to allow the responsible party to file for a permissive change¹⁶⁶ in accordance with the existing rules and practices, provided that: (1) the LPR device operates only within the frequency bands authorized by rules proposed herein; (2) measurement data taken in accordance with the measurement procedure proposed above is provided to demonstrate compliance with the new emission limits specified in these proposed rules; and (3) operational changes to the device are being implemented by software upgrade without any hardware change.¹⁶⁷ We continue to believe that these provisions are appropriate because, consistent with our existing practice, they minimize additional certification burdens on applicants without causing an increased potential for harmful interference to authorized services. We will implement the above changes in our equipment certification guidelines for LPRs. We also note that no comment was received on this proposal.

b. Additional Protection for the Radio Astronomy Service (RAS)

59. *Distance Separation and Height Restrictions.* As noted above,¹⁶⁸ CORF notes that RAS has primary allocations at 76-77.5 GHz and 78-85 GHz and does not oppose sharing these bands with LPRs provided the Commission adopts certain protections designed to ensure that RAS can operate in the interference-free environment that the service requires for picking up extremely weak signals.¹⁶⁹ More specifically, CORF and NRAO request that these protections include exclusion zones around RAS

¹⁶⁵ *Id.* In the *Notice and Order*, we instead proposed to require that TLPR devices designed to operate in the 77-81 GHz band be certified by the Commission's Laboratory rather than by TCBs. We noted that, because a standard test procedure for LPR devices had not yet been devised for use at these frequencies at that time, this requirement would give the Commission time to develop appropriate measurement guidelines for devices intended for operation in this frequency band. *Notice and Order, supra* at 610, para. 24. In the *FNPRM*, however, the Commission observed that the new proposals made in the *FNPRM* would facilitate the direct measurement of LPR emissions within the main beam of the antenna and were consistent with compliance measurement methodologies used with other types of unlicensed transmitters. *FNPRM, supra* at 3674, para. 35. Accordingly, the Commission proposed to permit TCBs to certify LPR devices for the proposed operations in the 77-81 GHz band. *Id.*

¹⁶⁶ 47 C.F.R. § 2.1043 defines three classes of permissive changes that may be made without obtaining a new grant of equipment authorization and labeling a device with a new FCC identification number. The three classes of permissive changes are: (1) Class I, which includes those modifications in the equipment that do not degrade the characteristics reported by the manufacturer and accepted by the Commission when certification is granted; (2) Class II, which includes those modifications that degrade the performance characteristics as reported to the Commission at the time of the initial certification; and (3) Class III, which includes modifications to the software of a software defined radio transmitter that change the frequency range, modulation type, or maximum output power (either radiated or conducted) outside the parameters previously approved or that change the circumstances under which the transmitter operates in accordance with Commission rules. 47 C.F.R. § 2.1043(b). No filing is required with the Commission or a TCB for a Class I permissive change. Class II and III permissive changes require an abbreviated filing with the Commission or a TCB and an acknowledgement that the changes are acceptable before the changed equipment can be marketed but do not require a complete application for certification or new FCC identification number. Class III permissive changes are not permitted on a device that has had a Class II permissive change. *See also*, Knowledge Data Base (KDB) No. 178919 at <https://apps.fcc.gov/oetcf/kdb/forms/FTSSearchResultPage.cfm?id=33013&switch=P>.

¹⁶⁷ *FNPRM, supra* at 3674, para. 36.

¹⁶⁸ *See* para. 28, *supra*.

¹⁶⁹ CORF comments at 1-3.

stations, restrictions on the height of LPR antennas, requirements for antenna installation, a restriction of operations to fixed installations only, and the deployment of a publicly accessible database of all LPR installations. CORF and NRAO state that the ECC Report 139 recommends a geographical region in which LPRs cannot be installed within 4 km from RAS locations and a limit of 15 meters above ground level on LPR antenna height within 40 km of these locations.¹⁷⁰ They request that the Commission require the same distance separation and height restrictions to protect RAS stations, particularly in the 6650-6675.2 MHz¹⁷¹ (part of the 5.925-7.250GHz band) and 75-85 GHz bands.¹⁷² MCAA, which represents the LPR industry, agrees with the separation distance and height restrictions to protect RAS sites.¹⁷³

60. The Commission did not propose these restrictions in the *FNPRM* because interference to RAS observatories from downward-looking LPRs is unlikely. First, the ETSI/ECC distance and antenna height limitation requirements are based on the RAS operating environment in Europe where RAS sites are typically found in urban areas; this is a different environment than in the United States, where RAS receivers are commonly located in remote or rural areas, not the industrial areas where LPRs are likely to be found. Second, in the *FNPRM*, the Commission proposed radiated emission limits for LPRs, designed to ensure that, at 3 meters from the LPR, the reflected emission level is less than the existing general limit of -41.3 dBm EIRP of Section 15.209, which is the limit currently applicable to Part 15 devices, such as computers and video monitors, which are likely being used inside a RAS site, apparently without harm. Third, RAS receivers discriminate against off-beam signals and are pointed skyward, discriminating against reflected signals that would be reflected from the side or below. Even in the case of LPRs installed over waterways in remote areas, because the radio astronomy observatories typically have control over access to a distance of one kilometer from the telescopes to provide protection from interference caused by uncontrolled RFI sources,¹⁷⁴ the potential for interference caused by LPRs at that distance (one kilometer) would be infinitesimal, when also taking into account the variability in propagation characteristics due to terrain, weather and other factors.¹⁷⁵ Given these factors and the additional operational and marketing restrictions on LPR devices that we are adopting herein (e.g., integrated antennas, downward operation, prohibition on marketing to consumers), we do not find that it is necessary to also prohibit LPRs by rule to avoid operating in the line of sight of RAS stations as NRAO requested.¹⁷⁶ While the MCAA does not oppose the restrictions proposed by CORF and NRAO, MCAA represents only a segment of current LPR users of the band and does not necessarily anticipate future uses. Accordingly, we are denying CORF and NRAO's requests for separation distances from radio astronomy observatories and for a limitation on LPR antenna height within certain distances of the line of sight of RAS stations.

¹⁷⁰ CORF comments at 6, NRAO comments at 3. CORF comments are mostly concerned with the 75-85 GHz band.

¹⁷¹ Although the radio astronomy service (RAS) has no allocation in the 6650-6675.2 MHz band, NRAO observes that footnote US 342 to the Table of Frequency Allocations states that "all practicable steps shall be taken to protect the radio astronomy service from harmful interference." NRAO comments at 2.

¹⁷² With respect to the specific bands mentioned for operation of LPR, radio astronomy has primary spectrum allocations over the entirety of the region 76-85 GHz, except at 77.5-78 GHz where it is secondary. *Id.*

¹⁷³ MCAA comments at 3-4, MCAA reply comments at 5.

¹⁷⁴ See *Amendment of Parts 2, 15 and 97 of the Commission's Rules to Permit the Use of Radio Frequencies Above 40 GHz for New Radio Applications, Third Memorandum Opinion and Order*, ET Docket No. 94-124, 15 FCC Rcd 10515, 10517-18, para. 8 and n.15 (2000).

¹⁷⁵ At $d = 1000$ m and $f = 76.50$ GHz, free-space path loss is approximately 130 dB. See also *Amendment of Sections 15.35 and 15.253 of the Commission's Rules Regarding Operation of Radar Systems in the 76-77 GHz Band and Amendment of Section 15.253 of the Commission's Rules to Permit Fixed Use of Radar in the 76-77 GHz Band, Report and Order*, ET Docket Nos. 11-90 and 10-28, 27 FCC Rcd 7880, 7885, para. 15 (2012).

¹⁷⁶ NRAO comments at 3.

61. *LPR Installation Database.* CORF and NRAO request that we implement a publicly available LPR installation database so that RAS operators can readily identify sources of interference to their stations should interference occur.¹⁷⁷ They point out that the Commission required LPR manufacturers to maintain such information and make it available to the Commission upon request when we granted waivers to TLPR manufacturers to operate in the 77-81 GHz band.¹⁷⁸ NRAO recognizes the likely diversity of LPR vendors, installers and providers but continues to request that given the limited number of RAS sites, only installations within 40 km of RAS sites need to be identified by sending an email or a letter to the Spectrum Management Office at the National Science Foundation (NSF).¹⁷⁹ MCAA and Krohne strongly oppose these requests for a database of LPR installation sites. Krohne states that its customers, especially governmental users, need to protect their sensitive operational data, which often include the location of tanks and storage facilities. Krohne also rejects NRAO's suggestion to just receive a letter or an email of new location installations, citing the cost burden, as well as the same type of confidentiality concerns that it raised with respect to the proposal for a public database. MCAA states that many installations are performed by third-party companies, so the manufacturers have no reliable mechanism for maintaining location data.

62. We decline to require a publicly available LPR installation database or to require manufacturers to maintain lists of LPR installation sites. We note that it is customary for the Commission to proceed in a very cautious manner in a waiver proceeding by imposing specific conditions on operations that typically involve new technology products or new applications of existing technologies and with which the Commission may have little or no prior experience regulating. In the case of the waiver grant for TLPR devices operating in the 77-81 GHz band, we required manufacturers to maintain a list of LPR installation sites as an additional safeguard to permitting LPR operations in a restricted band, even though we expected that TLPR devices would not be operating in close proximity to radio astronomy sites and thus not likely to cause harmful interference to them.¹⁸⁰ As we discuss above in the Report and Order, we are adopting new rules based on ETSI/ECC's analysis which derived the limits for LPR main-beam emissions by mathematically correlating them with reflected emissions from an LPR; the resulting values are the same as the existing Part 15 average emission limit.¹⁸¹ The LPR main-beam emission limits therefore would maintain the existing level of interference protection to incumbent radio services, including RAS sites -- a level that has already proven to be adequate. We find that NRAO's recommendation that the NSF be notified of each LPR installation site is an unnecessary cost without countervailing benefits, and agree with the LPR industry that this could give rise to confidentiality issues. We conclude that the downward-looking operation of LPRs at such emission limits, when combined with the various operating/marketing restrictions, is extremely unlikely to cause harmful interference to radio astronomy telescopes, thereby making a database or list of LPR installation sites, or notification to authorized users unnecessary. Further, we find that our decision not to require a publicly available database addresses the LPR industry's concern over potential security risks from the disclosure of LPR locations.

63. *Cost Benefit Analysis.* In the *FNPRM*, the Commission provided an analysis on the potential costs of the proposed LPR regulation versus its potential benefits.¹⁸² The Commission stated that, because LPR devices need higher power and wider bandwidth than that which is permitted under the existing Part 15 rules to fully achieve the potential of this measuring technology, the proposed rules

¹⁷⁷ CORF comments at 4-5; NRAO comments at 3.

¹⁷⁸ *Notice and Order, supra* at 614, para. 38.

¹⁷⁹ NRAO reply comments at 2.

¹⁸⁰ *Notice and Order, supra* at 614, para. 38.

¹⁸¹ *See supra* para. 33, note 102.

¹⁸² *FNPRM, supra* at 3674-75, para. 37.

would tender a necessary remedy for LPR devices to operate at the power levels and in the appropriate frequency bands required to deliver the needed accuracy for diverse applications, thereby promoting the expanded development and use of this technology to the benefit of businesses, consumers, and the economy. The Commission tentatively concluded that the proposed higher power levels in the proposed frequency bands would further the development of better and improved level-measuring tools, but these changes would not increase the potential for interference to authorized users beyond what is permitted under the current rules. The Commission also considered how the proposed rules would help to simplify equipment development and certification of LPR devices, as well as provide a simplified method for measuring the radiated emissions from these devices.¹⁸³

64. Except for a comment from EIBASS, none of the commenters took issue with any of these factors or with our tentative conclusion. As we discussed above,¹⁸⁴ EIBASS argues that the *FNPRM* cost-benefit analysis fails to consider the costs to incumbent TV BAS licensees in the 6 GHz frequency range in tracking down harmful interference caused by unlicensed high power LPRs.¹⁸⁵ We do not anticipate, however, that BAS licensees will incur costs to investigate interference from LPR; we do not find that LPRs will cause harmful interference to BAS or any other licensed user in any of the adopted frequency bands for LPR operation, as discussed at length, above.¹⁸⁶ We conclude that the rules adopted herein will provide significant benefits to LPR manufacturers and users with no apparent cost to any party.

IV. ORDER

65. In this Order, we are dismissing a waiver request from VEGA to operate LPR devices in the 24.6-27 GHz frequency band under Section 15.252 as moot. The Commission previously held this request in abeyance pending final action in this rulemaking proceeding because this waiver raises issues that are, in part, similar to those raised in the *FNPRM*.¹⁸⁷

66. VEGA requested a waiver of Section 15.252(a) to operate LPR devices in the 24.6-27 GHz frequency band under this section as a fixed structure, either in tanks or in open air.¹⁸⁸ Section 15.252(a) permits the use of field disturbance sensors within the frequency bands 16.2-17.7 GHz and 23.12-29.0 GHz but requires them to be mounted in terrestrial transportation vehicles, whereas VEGA's LPR devices would only be installed at fixed locations.¹⁸⁹ The waiver request also proposed an emission method of measurement that does not take into account boresight emissions. After the release of the *FNPRM*, VEGA amended this waiver request on June 6, 2012 for permission to market its 6 GHz and 26 GHz LPRs that would comply with the proposed rules.¹⁹⁰ Because the rules we adopt in this Report and Order will enable VEGA to operate LPR devices in the 24.6-27 GHz frequency band without a

¹⁸³ *Id.*

¹⁸⁴ *See supra* at para. 54, note 158.

¹⁸⁵ However, EIBASS concedes that tracking down interference from a stationary, continuously radiating IX source is far easier than trying to locate interference from a mobile or intermittently transmitting device. EIBASS comments at para. 11.

¹⁸⁶ *See e.g., supra* at paras. 15, 34 and 36.

¹⁸⁷ *FNPRM, supra* at 3664, para. 9.

¹⁸⁸ *See Ohmart/VEGA Corporation Request for Waiver of Section 15.252 to Permit the Marketing of Level Probing Radars in the 26 GHz Band*, ET Docket No. 10-27; *see also supra* n. 20. After the adoption of the *FNPRM*, Ohmart/VEGA amended this waiver on April 26, 2012, to request immediate operation under the *FNPRM*'s proposed rules pending the conclusion of this rulemaking. *Id.*

¹⁸⁹ 47 C.F.R. § 15.252(a).

¹⁹⁰ *Ohmart/VEGA Corporation Request for Waiver of Section 15.252 to Permit the Marketing of Level Probing Radars in the 26 GHz Band*, ET Docket No. 10-27; *see also supra* n. 20.

waiver of the usage restrictions in Section 15.252(a), VEGA will be able to apply for LPR certification under new Section 15.256 for both in tank and open air applications. Accordingly, we dismiss VEGA's waiver request as moot.

V. PROCEDURAL MATTERS

67. *Final Regulatory Flexibility Analysis.* As required by Section 603 of the Regulatory Flexibility Act, 5 U.S.C. § 603, the Commission has prepared a Final Regulatory Flexibility Analysis (IRFA) of the possible significant economic impact on small entities of the changes adopted in this document. The FRFA is set forth in Appendix A.

68. *Paperwork Reduction Analysis.* This document contains no new or modified information collection requirements subject to the Paperwork Reduction Act of 1995 (PRA), Public Law 104-13. In addition, therefore, it does not contain any new or modified "information collection burden for small business concerns with fewer than 25 employees," pursuant to the Small Business Paperwork Relief Act of 2002, Public Law 107-198, *see* 44 U.S.C. 3506(c)(4).

69. *Congressional Review Act.* The Commission will send a copy of this Report and Order in a report to be sent to Congress and the Government Accountability Office pursuant to the Congressional Review Act, *see* 5 U.S.C. 801(a)(1)(A).

VI. ORDERING CLAUSES

70. IT IS ORDERED that pursuant to Sections 4(i), 301, 302, 303(e), 303(f), 303(g), and 303(r) of the Communications Act of 1934, as amended, 47 U.S.C. Sections 154(i), 301, 302a, 303(e), 303(f), 303(g), and 303(r), this Report and Order is hereby ADOPTED and Part 15 of the Commission's Rules ARE AMENDED as set forth in Appendix D, effective 30 days after publication in the Federal Register.

71. IT IS FURTHER ORDERED that pursuant to authority in Section 1.3 of the Commission's rules, 47 C.F.R. Section 1.3, and Sections 4(i), 302, and 303(e), of the Communications Act of 1934, as amended, 47 U.S.C. Sections 154(i), 302, and 303(e), the Request for Waiver filed by VEGA Americas, Inc. (formerly Ohmart/VEGA Corporation) filed on December 3, 2009, IS DISMISSED, consistent with the terms of this Order. This action is effective upon release of this Order.

72. IT IS FURTHER ORDERED that the Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, SHALL SEND a copy of this Report and Order, including the Final Regulatory Flexibility Analysis, to the Chief Counsel for Advocacy of the Small Business Administration.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

APPENDIX A

Final Regulatory Flexibility Analysis

1. As required by the Regulatory Flexibility Act (RFA),¹ an Initial Regulatory Flexibility Analysis (IRFA) was incorporated in the *Further Notice of Proposed Rulemaking (FNPRM)* in ET Docket No. 10-23.² The Commission sought written public comment on the proposals in the *FNPRM*, including comment on the IRFA. This present Final Regulatory Flexibility Analysis (FRFA) conforms to the RFA.

A. Need for, and Objectives of, the Report and Order

2. In this Report and Order, we modify our rules to provide a set of new technical and operational rules to govern the operation of level probing radar (LPR) devices installed both in open-air environments and inside storage tanks (TLPR applications) in the following frequency bands: 5.925-7.250 GHz, 24.05-29.00 GHz, and 75-85 GHz. To permit LPR operation in the 75-85 GHz band, we also modify the existing Section 15.205 of the rules to remove the prohibition on intentional emissions in this band. The amended rules will allow devices with accurate and reliable target resolution to identify water levels in rivers and dams or critical levels of materials such as fuel or sewer-treated waste, reducing overflow and spillage and minimizing exposure of maintenance personnel in the case of high risk substances. The amended rules would also, to the extent practicable, harmonize our technical rules for LPR devices with similar European standards and would improve the competitiveness of U.S. manufacturers in the global economy, leading to potential cost savings for small businesses, all without causing harmful interference to authorized spectrum users in the affected frequency bands.

B. Statement of Significant Issues Raised by Public Comments in Response to the IRFA

3. There were no public comments filed that specifically addressed the rules and policies proposed in the IRFA.

C. Response to Comments by the Chief Counsel for Advocacy of the Small Business Administration

4. Pursuant to the Small Business Jobs Act of 2010, the Commission is required to respond to any comments filed by the Chief Counsel for Advocacy of the Small Business Administration, and to provide a detailed statement of any change made to the proposed rules as a result of those comments. The Chief Counsel did not file any comments in response to the proposed rules in this proceeding.

D. Description and Estimate of the Number of Small Entities to Which the Rules Will Apply

5. The RFA directs agencies to provide a description of, and, where feasible, an estimate of the number of small entities that may be affected by the proposed rules, if adopted.³ The RFA defines the term “small entity” as having the same meaning as the terms “small business,” “small organization,” and

¹ See 5 U.S.C. § 603. The RFA, *see* 5 U.S.C. § 601-612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), Public Law No. 104-121, Title II, 110 Stat. 857 (1996), and the Small Business Jobs Act of 2010, Public Law No. 111-240, 124 Stat. 2504 (2010).

² *Further Notice of Proposed Rulemaking* in ET Docket No. 10-23 (*In the Matter of Amendment of Part 15 of the Commission’s Rules To Establish Regulations for Tank Level Probing Radars in the Frequency Band 77-81 GHz and Amendment of Part 15 of the Commission’s Rules To Establish Regulations for Level Probing Radars and Tank Level Probing Radars in the Frequency Bands 5.925-7.250 GHz, 24.05-29.00 GHz and 75-85 GHz*), 27 FCC Rcd. 3660 (2012) (*FNPRM*).

³ See 5 U.S.C. § 603(b)(3).

“small business concern” under Section 3 of the Small Business Act.⁴ Under the Small Business Act, a “small business concern” is one that: (1) is independently owned and operated; (2) is not dominant in its field of operations; and (3) meets may additional criteria established by the Small Business Administration (SBA).⁵

6. **Small Businesses, Small Organizations, and Small Governmental Jurisdictions.** Our action may, over time, affect small entities that are not easily categorized at present. We therefore describe here, at the outset, three comprehensive, statutory small entity size standards that encompass entities that could be directly affected by the proposals under consideration.⁶ As of 2009, small businesses represented 99.9% of the 27.5 million businesses in the United States, according to the SBA.⁷ Additionally, a “small organization” is generally “any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.”⁸ Nationwide, as of 2007, there were approximately 1,621,315 small organizations.⁹ Finally, the term “small governmental jurisdiction” is defined generally as “governments of cities, counties, towns, townships, villages, school districts, or special districts, with a population of less than fifty thousand.”¹⁰ Census Bureau data for 2007 indicate that there were 89,527 governmental jurisdictions in the United States.¹¹ We estimate that, of this total, as many as 88,761 entities may qualify as “small governmental jurisdictions.”¹² Thus, we estimate that most governmental jurisdictions are small.

7. The adopted rules pertain to manufacturers of unlicensed communications devices. The appropriate small business size standard is that which the SBA has established for radio and television broadcasting and wireless communications equipment manufacturing. The Census Bureau defines this category as follows: “This industry comprises establishments primarily engaged in manufacturing radio and television broadcast and wireless communications equipment. Examples of products made by these establishments are: transmitting and receiving antennas, cable television equipment, GPS equipment, pagers, cellular phones, mobile communications equipment, and radio and television studio and

⁴ *Id.* § 601(3).

⁵ *Id.* § 632.

⁶ *See* 5 U.S.C. § 601(3)–(6).

⁷ *See* SBA, Office of Advocacy, “Frequently Asked Questions,” available at <http://web.sba.gov/faqs/faqindex.cfm?areaID=24> (last visited Aug. 31, 2012).

⁸ 5 U.S.C. § 601(4).

⁹ INDEPENDENT SECTOR, *THE NEW NONPROFIT ALMANAC & DESK REFERENCE* (2010).

¹⁰ 5 U.S.C. § 601(5).

¹¹ U.S. CENSUS BUREAU, *STATISTICAL ABSTRACT OF THE UNITED STATES: 2011*, Table 427 (2007).

¹² The 2007 U.S. Census data for small governmental organizations are not presented based on the size of the population in each such organization. There were 89,476 local governmental organizations in 2007. If we assume that county, municipal, township, and school district organizations are more likely than larger governmental organizations to have populations of 50,000 or less, the total of these organizations is 52,095. If we make the same population assumption about special districts, specifically that they are likely to have a population of 50,000 or less, and also assume that special districts are different from county, municipal, township, and school districts, in 2007 there were 37,381 such special districts. Therefore, there are a total of 89,476 local government organizations. As a basis of estimating how many of these 89,476 local government organizations were small, in 2011, we note that there were a total of 715 cities and towns (incorporated places and minor civil divisions) with populations over 50,000. CITY AND TOWNS TOTALS: VINTAGE 2011 – U.S. Census Bureau, available at <http://www.census.gov/popest/data/cities/totals/2011/index.html>. If we subtract the 715 cities and towns that meet or exceed the 50,000 population threshold, we conclude that approximately 88,761 are small. U.S. CENSUS BUREAU, *STATISTICAL ABSTRACT OF THE UNITED STATES 2011*, Tables 427, 426 (Data cited therein are from 2007).

broadcasting equipment.”¹³ The SBA has developed a small business size standard for firms in this category, which is: all such firms having 750 or fewer employees.¹⁴ According to Census Bureau data for 2007, there were a total of 939 establishments in this category that operated for part or all of the entire year. Of this total, 784 had less than 500 employees and 155 had more than 100 employees.¹⁵ Thus, under this size standard, the majority of firms can be considered small.

E. Description of Projected Reporting, Record keeping and Other Compliance Requirements for Small Entities

8. Unlicensed devices operating in the 5.925-7.250 GHz and 24.05-29.00 GHz band are already required to be authorized under the Commission's certification procedure as a prerequisite to marketing and importation, and the Report and Order makes no change to that requirement. *See* 47 C.F.R. §§ 15.101, 15.201, 15.250, and 15.252. Currently, the 75-85 GHz band is a restricted band in which unlicensed device may not only transmit spurious (unintentional) emissions. The Report and Order modifies the existing Section 15.205, 47 C.F.R. § 15.205, of the rules to remove the prohibition on intentional emissions in this band and adopt the same certification procedures for level probing radars operating in this band as for the other above-listed frequency bands. The technical requirements adopted in this Report and Order, as discussed below, do not impose significant burden and will not have a significant economic impact on a substantial number of small entities that are, or may be, subject to the requirements of the rules in the item.

F. Steps taken to Minimize Significant Economic Impact on Small Entities and Significant Alternatives Considered

9. The RFA requires an agency to describe any significant alternatives that it has considered in reaching its proposed approach, which may include the following four alternatives (among others): (1) the establishment of differing compliance or reporting requirements or timetables that take into account the resources available to small entities; (2) the clarification, consolidation, or simplification of compliance or reporting requirements under the rule for small entities; (3) the use of performance, rather than design, standards; and (4) an exemption from coverage of the rule, or any part thereof, for small entities.¹⁶

10. In this Report and Order, we modify our rules to provide a set of new technical and operational rules to govern the operation of LPR devices installed both in open-air environments and inside storage tanks (TLPR applications) in the following frequency bands: 5.925-7.250 GHz, 24.05-29.00 GHz, and 75-85 GHz. To permit LPR operation in the 75-85 GHz band, we also modify the existing Section 15.205 of the rules to remove the prohibition on intentional emissions in this band. These rule changes will provide needed flexibility and cost savings for LPR devices, benefiting the U.S. consumers and manufacturers without causing harmful interference to authorized services. The amended rules will allow devices with accurate and reliable target resolution to identify water levels in rivers and dams or critical levels of materials such as fuel or sewer-treated waste, reducing overflow and spillage and minimizing exposure of maintenance personnel in the case of high risk substances. The amended rules would also, to the extent practicable, harmonize our technical rules for LPR devices with similar

¹³ U.S. Census Bureau, 2007 NAICS Definitions, “334220 Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing”; <http://www.census.gov/naics/2007/def/ND334220.HTM#N334220>.

¹⁴ 13 C.F.R. § 121.201, NAICS code 334220.

¹⁵ http://factfinder.census.gov/servlet/IBQTable?_bm=y&-fds_name=EC0700A1&-geo_id=&-_skip=300&-ds_name=EC0731SG2&-_lang=en.

¹⁶ 5 U.S.C. § 603(c).

European standards and would improve the competitiveness of U.S. manufacturers in the global economy, leading to potential cost savings for small businesses. We find that the benefits of the above changes to the rules outweigh their regulatory costs. We believe that the adopted rules will apply equally to large and small entities. Therefore, there is no inequitable impact on small entities.

11. **Report to Congress:** The Commission will send a copy of the Report and Order, including this FRFA, in a report to be sent to Congress pursuant to the Congressional Review Act.¹⁷ In addition, the Commission will send a copy of the Report and Order, including this FRFA, to the Chief Counsel for Advocacy of the SBA. A copy of the Report and Order and FRFA (or summaries thereof) will also be published in the Federal Register.¹⁸

¹⁷ See 5 U.S.C. § 801(a)(1)(A).

¹⁸ See 5 U.S.C. § 604(b).

APPENDIX B
Parties Submitting Comments

Comments

1. Delphi Automotive (Delphi)
2. Engineers for the Integrity of Broadcast Auxiliary Services Spectrum (EIBASS)
3. Emerson Process Management (Emerson)
4. Hach Company (Hach)
5. High Sierra Electronics (High Sierra)
6. Krohne America, Inc. (Krohne)
7. Magnetrol International, Incorporated (Magnetrol)
8. Measurement, Control & Automation Association (MCAA)
9. National Academy of Science's Committee on Radio Frequencies (CORF)
10. National Radio Astronomy Observatory (NRAO)
11. Siemens Milltronics Process Instruments (Siemens)
12. Sutron Corporation (Sutron)
13. VEGA Americas, Inc. (formerly Ohmart/VEGA Corporation) (VEGA)
14. YSI Incorporated (YSI)

Reply Comments

1. Hach Company (Hach)
2. Krohne America, Inc. (Krohne)
3. Magnetrol International, Incorporated (Magnetrol)
4. Measurement, Control & Automation Association (MCAA)
5. National Radio Astronomy Observatory (NRAO)
6. O3b Limited (O3b)
7. Siemens Milltronics Process Instruments (Siemens)
8. Sutron Corporation (Sutron)
9. VEGA Americas, Inc. (formerly Ohmart/VEGA Corporation) (VEGA)

APPENDIX C

Antenna Side-Lobe Gain

1. Antennas can produce emissions in unwanted directions due to side lobes. The side lobes are smaller beams that are away from the main beam. A good (highly efficient) antenna would concentrate power into the main beam and limit the number of side lobes as well as suppress side lobe emissions to very low levels, but could never completely eliminate them.

2. Although an LPR operates in a downward direction and is constrained to a narrow beamwidth, there are horizontal emissions from the LPR antenna side lobes. These emissions can be controlled by a side-lobe gain limit, such that side-lobe emissions are suppressed to less than the general emission limit in Section 15.209 (*i.e.*, -41.3 dBm EIRP), which has been established as the minimum interference protection level to authorized radio services from unlicensed operations above 960 MHz.

3. The proposed rules require that the LPR antenna beamwidth be less than 8 degrees for the 75-85 GHz band and less than 12 degrees for the 24.05-29.00 GHz and 5.925-7.250 GHz bands. The proposed rules also require a fixed -10 dBi side-lobe gain for elevation angles greater than 60 degrees.

4. To achieve the above required antenna beamwidths, a parabolic antenna with 100 % efficiency must have a certain minimum gain. For an LPR operating at the maximum EIRP power with a parabolic antenna at the minimum main beam gain required to meet the maximum beamwidth limit, the table below shows the maximum side-lobe gain limit when it is specified relative to the main beam gain rather than an absolute gain limit of -10 dBi and the difference between the two limits.

Table 2 – Fixed Side-Lobe Gain vs. Relative Side-Lobe Gain

A	B	C	D	E	F	G
Frequency Band (GHz)	Main Beam EIRP Limit (dBm/MHz) (Note 1)	Side lobe EIRP Limit (dBm/MHz) (Note 2)	Minimum Main Beam Gain (dBi) (Note 3)	Relative Side lobe Gain Limit (dB) (C) – (B)	Side lobe Gain Limit (dBi) (D) + (E)	Difference between Fixed -10 dBi Proposed Limit and Relative Side Lobe Gain (dB) (-10 – (F))
5.925-7.250	-33	-55	22.7	-22	0.7	-10.7
24.05-29.00	-14	-41	22.7	-27	-4.3	-5.7
75-85	-3	-41	26.3	-38	-11.7	1.7

- Notes:
1. These limits are the proposed EIRP limits for the different LPR frequency bands.
 2. These limits are the general interference protection criteria for the different frequency bands.
 3. These numbers show the minimum main beam gain for a parabolic antenna operating in accordance with the required antenna beamwidth (less than 8 degrees for the 75-85 GHz band and less than 12 degrees for the lower frequency bands.)

5. As illustrated in Table 2 above, when the LPR operates at maximum EIRP power with the minimum main beam gain for a parabolic antenna, the side-lobe gain limit based on the relative gain

specification varies from 1.7 dB below to 10.7 dB above the proposed fixed -10 dBi side-lobe antenna gain limit. Therefore, in the 75-85 GHz band, the relative side-lobe gain is 1.7 dB less than an antenna with a -10 dBi fixed side-lobe gain, while in the two lower frequency bands, the relative side-lobe gain limit is 5.7 dB and 10.7 dB higher than an antenna with a -10 dBi fixed side-lobe gain. The difference between the two limits will depend on the actual main beam gain of the antenna. Based on the examples above, when the LPR is operated at the maximum proposed EIRP power limits, a fixed side-lobe gain limit may result in side-lobe power which may be greater or less than the side-lobe limits shown in column C in Table 2. Side-lobe power greater than the limit increases the interference potential and side-lobe power less than the limit requires the side-lobe suppression to be more than necessary, making the antenna design more challenging.

6. These problems can be eliminated by specifying the antenna side-lobe gain limit relative to the main-beam gain, instead of the proposed -10 dBi fixed side-lobe gain. If an antenna has a low main-beam gain because of losses due to inefficiency and the input power to the antenna is increased to compensate for the loss and to attain the maximum main beam EIRP, a side-lobe EIRP gain limit relative to the main beam gain will ensure that side-lobe power is always suppressed to less than the general emission limit of Section 15.209. This will maintain the existing interference protection criteria for authorized radio services. The side-lobe gain limits relative to main-beam gain limits are illustrated in Table 3 below.

Table 3 – Side-Lobe Gain Limit Relative to Main Beam Gain Limit

Frequency Range (GHz)	Antenna Side lobe Gain Relative to Main Beam Gain (dB)
5.925-7.250	-22
24.05-29.00	-27
75-85	-38

APPENDIX D

Final Rule Changes

For the reasons discussed in the preamble, the Federal Communications Commission amends title 47 of the Code of Federal Regulations Part 15 to read as follows:

Part 15 – RADIO FREQUENCY DEVICES

1. The authority citation for Part 15 continues to read as follows:

Authority: 47 U.S.C. 154, 202, 303, 304, 307 and 544A.

2. Section 15.3 is amended by adding paragraph (ii) to read as follows:

§ 15.3 Definitions.

* * * * *

(ii) Level Probing Radar (LPR): A short-range radar transmitter used in a wide range of applications to measure the amount of various substances, mostly liquids or granulates. LPR equipment may operate in open-air environments or inside an enclosure containing the substance being measured.

* * * * *

3. Section 15.31 is amended by revising paragraphs (c) and (g) and adding paragraph (q) to read as follows:

§ 15.31 Measurement standards.

* * * * *

(c) Except as otherwise indicated in § 15.256, for swept frequency equipment, measurements shall be made with the frequency sweep stopped at those frequencies chosen for the measurements to be reported.

* * * * *

(g) Equipment under test shall be positioned and adjusted, using those controls that are readily accessible to or are intended to be accessible to the consumer, in such a manner as to maximize the level of the emissions. For those devices to which wire leads may be attached by the operator, tests shall be performed with wire leads attached. The wire leads shall be of the length to be used with the equipment if that length is known. Otherwise, wire leads one meter in length shall be attached to the equipment. Longer wire leads may be employed if necessary to interconnect to associated peripherals.

* * * * *

(q) As an alternative to § 15.256 of this part, a level probing radar (LPR) may be certified as an intentional radiator by showing compliance with the general provisions for operation under Part 15 Subpart C of this chapter, provided that the device is tested in accordance with the provisions in either

paragraphs (q)(1) or (q)(2) below. Compliance with the general provisions for an intentional radiator may require compliance with other rules in this part, e.g., § 15.5, § 15.31, § 15.35, etc., when referenced.

(1) An LPR device intended for installation inside metal and concrete enclosures may show compliance for radiated emissions when measured outside a representative enclosure with the LPR installed inside, in accordance with the measurement guidelines established by the Commission for these devices. LPR devices operating inside these types of enclosures shall ensure that the enclosure is closed when the radar device is operating. Care shall be taken to ensure that gaskets, flanges, and other openings are sealed to eliminate signal leakage outside of the structure. The responsible party shall take reasonable steps to ensure that LPR devices intended for use in these types of enclosures shall not be installed in open-air environments or inside enclosures with lower radio-frequency attenuating characteristics (e.g., fiberglass, plastic, etc.). An LPR device approved under this subsection may only be operated in the type of enclosure for which it was approved.

(2) Except as provided in paragraph (q)(1) of this section, an LPR device shall be placed in testing positions that ensure the field strength values of the radiated emissions are maximized, including in the main beam of the LPR antenna.

* * * * *

4. Section 15.35 is amended by revising paragraphs (b) and (c) to read as follows:

§ 15.35 Measurement detector functions and bandwidths.

* * * * *

(b) Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. When average radiated emission measurements are specified in this part, including average emission measurements below 1000 MHz, there also is a limit on the peak level of the radio frequency emissions. Unless otherwise specified, e.g., see §§ 15.250, 15.252, 15.255, 15.256, and 15.509-15.519 of this part, the limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test. This peak limit applies to the total peak emission level radiated by the device, e.g., the total peak power level. Note that the use of a pulse desensitization correction factor may be needed to determine the total peak emission level. The instruction manual or application note for the measurement instrument should be consulted for determining pulse desensitization factors, as necessary.

(c) Unless otherwise specified, e.g., Section 15.255(b), and Section 15.256(l)(5), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to notification or verification.

* * * * *

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

§ 15.205 Restricted bands of operation.

* * * * *

(d) * * *

* * * * *

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

* * * * *

6. New Section 15.256 is added to read as follows:

§ 15.256 Operation of level probing radars within the bands 5.925-7.250 GHz, 24.05-29.00 GHz, and 75-85 GHz.

- (a) Operation under this section is limited to level probing radar (LPR) devices.
- (b) LPR devices operating under the provisions of this section shall utilize a dedicated or integrated transmit antenna, and the system shall be installed and maintained to ensure a vertically downward orientation of the transmit antenna’s main beam.
- (c) LPR devices operating under the provisions of this section shall be installed only at fixed locations. The LPR device shall not operate while being moved, or while inside a moving container.
- (d) Hand-held applications are prohibited.
- (e) Marketing to residential consumers is prohibited.
- (f) The fundamental bandwidth of an LPR emission is defined as the width of the signal between two points, one below and one above the center frequency, outside of which all emissions are attenuated by at least 10 dB relative to the maximum transmitter output power when measured in an equivalent resolution bandwidth.
 - (1) The minimum fundamental emission bandwidth shall be 50 MHz for LPR operation under the provisions of this section.
 - (2) LPR devices operating under this section must confine their fundamental emission bandwidth within the 5.925-7.250 GHz, 24.05-29.00 GHz, and 75-85 GHz bands under all conditions of operation.
- (g) Fundamental Emissions Limits
 - (1) All emission limits provided in this section are expressed in terms of Equivalent Isotropic Radiated Power (EIRP).
 - (2) The EIRP level is to be determined from the maximum measured power within a specified bandwidth.
 - (i) The EIRP in 1 MHz is computed from the maximum power level measured within any 1-MHz bandwidth using a power averaging detector;
 - (ii) The EIRP in 50 MHz is computed from the maximum power level measured with a peak detector in a 50-MHz bandwidth centered on the frequency at which the maximum average power level is realized and this 50 MHz bandwidth must be

contained within the authorized operating bandwidth. For a RBW less than 50 MHz, the peak EIRP limit (in dBm) is reduced by $20 \log(\text{RBW}/50)$ dB where RBW is the resolution bandwidth in megahertz. The RBW shall not be lower than 1 MHz or greater than 50 MHz. The video bandwidth of the measurement instrument shall not be less than the RBW. If the RBW is greater than 3 MHz, the application for certification filed shall contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation employed in the testing.

- (3) The EIRP limits for LPR operations in the bands authorized by this rule section are provided in Table 1 below:

Frequency Band of Operation (GHz)	Average Emission Limit (EIRP in dBm measured in 1 MHz)	Peak Emission Limit (EIRP in dBm measured in 50 MHz)
5.925-7.250	-33	7
24.05-29.00	-14	26
75-85	-3	34

Table 1 – LPR EIRP emission limits

The emission limits in Table 1 are based on boresight measurements (*i.e.*, measurements performed within the main beam of an LPR antenna).

(h) Unwanted Emissions Limits

Unwanted emissions from LPR devices shall not exceed the general emission limit in § 15.209 of this chapter.

(i) Antenna Beamwidth

- (1) LPR devices operating under the provisions of this section within the 5.925-7.250 GHz and 24.05-29.00 GHz bands must use an antenna with a -3 dB beamwidth no greater than 12 degrees.
- (2) LPR devices operating under the provisions of this section within the 75-85 GHz band must use an antenna with a -3 dB beamwidth no greater than 8 degrees.

(j) Antenna Side Lobe Gain

LPR devices operating under the provisions of this section must limit the side lobe antenna gain relative to the main beam gain for off-axis angles from the main beam of greater than 60 degrees to the levels provided in Table 2 below:

Frequency Range (GHz)	Antenna Side Lobe Gain Limit Relative to Main Beam Gain (dB)
5.925-7.250	-22
24.05-29.00	-27
75-85	-38

Table 2 – Antenna side lobe gain limits

- (k) Emissions from digital circuitry used to enable the operation of the transmitter may comply with the limits in § 15.209 of this chapter provided it can be clearly demonstrated that those emissions are due

solely to emissions from digital circuitry contained within the transmitter and the emissions are not intended to be radiated from the transmitter's antenna. Emissions from associated digital devices, as defined in § 15.3(k) of this chapter, *e.g.*, emissions from digital circuitry used to control additional functions or capabilities other than the operation of the transmitter, are subject to the limits contained in Subpart B of Part 15 of this chapter. Emissions from these digital circuits shall not be employed in determining the -10 dB bandwidth of the fundamental emission or the frequency at which the highest emission level occurs.

(l) Measurement Procedures

- (1) Radiated measurements of the fundamental emission bandwidth and power shall be made with maximum main-beam coupling between the LPR and test antennas (boresight).
- (2) Measurements of the unwanted emissions radiating from an LPR shall be made utilizing elevation and azimuth scans to determine the location at which the emissions are maximized.
- (3) All emissions at and below 1000 MHz except 9-90 kHz and 110-490 kHz bands are based on measurements employing a CISPR quasi-peak detector.
- (4) The fundamental emission bandwidth measurement shall be made using a peak detector with a resolution bandwidth of 1 MHz and a video bandwidth of at least 3 MHz.
- (5) The provisions in §§ 15.35(b) and (c) of this part that require emissions to be averaged over a 100 millisecond period and that limits the peak power to 20 dB above the average limit do not apply to devices operating under paragraphs (a)-(l) of this section.
- (6) Compliance measurements for minimum emission bandwidth of frequency-agile LPR devices shall be performed with any related frequency sweep, step, or hop function activated.
- (7) Compliance measurements shall be made in accordance with the specific procedures published or otherwise authorized by the Commission.