

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

In the Matter of
Revision of Part 15 of the Commission's Rules to
Permit Unlicensed National Information
Infrastructure (U-NII) Devices in the 5 GHz Band
ET Docket No. 13-49

FIRST REPORT AND ORDER

Adopted: March 31, 2014

Released: April 1, 2014

By the Commission: Chairman Wheeler and Commissioners Clyburn, Rosenworcel, Pai and O'Rielly
issuing separate statements.

TABLE OF CONTENTS

Table with 2 columns: Heading and Paragraph #. Includes sections I-V and APPENDIX A-C.

I. INTRODUCTION

1. In 2013, the Commission issued the Notice of Proposed Rule Making that initiated this proceeding, with the goal of supporting the growing needs of businesses and consumers for fixed and mobile broadband communications using Unlicensed National Information Infrastructure (U-NII) devices in the 5.15-5.35 GHz and 5.47-5.850 GHz bands.

1 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. 1749, (2013) (NPRM); 47 C.F.R. Part 15 Subpart E—Unlicensed National Information Infrastructure Devices.

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rules to better ensure that these devices do not cause harmful interference to authorized Federal and non-Federal users in these bands. U-NII devices are unlicensed intentional radiators, which use wideband digital modulation techniques to provide a wide array of high-data-rate mobile and fixed communications used by individuals, businesses, and institutions, particularly for wireless local area networking – including Wi-Fi – and broadband access.²

2. In this First Report and Order (First R&O), we increase the utility of the 5 GHz band where U-NII devices are currently permitted to operate, and modify certain U-NII rules and testing procedures to ensure that U-NII devices do not cause harmful interference to authorized users of these bands. Specifically:

- For U-NII devices in the 5.15-5.25 GHz band, we remove the indoor-only restriction and increase the permitted power, thus increasing the utility of spectrum and accommodating the next generation of Wi-Fi technology.
- We extend the upper edge of the 5.725-5.825 GHz band to 5.85 GHz and consolidate the Part 15 rules applicable to all digitally modulated devices operating across this 125 megahertz of spectrum to ensure that all such devices comply with U-NII requirements intended to protect authorized users from harmful interference.
- We require that all U-NII device software be secured to prevent its modification to ensure that the devices will operate as authorized by the Commission, thus reducing the potential for harmful interference to authorized users.
- To protect Terminal Doppler Weather Radar (TDWR) systems and other radar systems operating in the 5.250-5.350 GHz and 5.470-5.725 GHz bands from harmful interference, we modify certain technical rules and compliance measurement procedures for U-NII devices operating in these bands.

II. BACKGROUND

A. Current Frequency Allocations

3. Part 15 of the Commission's rules permits the operation of radio frequency devices without issuing individual licenses to operators of these devices. The Commission's Part 15 rules are designed to ensure that there is a low probability that these devices will cause harmful interference to other users of the same or adjacent spectrum. Typically, unlicensed devices operate at very low power over relatively short distances, and often employ various techniques, such as dynamic spectrum access or listen-before-talk protocols, to reduce the interference risk to others as well as themselves. The primary operating condition for unlicensed devices is that the operator must accept whatever interference is received and must not cause harmful interference. Should harmful interference occur, the operator is required to immediately correct the interference problem or to cease operation.³

4. In 1997, the Commission made available 300 megahertz of spectrum for use by U-NII devices, which are regulated under Part 15, Subpart E of the Commission's rules. The Commission established rules for the 5.15-5.25 GHz (U-NII-1 band), 5.25-5.35 GHz (U-NII-2A band), and 5.725-

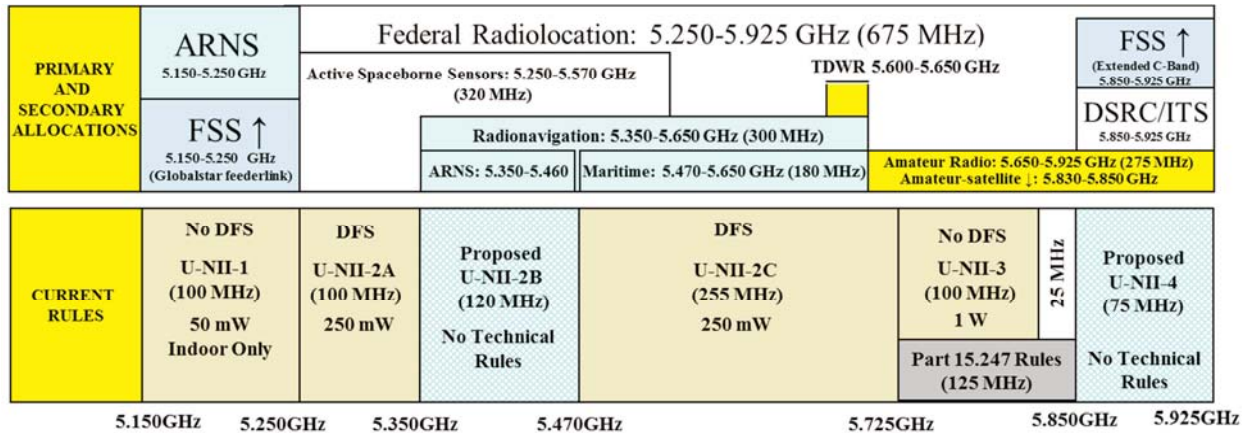
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Report & Order does not address the use of U-NII devices into the 5.35-5.47 GHz and 5.85-5.925 GHz bands, pending additional technical analyses of those bands. *See NPRM* at paras. 75-112. These bands are the subject of further study and will be addressed in a separate future order. *See also* 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. A copy of this report has been placed in the docket of this proceeding.

² *See* 47 C.F.R. § 15.403(s).

³ *See* 47 C.F.R. §§ 15.5(b) and (c).

5.825 GHz (U-NII-3 band).⁴ In 2003, the Commission made an additional 255 megahertz of spectrum available for U-NII devices at 5.47-5.725 GHz (U-NII-2C band).⁵ These actions aligned the frequency bands used by U-NII devices in the United States with the frequency bands used by such devices in other parts of the world, thus decreasing development and manufacturing costs by allowing for the same products to be used in most parts of the world. The chart below summarizes the frequency bands for U-NII device operation that were discussed in the *NPRM*. The chart also indicates that unlicensed devices may currently be authorized under the digital modulation rules in Section 15.247 to operate in the U-NII-3 band, as well as in the 25 megahertz between that band and the potential future U-NII-4 band.



5. The U-NII-1 band is allocated on a primary basis to the Aeronautical Radionavigation Service (ARNS) for both Federal and non-Federal operations and on a primary basis for Fixed Satellite Service (FSS) (Earth-to-space) for non-Federal MSS feeder link operations.⁶

6. The U-NII-2A band is allocated on a primary basis to the Earth Exploration Satellite (active), Radiolocation, and Space Research (active) Services for Federal operation, and for non-Federal operation on a secondary basis.⁷

7. The U-NII-2C band is allocated on a primary basis to the Radiolocation Service for Federal operation. The 5.47-5.65 GHz portion of that band is also allocated on a primary basis to the Radiolocation Service for non-Federal operation, and on a primary basis to the Maritime Radionavigation Service for both Federal and non-Federal operations. The 5.47-5.57 GHz band segment is allocated on a primary basis to the Earth Exploration-Satellite (active) and Space Research (active) Services for Federal operation and on the secondary basis for non-Federal operation. The 5.6-5.65 GHz subportion is also

⁴ See Amendment of the Commission’s Rules to Provide for Operation of Unlicensed NII Devices in the 5 GHz Frequency Range, *Report and Order*, ET Docket No. 96-102, 12 FCC Rcd 1576 (1997). (*U-NII Report and Order*). See 47 C.F.R. Part 15 Subpart E. In the *NPRM*, the Commission assigned sequential numbers to identify the 5 GHz band segments, both the current U-NII bands and future potential U-NII bands, which are discussed below. The Commission explained that while different organizations, both Federal and non-Federal, have used a variety of different identifiers for these band segments, it used sequential numbering to make it easier for the reader to follow the discussion in the *NPRM*. See *NPRM, supra*, at 1770-71, para. 4. To be consistent with the discussion in the *NPRM*, we will use the same sequential numbering convention to refer to the U-NII bands in this First R&O.

⁵ See Revision of Parts 2 and 15 of the Commission’s Rules to Permit Unlicensed National Information Infrastructure (U-NII) devices in the 5 GHz band, *Report and Order*, ET Docket No. 03-122, 18 FCC Rcd 24484 (2003). In this decision, the Commission also required that U-NII devices in the U-NII-2A and U-NII-2C bands employ dynamic frequency selection (DFS) to protect Federal radar operations and transmit power control (TPC) to protect the Earth exploration satellite service. See 47 C.F.R. § 15.407(h).

⁶ See 47 C.F.R. § 2.106, Table of Frequency Allocations.

⁷ *Id.*

allocated on a primary basis to the Meteorological Aids Service for both Federal and non-Federal operations. The band segment at 5.65-5.725 GHz is allocated on a secondary basis to the Amateur Radio Service for non-Federal operation.⁸

8. The U-NII-3 band is allocated on a primary basis to the Radiolocation Service for Federal operation, and is allocated on a secondary basis to the Amateur Radio Service for non-Federal operation.⁹

B. Expanding Utility of Existing U-NII Bands

9. In the *NPRM*, the Commission noted that this an opportune time for the Commission to re-examine the U-NII rules. A new Wi-Fi standard—IEEE 802.11ac—allows for wider bandwidth transmissions by devices that operate across more than one U-NII band, thus increasing use of the band for broadband services, permitting faster speeds, and easing Wi-Fi congestion.¹⁰ Currently, three sets of Wi-Fi standards are used for the 5-GHz U-NII bands: 802.11a, 802.11n and 802.11ac. Each standard specifies different channel bandwidths and data rates. For example, the 802.11a standard defines a 20-megahertz channel bandwidth with maximum data rate up to 54 Mbit/s,¹¹ and the 802.11n standard specifies 20- and 40-megahertz channel bandwidths with maximum data rate from 54 Mbit/s to 600 Mbit/s.¹² The new 802.11ac standard would allow for a significant increase in bandwidth and data rates in the 5 GHz band—it specifies bandwidths of 20, 40, 80, and 160 megahertz with a link data rate of approximately 1 Gbit/s.¹³

10. The amount of contiguous spectrum available for U-NII devices may also increase in the future as the Commission, in conjunction with NTIA and industry, continue technical analyses of the U-NII-2B and U-NII-4 bands to determine whether U-NII devices may operate in those bands without causing harmful interference to incumbent users of those bands. Due to the ongoing analyses, the Commission is not addressing those bands in this First R&O.

C. Terminal Doppler Weather Radar Interference Issues

11. In early 2009, the Federal Aviation Administration (FAA) reported harmful interference to their Terminal Doppler Weather Radar (TDWR) that operates within the 5.6-5.65 GHz band. Early field studies performed by the National Telecommunications and Information Administration's (NTIA's) Institute for Telecommunications Sciences (ITS) and FAA staff indicated the interference sources were certain unlicensed U-NII devices that operated in the same frequency band as these Federal radar systems. This interference was occurring despite the Commission's rules that require U-NII devices operating in this band to incorporate an interference mitigation technique called dynamic frequency selection (DFS).¹⁴

⁸ *Id.*

⁹ *Id.*

¹⁰ See www.Wi-Fi.org. How does Wi-Fi technology work? Wi-Fi is a short range technology that is often used in conjunction with a customer's DSL, Fiber, or cable modem service to connect end-user devices, such as PCs, laptops and smart phones, located within the customer's home or business to the Internet. In these cases, Wi-Fi allows users to move Wi-Fi enabled devices around within their homes or businesses without installing additional inside wiring, but the actual "connection" to the service provider is via the customer's DSL, Fiber, or cable modem service. Wi-Fi is widely available in airports, city parks, restaurants, bookstores and other public places called "hotspots," allowing those who are away from their homes or businesses to access the Internet.

¹¹ The 802.11a standard is an amendment to the original standard that was ratified in 1999. The amendment was incorporated into the published IEEE 802.11-2007.

¹² IEEE 802.11n is an amendment to the IEEE 802.11-2007 standard and was published in 2009.

¹³ The IEEE 802.11ac standard was published in December of 2013.

¹⁴ DFS is a mechanism that detects the presence of radar signals and dynamically guides a transmitter to switch to another channel whenever a particular condition (indicating a conflict with an active radar operation) is met. Prior to the start of any transmission, a U-NII device equipped with DFS capability must continually monitor the radio

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12. NTIA, FAA, the FCC's Enforcement Bureau and Office of Engineering and Technology, and industry participants analyzed the interference reports. Following these investigations, the Commission took actions to mitigate the interference situation, including issuing enforcement advisories to heighten users' awareness of TDWR interference issues,¹⁵ and placing conditions on U-NII device certifications to curtail the interference risk.¹⁶ The Commission also sent enforcement teams to work with FAA staff in the field, and took enforcement actions against operators of U-NII devices that caused harmful interference to TDWR installations, including issuing Letters of Inquiry and Notices of Apparent Liability for Forfeitures.¹⁷ Most of these interference cases were determined to have been caused by devices not certified for operation in the U-NII-2C band, which includes the 5.6-5.65 GHz band used by the TDWRs; no cases have been attributed to certified equipment operating properly in accordance with their grant of equipment authorization. Instead, these devices had been certified for operation in the U-NII-3 band, either as U-NII devices under Section 15.407 of our rules, or as digitally modulated intentional radiators under Section 15.247 of our rules, and had been illegally modified and operated at high power levels in elevated locations.

13. The Commission's investigations found that most 5 GHz devices are manufactured to enable operation across a wide range of frequencies, extending down into the 4 GHz bands and up to almost 6 GHz. The devices are controlled by software that manages the specific parameters used in the equipment. In most of those cases for which a specific cause was determined, the harmful interference was the result of third parties or users modifying the software configurations to enable operation in frequency bands other than those for which the device had been certified, but without meeting the

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environment for radar's presence. If the U-NII device determines that a radar signal is present, it must either select another channel to avoid harmful interference with radar, or go into a "sleep mode" if no other channel is available.

¹⁵ See FCC Enforcement Advisory, TDWR and U-NII Devices, "Enforcement Bureau Takes Action to Prevent Interference to FAA-Operated Terminal Doppler Weather Radars Critical to Flight Safety," (TDWR Enforcement Advisory) DA 12-459, September 27, 2012, Enforcement Advisory No. 2012-07, available at: <http://www.fcc.gov/encyclopedia/weather-radar-interference-enforcement>. Users of U-NII devices include wireless Internet service providers (WISPs), which were the focus of the Enforcement Advisory for outdoor fixed installations, as well as consumers for indoor wireless networking.

¹⁶ See Memorandum from Julius Knapp, Chief, FCC Office of Engineering and Technology and P. Michele Ellison, Chief, FCC Enforcement Bureau to Manufacturers and Operators of Unlicensed 5 GHz Outdoor Network Equipment, dated July 27, 2010. <http://www.fcc.gov/encyclopedia/weather-radar-interference-enforcement>.

¹⁷ See *VPNet, Inc.*, Order & Consent Decree, 28 FCC Rcd 15429 (Enf. Bur. 2013); *Ayustar Corporation*, Order & Consent Decree, 28 FCC Rcd 15420 (Enf. Bur. 2013); *Towerstream Corporation*, Notice of Apparent Liability for Forfeiture and Order, 28 FCC Rcd 11604 (Enf. Bur. 2013); *Argos Net, Inc.*, Forfeiture Order, 28 FCC Rcd 1126 (Enf. Bur. 2013); *Directlink, LLC*, Notice of Apparent Liability for Forfeiture and Order, 28 FCC Rcd 37 (Enf. Bur. 2013); *Skybeam Acquisition Corporation*, Notice of Apparent Liability for Forfeiture and Order, 27 FCC Rcd 11337 (Enf. Bur. 2012); *AT&T, Inc.* Forfeiture Order, 27 FCC Rcd 10803 (Enf. Bur. 2012); *VPNet, Inc.*, Notice of Apparent Liability for Forfeiture and Order, 27 FCC Rcd 2879 (Enf. Bur. 2012); *Argos Net, Inc.*, Notice of Apparent Liability for Forfeiture and Order, 27 FCC Rcd 2786 (Enf. Bur. 2012); *Insight Consulting Group of Kansas City, LLC*, Notice of Apparent Liability of Forfeiture and Order, 26 FCC Rcd 10699 (Enf. Bur. 2011); *Ayustar Corp.*, Notice of Apparent Liability for Forfeiture and Order, 26 FCC Rcd 10693 (Enf. Bur. 2011); *Rapidwave, LLC*, Notice of Apparent Liability for Forfeiture and Order, 26 FCC Rcd 10678 (Enf. Bur. 2011); *AT&T, Inc.*, Notice of Apparent Liability for Forfeiture, 26 FCC Rcd 1894 (Enf. Bur. 2011); *Utah Broadband*, Notice of Apparent Liability for Forfeiture, 26 FCC Rcd 1419 (Enf. Bur. 2011) (forfeiture paid). See also *Ayustar Corp.*, Memorandum Opinion and Order, 25 FCC Rcd 16,249 (Enf. Bur. 2010); *Sling Broadband, LLC*, Forfeiture Order, 26 FCC Rcd 13062 (Enf. Bur. 2011). (hereinafter TDWR Enforcement Cases) Nearly all of these cases involved Enforcement Bureau findings that devices were operated outside of their certification, resulting in violations of the Communications Act because the operators of the devices did not have a license to operate equipment that had been modified and thus did not meet the technical requirements in Part 15 of our Rules. The Notice of Apparent Liability issued to Towerstream was an action by the full Commission, and covered both operation of radio transmitters without a license, and causing harmful interference to TDWRs.

technical requirements for operation in those frequency bands (such as the U-NII-2C band where interference to the TDWR was occurring).

14. Previously, in 2006, the Commission had issued measurement procedures to test devices to ensure that they comply with the radar detection and the DFS requirements for the U-NII-2A and U-NII-2C bands.¹⁸ Following the investigations, the Office of Engineering and Technology provided applicants for certification a representative way for demonstrating that their U-NII devices would not cause harmful interference to TDWR installations operating in the U-NII-2C band. Specifically, the FCC's Office of Engineering and Technology (OET) has advised applicants that it will approve such devices only upon assurance by the applicant that: (a) U-NII devices may not operate co-frequency with TDWR operations at 5.6-5.65 GHz;¹⁹ (b) grantee will provide owners, operators and installers of these devices with instructions that a master or client device within 35 km of a TDWR location must be separated by at least 30 megahertz (center-to-center) from the TDWR operating frequency and procedures for registering the devices in an industry-sponsored database;²⁰ (c) the device does not include configuration controls to change the frequency of operation to any frequency other than those specified in the grant of certification; and (d) the device's software configurations do not allow for ad hoc networking, country code selection, or other mode of operation that would disable the DFS functionality of the U-NII device.²¹ Subsequently, NTIA and the FAA recommended to the Commission that the 2006 compliance and measurement procedures for DFS be revised to include modified definitions, technical requirements (e.g., detection bandwidth and pulse repetition interval values), radar test waveforms, test procedures, and test report guidelines.²²

III. DISCUSSION

15. U-NII devices already play an important role in meeting public demand for wireless broadband service, particularly wireless local area networking and broadband access. This foundation, coupled with increasing demand for wireless broadband applications and new Wi-Fi technology, signals a

¹⁸ These procedures were based on the work of the International Telecommunication Advisory Committee-Radiocommunication (ITAC-R) Government/Industry Project Team (Project Team) /Industry Project Team (Project Team) and recommendations from NTIA. See Letter from Fredrick R. Wentland, Associate Administrator, NTIA to Julius Knapp, Deputy Chief, OET, filed in ET Docket No. 03-122 on March 30, 2006, and the enclosure *Compliance Measurement Procedures for Unlicensed National Information Infrastructure Devices Operating in the 5250-5350 MHz and 5470-5725 MHz bands Incorporating Dynamic Frequency Selection (Compliance Measurement Procedures)*. See also Revision of Parts 2 and 15 of the Commission's Rules to permit Unlicensed National Information Infrastructure (U-NII) devices in the 5 GHz Band, *Memorandum Opinion and Order*, ET Docket No.03-122, 21 FCC Rcd 7672, Appendix: Compliance Measurement Procedures for Unlicensed-National Information Infrastructure Devices Operating in the 5250-5350 MHz and 5470-5725 MHz Bands Incorporating Dynamic Frequency Selection. (hereinafter 2006 DFS Compliance Measurement Procedures). These procedures describe only the measurement procedures used to demonstrate compliance with DFS requirements. U-NII devices are also required to comply with other technical requirements which are not described in these procedures.

¹⁹ This restriction is placed on the certification grant as a condition of operation. See FCC, OET, "Interim Plans to Approve UNII Devices Operating in the 5470-5725 MHz Band with Radar Detection and DFS Capabilities", KDB Publication No. 443999 DOI.

²⁰ We note that the Wireless Internet Service Providers Association (WISPA) maintains a voluntary database accessible to the public, containing TDWR system locations. See <http://www.wispa.org>.

²¹ See, e.g., KDB 594280 available at: <http://www.fcc.gov/labhelp>.

²² The Federal Government had been considering the 5.15-5.25 GHz band as potential spectrum for relocation of services displaced from the 1755-1850 MHz band. However, the NTIA ultimately chose to pursue options that did not require relocation of Federal telemetry systems into this band. See Letter from Lawrence E. Strickling, Administrator, NTIA to Julius Genachowski, Chairman, FCC, filed February 19, 2013, and the enclosure *Appendix - Proposal for New Unlicensed National Information Infrastructure Dynamic Frequency Selection Certification Waveforms*. A copy of this document has been placed in the docket file for this proceeding.

bright future for unlicensed operations in the 5 GHz band. To meet continuing demand, in this First R&O we are taking a number of actions to increase the utility of the 555 megahertz of the 5 GHz band already available for U-NII operations, while protecting incumbent users from harmful interference.

16. In this First R&O, we modify the Part 15 rules for the U-NII-1 band by removing the indoor-only restriction and increasing the permitted power level.²³ These changes provide more flexibility for providing broadband service, whether indoors or outdoors, and take advantage of the new 802.11ac standard to achieve higher data rate transmissions across multiple U-NII segments of the 5 GHz band.

17. We also modify our rules to require manufacturers to secure the software in all U-NII devices to prevent modifications that would allow the device to operate in a manner inconsistent with the equipment certification. This change will reduce the likelihood of harmful interference not only to TDWR systems, but to all authorized services in the 5 GHz bands.

18. To protect TDWR and other radar systems in the U-NII-2A and U-NII-2C segments from harmful interference, we also modify certain technical rules for U-NII devices authorized to operate in these bands. We also direct the Office of Engineering and Technology to update its compliance measurement procedures to improve testing for radar detection and to eliminate certain outdated performance tests.

19. We consolidate the provisions applicable to digitally modulated devices under Section 15.247 of the rules for this band with the U-NII rules in Section 15.407 so that all the digitally modulated devices operating in the 5 GHz band will operate under the combined rules and be subject to the new device security requirement. This change will eliminate a major cause of harmful interference to the TDWR: when users illegally modify devices certified to operate under Section 15.247 to operate in the 5.47-5.725 GHz band without implementing DFS. This rule consolidation also will reduce complexity and costs in authorizing technically similar devices under different rules.

20. We adopt several miscellaneous rule modifications related to U-NII operations at 5 GHz, and adopt transition periods for the new rules we adopt today.

21. Finally, we direct OET to revise the 2006 DFS Compliance Measurement Procedures and other compliance measurement guidelines for U-NII devices, consistent with the decisions made in this First R&O. We further direct OET to publish the revised measurement procedures and guidelines online in the Knowledge Database (KDB).²⁴

A. Increasing the Utility of the U-NII-1 Band

22. *Background.* The U-NII-1 band was one of the first 5 GHz band segments made available for U-NII devices in 1997. The Commission adopted technical rules for U-NII devices in this band to protect the nascent NGSO/MSS industry which had gained an international FSS allocation at 5 GHz in 1995. Specifically, the Commission adopted a peak transmitter output power limit of 50 mW with up to 6 dBi antenna gain permitted, which equates to 200 mW EIRP,²⁵ and a transmitter peak power spectral density of 2.5 mW/MHz (4 dBm/MHz).²⁶ The Commission believed that a 50 mW peak output

²³ See Letter from Karl B. Nebbia, Associate Administrator, Office of Spectrum Management, to Julius P. Knapp, Chief, Office of Engineering and Technology (July 22, 2013) at Enclosure 1.

²⁴ See www.fcc.gov/labhelp.

²⁵ See 47 C.F.R. §2.1. EIRP is defined as the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna.

²⁶ See 47 C.F.R. §15.403. Power Spectral Density is defined as the total energy output per unit bandwidth from a pulse or sequence of pulses for which the transmit power is at its peak or maximum level, divided by the total duration of the pulses. This total time does not include the time between pulses during which the transmit power is off or below its maximum level.

power with up to 6 dBi gain antenna would provide U-NII devices with sufficient flexibility in using the band. The Commission also restricted U-NII devices to indoor operation, to provide additional protection to co-channel NGSO/MSS operations. The Commission determined that the low power limits would allow U-NII devices to provide a variety of short-range communications within a very local area, such as in a room or in adjoining rooms, and, along with the restriction on outdoor operation, balanced the need to provide sufficient power for U-NII devices with protection of co-channel NGSO/MSS operations.²⁷

23. We have examined our licensing databases, and we have found that there is currently no use of the ARNS in the U-NII-1 band. We also note that the allocation for the FSS in the U-NII-1 band is limited to feeder links for non-geostationary orbit (NGSO) satellite systems in the Mobile Satellite Service (MSS), and Globalstar is the only MSS operator in the United States using this band. Its satellites communicate with mobile end-user devices via spot beams using the Lower Big LEO band at 1.61-1.618725 GHz for the uplink and using the Upper Big LEO band at 2.4835-2.5 GHz for the downlink. The satellites are connected to the phone network and Internet through a terrestrial network of ground stations called gateways. These gateways use the 5.096-5.25 GHz band for uplink communication and the 6.875-7.055 GHz band for downlink communication.²⁸

24. In the *NPRM*, the Commission envisioned that harmonizing the power and use conditions across the lower 200 megahertz of U-NII spectrum (U-NII-1 and U-NII-2A) would likely permit the introduction of a wide-range of new broadband products capable of operating at higher data rates than is now possible. We therefore sought comment on whether the rules for the U-NII-1 band should be modified to eliminate the restriction on outdoor operation.²⁹ We also sought comment on whether the rules for the U-NII-1 band should be modified to harmonize with the rules for the U-NII-2A band in two areas.³⁰ Specifically, we sought comment on whether we should increase the power limits to those applicable in the U-NII-2A band, *i.e.*, 250 mW with a maximum EIRP of 30 dBm with 6 dBi antenna gain.³¹ We also invited comment on whether the rules for the U-NII-1 band should be modified to increase the power spectral density (PSD) limits to those applicable in the U-NII-2A band, *i.e.*, 11 dBm/MHz.³² Alternatively, the Commission sought comment on whether the rules for the U-NII-1 band should be harmonized with the rules for the U-NII-3 band to: (a) increase the power limits to 1 W with 6 dBi antenna gain; (b) increase the PSD limits to 17 dBm/MHz; and (c) maintain the current EIRP limit on out-of-band emissions limit of -27 dBm/MHz.³³

25. *Comments.* Initially, Globalstar and the Mobile Satellite Users Alliance supported maintaining the current prohibition on outdoor operation in the U-NII-1 band in order to protect the MSS from the potential of harmful interference.³⁴ All other parties that commented on the indoor-use restriction (largely representing Wi-Fi manufacturers and internet service providers) favored eliminating

²⁷ See *U-NII Report and Order*, *supra* at 1595-96, para. 44.

²⁸ See *Globalstar Licensee LLC Application for Modification of Non-geostationary Mobile Satellite Service Space Station License*, *Order*, 26 FCC Rcd 3948 (Int'l Bur., 2011). Globalstar is currently licensed to operate 4 gateway stations in the United States.

²⁹ See *NPRM*, *supra* at 1782, para. 39.

³⁰ The U-NII-2A band includes requirements for DFS to protect radar operations and TPC to protect EESS operations, neither of which operates in the U-NII-1 band. Thus U-NII-1 devices would not need to include these functions.

³¹ See *NPRM* *supra* at 1781 at para. 39.

³² *Id.*

³³ See *NPRM*, *supra* at 1782, para. 40.

³⁴ See *Globalstar Comments* at 4, *MSUA Comments* at 1.

the prohibition in order to facilitate the development of outdoor access points critical to the success of Wi-Fi and broadband networks.³⁵

26. Many commenters generally favor harmonizing power limits across U-NII bands, at a minimum to the power levels in the adjacent U-NII-2A band.³⁶ Comcast notes that consistency between adjacent bands would advance gigabit Wi-Fi by enabling operators to take advantage of the 160 megahertz channels contemplated by the next generation 802.11ac standard.³⁷ Motorola Mobility believes that by bringing uniformity to the technical rules, the Commission could promote innovative uses of the U-NII-1 and U-NII-2A bands.³⁸ Cisco believes that the Commission should harmonize the U-NII-1 power and PSD rules with those of the U-NII-2A band at a minimum, and should seriously explore possible harmonization with the U-NII-3 rules.³⁹ The National Cable Television Association (NCTA) also notes that adopting higher power limits would allow operators to choose to use a contiguous 160 megahertz channel spanning the U-NII-1 and U-NII-2A bands.⁴⁰ At the same time, NCTA also notes that operators could use a new non-contiguous 160 megahertz channel comprising 80 megahertz of spectrum at U-NII-1 and 80 megahertz of spectrum at U-NII-3. NCTA states that increasing the transmit power limit in the U-NII-1 band is very important for unlicensed operations because higher power results in improved range, coverage and throughput characteristics.

27. Other commenters specifically support adoption of power limits that would harmonize operations in the U-NII-1 band with those in the U-NII-3 band.⁴¹ WISPA urges the Commission to permit outdoor operations in the U-NII-1 band under the U-NII-3 rules, including allowing for higher gain point-to-point antennas.⁴² Fastback Networks supports using the U-NII-3 power limits for a category of devices that it calls “professionally-installed fixed devices,” while maintaining the current U-NII-1 limits for “transportable devices” which would consist of any equipment not meeting their proposed “professionally-installed fixed device” definition.⁴³

28. While the majority of commenters supported harmonization with either the U-NII-2A or the U-NII-3 band power levels, Globalstar initially stated that an increase in power limits in the U-NII-1 band up to the limits permitted in the U-NII-2A band would be manageable in terms of interference to its feeder link operations only if the Commission maintains its prohibition on outdoor operations.⁴⁴

³⁵ See NCTA Comments at 15, Cablevision Comments at 6, Comcast Comments at 25, Cisco Comments at 54, Ericsson Comments at 5, IEEE 802 LMSC Comments at 28, Motorola Mobility Comments at 5, Motorola Solutions Comments at 4, Wi-Fi Alliance Comments at 25, Ruckus Wireless Comments at 4, Fastback Networks Comments at 5, Exalt Communications Comments at 4, ITIC Comments at 10, WISPA Comments at 9, Google and Microsoft Comments at 5, Time Warner Cable Comments at 3.

³⁶ See CEA Comments at 4, Engine Advocacy Comments at 1, ITIC Comments at 9, Cisco Comments at 54, ComCast Comments at 3, Wi-Fi Alliance Comments at 24, Ericsson Comments at 5, Motorola Mobility Comments at 2, IEEE 802 LMSC Comments at 4.

³⁷ See Comcast Comments at 21

³⁸ See Motorola Mobility Comments at 5.

³⁹ See Cisco Comments at 54.

⁴⁰ See NCTA Comments at 14.

⁴¹ See Cablevision Comments at 5, Fastback Networks Comments at 5, Motorola Solutions Comments at 4, NCTA Reply Comments at 21, Time Warner Cable Comments at 3, WISPA Comments at 9, Ruckus Wireless Comments at 4.

⁴² See WISPA Comments at 9.

⁴³ See Fastback Comments at 5.

⁴⁴ See Globalstar Comments at 6. Globalstar stipulates that if the Commission raises the power limit to the UNII-2A limit, it will have to account for the increased noise level in Globalstar’s feeder uplink spectrum if in the future a co-primary aeronautical radionavigation operator seeks authority to provide service in the United States.

Globalstar claimed that removal of the outdoor prohibition would significantly increase radio noise picked up by the satellite receiver used in Globalstar's NGSO feeder links. Globalstar stated that this increase would be caused by an aggregate of the radio noise from all devices operating across the United States because the satellite receiver employs a nationwide footprint. Globalstar asserted that this increase in radio noise constitutes harmful interference because it would significantly reduce the capacity and coverage of its two-way MSS offerings.

29. Globalstar initially provided a technical analysis to support its contention that if the Commission were to combine outdoor operations with increased U-NII-1 power limits, the number of devices that could simultaneously operate at 5.15-5.25 GHz without causing harmful interference to Globalstar would decrease from more than 200,000 devices to either 798 or 201 devices (depending on whether the power limits were raised to U-NII-2A or U-NII-3 levels).⁴⁵ Globalstar reached this conclusion solely by examining interference to the space station receiver, without considering the overall system impact (*i.e.* interference to the user's MSS handset).

30. In opposition, NCTA asserted that the Commission set rules in 1997 based on the assumption that many different MSS companies would share the U-NII-1 band, whereas today Globalstar is the only satellite operator that operates feeder link stations domestically in the 5096-5250 MHz band.⁴⁶ In its reply comments, NCTA provided an analysis which concludes that the interference risk is much lower than Globalstar has claimed.⁴⁷ NCTA contended that Globalstar makes a variety of errors that overstate interference risk, and that an analysis using an appropriate methodology and reasonable assumptions demonstrates that there is very little risk to Globalstar's systems from expanding Wi-Fi access in the U-NII-1 band.⁴⁸ Specifically, NCTA stated that the single-link analysis using only noise-based thresholds provided by Globalstar examined only the feeder link from the gateway earth station to the satellite, and does not account for the "bent-pipe" architecture of the Globalstar system.

31. After the comment and reply comment periods had closed, Globalstar and NCTA continued to file multiple *ex parte* presentations responding to the opposing party, advocating for the propriety of their own analyses and assumptions, while criticizing those of the other.⁴⁹ Late in 2013, NCTA and Globalstar began engaging in joint technical discussions with a goal of reaching a mutually agreeable resolution to the U-NII-1 issues.⁵⁰ Globalstar states that during these discussions, it presented a specific proposal to NCTA designed to permit large numbers of outdoor U-NII-1 devices, while providing reasonable protection to Globalstar, its MSS network, and its customers. Its proposal focuses on two approaches to limiting the harmful effects from the outdoor deployment of U-NII-1 access points: antenna standards limiting access point antenna gain at 30 degrees, and a sequenced roll-out mechanism for outdoor U-NII-1 devices based on Globalstar's continuous measurement of the noise rise at its satellites.⁵¹ Globalstar proposes that the antenna gain be capped at -11 dBi at 30 degrees and higher (assuming U-NII-2A power limits, resulting in 13 dBm EIRP above 30 degrees) in order to lower the noise rise at its satellites, and that the Commission provide a regulatory "backstop" to control unrestricted

⁴⁵ See Globalstar Comments at 5.

⁴⁶ See NCTA Reply Comments at 15.

⁴⁷ See NCTA Reply Comments.

⁴⁸ See NCTA *ex parte* (9/18/13) at 4.

⁴⁹ See NCTA *ex parte* (9/18/13), NCTA *ex parte* (9/23/13), NCTA *ex parte* filings (10/22/13), NCTA *ex parte* (10/28/13), NCTA *ex parte* (1/17/14), NCTA *ex parte* (1/22/14), NCTA *ex parte* (2/03/14), NCTA *ex parte* filings (2/26/14). Globalstar *ex parte* filings (11/22/13), Globalstar supplemental comments (11/29/13), Globalstar supplemental comments (12/13/13), Globalstar *ex parte* (1/28/14), Globalstar Investors *ex parte* filings (1/31/14), Globalstar *ex parte* (2/7/14), Globalstar *ex parte* (2/14/14), Globalstar *ex parte* (2/20/14).

⁵⁰ See Globalstar *ex parte* (2/23/14) at 3.

⁵¹ *Id.*

roll-out if Globalstar's encounters a noise rise of 2 dB caused by uplink interference generated by outdoor U-NII-1 devices at the satellite.⁵²

32. In response to Globalstar's proposal, NCTA suggests that U-NII devices be permitted to operate at 1 W power if they meet one of three possible conditions: (1) the device is an outdoor access point whose radiated power does not exceed 125 mW (21 dBm) at elevation angles above 30 degrees; (2) the device is used for a point-to-point link; or (3) the device operates indoors.⁵³ It further proposes that devices that do not meet one of these criteria should be limited to 250 mW conducted power.⁵⁴

33. In its subsequent filing, Globalstar states that it supports NCTA's proposal for a minimum standard for outdoor U-NII-1 antennas because antennas that radiate power vertically create the greatest impact on Globalstar's constellation, and Globalstar agrees with NCTA that its antenna proposal would significantly limit the energy radiated toward its Big LEO satellites, and should provide Globalstar with meaningful protection from harmful aggregate interference.⁵⁵ Globalstar however disagrees with NCTA's proposal to permit outdoor deployments at 250 mW conducted power without limiting the antenna. Globalstar also restates its belief that unlimited access points operating outdoors at 250 mW without constraining the power in the vertical direction would have a detrimental impact and states that the only reasonable exception would be to allow outdoor U-NII-1 access points deployed as of March 4, 2014, to operate at NCTA's proposed 250 mW conducted power level.⁵⁶ Globalstar also reiterates its belief that the 2 dB backstop is necessary because limiting the energy transmitted in the vertical direction does not guarantee that Globalstar's customers will not be negatively impacted.⁵⁷ In lieu of codifying a 2 dB noise rise threshold as harmful interference to the satellite constellation, Globalstar suggests that the Commission detail a mitigation approach and account for Globalstar's ability to measure the noise rise at its satellites. To that end, Globalstar urges the Commission to require U-NII-1 operators to inform the Commission if and where they plan to deploy a substantial number of outdoor U-NII-1 access points and to describe their network management capabilities.⁵⁸

34. *Decision.* The majority of commenters support allowing outdoor operations in the U-NII-1 band, and some level of harmonization across the U-NII bands. For the reasons set forth below, we conclude that it is in the public interest to permit outdoor operation of U-NII devices in the U-NII-1 band, and that we can do so while appropriately protecting MSS service from harmful interference. Specifically, we revise our rules to permit transmitter power levels up to 1 W, as permitted in the U-NII-3 band, with safeguards described below to minimize the likelihood of harmful interference to Globalstar's MSS system.

35. We observe that NCTA's and Globalstar's analyses are based on fundamentally different assumptions about future factors such as the extent of deployments, the technical characteristics of the equipment, and the extent of the communications traffic. While these assumptions are inherently uncertain, we can minimize their significance with a technical resolution which restricts a device's emissions when operating above a certain elevation angle, coupled with a reporting requirement directed at large-scale deployments, which will facilitate corrective measures should they become necessary.

36. More specifically, since the noise floor increase seen by the satellite will be a function of the aggregated energy from U-NII-1 emissions at elevation angles above 30 degrees, we can readily

⁵² See Globalstar ex parte (2/27/14) at 2-3.

⁵³ See NCTA ex parte (3/4/14) at 2-3.

⁵⁴ *Id.*

⁵⁵ See Globalstar ex parte (03/06/14) at 2.

⁵⁶ *Id.* at 4.

⁵⁷ *Id.*

⁵⁸ *Id.*

address the likelihood of interference to the satellite attributable to this potential increase. Applying technological measures to operations above this elevation angle will sharply reduce the energy that will be received by the satellite from each individual access point, resulting in reduced aggregate noise at the satellite. As a result, it is far less likely that harmful interference will occur, even for proliferation of access points greater than that presumed in either party's earlier analysis, making moot to a large degree the disagreements as to the number of access points that might be deployed.

37. We conclude that generally allowing fixed access point outdoor operations at a conducted power level of up to 1 W (30 dBm), and a PSD of 17 dBm/MHz with an allowance for a 6 dBi antenna gain (*i.e.* a total 36 dBm EIRP), and limiting the maximum EIRP above 30 degrees elevation to 125 mW (21 dBm) EIRP, provides reasonable protection from harmful interference to Globalstar's system. Both NCTA and Globalstar⁵⁹ agree that this protocol would provide interference protection to Globalstar, while permitting access to the spectrum for U-NII users.⁶⁰ We believe that expressing a limit in terms of EIRP will provide U-NII manufacturers and operators with flexibility regarding how to design their equipment, while still achieving the required levels of protection. Manufacturers will be able to demonstrate compliance with the EIRP limit by reducing antenna gain in the upward direction, or by limiting the transmitter power, or a combination of the two, as best suits their particular purpose.

38. We decline to require a regulatory "backstop" as proposed by Globalstar. Consistent with Commission precedent, we will not numerically define "harmful interference" here, beyond the current definition in our rules.⁶¹ While we do not believe that Globalstar's "backstop" is an appropriate prophylactic – we have determined that the rules we adopt today should not result in harmful interference to Globalstar's MSS operations and we will continue to monitor developments in this band. Globalstar has expressed strong concerns in this proceeding that proposed unchecked, widespread deployments of outdoor access points may disrupt licensed services in the band. To provide a safeguard and require accountability for such large deployments, we adopt the following filing requirement. Before deploying an aggregate total of more than one thousand outdoor access points⁶² within the U-NII-1 band, companies must submit a letter to the Commission acknowledging that, should harmful interference to licensed services in this band occur, they will be required to take corrective action. Corrective actions may include reducing power, turning off devices, changing frequency bands, and/or further reducing power in the vertical direction. This reporting requirement provides us a means to identify readily the largest deployments of U-NII access points, in the unlikely event the number of installations reaches a point where aggregate noise does cause harmful interference to Globalstar and we must take action to avoid such a result. We believe that the power limits above 30 degrees described above for individual devices, combined with the filing requirement for deployments of large numbers of devices will provide us with sufficient means for avoiding harmful interference and addressing it if it does occur.

⁵⁹ See NCTA ex parte (3/04/14), Globalstar ex parte (3/6/14).

⁶⁰ We note that Globalstar characterizes its current position as an acceptance of harmful interference, rather than a determination of what constitutes harmful interference to its operation. See Globalstar ex parte (2/27/14) at 3.

⁶¹ See 47 C.F.R. § 2.1, Terms and Definitions. Our rules define harmful interference as interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a Radiocommunication service operating in accordance with the Radio Regulations. 47 C.F.R. § 2.1(c) (setting forth terms and definitions generally applicable to FCC Rules, including the term "harmful interference").

⁶² We define access points in this context as point-to-multipoint devices. We believe that this numerical threshold will identify the companies that will provide the vast majority of access points, and thus the greatest impact on the noise floor. The types of networks deployed in this manner tend to have network administration and management systems that permit a network operator to remotely control and adjust the parameters for the devices within the deployments on the fly. Globalstar for instance agrees with this approach. See Globalstar ex parte (03/6/14) at 4. Globalstar for instance agrees with this approach

39. We understand that a considerable number of unlicensed devices (possibly as many as 200,000 units or more) have been deployed and operate in the U-NII-3 band. While these devices are certified to operate in the U-NII-3 band, operators of this equipment expect that, working with the device manufacturers, they could potentially reprogram these devices to operate at power limits we adopt today in the U-NII-1 band, and thus quickly begin more flexible operation in the U-NII-1 band using this existing equipment.⁶³ These devices may have been certified under either the U-NII-3 rules or under Section 15.247, which are both being modified in this First R&O.

40. We will permit such devices to operate under the new U-NII-1 rules under two potential scenarios, but in both cases, the equipment must comply with the software security requirements described below that we adopt today to prevent unauthorized device modifications.⁶⁴ First, at any time manufacturers or equipment operators may file a request for a permissive change to their current equipment authorizations demonstrating compliance with the rules we adopt today. If manufacturers of the previously deployed equipment are able to demonstrate compliance with the EIRP requirement described above, we will allow a permissive change with up to 1 W of conducted power.

41. Second, if outdoor U-NII-3 band systems installed prior to the effective date of the rules adopted today are not able to comply with the EIRP requirement, we encourage manufacturers or equipment operators to file for a waiver of certain technical requirements for operation in the U-NII-1 band,⁶⁵ no later than 30 days after of the effective date of the new rules.⁶⁶ More specifically, if the waiver is designed to enable such existing deployments to operate within the U-NII-1 band with up to 250 mW of conducted power and a PSD of 11 dBm/MHz with a 6 dBi gain antenna,⁶⁷ then we believe we can make a quick and likely favorable good cause determination sufficient to grant the waiver request, barring any unforeseen circumstances in a given case. We believe that providing the following about the waiver petitioner's existing deployments will be important to our ability to assess waiver requests: the number of devices installed, general location of each deployment, ability to reprogram the devices, and ability to adjust operating power from a central network management system. We can conclude now that waiver requests meeting these parameters and made within a short period of time are likely to serve the public interest because granting them is highly unlikely to create any risk of harmful interference, given the small numbers involved and the limited departure from the new technical requirements for the U-NII-1 band. More specifically, given the limited current deployment of devices, we expect the number of operators and manufacturers that will apply for approval during the first 30 days of the new rules will be relatively low, compared to the millions of devices considered in both the NCTA and Globalstar analyses.⁶⁸ Indeed, Globalstar has acknowledged that it would be reasonable to approve waiver requests

⁶³ See NCTA ex parte (3/04/14) at 3, Globalstar ex parte (3/6/14) at 3.

⁶⁴ Under both of the permissive change procedures we describe, the U-NII-1 band may be added to equipment currently authorized to operate in the U-NII-3 band, but the U-NII-3 component of such equipment does not need approval beyond that in its current grant of equipment authorization.

⁶⁵ 47 C.F.R. § 1.3. See also *WAIT Radio v. FCC*, 418 F.2d 1153 (1969).

⁶⁶ With the exception of those rules whose effective date is delayed pending compliance with the requirements of the Paperwork Reduction Act of 1995, the effective date of the rules we adopt today (and which we use as a benchmark for stating the above-referenced waivers) is set at 30 days following publication of this Report and Order in the Federal Register. Thus, the filing period for a waiver petitioner seeking the benefit of the broad type of approach toward waivers described in this paragraph begins once the rules generally become effective (*i.e.*, 30 days after Federal Register publication of this Report and Order) and ends 30 days thereafter (*i.e.*, 60 days after Federal Register publication of the Report and Order).

⁶⁷ All new outdoor devices installed as of the effective date of the rules that utilize the U-NII-1 band, including those operating at 250 mW or below, will be required to observe the EIRP limits adopted herein.

⁶⁸ We note that Globalstar had requested that only equipment deployed by March 4, 2014, be allowed to operate under this exception. See Globalstar ex parte (3/06/14) at 3. We believe that using 30 days after the effective date of the rules as a cutoff date for currently deployed equipment is more appropriate than March 4, 2014 because the

(continued...)

for previously installed devices.⁶⁹ In addition, the comparatively small number of installed devices strongly suggests a negligible risk of harmful interference from allowing this exception, and the expedient approval of such waivers would benefit the public by promptly and efficiently expanding broadband use in this band. Moreover, having such waiver petitioners provide information about the numbers of installed devices that would be covered by the grant, as well as their general location, will help us monitor the accuracy of our predictions in these regards and allow us to alter course or take effective corrective action if necessary. Following the 30-day window, operators and manufacturers may continue to file petitions for waiver, but we will decide such petitions without the assurances of good cause provided by the above-described approach.⁷⁰

42. We delegate authority to the Office of Engineering and Technology to consider and act on all waiver petitions that are received within 30 days after the rules adopted today generally become effective (*i.e.*, petitions filed no later than 60 days after publication of the Federal Register summary of the order we adopt today), and which conform to the description set forth in the above paragraph. Given the simplicity of the information required, we find that 30 days after the effective date of the rules will give parties sufficient time to file a letter with OET concerning their existing equipment, and this deadline will provide significant assurance that equipment deployed after the effective date will comply with the rules we adopt today. All parties receiving a waiver must then demonstrate compliance with the technical requirements through the equipment certification process by filing a permissive change request including the approved waiver. There is no deadline for filing for such a permissive change.

43. Notwithstanding the above, and consistent with WISPA's request described above, we will permit fixed point-to-point devices operating in the U-NII-1 band to employ transmitting antennas with directional gain up to 23 dBi without any corresponding reduction in the transmitter maximum output power or maximum power spectral density, and with no reduction of power in the vertical direction. We will not require these devices to reduce the antenna gain in the vertical direction. Such point-to-point operations are typically highly directional and aim their signals along the earth, and therefore are less likely to contribute significant energy to that received by the satellite. They are also relatively few in numbers as compared to the widespread distribution of access points examined by Globalstar and NCTA.

44. We will permit indoor access points operating in the U-NII-1 band at 1 W of conducted power with a 6 dBi antenna gain and no reduction in vertical antenna gain coupled with a requirement for a 1 dB reduction in conducted power for every 1 dB that the antenna gain exceeds 6 dBi. These types of consumer-oriented devices should not contribute to interference concerns, as the building materials used in indoor environments should sufficiently attenuate energy transmitted from indoor devices to prevent any significant contribution to any noise rise seen by Globalstar's satellite.

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later date will allow operators to complete deployments that have already been planned. The total number of devices deployed between March 4, 2014 and the 30-day deadline after the effective date of the rules will be small compared with the number of devices deployed under the new rules, and thus will not contribute significantly to noise levels received at Globalstar's satellites.

⁶⁹ See Globalstar *ex parte* dated March 6, 2014 at 3.

⁷⁰ While the 30-day filing window is not dictated by precise calculations, it is a reasonable choice for making this inherently imprecise line-drawing determination, as waivers granted within this time period, under the conditions described above will not increase the risk of harmful interference. After that point, we do not make any determinations here, but rather leave it to a waiver petitioner to make a case without any particular benefits of our determinations made about good cause under the above-described circumstances. We also note that without a waiver, any previously installed or new outdoor device that will be used in the U-NII-1 band, even previously installed ones operating at or below 250 mW, will be required to observe the EIRP limits adopted herein.

45. We permit any client device which operates under control of an access point⁷¹ in the U-NII-1 band to operate at conducted power levels up to 250 mW and a PSD of 11 dBm/MHz with a 6 dBi gain antenna without distinction to whether devices are located indoor or outdoor; power must be reduced by 1 dB for every dB that the antenna gain exceeds 6 dBi. These devices will not cause interference to Globalstar's MSS because of their nature of operation. A client device operates with an access point in a very asymmetric nature, in that very little data is transmitted in the uplink direction (*i.e.* transmitted from the client device) as compared to data transmitted in the downlink direction (*i.e.* transmitted from the access point). Client devices are typically mobile or portable,⁷² such as handsets or laptops and tablets. These devices are not typically installed in permanent outdoor locations, and due to their mobile nature the antenna gain in any particular direction cannot be guaranteed. Because client devices will most often be used in indoor locations with very low antenna heights any emissions will be shielded to some extent by buildings, foliage or other obstructions. While many such devices are able to operate in either a client mode, hotspot mode or a peer-peer mode, we do not believe that such peer-peer modes will be used frequently or deployed as part of an outdoor network; and thus, we will permit mobile or portable client devices to operate in either mode without changing maximum power levels. Finally, many client devices incorporate power control features that cause the device to use as little power necessary to provide necessary communications. These factors compound each other and point to a very low impact from client devices and we do not find a need to impose the antenna requirements described above for access points.

46. We reaffirm that Globalstar's licensed mobile satellite service is protected against harmful interference from unlicensed operations. We note that Globalstar has the capability to monitor increases in noise levels at its satellites, and anticipate that Globalstar will report to us any significant changes in the noise levels and provide specific details as to how it is affecting its operations. We also encourage all interested parties to continue to communicate regularly among each other and with Commission staff regarding developments in this band.

B. Security Features for All U-NII Bands

47. Because the current and future use of the 5 GHz U-NII bands is heavily reliant on the successful implementation of our technical rules, the Commission proposed to require that manufacturers implement security features in any digitally modulated device capable of operating in any of the U-NII bands, so that third parties are not able to reprogram the device to operate outside the parameters for which the device was certified.⁷³ Specifically, we sought comment on whether we should require manufacturers to make it difficult for third parties to reprogram the transmitter in certified devices, and whether we should require that manufacturers ensure that modifying or reconfiguring firmware or software will make a device inoperable in certain bands.⁷⁴ We also sought comment on whether we should require U-NII devices to transmit identifying information so that, in the event harmful interference to authorized users occurs, the source of interference and its location can be identified.⁷⁵

48. *Device Security.* Commenters are generally in favor of requiring device manufacturers to implement greater security for devices that operate throughout the 5 GHz band to prevent modification by

⁷¹ See 47 C.F.R. §15.202.

⁷² See 47 C.F.R. §2.1091 and §2.1093.

⁷³ See *NPRM*, *supra* at 1785, para. 51.

⁷⁴ *Id.*

⁷⁵ *Id.* We note, for example, that our rules require unlicensed fixed TV band devices to transmit identifying information that conforms to a standard established by a "recognizable industry standards setting organization" and should be sufficient "to identify the device and its geographic coordinates." See 47 C.F.R. § 15.711(d).

end users.⁷⁶ Several manufacturers also indicate that they already implement security features in their equipment to prevent modifications by unauthorized parties.⁷⁷ The Wireless Internet Service Providers Association (WISPA) comments that it does not object to the imposition of more stringent security features to be installed in equipment as an alternative to adopting more severe restrictions that could negatively affect broadband delivery to distant communities.⁷⁸

49. Several commenters propose that the Commission's security objectives can be achieved by requiring device manufacturers to answer several questions as part of their certification application.⁷⁹ A few commenters believe the Commission should require more general rules rather than specifying any particular technical parameters that U-NII devices must have to ensure device protection. For instance, NCTA supports reasonable changes to the rules for equipment certification, but urges the Commission to adopt rules that identify the capabilities the device must have rather than mandating specific technical requirements for those devices. They believe that "[m]andating specific technical requirements can increase the cost to manufacturers to design and build devices, which in turn increases the cost for cable companies that rely on such devices to build out their cable Wi-Fi networks."⁸⁰ Likewise, Motorola Solutions agrees that manufacturers should take steps to ensure that their equipment cannot be programmed to operate in ways exceeding their certifications. However, they believe there is no need for the Commission to mandate specific security mechanisms or complex interference mitigation techniques beyond those already called for in the current and proposed rules.⁸¹

50. IEEE 802 LMSC states the FCC should require an improved security showing because if such a showing would have been in effect for master devices in the U-NII-3 band, it would have prevented most harmful interference cases, based on the record of cases resolved to date.⁸² IEEE 802 LMSC asserts that the FCC should apply the security requirements only to devices that are classified as "master" devices, which control the radio transmissions to and from their client devices.⁸³

51. Many commenters addressed the potential costs of implementing such security features, and the record indicates general agreement that the benefits achieved by eliminating interference concerns

⁷⁶ See Ericsson Comments at 6, IEEE 802 LMSC Comments at 16, Wi-Fi Alliance Comments at 15, Ruckus Wireless Comments at 4, Cambium Comments at 2, Baron Services, Inc. Comments at 9-10, NAB Comments at 7..

⁷⁷ See Ericsson Comments at 6, Motorola Solutions Comments at 5(Motorola Solutions states that it already includes in its 5-GHz band devices features that prevent operators and users from programming them in ways that conflict with their granted equipment authorizations, such as disabling dynamic frequency selection ("DFS") on U-NII-2 devices).

⁷⁸ See WISPA Comments at 15.

⁷⁹ See IEEE 802 LMSC Comments at 15, Cisco Comments at 32-33, Wi-Fi Alliance Comments at 16. These suggestions include, for example: 1) describe the procedure that ensures third parties cannot operate devices sold in the United States on non-U.S. frequencies or in violation of any rule; 2) explain if any third parties have the ability described above to change a device and operate it outside of U.S. requirements; 3) describe how the software updates are distributed for all regulatory domains and what procedures ensure that a product sold in the United States can only operate under U.S. rules; 4) if you assert that your product can only be operated per US rules, explain how this is achieved; 5) What stops third parties from loading non-U.S. versions of software on to the device?; 6) can third parties make factory level changes to reload non-U.S. domain codes, etc.; 7) how would your code defeat or mitigate against unauthorized changes; and 8)what are your provisions for labeling and general software description (block diagram). See IEEE 802 LMSC Comments at 15, Cisco Comments at 32-33, Wi-Fi Alliance Comments at 16.

⁸⁰ See NCTA Comments at 23.

⁸¹ See Motorola Solutions Comments at 5.

⁸² See IEEE 802 LMSC Comments at 16.

⁸³ See IEEE 802 LMSC Comments at 14-15.

would outweigh the costs of implementation.⁸⁴ For example, WISPA asserts that based on input it has received from equipment manufacturers, security features can be incorporated into U-NII devices with little technical difficulty. WISPA further believes that any incremental cost to "harden" devices will be more than offset by increased sale and production of U-NII devices designed to operate under a baseline set of technical requirements.⁸⁵ Cambium considers that there may be some additional development costs for manufacturers that do not presently implement software security, but it is unlikely that there will be any additional manufacturing costs.⁸⁶

52. Several commenters argue that manufacturers should ensure that modifying or reconfiguring firmware or software will render the device inoperable. Cisco believes that master devices should include a mechanism that will disable operations in the U-NII-2A and U-NII-2C bands if software or firmware is replaced, modified or reconfigured by anyone other than the manufacturer to provide an additional level of protection to radar systems, and that such functionality should not be particularly difficult or costly for manufacturers to implement.⁸⁷ NAB states that it supports the requirement, proposed in the *NPRM*, that a device should become inoperable if a user tries to modify the software or firmware.⁸⁸ Fastback Networks agrees that such functionality should be required and codified in revised U-NII band rules.⁸⁹

53. Other commenters oppose the implementation of such a requirement. Ericsson cautions that such a solution would be excessively complex, requiring locking/encrypting binary images in those devices. Instead, Ericsson supports methods that simply prevent reconfiguration of a device's operating parameters outside of allowable ranges.⁹⁰ Similarly, Motorola Solutions argues, for manufacturers that comply with the existing rules, the imposition of additional security features into the rules, such as disabling a device from operation in certain bands if it is improperly programmed, would be redundant, unnecessary, and costly.⁹¹ Shared Spectrum Company (SSC) believes that the additional cost and complexity of tamper-proof solutions may impede further deployment of Wi-Fi and other unlicensed services.⁹²

54. *Decision.* Because 5 GHz U-NII devices are able to operate across such a wide swath of spectrum as described above, any device could potentially be reprogrammed to operate outside of its certified frequency range. Accordingly, we are adopting the proposal in the *NPRM* that manufacturers must take steps to prevent unauthorized software changes to their equipment in all of the U-NII bands.⁹³ We leave the precise methods of ensuring the integrity of the software in a radio to the manufacturer, but require the manufacturer to document those methods in its application for equipment authorization. We decline to set specific security protocol or authentication requirements at this time because they could hinder the development of the technology used to provide such security, and be unduly burdensome on manufacturers.

⁸⁴ See IEEE 802 LMSC Comments at 16, Cisco Comments at 33.

⁸⁵ See WISPA Comments at 17.

⁸⁶ See Cambium Comments at 2.

⁸⁷ See Cisco Comments at 34.

⁸⁸ See NAB Comments at 7-8.

⁸⁹ See Fastback Networks Comments at 7.

⁹⁰ See Ericsson Comments at 7.

⁹¹ See Motorola Solutions Comments at 6.

⁹² See Shared Spectrum Company (SSC) Comments at 5.

⁹³ See *NPRM*, *supra* at 1785, para. 51.

55. It is possible that we may have to specify more detailed security requirements at a later date as software driven radio technology develops. We direct OET to provide guidance, through the KDB, on what types of security measures work effectively, and what types do not, as well as on the level of detail the FCC will typically need to evaluate the authorization request.

56. We do not agree with IEEE 802 LMSC's proposal that the security requirement should apply only to the class of master devices that dictate radio emissions. In the *NPRM*, the Commission observed that some radios are designed so that they can communicate directly with each other, rather than through a control point, and thus they could function as either a "master" that initiates a network or as a "client" device within the network.⁹⁴ We also believe that it is important to ensure that client devices cannot be unlawfully reprogrammed to perform the functions of an access point. Thus, we conclude that all devices that operate under the U-NII rules must be subject to the device security requirements.

57. We believe the enhanced security measures will be effective, and conclude that there is no need for a reactive scheme such as disabling modified devices. We intend to enforce our security protocol requirement carefully and vigorously. We agree with commenters that a requirement to disable modified equipment would be redundant and should be unnecessary. Given the additional complexity and costs such a requirement would add to equipment for questionable benefits, at this time we decline to adopt rules that require manufacturers to render a device inoperable if the software is modified or tampered with.⁹⁵

58. *Transmitter ID.* Some commenters stated that current standards do not provide for a convenient way to transmit identifying information, that such information is inadequate to help in resolving harmful interference, and that it is unnecessary if we adopt the increased security requirements as proposed in the *NPRM*. For example, IEEE 802 LMSC states that it is not aware of any identifying information within the Wi-Fi standards that would prove useful in identifying and pinpointing where a particular device is located, and that they are unaware of any technical capability that would allow 802.11 devices to transmit reliable identifying information for the purpose of identifying the cause of interference or its source. They further note that Service Set Identifiers (SSIDs) are usually broadcast by access points, but they do not have to be broadcast, and often don't provide identifying information.⁹⁶ The Wi-Fi Alliance contends that U-NII devices should not be required to transmit identifying information as implementing stronger protections for security and other proposed changes should be more than sufficient to prevent harmful interference to government systems.⁹⁷

59. NAB, by contrast, asserts that U-NII devices should be required to transmit identifying information so that each device can easily be identified in the event of harmful interference.⁹⁸

60. *Decision.* We decline to require U-NII devices to transmit identifying information. While our experience in the field has indicated that a transmitter ID requirement would help to more quickly identify and locate devices that cause harmful interference, we are not persuaded that the benefits accrued from such a requirement would outweigh the costs to implement it at this time. One of our primary goals throughout this proceeding is to prioritize eliminating the occurrence of harmful

⁹⁴ See *NPRM*, *supra* at 1790-91, para. 69.

⁹⁵ Ruckus Wireless suggests that U-NII devices that are not certified under the Commission's rules as software defined radios ("SDRs") might lack safeguards required for SDRs, and that changing some of the permissive change restrictions currently enforced on SDRs would encourage manufacturers to seek certification of their equipment as SDRs. Ruckus Wireless Comments at 5. We find that, while in the *NPRM* the Commission proposed to modify certain sections of the Part 15 rules, it did not propose to modify the permissive change rules, and that this matter is beyond the scope of this proceeding.

⁹⁶ SSIDs are 32 character text strings that identify the access point.

⁹⁷ See Wi-Fi Alliance Comments at 16.

⁹⁸ See NAB Comments at 7-8.

interference in the first instance. Our adoption of enhanced security requirements, discussed above, directly addresses this priority, whereas a transmitter identification requirement does not. However, if harmful interference continues to be a problem we will reevaluate the costs and benefits associated with a transmitter ID requirement, recognizing that it may be necessary to implement more costly solutions to eliminate the harmful interference if devices operating in the band continue to cause harmful interference.

C. U-NII-2 Bands

61. In addition to the security requirements applicable to all U-NII devices operating in the 5 GHz band described above, we revise the technical rules for operation in the U-NII-2A and U-NII-2C bands to further mitigate potential harmful interference to TDWR and other radar systems that operate in those bands. We also modify our rules and update our U-NII compliance measurement procedures to improve testing for radar detection and eliminate certain outdated performance tests.

1. Interference Mitigation Techniques.

62. To be certified for operation in the U-NII-2A and U-NII-2C bands, devices must include a DFS radar detection function. In its field investigations, the Commission's Enforcement Bureau found that certain models of devices certified for use in these bands were designed in a way that users were able to disable the DFS mechanism. With the DFS mechanism inactive, the device could transmit on an active radar channel and cause harmful interference. In the *NPRM* we therefore proposed that manufacturers prevent the DFS mechanism from being disabled in devices certified to operate in the U-NII-2A and U-NII-2C bands.⁹⁹ We also proposed that U-NII devices certified to operate in these bands must be operated with the DFS function on.¹⁰⁰ We also noted in the *NPRM* that the NTIA Third Technical Report and our own discussions with NTIA, FAA and industry representatives have identified additional techniques that could mitigate in-band and adjacent band interference to incumbents.¹⁰¹ These include increasing the sensing frequency range (*e.g.*, detection bandwidth) of U-NII devices operating in the U-NII-2A and U-NII-2C bands; using a database registration process combined with geo-location technology to determine whether there is any potential harmful interference to radar systems such as the TDWR; and limiting the unwanted emission levels of the U-NII devices.

63. *DFS Functionality.* No commenters opposed our proposal that DFS must be active for any devices operating in the U-NII-2A and U-NII-2C bands. Motorola Solutions states that it already includes features in its 5 GHz band devices that prevent operators and users from programming them in ways that conflict with their granted equipment authorizations, such as disabling DFS on U-NII-2 devices.¹⁰² Baron Services believes that the Commission should require manufacturers to implement security measures to prevent end users from modifying the operating parameters of U-NII devices, and require that a U-NII device's DFS functionality cannot be turned off.¹⁰³

64. The technical rules for equipment authorized to operate in the U-NII-2A and U-NII-2C bands already require the implementation of DFS. The requirement to preclude software changes that would allow devices to operate outside of their authorized parameters includes the DFS functionality. That is, the devices must be designed to prohibit software changes that would disable the DFS functionality. We also modify our rules to explicitly prohibit operators from using equipment without

⁹⁹ See *NPRM, supra* at 1785, para. 68.

¹⁰⁰ *Id.*

¹⁰¹ See *NPRM, supra* at 1786, para. 53.

¹⁰² See Motorola Solutions Comments at 5. Baron Services believes that the Commission should require manufacturers to implement security measures to prevent end users from modifying the operating parameters of U-NII devices, and require that a U-NII device's DFS functionality cannot be turned off. Baron Services comments at 9-10.

¹⁰³ See Baron Services Comments at 9-10.

operational DFS in the U-NII-2 bands, and require the DFS function to be turned on when operating in these bands.¹⁰⁴ This explicit requirement will help our Enforcement Bureau eliminate harmful interference should they encounter modified equipment in the field.

65. *DFS Sensing Bandwidth.* The *NPRM* sought comment on whether to require that DFS enabled U-NII devices sense for radar signals at or exceeding 100 percent of its occupied bandwidth in U-NII-2A and U-NII-2C bands, or to continue to reference this as part of the 2006 DFS Compliance Measurement Procedures.¹⁰⁵ We noted that expanding the sensing bandwidth would prevent the co-channel operations between U-NII-2A, U-NII-2C band devices and radars that are to be protected, and thus would reduce the potential for harmful interference.¹⁰⁶

66. Commenters are split on this issue. Those opposing an increase in the bandwidth over which U-NII devices must detect radars contend that their field experience shows that sensing over 80 percent of the device bandwidth provides adequate protection to radars, and they further express concern that sensing at 100 percent of the device bandwidth would lead to false-positive detections without any corresponding benefit to the radars.¹⁰⁷ Commenters supporting an increased sensing requirement both with a complementary geolocation/database approach and as a stand-alone feature argue that this is useful to keep U-NII unwanted emissions far enough away in frequency from the TDWR fundamental frequency to prevent harmful interference.¹⁰⁸ Ruckus Wireless supports increased sensing for outdoor devices, but believes that no change is warranted for indoor, low-power equipment.¹⁰⁹

67. We modify our rules to require U-NII devices to sense for radar signals at 100 percent of their emissions bandwidth in U-NII-2A and U-NII-2C bands. The current implementation of the sensing bandwidth will ensure co-channel interference protection only when the radar signal falls within 80 percent of the U-NII device's emissions bandwidth. Therefore, it is possible for the U-NII device to transmit on the same frequency as the radar when the radar signal falls within the 20 percent of emissions bandwidth that does not require sensing. When the radar signal falls within the region of emissions bandwidth that does not require sensing, the U-NII device could continue to transmit. This could result in transmissions from the U-NII devices that fall within the TDWR receiver bandwidth, which would increase the potential for harmful interference. Expanding the sensing requirement to the entire emissions bandwidth will prevent co-channel operations between U-NII-2A, U-NII-2C band devices and radars and thus will reduce the potential for harmful interference. We find that requiring a U-NII device to sense for radar signals within 100 percent of its bandwidth would provide an additional security layer to protect the TDWR from any possible harmful interference. We direct OET to update the 2006 DFS Compliance measurement procedures to ensure that DFS functionality is measured across a device's entire emissions bandwidth.

68. *Geolocation/Database.* In the *NPRM*, the Commission noted that, because the TDWR locations are known and somewhat limited in number, implementation of geo-location and database registration might be very straightforward and easy to accomplish.¹¹⁰ With this interference avoidance

¹⁰⁴ This rule addresses several sets of circumstances. Some older equipment certified to operate in the U-NII-2A band may not have DFS functionality; some older equipment certified to operate in the U-NII-2A and U-NII-2C bands may allow the operator to turn off the DFS function; and some equipment certified under Section 15.247 which does not require DFS functionality may have been modified to operate in the U-NII-2 band.

¹⁰⁵ See *NPRM*, *supra* at 1790, para. 65.

¹⁰⁶ *Id.*

¹⁰⁷ See Ericsson Comments at 8, IEEE 802 LMSC Comments at 22, Cisco Comments at 40.

¹⁰⁸ See Shared Spectrum Company Comments at 5-6, Baron Services Comments at 10-11. We discuss the geolocation database proposal below.

¹⁰⁹ See Ruckus Wireless Comments at 6.

¹¹⁰ See *NPRM*, *supra* at 1787, para. 55.

method, the location of an unlicensed device could be determined by a professional installer or by using geo-location technology such as GPS incorporated within the device. Using either of these methods, a user could determine from either an internal or external database whether the unlicensed device is located far enough from the TDWR to avoid causing harmful interference; if not, the unlicensed device could transmit on a frequency farther away from the TDWR's center frequency. The Commission sought comment on whether, given the limited number of TDWR locations, a geo-location/database approach could be effectively implemented and maintained for numerous U-NII devices that would operate in the 5.6-5.65 GHz band, and how this approach would protect other incumbent operations.¹¹¹

69. Several commenters oppose use of a database and geo-location technology, typically citing the large potential cost to implement the database as compared to the limited benefit they claim would be realized, especially if the Commission adopts its proposed security requirements.¹¹² The NAB, Shared Spectrum, and Spectrum Bridge state that the Commission should adopt a geo-location database solution in addition to enhanced sensing requirements.¹¹³ Google and Microsoft state that geo-location database approaches might provide a useful alternative approach to DFS.¹¹⁴ Ruckus believes that a geo-location/database approach could be effectively implemented for high power, outdoor U-NII devices and that geo-location technologies such as GPS should be encouraged in the U-NII-2C band.¹¹⁵

70. We decline to adopt a geo-location database requirement for several reasons. First, we are taking several actions in this First R&O that would have prevented most of the harmful interference cases that we have observed to date, and which will prevent future interference cases. Second, we are making several changes to our Part 15 rules and compliance measurement procedures to improve the DFS functionality, thus further reducing the harmful interference risk to TDWR and other radar systems, *e.g.* increasing the sensing bandwidth, modifying the sensing threshold, and testing DFS functions against a new radar waveform. These changes will be sufficient for U-NII devices to avoid radar systems operating in these bands.¹¹⁶

71. We agree with commenters that the incremental benefit provided by implementing a geo-location/database approach as a supplement to DFS is not sufficient to justify the expense of doing so. Implementation of a geo-location/database approach could be prohibitively expensive as a practical matter and would be out of proportion to the incremental benefit accrued. A geo-location database solution would require a major retrofit of existing U-NII equipment, and a significant modification in the way U-NII devices operate and are certified. Permitting a geo-location/database approach as an alternative to requiring DFS functionality would also present some practical concerns in overall management of the interference environment, since two different types of devices would be operating under different authorization procedures and operating rules.

72. We note that although we are not adopting a database requirement, WISPA maintains a database accessible to the public which contains TDWR system locations¹¹⁷ Our actions in this First R&O will not prevent the use of any voluntary databases such as the one implemented by WISPA.

¹¹¹ *Id.*

¹¹² See Ericson Comments at 7, IEEE 802 LMSC Comments at 20, and Wi-Fi Alliance at 22.

¹¹³ See NAB Comments at 6-7 and Shared Spectrum Comments at 5.

¹¹⁴ See Google and Microsoft Comments at 6.

¹¹⁵ See Ruckus Wireless Comments at 5.

¹¹⁶ A search of the Commission's Universal Licensing System and NTIA's Government Master File indicate that there are approximately 350 frequency assignments for radar systems nationwide operating in these bands. In many cases a single frequency assignment can represent multiple radar systems.

¹¹⁷ See <http://www.wispa.org>.

73. *Out-of-Band Emissions in the UNII-2 Bands.* In the *NPRM*, the Commission noted that emissions outside of the U-NII device's occupied bandwidth may have the potential to cause harmful interference to TDWRs.¹¹⁸ Aside from increasing frequency separation or distance separation, U-NII devices may avoid causing harmful interference by lowering the emissions on the radar's fundamental frequency. This equates to lowering all emissions from U-NII devices at the frequencies outside of the device's operating bandwidth.¹¹⁹ The Commission sought comment on whether requiring lower unwanted emission limits for U-NII devices operating in the U-NII-2A and UNII-2C bands was appropriate, and whether it should modify the emission limits based on findings in NTIA's report.¹²⁰

74. The Commission also sought comment on modifying its rules to adopt out-of-channel limits for indoor versus outdoor U-NII devices, including how it should define the terms "indoor" and "outdoor," and how different operating requirements for indoor versus outdoor operations can be accommodated through its equipment authorization and enforcement procedures.

75. We decline to adopt these proposals that would require reductions in out-of-band emissions below the levels currently allowed under Section 15.407. We have not seen evidence in the harmful interference cases that we have investigated that problems are being caused by unwanted emissions from properly certified and properly functioning equipment. Instead, the majority of cases have been caused by devices that have been modified to operate in frequency bands in which they are not certified to operate, or by devices in which DFS had been disabled. Consolidating the technical rules in the U-NII-3 band, as discussed below, along with enhancing the software security requirements of all U-NII devices, discussed above, would have prevented most of the harmful interference cases that we have observed to date. Accordingly, we agree with commenters that a reduction in unwanted emissions from properly certified and properly functioning equipment would be overly restrictive and would not provide any long-term interference mitigation, that no harmful interference cases appear to be caused by adjacent channel operations, and that benefits of applying reduced emission limits would be speculative, while the costs imposed on manufacturers and users are real and would result in decreased equipment capabilities.¹²¹

2. Other U-NII-2 Rules and Measurement Procedures

76. *Sensing Threshold.* The current rules require that the DFS mechanism continuously monitor the device's environment for the presence of radar, both prior to and during operation. We require that U-NII devices certified under our rules use two detection thresholds to ascertain whether radar signals were present. The required threshold levels are: (a) -62 dBm for lower power devices with a maximum EIRP less than 200 mW (23 dBm), and (b) -64 dBm for higher power devices with a maximum EIRP between 200 mW (23 dBm) and 1 W (30 dBm), averaged over 1 μ s.¹²² The lower power U-NII devices are currently permitted to use the relaxed sensing threshold because the range at which these devices can potentially cause harmful interference is reduced and thus they are capable of operating closer to the radar without causing harmful interference. In order to ensure that the potential for harmful interference does not increase with the use of the relaxed sensing threshold, we proposed in the *NPRM* to

¹¹⁸ See *NPRM*, *supra* at 1781, para. 57.

¹¹⁹ Commission rules typically specify unwanted emission levels outside of the frequency band in which the unlicensed device is intended to operate, without requiring further attenuation on frequencies outside of the device's occupied bandwidth, but still within the specified frequency band.

¹²⁰ The out-of-channel limit refers to the region of spectrum between the edge of the occupied bandwidth of the U-NII device and the edge of the U-NII band of operation.

¹²¹ See Ericsson Comments at 7-8, IEEE 802 LMSC Comments at 21-22, Ruckus Wireless Comments at 6, Fastback Networks Comments at 8.

¹²² See 47 CFR §15.407(h)(2). The DFS detection threshold is defined as the received power averaged over 1 μ s referenced to a 0 dBi antenna.

apply a reduction in EIRP spectral density for devices that use the -62 dBm sensing threshold. We proposed that devices must operate with both an EIRP of less than 200 mW (23 dBm), and an EIRP spectral density of less than 10 dBm/MHz (10 mW/MHz), in order to use the relaxed sensing detection threshold of -62 dBm. Devices that do not meet the proposed EIRP and EIRP spectral density requirements would then use the -64 dBm sensing threshold. We noted that a reduction in the EIRP spectral density limit would be consistent with recent actions taken by European Telecommunications Standards Institute (ETSI).¹²³ Specifically, ETSI chose to restrict a device's use of the relaxed sensing threshold by reducing both the EIRP and the EIRP spectral density to 23 dBm (200 mW) and 10 dBm/MHz (10 mW/MHz), respectively.¹²⁴

77. No commenters opposed our proposal to change the DFS sensing threshold. Several commenters supported our proposal in order to further enhance interference protection for licensed services and also to harmonize with the technical requirements in Europe.¹²⁵

78. We adopt our proposal to revise the DFS sensing rules by introducing a Power Spectral Density (PSD) limit for devices that meet the requirements for this relaxed sensing threshold. We modify our rules to require that devices operate with both an EIRP of less than 200 mW (23 dBm), and an EIRP spectral density of less than 10 dBm/MHz (10 mW/MHz), in order to use the relaxed sensing detection threshold of -62 dBm. Devices that do not meet the proposed EIRP and EIRP spectral density requirements must use the -64 dBm sensing threshold. This change will further enhance protection for radars from co-channel interference by reducing both the range and the in-band spectral density of the U-NII devices that use the relaxed sensing threshold.

79. *Bin 1 Waveforms.* U-NII devices that operate in the U-NII-2A and the U-NII-2C bands are certified using a testing regime that considers how the U-NII equipment responds to sample waveforms that simulate typical parameters that are used by radars that operate in these bands. The radar parameters are divided up into several "bins," each representing a different category of radar system. In the *NPRM*, we proposed to use an updated set of "Bin-1" radar waveforms to be used in certifying U-NII equipment. The new waveforms contained in the proposed measurement procedures are expected to account for current and, to the extent possible, future TDWR characteristics. We proposed that modifications in the Bin-1 radar simulating waveform used in our measurement procedures will reduce the potential for co-channel interference to the TDWR and other radar systems.¹²⁶

80. Many commenters support adoption of the revised Bin 1 Waveforms set forth in Appendix B of the *NPRM*.¹²⁷ Baron, however, proposes additional DFS broadcast weather Radar detection test waveforms.¹²⁸ It proposes DFS certification tests designed to ensure that U-NII devices operating in the 5.25-5.725 GHz (U-NII-2A and U-NII-2C) bands will not interfere with incumbent broadcast weather radar systems operating in the 5.35-5.47 GHz and 5.6-5.65 GHz band. Baron indicated

¹²³ See *NPRM, supra* at 1791-92, para. 72, citing ETSI EN 301 393 V1.6.1, Broadband Radio Access Networks; 5 GHz high performance RLAN; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive (2011-11), Page 70. The Commission also noted that its proposed limits were those adopted by ETSI, and that adopting a rule that is consistent with ETSI standards would allow it to foster American industry's flexibility to develop devices for international markets and promote economies of scale in production of equipment.

¹²⁴ See *NPRM, supra* at 1791-92, para. 72.

¹²⁵ See Cisco Comments at 49, Fastback Networks Comments at 9, Ericsson Comments at 8, and Wi-Fi Alliance Comments at 19.

¹²⁶ See *NPRM, supra* at 1792, para. 73.

¹²⁷ See Cisco Comments at 29, IEEE 802 LMSC Comments at 23, Wi-Fi Alliance Comments at 17, WISPA Comments at 18.

¹²⁸ See Baron Services Comments at 11.

that its proposed tests are modeled after the tests proposed in Appendix B of the *NPRM*.¹²⁹ Baron states that their additional tests proposed are intended to be in addition to, not in lieu of, the tests the Commission ultimately adopts with respect to TDWR radars.¹³⁰

81. We believe that these changes will reduce the potential for co-channel interference to the TDWR and other radar systems, and direct OET to modify the Bin-1 radar simulating waveform used in the 2006 DFS Compliance Measurement Procedures. Based on the reported co-channel interference to TDWR, and our investigations into complaints, we believe the modifications to the test waveforms in the measurement procedures are required. The test waveforms proposed in the *NPRM* were created by NTIA with input from a number of agencies and with the industry stakeholders after a long evaluation period. The tests are a generalized procedure and are not intended to cover every radar device exactly. In fact, all the test waveforms were created by “mixing” a number of radar types. Thus, they are not exact representations, but a generalized view of pulse types to be detected. In practice, a U-NII device is expected to detect any radar types and not just the parameters used for test purposes. The list of parameters proposed by Baron Services is derived from Baron Services’ specific radars, and is not necessarily applicable to all radars. Developing an exhaustive list to cover all potential radars is overly burdensome, and we believe the better approach to ensure that all radars can be adequately detected is to apply the generalized waveforms we are adopting. For these reasons, we believe that the test waveforms are sufficiently broad to include most radar types including those operated by Baron Services. Baron Services has not demonstrated that the waveforms they propose are so different as to have an impact on the ability of DFS equipped devices to detect their broadcast weather radar, and thus we do not need to include the specific parameters requested by Baron Services.

82. *Channel Spreading.* Our current rules and measurement procedures require that the DFS function provide a uniform spreading of loading over all available channels.¹³¹ The measurement procedure further explains this provision by stating that “Uniform Channel Spreading” is the spreading of U-NII devices operating over the DFS bands to avoid dense clusters of devices operating on the same channel. Some manufacturers comply with this requirement by using random channel selection, but in the *NPRM* we proposed that similar benefits could be obtained by manual selection of channels, and may actually result in better spectrum usage at a given location. In particular, we noted that enhanced spectrum use may be possible when devices use a very high bandwidth and the number of usable channels is small. We also noted that the trend for U-NII devices is to operate with ever wider bandwidths such as contained in the new 802.11ac standard. Operation over wider bandwidths causes U-NII energy to be spread throughout the frequency band in which the device is operating, rather than concentrated in a narrow bandwidth. This potentially makes the uniform channel-spreading requirement unnecessary. We thus proposed to remove the “Uniform Channel Spreading” requirement from our rules and measurement procedures. We also proposed to permit either random channel selection or manual selection of the initial channel.¹³² All parties who commented on this issue support modifying the rules as proposed in the *NPRM*, variously expressing support or the greater flexibility and efficiency they will provide.¹³³

83. We modify our rules to eliminate the last portion of Section 15.407(h)(2) that requires that the DFS process provide a uniform spreading of the loading over all of the available channels, and we direct OET to update the 2006 DFS Compliance Measurement Procedures to remove the channel

¹²⁹ See Baron Services Reply Comments, Attachment at 1.

¹³⁰ *Id.*

¹³¹ See 47 C.F.R. §15.407(h)(2).

¹³² See *NPRM*, *supra* at 1792, para. 74. The DFS Channel Availability Check would still have to be performed for random or manual channel selection.

¹³³ See Cisco Comments at 50; Ericsson Comments at 9; IEEE 802 Comments at 24; Wi-Fi Alliance comments at 20; Fastback Networks at 10; Motorola Solutions Comments at 8; Ruckus Wireless Comments at 7.

spreading requirement. The Uniform Channel Spreading requirement on DFS is outdated and does not reflect the current state and trajectory of wireless technology. Implementation of this proposal will give U-NII equipment manufacturers significant flexibility to design and develop radar avoidance methods, while increasing effective use of the spectrum.

84. *Channel Loading.* Our measurement procedures require that system testing be performed with an MPEG test file that streams full motion video at 30 frames per second for channel loading. Experience certifying U-NII devices has indicated that not all U-NII devices are designed for video transmission or support the specific coding format, and that other methods of channel loading are used. In the *NPRM* we sought comment on whether specifying video streaming as the preferred channel loading method for compliance measurements is as appropriate today as it was when the measurement procedures were created, or whether the channel loading requirement in our test procedures should be specified in a more general manner so as only to specify that measurements be conducted with the device under test operating in a loaded condition.¹³⁴

85. All parties that commented on channel loading are supportive of removing the MPEG test file requirement.¹³⁵ Considering the unanimous positive response in the comments, and given that, in the wide variety of unlicensed devices designed for operation within the U-NII rules, there is a subset of devices that are not designed for video use and therefore cannot be effectively tested with a video-based process, we conclude that a more flexible approach is warranted, which permits channel-loading testing to be performed using means appropriate to the data types that are used by the unlicensed device at issue.

86. Accordingly, we direct OET to update the 2006 DFS Compliance Measurement Procedures to indicate the general requirement that DFS functionality be tested using a method and level of channel loading that is representative of the data types used by the U-NII device without specifying that the system testing be performed with an MPEG test file that streams full motion video at 30 frames per second for channel loading.

D. U-NII-3 Band Features

87. As mentioned above, our rules permit the certification of devices that operate in 5.725-5.85 GHz band under two different rule sections. Section 15.247 was originally adopted in 1985 to govern spread spectrum operations. The U-NII rules were adopted in 1997 and were designed to accommodate new digital modulation technologies. In 2002, the Commission modified the original spread spectrum rules to allow digitally modulated devices under Section 15.247, but were not fully aligned with the U-NII rules. The differences in these rules have persisted and lead to the situation where devices authorized under the frequencies permitted under Section 15.247 were modified to operate on frequencies permitted only for U-NII devices without complying with the rules designed to prevent interference to other radio services, resulting in harmful interference to TDWRs. The Commission therefore proposed to consolidate the rules for the digitally modulated devices that operate in the 5.725-5.85 GHz band in Section 15.407.¹³⁶

88. As we discuss in more detail below, we adopt the *NRPM* proposals for the U-NII-3 band with one exception. We adopt the provisions from each respective rule section which will provide for the most effective and efficient use of spectrum while protecting incumbents. First, we are extending the upper edge of the U-NII-3 band from 5.825 GHz to 5.85 GHz to match the amount of spectrum available for digitally-modulated devices under Section 15.247. We believe that this change will eliminate the complexity and costs associated with multiple rule part certifications for these devices which are

¹³⁴ See *NPRM, supra* at 1792-93, para. 74.

¹³⁵ See IEEE 802 LMSC Comments at 24, Wi-Fi Alliance Comments at 20, Motorola Solutions Comments at 8, Ruckus Wireless Comments at 7, and Fastback Networks Comments at 10.

¹³⁶ See *NPRM, supra* at 1778, para. 28.

technically similar. Implementing this change will not increase the potential for harmful interference because this 25 megahertz segment is already available for devices certified under Section 15.247.

89. Second, we consolidate the Section 15.247 technical rules for digitally-modulated devices in the 5.725-5.85 GHz band with the Section 15.407 U-NII rules, while maintaining many of the technical rules that currently make equipment authorization under Section 15.247 more attractive for equipment manufacturers.¹³⁷ We remove the 5.725-5.85 GHz band for digital modulation devices from Section 15.247 to ensure that all digitally modulated equipment that are technically similar operate under a single set of technical rules in this band.

90. In consolidating the Section 15.247 and Section 15.407 rules for digitally modulated devices in the 5.725-5.85 MHz band, we adjust the rules for technical parameters such as the frequency band of operation, the power and power spectral density limits, emission bandwidth, antenna gain, unwanted emission limits, and the peak to average ratio permitted in our rules. We adopt a modified version of our proposed rule for antenna gain to retain the provisions for high-gain point-to-point operations. The table below shows the old technical parameters associated with both Section 15.247 and Section 15.407, along with the parameters that we are adopting.

Parameter	Old 15.247	Old 15.407	First R&O Decisions
Frequency Band	5.725-5.85 GHz	5.725-5.825 GHz	5.725-5.85 GHz
Conducted Power	1 Watt (30 dBm)	Lesser of 1 Watt (30 dBm) or 17 dBm + 10 log B	1 Watt (30 dBm)
Power Spectral Density	8 dBm/3 kHz (33 dBm/MHz)	17 dBm/MHz	30 dBm/ 500 kHz
Emission Bandwidth	Minimum 6-dB BW of 500 kHz	26 dB BW used for power calculation	Minimum 6-dB BW of 500 kHz
Antenna Gain	6 dBi (1 dB reduction in power for every 1 dB that antenna gain exceeds 6 dBi) No reduction required for fixed point-to-point systems	6 dBi (1 dB reduction in power required for every 1 dB that antenna gain exceeds 6 dBi) For fixed point-to-point systems, 1 dB reduction in power for every 1 dB that antenna gain exceeds 23 dBi	6 dBi (1 dB reduction in power required for every 1 dB that antenna gain exceeds 6 dBi) No reduction required for fixed point-to-point systems
Unwanted Emissions	20 dB of attenuation	Below -17 dBm/MHz within 10 MHz of band edge, below -27 dBm/MHz beyond 10 MHz of the band edge. 15.209 general	Below -17 dBm/MHz within 10 MHz of band edge, below -27 dBm/MHz beyond 10 MHz of the band edge. 15.209 general

¹³⁷ See *NPRM*, *supra* at 1778-79, para. 28.

		emission limits below 1 GHz.	emission limits below 1 GHz.
Peak-to-Average Ratio	None	13 dB	None

1. Frequency Band

91. Section 15.247 allows operation throughout the 5.725-5.85 GHz band, while Section 15.407 allows operation only in the 5.725-5.825 GHz band. The extra 25 megahertz of spectrum that is allowed under Section 15.247 provides incentive for device manufacturers to certify devices under that rule rather than under Section 15.407. In investigating TDWR harmful interference complaints, the Commission found that the software for devices certified under Section 15.247 was sometimes modified to operate in the U-NII-2 frequency bands without meeting all of the technical requirements for operation in these bands, thus resulting in harmful interference to TDWRs.¹³⁸

92. In the *NPRM*, the Commission proposed to expand the frequency band of operation in Section 15.407 to include the 5.825-5.85 GHz band. This would allow U-NII-3 devices to operate across the full range of spectrum that can currently be accessed by digitally modulated devices under Section 15.247.¹³⁹ This rule change would decrease unnecessary complexity in the equipment authorization process. More importantly, this change combined with the software security changes we are adopting, should help eliminate potential harmful interference from unlicensed devices to other spectrum users.

93. Cable operators and associations support the Commission's proposal to add the 5.825-5.85 GHz segment of the U-NII-3 band to support devices that use higher data rates.¹⁴⁰ Automotive and transportation related groups are concerned that devices operating in the U-NII-3 band would place U-NII unwanted emissions into frequency bands used by Dedicated Short Range Communication (DSRC) Systems at levels that may cause harmful interference.¹⁴¹ Commenters also note the Amateur service allocation in the U-NII-3 band.¹⁴² ARRL proposes that the Commission take actions to protect Amateur operations by extending mitigation techniques such as DFS and transmitter power control (TPC) throughout the 5.650-5.925 GHz segment, which would include the U-NII-3 band, to help minimize instances of harmful interference between U-NII devices and amateur stations. HamWAN commented that amateur users are denied access to their allocations at tower locations because of the commercial success of U-NII devices. It proposes that we extend the amateur allocations downwards to overlap all of the frequency bands used by U-NII devices to increase opportunities for amateur licensees.¹⁴³

94. We adopt our proposal to consolidate the provisions for operation in the 5.725-5.85 GHz band into the U-NII rules under Section 15.407. We expect this rule change to decrease unnecessary complexity in the equipment authorization process and eliminate the incentives for gaming the rules as described above. More importantly, this change, combined with the above-discussed software security changes we are adopting, should help eliminate potential harmful interference from unlicensed devices to other spectrum users. We disagree with Alliance and Global that extending the upper edge of the U-NII-3 band will increase the harmful interference risk to DSRC services. Unlicensed devices are already

¹³⁸ See TDWR Enforcement Cases.

¹³⁹ See *NPRM*, *supra* at 1779, para. 29.

¹⁴⁰ See NCTA Comments at 17, Time Warner Cable Comments at 9, Comcast Comments at 24.

¹⁴¹ See Society of Automotive Engineers Reply Comments at 2-3, Alliance of Automobile Manufacturers, Inc. and the Association of Global Automakers (Alliance and Global) Comments at 30.

¹⁴² See ARRL Comments at 11-13, HamWAN Comments at 1.

¹⁴³ See HamWAN Comments at 1.

allowed to operate within the 5.825-5.85 GHz band under Section 15.247 of our rules with higher unwanted emission levels than we are adopting for the new combined rule part. We are simply consolidating the existing rules into a single rule section, which will not increase the risk of harmful interference to DSRC services.

95. ARRL's proposal to require DFS and TPC mitigation techniques for U-NII-3 devices is not necessary, would be overly burdensome, and is not based on a demonstrated need. We also disagree with HamWAN's assertion that amateurs are denied access to the 5 GHz bands at tower locations. The Amateur service is an allocated service entitled to interference protection within the 5 GHz spectrum, whereas U-NII devices operate under our Part 15 rules. Any preference by tower owners to prioritize unlicensed use on their towers is not a result of FCC spectrum allocations. We believe that the Amateurs have adequate access to spectrum necessary in this band, and we decline to extend the Amateur Radio allocation downwards to overlap the rest of the U-NII spectrum, as HamWAN proposes, as this request is beyond the scope of this proceeding.

2. Power

96. Section 15.247 allows 1 Watt of total peak conducted power whereas Section 15.407 limits maximum conducted output power to the lesser of 1 Watt or $17 \text{ dBm} + 10 \log B$ (where B is bandwidth in MHz).¹⁴⁴ In addition to the 1 Watt power limit, there are different PSD limits in Sections 15.247 and 15.407 such that 1 Watt of total power is available only when the 6-dB bandwidth is 500 kilohertz or more under Section 15.247 and when the 26-dB bandwidth is 20 megahertz or more under Section 15.407.¹⁴⁵ Because we are trying to accommodate digitally modulated devices that are currently permitted under both rules, we proposed in the *NPRM* to remove the bandwidth dependent term (*i.e.*, remove $17 + 10 \log B$) from Section 15.407, so that the power limit would be 1 Watt.¹⁴⁶ In the *NPRM*, the Commission did not expect that removing the variable power limit in Section 15.407 would increase the potential for harmful interference, because under current rules manufacturers are able to certify equipment that uses up to 1 Watt of power under Section 15.247.

97. We modify our rules to remove the bandwidth-dependent term from Section 15.407(a)(3) of our rules as proposed. As we initially suggested and the majority of commenters agree, utilizing the 1-Watt power limit will not increase the potential for harmful interference because unlicensed devices are already allowed to operate without the bandwidth-dependent term under Section 15.247.¹⁴⁷

3. Power Spectral Density

98. Section 15.247(e) requires a maximum PSD of 8 dBm/3 kHz (33 dBm/MHz), whereas Section 15.407(a)(3) requires a maximum PSD of 17 dBm/MHz. The difference between these two PSD limits is the bandwidth at which the device reaches the 1-Watt total power limit. Specifically, Section 15.247(e) allows a higher PSD when the device emission bandwidth is between 0.5 and 20 megahertz. Whenever devices use an emission bandwidth above 20 megahertz, the 1 Watt power limit becomes the limiting parameter, and the effective PSD at which the device operates is the same under both Sections 15.247 and 15.407. In the *NPRM*, the Commission proposed to conform the PSD limit in Section 15.407 to the PSD limit in Section 15.247(e) (*i.e.*, 8 dBm/3 kHz (33 dBm/MHz)), so that digitally-modulated devices designed to meet this limit will continue to comply with the new PSD requirement in Section

¹⁴⁴ See 47 C.F.R. §§ 15.247(b)(3) and 15.407(a)(3). See also KDB 644545 D01 – Guidance for IEEE 802.11ac and Pre-ac Device Emission Testing and KDB 644545 D02 Alternative Guidance for IEEE 802.11ac and Pre-ac Emissions Testing. These KDB documents are available at: www.fcc.gov/labhelp.

¹⁴⁵ See 47 C.F.R. §§ 15.247(e) and 15.407(a)(3).

¹⁴⁶ See *NPRM*, *supra* at 1779, para. 30.

¹⁴⁷ See Cisco Comments at 43, Ericsson Comments at 5, IEEE 802 LMSC Comments at 17, Motorola Solutions Comments at 3-4, Wi-Fi Alliance Comments at 12, and Ruckus Wireless Comments at 3.

15.407. We also noted that limiting the PSD to 8dBm/3kHz (33dBm/MHz) would result in a PSD that is higher than the total power limit of 1 Watt (30dBm).¹⁴⁸

99. In addition, we recognized that requiring devices that employ wider bandwidths to utilize a measurement bandwidth of 3 kHz may unnecessarily increase the time that it takes to complete measurement tests. We sought comment on whether we should increase the measurement bandwidth to 1 megahertz to reduce the complexity in measurement tests.¹⁴⁹ We noted that changing the measurement bandwidth would promote consistency within the U-NII rules.¹⁵⁰ We also invited comment on different measurement bandwidths, such as 500 kHz.¹⁵¹

100. Commenters agree that we should adopt the 8 dBm/3 kHz (33 dBm/MHz) PSD that we proposed in the *NPRM*. They believe that the proposed PSD would provide the greatest amount of internal consistency in the rules, and thus facilitate the creation of larger channel widths.¹⁵² In addition, Ruckus encourages the Commission to increase the measurement bandwidth to 1 megahertz to promote consistency between rules and efficiencies during the testing process.¹⁵³ IEEE 802 LMSC supports changing the measurement bandwidth to 1 MHz.¹⁵⁴ Cisco states that if the Commission modifies Section 15.407(a)(3) to eliminate the bandwidth-dependent limitation on total power, the measurement bandwidth of Section 15.407(a)(5) would require a similar modification.¹⁵⁵

101. We do not adopt the proposed PSD limit of 33dBm/MHz because the overall power limit of 1 Watt (30 dBm) that we adopted in this order above would limit the PSD to a lower level. Because 33 dBm/MHz PSD is higher than the 30-dBm (1-Watt) total power limit, we instead calculate a PSD limit that can be practically measured and would not be higher than the conducted power limit of 30 dBm. We will adjust the 33 dBm/MHz proposed in the *NPRM* by simply converting the PSD into a smaller bandwidth such that the power allowed in that bandwidth does not exceed 30 dBm. Stated simply, we modify the proposed PSD limit by decreasing the power by 3 dB, and at the same time reduce the bandwidth by half, making the PSD that we are adopting 30 dBm/500 kHz. Assuming that emission levels are evenly distributed throughout the bandwidth, this is equivalent to the 8 dBm/3 kHz (33 dBm/MHz) that was proposed in the *NPRM*.

102. Furthermore, we continue to believe that the 3-kilohertz measurement bandwidth is unnecessary, as it creates an exceedingly long time for labs to complete the measurements for devices that use 20 megahertz or even wider channels. With the introduction of 80- and 160-megahertz channels with the IEEE 802.11 ac standard, the time to complete a single measure would increase significantly. Because we are adopting a PSD limit in a 500-kHz bandwidth, we modify our measurement procedures to correspondingly be performed using a 500 kHz reference bandwidth. Likewise, we modify Section 15.407(a)(5) to specify a 500-kHz reference bandwidth for the U-NII-3 band. This will allow measurements of unlicensed devices being certified for operation in the U-NII-3 band to be performed in a timely manner, resulting in efficiencies and cost savings for manufacturers, test facilities, and ultimately to consumers.

¹⁴⁸ See *NPRM*, *supra* at 1779, para.31. See also 47 C.F.R. §§ 15.247(b)(3) and 15.407(a)(3).

¹⁴⁹ *Id.*

¹⁵⁰ *Id.*

¹⁵¹ *Id.*

¹⁵² See Cisco Comments at 44, Ericsson Comments at 5, IEEE 802 LMSC Comments at 17-18, Wi-Fi Alliance Comments at 12, and Ruckus Wireless Comments at 3-4.

¹⁵³ See RuckusWireless Comments at 4.

¹⁵⁴ See IEEE 802 LMSC Comments at 18.

¹⁵⁵ See Cisco Comments at 45-46.

4. Emission Bandwidth

103. Section 15.247(a)(2) requires a minimum 6-dB bandwidth of 500 kilohertz. No minimum or maximum bandwidth is required under Section 15.407, but the emission bandwidth is defined and measured at the 26-dB-down points of the U-NII signal and is used to determine the total power allowed under that rule.¹⁵⁶ In the *NPRM* we proposed to modify Section 15.407 to eliminate the 26-dB bandwidth requirement, and to add the minimum 6-dB bandwidth requirement from Section 15.247.¹⁵⁷

104. We conclude that using a minimum 6-dB bandwidth of 500 kilohertz will continue to provide sufficient flexibility to foster development, frequency sharing and frequency reuse in the band, and we modify Section 15.407 to include that minimum-bandwidth requirement. No parties have opposed our proposal to incorporate the 500-kHz minimum bandwidth into the Section 15.407 rules. As commenters note, mandating a minimum bandwidth will help ensure that the band does not become congested with narrow-bandwidth applications for which other spectrum could be available and would promote use of the 5 GHz U-NII bands to meet the growing demand for high-speed Wi-Fi connectivity.¹⁵⁸

5. Antenna Gain

105. Under the antenna gain requirements in Section 15.247, a 1 dB reduction in power required for every 1 dB that the antenna gain exceeds 6 dBi, except for fixed point-to-point systems, for which no power reduction is required.¹⁵⁹ Under Section 15.407, a 1 dB reduction in power is also required for every 1 dB that the antenna gain exceeds 6 dBi, but for fixed point-to-point systems, a 1 dB reduction in power is required for every 1 dB that the antenna gain exceeds 23 dBi.¹⁶⁰ The main difference between the two rules is the maximum antenna gain that can be deployed for fixed point-to-point systems without a reduction in transmitter power. In the *NPRM*, we invited comment generally on reconciling the technical requirements for digitally modulated devices that are currently in Sections 15.247 and 15.407.¹⁶¹ Specifically, we proposed to apply the more stringent 23-dBi maximum antenna gain that is currently required under Section 15.407, because using the more stringent antenna gain requirement would ensure that there is no increase in the potential for harmful interference from unlicensed devices operating under the new combined rule parts.¹⁶²

106. Several commenters oppose the proposal to limit the antenna gain for point-to-point systems. Cambium believes that the addition of a limit in EIRP for fixed point-to-point applications will hamper useful deployment of longer links in hard-to-reach rural areas. Cambium states that non-line-of-sight links (NLOS) can be operated in the 5.7 GHz band using polarization diversity in cost-effective deployments where a licensed band link would require one or more repeaters.¹⁶³ Fastback Networks opposes the proposed changes to the antenna gain requirements because the current requirements in place today have permitted WISPs around the country to provide broadband services to under and unserved rural and other remote areas.¹⁶⁴

¹⁵⁶ See 47 C.F.R. §15.403(i).

¹⁵⁷ See *NPRM*, *supra* at 1780, para. 32.

¹⁵⁸ See Cisco Comments at 45, IEEE 802 LMSC Comments at 18, Wi-Fi Alliance Comments at 12.

¹⁵⁹ See 47 C.F.R. §15.247(c)(1)(ii).

¹⁶⁰ See 47 C.F.R. §15.407(a)(3).

¹⁶¹ See *NPRM*, *supra* at 1776, para. 20.

¹⁶² See *NPRM*, *supra* at 1780, para. 33.

¹⁶³ See Cambium Comments at 4.

¹⁶⁴ See Fastback Networks Comments at 3.

107. Exalt Communications Inc. (Exalt) and others believe that a higher-gain antenna has a reduced off-axis interference pattern and has volumetrically the equivalent interference to neighboring devices with respect to overall spectral density. More importantly, the higher-gain antenna promotes spectral reuse, much in the way that is seen in licensed bands such as the 6-GHz and 11-GHz bands which restrict antennas to a minimum for this exact purpose.¹⁶⁵ Exalt also states it can be safely assumed that users of the devices in these bands would not deploy an unnecessarily large antenna simply to overpower other emitters, as the cost of these antennas, and the structural and leasing costs, are very prohibitive.¹⁶⁶

108. Similarly, WISPA and others state that in many cases a WISP would be unable to provide broadband access to distant communities using a link operating under the more stringent requirements of Section 15.407, but can do so under the more permissive rules set out in Section 15.247.¹⁶⁷ WISPA believes that nearly every WISP, especially those that serve remote and rural areas where other broadband services would otherwise not be available, utilize point-to-point ISM band equipment with antenna gains higher than 23 dBi, as permitted under Section 15.247.¹⁶⁸

109. The Fixed Wireless Communication Coalition (FWCC) states that Commercial providers and professional users of licensed fixed service facilities—including wireless phone companies needing backhaul, entities that maintain and support critical infrastructure, and companies handling time-sensitive business data—sometimes must operate a link immediately, without waiting for Part 101 frequency coordination and license application. FWCC further states a common practice in these cases is to install a 5.8-GHz unlicensed link temporarily, until the licensed link can lawfully be turned on. The needed EIRP for these temporary links sometimes exceeds the 53 dBm permitted under Section 15.407.¹⁶⁹ Moreover, when the licensed link will use the 6-GHz band, it is often feasible to operate the temporary unlicensed 5.8-GHz link through the same antenna that is proposed for the 6 GHz licensed link. The Commission's antenna standards for 6 GHz, however, require gains of either 38 dBi or 32 dBi, well above the 23 dBi permitted under the U-NII rules without a power reduction. FWCC claims that imposition of the U-NII antenna rules on the 5725-5850 MHz band would eliminate the possibility of these extremely useful 5.8-GHz links on a temporary basis, and put the operator to the trouble and expense of installing an antenna that will serve for only a short time.¹⁷⁰

110. The Utilities Telecom Council (UTC) asserts that if as the FCC proposes, point-to-point operations are required to reduce power 1 dB for every increase in antenna gain of 1 dB above 23 dBi, it would restrict the power of point-to-point systems that utilities operate in the U-NII-3 band, thereby reducing the range of communications between the links and effectively precluding utilities' existing and future operations in the band. UTC asserts that utilities make extensive use of the U-NII-3 band and have made significant investments in equipment and infrastructure to support the safe, reliable and effective delivery of essential electric, gas and water services to the public at large, and that they also need to be able to upgrade those systems in the future. They state that the proposed rule would create gaps in coverage between existing links, prevent utilities from upgrading their existing systems in the future, and wipe out hundreds of utility 5.8-GHz systems across the United States. Therefore, UTC urges the Commission not to preclude the certification of equipment under Section 15.247 of the Commission's Rules.¹⁷¹

¹⁶⁵ See Exalt Comments a 1-2.

¹⁶⁶ See *Id.* at 2, see also WISPA Comments at 13-14.

¹⁶⁷ See WISPA Comments at 13-14, SpitwSpots Comments at 4, and First Step Internet, LLC (FSI) Comments at 4.

¹⁶⁸ See WISPA Comments at 13.

¹⁶⁹ See FWCC Reply Comments at 3.

¹⁷⁰ *Id.*

¹⁷¹ See UTC Reply Comments at 1-2.

111. Fastback Networks makes an alternate proposal for new antenna gain rules that would allow for the increased antenna gain to be partially extended to professionally-installed fixed point-to-multipoint systems where a professionally-installed common aggregation end fixed transmitter communicates with a small number of professionally-installed remote end fixed receivers.¹⁷² Exalt Communications submits that if the Commission reduces the antenna gain for fixed point-to-point systems, then it should consider an alternate proposal for transmitter power reduction that is a different ratio than 1-for-1, such as 1-for-6, and only apply this limit for antenna configurations that result in an EIRP limit above a certain value.¹⁷³

112. We decline to adopt our initial proposal to revise Section 15.247 to require a limit in antenna gain, and will continue to permit the use of unlicensed high gain point-to-point antennas as in the U-NII-3 band. Proposals in the *NPRM* were not intended to reduce the capabilities of any of the equipment previously certified under either rule. We are persuaded that revising those gain requirements as we proposed would be inconsistent with that goal. Instead, we modify Section 15.407 to permit point-to-point operation under the same gain requirements currently in Section 15.247. The current rules allow service providers to deploy cost-effective wireless links in what would otherwise be considered high cost areas, and allow for the quick setup and transitioning of unlicensed and licensed microwave links. There were no harmful interference cases caused by compliant high-gain point-to-point systems; rather harmful interference was caused by high-gain systems that were illegally modified. We believe that our enhanced security requirements will ensure that these point-to-point systems operate in modes consistent with their certification, and therefore there should be no increase in harmful interference by allowing them to continue to operate as before.

113. We find that Fastback's proposal to increase the eligibility for higher antenna gain to point-to-multipoint systems would be an expansion of usage in the U-NII-3 band, and therefore is beyond our proposal to consolidate the Section 15.247 and the Section 15.407 rules in the U-NII-3 band. Thus Fastback's proposal is outside the scope of this proceeding. Exalt's alternate proposal for antenna gain is obviated by our decision to continue to allow unlimited antenna gain for point-to-point systems operating in the U-NII-3 band.

6. Unwanted Emissions

114. Section 15.247(d) requires 20 dB of attenuation (30 dB if the alternate measurement procedure detailed in Section 15.247(b)(3) is used) for unwanted emissions. In restricted bands,¹⁷⁴ emissions must meet the Section 15.209 general emission limits.¹⁷⁵ Section 15.407 requires unwanted emissions to be below -17 dBm/MHz within 10 megahertz of the band edge, and below -27 dBm/MHz beyond 10 megahertz of the band edge.¹⁷⁶ Also, all emissions below 1 GHz must comply with the Section 15.209 general emission limits. The unwanted emission limits in Section 15.407 are somewhat more restrictive than those in Section 15.247. Because unwanted emission can be reduced without

¹⁷² See Fastback Networks Comments at 4.

¹⁷³ See Exalt Comments at 3.

¹⁷⁴ See 47 C.F.R. § 15.205(a). There are a number of restricted bands in which low power, non-licensed transmitters are not allowed to operate because of potential harmful interference to sensitive radio communications such as aircraft radionavigation, radio astronomy and search and rescue operations. Only spurious emissions from Part 15 devices are permitted in these restricted bands.

¹⁷⁵ See 47 C.F.R. § 15.247(d). See also 47 C.F.R. § 15.209.

¹⁷⁶ See 47 C.F.R. § 15.407(b)(4). In KDB 789033 D01– UNII General Test Procedures v01r02 (available at: <http://www.fcc.gov/labhelp>), our Office of Engineering and Technology (OET) has advised applicants that they can demonstrate compliance with the -27 dBm/MHz and -17 dBm/MHz out-of-band emission limits outside of the restricted bands with spectrum measurements performed with the peak detection and “max hold” settings of the spectrum analyzer.

affecting the utility of the device, and because using the more stringent unwanted emissions requirement will ensure that there is no increase in the potential for harmful interference from unlicensed devices operating under the new combined rule parts, we proposed in the *NPRM* that the more restrictive limits in Section 15.407 be required for digitally modulated devices.¹⁷⁷

115. The majority of commenters support the Commission's proposal to apply the more restrictive unwanted emissions limits from Section 15.407 of our rules to the new consolidated rule section.¹⁷⁸ However, Exalt is opposed to our proposal because it believes it will likely result in a more restrictive tuning range, and/or significantly higher manufacturing costs for more stringent filtering.¹⁷⁹ Exalt recognizes the intention for reduced interference out-of-band, but indicate that there are no specific references indicating that the Section 15.247 regulations have caused any issues in this regard.¹⁸⁰

116. Similarly, Cambium asserts that the existing out-of-band emission limits for devices certified under Section 15.407 are substantially more stringent than for devices certified under Section 15.247. It believes that, if devices operating in the 5.7 GHz band are to meet the out-of-band emission limits from Section 15.407, they must incorporate transmitter sections of considerably greater complexity than those found in Section 15.247 devices, including the use of additional high performance RF filters. The additional complexity would result in higher manufacturing costs, increasing the selling price of unlicensed devices to the extent that many existing applications for lower-tier U-NII band devices may well cease to be cost effective.¹⁸¹

117. Cambium also states that they are not aware of a documented link between out-of-band emissions for devices certified under Section 15.247 and interference to TDWRs operating at 5.6 GHz to 5.650 GHz, and they request that the Commission relax the emission rules for the U-NII 3 band to match or approach the existing rules for Section 15.247. Cambium takes the view that incumbent systems in the U-NII 2C band are more likely to be affected by the fundamental emission from unlicensed devices in the same band than from unwanted out of band radiation from devices in the U-NII 3 band.¹⁸²

118. Alliance and Global further state that the Commission's proposed unwanted emissions limits for U-NII-3 devices would allow emissions that extend into the 5.85-GHz band at levels that would likely cause harmful interference for DSRC devices.¹⁸³

119. We adopt our proposal to apply the more restrictive unwanted emissions limits in Section 15.407 for the combined new rule, rather than the more lenient unwanted emissions limit currently in Section 15.247. This decision is consistent with our decision to apply the 15.407 out-of-band emission levels in the U-NII-2 bands¹⁸⁴ and having a single limit for devices that operate in any U-NII band will provide clarity and simplicity, while providing appropriate protection to incumbent services. As noted above, the record shows broad support for adopting the tighter unwanted-emissions limits of Section 15.407 limits. We recognize that high gain point-to-point systems certified under Section 15.247 may have to be modified to comply with the lower out-of-band emissions limit from Section 15.407.

¹⁷⁷ See *NPRM*, *supra* at 1780, para. 34.

¹⁷⁸ See NCTA Comments at 30, Comcast Comments at 23, Wi-Fi Alliance Comments at 13, Motorola Solutions Comments at 3, IEEE 802 LMSC Comments at 26, Cisco Comments at 47, Ericsson Comments at 4, Globalstar Comments at 3, Motorola Mobility Comments at 4, TIA Comments at 12, and Ruckus Wireless Comments at 3.

¹⁷⁹ See Exalt Comments at 3.

¹⁸⁰ See Exalt Comments at 3-4

¹⁸¹ See Cambium Comments at 3-4.

¹⁸² See Cambium Comments at 4.

¹⁸³ See Alliance and Global Reply Comments at 30.

¹⁸⁴ See *supra* para. 75

Manufacturers have the flexibility to determine how they should meet the lower out-of-band emissions limit whether by reducing power, decreasing antenna gain, or utilizing tighter filters.

120. We disagree with Alliance and Global that adopting the more stringent unwanted emission limit from Section 15.407 will increase the harmful interference risk to DSRC services. Unlicensed devices are already allowed to operate within the 5.825 -5.85 GHz band under Section 15.247 of our rules with higher unwanted emission levels than we are adopting for the new combined rule part. We are simply consolidating the existing rules into a single section, which will decrease, not increase the risk of harmful interference to DSRC services.

7. Peak-to-Average Power Ratio

121. Section 15.407 contains a requirement to maintain a peak-to-average power ratio of no more than 13 dB across any 1 megahertz band, whereas Section 15.247 does not contain any peak-to-average ratio requirement.¹⁸⁵ In the *NPRM* we proposed to keep the peak-to-average ratio requirement that is currently in Section 15.407 in order to ensure that there is no increase in the potential for harmful interference from unlicensed devices operating under the new combined rule.¹⁸⁶

122. Exalt opposes any peak-to-average power ratio requirement, stating that the Section 15.247 rules are sufficient and would cause fewer issues with product/technology transition.¹⁸⁷ William Graff suggests eliminating the peak-to-average limit, which he believes is no longer necessary because this is a test for which he has never seen failure, and which occupies a significant portion of a test laboratory's time.¹⁸⁸ As an alternative to the current peak-to-average requirement, Mark Briggs suggests removing the Peak Excursion requirement and replacing it with either a Peak-to-Average Power Ratio of 13 dBm (measured using the procedures outlined in the FCC guidance for licensed wide-band transmitters) or a peak power density limit of 30 dBm/MHz.¹⁸⁹ We agree with commenters that this measurement is no longer necessary, and eliminate this requirement from the rules.

8. Hybrid Devices

123. In the *NPRM* we stated that we would continue to authorize under Section 15.247 frequency hopping spread spectrum devices in the 5725-5850 MHz band and hybrid devices, *i.e.*, those that can function as either spread spectrum or digitally modulated systems, because these devices have not been observed to cause harmful interference to TDWRs and do not have the similarities to U-NII devices that other digitally modulated systems have.¹⁹⁰ We will continue to authorize under Section 15.247 frequency hopping spread spectrum devices and the frequency hopping spread spectrum portion of hybrid devices in the 5725-5850 MHz band. The digitally modulated portion of hybrid devices will have to meet the modified U-NII rules for this band.

E. Adoption of Miscellaneous Rule Modifications

124. The *NPRM* proposed several rule modifications to simplify and clarify Part 15 of the rules. Our review revealed several sections of the rules that referenced procedures or provisions that are no longer in use and therefore, are no longer necessary. No party opposes the miscellaneous rule modifications that we proposed and thus we adopt them. In Section 15.403 (m) we replace "Peak Power

¹⁸⁵ See 47 C.F.R. §15.407(a)(6).

¹⁸⁶ See *NPRM*, *supra* at 1780, para. 35.

¹⁸⁷ See Exalt Comments at 4.

¹⁸⁸ See William Graff Comments and Reply Comments.

¹⁸⁹ See Mark Briggs Comments.

¹⁹⁰ See *NPRM*, *supra* at 1778, fn 38. The statement in the *NPRM*, that we would continue to authorize hybrid devices under Section 15. 247, was only intended to apply to the frequency hopping spread spectrum portion of hybrid devices as we clearly proposed to bring all digitally modulated devices under the U-NII rules.

Spectral Density” with “Maximum Power Spectral Density.” In addition, we delete “peak or” from Section 15.403 (o) for clarity. We also delete section 15.247 (b)(4)(i) through (b)(4)(ii) to eliminate repetitive language that is found in section 15.247 (c)(1)(i) through (c)(1)(iii)

125. In Section 15.407 we delete the second sentence in paragraph (a)(4) because it contains language that is no longer relevant. We also correct the wording in paragraphs (a)(2) and (a)(5) by replacing “peak” with “maximum.” We also correct the wording in paragraph (b)(8) by replacing “block edges” with “band edges.” We also clarify rule Section 15.215(c) to allow the operation of a U-NII device over multiple channels/bands. U-NII Band straddling in the 5-GHz region of U-NII spectrum is allowed and applies to 802.11ac bonded 80-megahertz and 160-megahertz channels. We also modify Section 15.407(h)(2) to clarify the language for DFS requirements once the emission bandwidth of a U-NII device is straddled across multiple U-NII bands.

F. Transition Periods

126. In the *NPRM*, the Commission proposed to establish a 12-month timetable after the effective date of any new or modified rules for manufacturers to produce U-NII devices that comply with new or modified rules. We also proposed to establish a two-year timetable after the effective date of any new or modified rules for requiring that any U-NII devices manufactured in or imported into the United States for sale comply with the new or modified rules. Additionally, we proposed to not allow Class II permissive changes after the two-year transition period for devices certified under the old rules.¹⁹¹ Finally, we proposed that U-NII devices that are already installed or in use should be grandfathered for the life of the equipment.¹⁹²

127. *Comments.* Cisco supports the proposal to allow the option to certify equipment under the new or modified rules during the proposed transition period as soon the test procedures are ready.¹⁹³ Several commenters oppose a 12-month deadline for U-NII devices to be certified under the new rules because they are concerned that the proposed transition plan does not allow an adequate amount of time for manufacturers to complete design, fabrication, and certification processes. Cambium states that under the proposed transition period, existing products must be withdrawn from sale within two years and this period is significantly shorter than the typical lifespan of an infrastructure product. Cambium does not believe that two years is a reasonable deadline to develop and bring to market a portfolio of new U-NII band products, and requests that the Commission allow for a longer transition period.¹⁹⁴ Similarly, MSI believes the Commission should instead adopt a final transition period of five years, with at least two years for manufacturers to begin producing U-NII devices that comply with the new rules.¹⁹⁵ Exalt urges the Commission to consider longer timetables for the transition period because a 12-month cycle is not long enough to plan, schedule, budget and produce new products, along with gaining approvals.¹⁹⁶ WISPA believes that both the 12-month and two-year deadlines should be extended by 12 months to allow for compliance.

128. Several commenters oppose the proposal to not allow Class II permissive changes after the two-year transition period. Cisco and the Wi-Fi Alliance state that Class II permissive changes to devices certified under the old rules should be permitted after the two-year transition period where those changes are designed to provide appropriate DFS protection to the new Bin 1 Waveforms adopted by

¹⁹¹ See *NPRM, supra* at 1803. See also, 47 C.F.R §2.1043(b)(2). A Class II permissive change class includes modifications which degrade the performance characteristics as reported to the Commission at initial certification.

¹⁹² See *NPRM, supra* at 1803, paras. 114-15.

¹⁹³ See Cisco Comments at 52.

¹⁹⁴ See Cambium Comments at 5.

¹⁹⁵ See Motorola Solutions Comments at 12.

¹⁹⁶ See Exalt Comments at 4-5, WISPA Comments at 18, and NCTA Comments at 24.

OET. Cisco states that given the importance of avoiding interference to TDWR, the Commission should not impose on manufacturers a disincentive to upgrading existing equipment to protect the new Bin 1 Waveforms.¹⁹⁷ Other parties suggest the Commission should permit permissive changes past the proposed two-year compliance deadline because many existing devices are already capable of operating in the new bands, or pursuant to the revised rules, after necessary firmware and software updates—even if they were not originally certified for operation on the U-NII bands. For example, MSI notes that a certification grant may be for 2.4 GHz and 5.8 GHz 802.11 WLAN equipment, but the data submitted with the original grant could be sufficient to demonstrate compliant operations on the U-NII-2 or UNII-3 bands under the new rules. MSI states that the Commission should facilitate these upgrades by allowing the addition of new operating bands to existing equipment certifications through Class II permissive changes.¹⁹⁸

129. *Decision.* We adopt our proposal to require that 12 months after the effective date of this First R&O, applications for certification of 5 GHz devices must meet the new and modified rules adopted herein. The manufacture, marketing, sale and importation into the United States of devices that do not meet the new or modified rules adopted herein must cease two years after the effective date of this First R&O.¹⁹⁹ While we are sympathetic to the arguments of commenters that the more restrictive unwanted emission limits for digital modulation devices may present design challenges for some manufacturers, we find that it is in the public interest to implement the changes as soon as possible to eliminate the potential of harmful interference to TDWRs.

130. Grandfathered devices must continue to employ DFS as required in Section 15.407(h)(2). Devices operating in the U-NII-2A or U-NII-2C bands that do not have DFS, or that have DFS turned off are not compliant with the Part 15 Rules, and any operators who use such devices may be subject to a forfeiture, as described earlier. As noted by the commenters, large numbers of 5 GHz U-NII devices are already in the marketplace and pose no threat of harmful interference unless they are modified in violation of the Commission's rules. However, should these devices be subsequently modified and cause harmful interference to TDWR or any other incumbent systems, the FCC Enforcement Bureau will continue its aggressive approach to ensuring compliance with our rules.²⁰⁰

131. We are modifying certain technical requirements in our rules for all U-NII devices to reduce the possibility that these devices could continue to cause harmful interference to TDWR systems and other incumbent services that operate in the 5 GHz band. We believe that the public interest is best served by minimizing the potential for harmful interference as soon as practicable. We also believe that the requirements that U-NII devices include security features and to incorporate and use appropriate interference mitigation technology are readily achievable. We decline to require mitigation techniques such as geo-location and database registration which may have proven more time-consuming to implement. Thus, we believe the transition period that we are adopting is appropriate.

132. Since 2010, the Commission has been certifying U-NII-2C devices under interim procedures which require that the 5.6-5.65 GHz band be notched out, and that certain devices within 35 km of a TDWR location be separated by at least 30 MHz (center-to-center) from the TDWR operating frequency.²⁰¹ We will permit U-NII-2C, *i.e.*, devices operating in the 5470-5725 MHz band, to be

¹⁹⁷ See Cisco Comments at 53.

¹⁹⁸ See Motorola Solutions Comments at 13.

¹⁹⁹ Use of devices sold within this period will be grandfathered for the life of the equipment.

²⁰⁰ The Commission has previously noted that harmful interference to TDWR poses a clear hazard to air traffic safety and requires aggressive enforcement. See *Towerstream Corporation*, Notice of Apparent Liability for Forfeiture and Order, 28 FCC Rcd 11604 (Enf. Bur. 2013).

²⁰¹ See FCC, OET, "Interim Plans to Approve UNII Devices Operating in the 5470-5725 MHz Band with Radar Detection and DFS Capabilities", KDB Publication No. 443999 DO1, available at: <http://www.fcc.gov/labhelp>.

certified either under these interim procedures or the new rules adopted herein for 12 months after the effective date of this First R&O. After 12 months, all U-NII-2C devices must meet the new rules in order to be certified.

133. We adopt our proposal to no longer allow Class II permissive changes for devices certified under either the old rules, or the U-NII-2C interim procedures, after two years unless they meet the new rules adopted here. Devices may continue to apply for Class II permissive changes that demonstrate compliance with the old rules for only up to two years after the effective date of the new rules. However, we are persuaded by commenters that it is in the public interest to continue to allow indefinitely Class II permissive changes to devices certified under the old rules in some instances.²⁰² We agree with Cisco²⁰³ that the Commission should not impose on manufacturers a disincentive to upgrading existing grandfathered equipment to protect the new Bin 1 Waveforms. We also agree with the commenters that Class II permissive changes should be permitted after the two-year transition period where those changes are designed to provide appropriate DFS protection or where existing devices are already capable of operating pursuant to the revised rules, after necessary firmware and software updates.²⁰⁴ We will therefore allow devices certified under the old rules, or U-NII-2C interim procedures, prior to the 12-month effective date of the new rules, to demonstrate compliance with the new or modified rules through Class II permissive changes.

134. We will continue to allow digital modulation equipment and the digital modulation portion of hybrid devices, *i.e.*, those that can function as either spread spectrum or digitally modulated systems, operating in the 5.725-5.850 GHz band to be certified to meet the Section 15.247 requirements for 12 months after the effective date of the new rules. After 12 months, digital modulation devices and the digital modulation portion of hybrid devices must meet the new Section 15.407 U-NII-3 rules in order to be FCC certified. The frequency hopping spread spectrum portion of hybrid devices will continue to be certified under the Section 15.247 spread spectrum rules. The manufacture, marketing, sale and importation into the United States of digitally modulated and hybrid devices certified under Section 15.247 operating in the 5.725-5.850 GHz band must cease two years after the effective date of this First R&O. Likewise they may apply for Class II permissive changes to demonstrate compliance with the old rules for up to two years after the effective date of these new rules. After two years, these devices must be certified to meet the new rules and Class II permissive changes may only be made if these devices meet the new rules as well.

IV. PROCEDURAL MATTERS

135. *Final Regulatory Flexibility Analysis.* As required by Section 603 of the Regulatory Flexibility Act, 5 U.S.C. § 604, the Commission has prepared a Final Regulatory Flexibility Analysis (FRFA) of the possible significant economic impact on small entities of the changes adopted in this document. The FRFA is set forth in Appendix A.

136. *Paperwork Reduction Analysis.* This document contains modified information collection requirements subject to the Paperwork Reduction Act of 1995 (PRA), Public Law 104-13. It will be submitted to the Office of Management and Budget (OMB) for review under Section 3507(d) of the PRA. OMB, the general public, and other Federal agencies are invited to comment on the new or modified information collection requirements contained in this proceeding. This collection of information will be covered under (OMB 3060-0057 Equipment Authorization).

137. *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).

²⁰² See Cisco Comments at 53, WI-FI Alliance at 31-32, and IEEE 802 LMSC at 25-26.

²⁰³ See Cisco Comments at 53.

²⁰⁴ See Cisco Comments at 53, WI-FI Alliance at 31-32, and IEEE 802 LMSC at 25-26.

V. ORDERING CLAUSES

138. 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 First Report and Order is hereby ADOPTED and Part 15 of the Commission's Rules ARE AMENDED as set forth in Appendix C, **[effective 30 days after date of publication in the Federal Register]** except for Section 15.407(j) which contains information collection requirements subject to the Paperwork Reduction Act of 1995, Public Law 104-13, that are not effective until approved by the Office of Management and Budget. The Federal Communications Commission will publish a document in the Federal Register announcing OMB approval and the effective date of this rule.

139. IT IS FURTHER ORDERED that the Office of Engineering and Technology Is delegated authority to grant waivers of the antenna requirements adopted herein consistent with the terms of this Order.

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

141. IT IS FURTHER ORDERED that the Office of Engineering and Technology shall publish, consistent with the terms of this Report and Order, measurement procedures that will be used for certifying equipment that will operate in the 5.15-5.35 GHz and 5.47-5.85 GHz bands.

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 *Notice of Proposed Rulemaking (NPRM)* in ET Docket No. 13-49.² The Commission sought written public comment on the proposals in the *NPRM*, 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. The First Report and Order amends the regulations for Information Unlicensed National Information Infrastructure (U-NII) devices which operate in the 5 GHz band.³ U-NII devices are unlicensed intentional radiators which use wideband digital modulation techniques to provide a wide array of high data rate mobile and fixed communications used by individuals, businesses, and institutions.⁴ As discussed below, we are modifying certain technical requirements in our rules for all U-NII devices to ensure that these devices do not cause harmful interference to Terminal Doppler Weather Radar (TDWR) systems and other radar systems that operate in the 5 GHz band. We are also extending the upper edge of the 5.725-5.825 GHz U-NII band from 5.825 GHz to 5.85 GHz and consolidating the provisions formerly applicable to digitally modulated devices under Section 15.247 of the rules for this band with the U-NII rules in Section 15.407. This change will eliminate a loophole in the former rules that allowed devices to be certified under the Section 15.247 rules and then modified to operate as U-NII devices without complying with all of the technical requirements of the U-NII rules - a practice that was shown to be a major source of harmful interference to TDWRs. Finally, we are removing the indoor only restriction and increasing the permitted power for U-NII devices in the 5.15-5.25 GHz band thus increasing the amount of spectrum available for next generation Wi-Fi services by 100 megahertz.

B. 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.

¹ See 5 U.S.C. § 603. The RFA, *see* 5 U.S.C. § 60-612, 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 See *Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band* in ET Docket No. 13-40, *Notice of Proposed Rulemaking*, 28 FCC Rcd. 1769 (2013) (*NPRM*).

³ See 47 C.F.R. Part 15 Subpart E – Unlicensed National Information Infrastructure Devices.

⁴ See 47 C.F.R. § 15.403(s).

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.⁵ The RFA defines the term “small entity” as having the same meaning as the terms “small business,” “small organization,” and “small business concern” under Section 3 of the Small Business Act.⁶ 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 any additional criteria established by the Small Business Administration (SBA).⁷

E. Small Businesses, Small Organizations, and Small Governmental Jurisdictions.

6. 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.⁸ As of 2009, small businesses represented 99.9% of the 27.5 million businesses in the United States, according to the SBA.⁹ Additionally, a “small organization” is generally “any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.”¹⁰ Nationwide, as of 2007, there were approximately 1,621,315 small organizations.¹¹ 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.”¹² Census Bureau data for 2007 indicate that there were 89,527 governmental jurisdictions in the United States.¹³ We estimate that, of this total, as many as 88,761 entities may qualify as “small governmental jurisdictions.”¹⁴ Thus, we estimate that most governmental jurisdictions are small.

⁵ See 5 U.S.C. § 603(b)(3).

⁶ *Id.* § 601(3).

⁷ *Id.* § 632.

⁸ See 5 U.S.C. § 601(3)–(6).

⁹ See SBA, Office of Advocacy, “Frequently Asked Questions,” available at <http://web.sba.gov/faqs/faqindex.cfm?areaID=24> (last visited Aug. 31, 2012).

¹⁰ 5 U.S.C. § 601(4).

¹¹ INDEPENDENT SECTOR, THE NEW NONPROFIT ALMANAC & DESK REFERENCE (2010).

¹² 5 U.S.C. § 601(5).

¹³ U.S. CENSUS BUREAU, STATISTICAL ABSTRACT OF THE UNITED STATES: 2011, Table 427 (2007).

¹⁴ 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).

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 broadcasting equipment.”¹⁵ The SBA has developed a small business size standard for firms in this category, which is: all such firms having 750 or fewer employees.¹⁶ 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.¹⁷ Thus, under this size standard, the majority of firms can be considered small.

F. Description of Projected Reporting, Record keeping and Other Compliance Requirements.

8. The Report and Order contains a non-substantial modification to the information collection requirements. The rules adopted in this First Report and Order will apply to small businesses that choose to use, manufacture, design, import, or sell Part 15 U-NII devices. There is no requirement, however, for any entity to use, market, or produce these types of products. Small businesses are already subject to the existing rules with regard to reporting, record keeping and other compliance requirements related to U-NII devices. The rules adopted in this First Report and Order do not add substantial additional compliance burden on small businesses.

G. 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.¹⁸

10. In this First Report and Order, we modify our rules for Unlicensed National Information Infrastructure (U-NII) devices which operate in the 5 GHz band.¹⁹ U-NII devices are unlicensed intentional radiators which use wideband digital modulation techniques to provide a wide array of high data rate mobile and fixed communications used by individuals, businesses, and institutions.²⁰ As discussed below, we are modifying certain technical requirements in our rules for all U-NII devices to ensure that these devices do not cause harmful interference to Terminal Doppler Weather Radar (TDWR) systems and other radar systems that operate in the 5 GHz band. We are also extending the upper edge of the 5.725-5.825 GHz U-NII band from 5.825 GHz to 5.85 GHz and consolidating the provisions formerly

¹⁵ 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>.

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

¹⁷ http://factfinder.census.gov/servlet/IBQTable?_bm=y&-fds_name=EC0700A1&-geo_id=&-_skip=300&-ds_name=EC0731SG2&-_lang=en.

¹⁸ 5 U.S.C. § 603(c).

¹⁹ See 47 C.F.R. Part 15 Subpart E – Unlicensed National Information Infrastructure Devices.

²⁰ See 47 C.F.R. § 15.403(s).

applicable to digitally modulated devices under Section 15.247 of the rules for this band with the U-NII rules in Section 15.407. This change will eliminate a loophole in the former rules that allowed devices to be certified under the Section 15.247 rules and then modified to operate as U-NII devices without complying with all of the technical requirements of the U-NII rules - a practice that was shown to be a major source of harmful interference to TDWRs. Finally, we are removing the indoor only restriction and increasing the permitted power for U-NII devices in the 5.15-5.25 GHz band thus increasing the amount of spectrum available for next generation Wi-Fi services by 100 megahertz.

Report to Congress

11. 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.²¹ 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.²²

²¹ See 5 U.S.C. § 801(a)(1)(A).

²² See 5 U.S.C. § 604(b).

APPENDIX B

Commenting Parties

Parties filing comments:

1. ACEA (European Automobile Manufacturers Association)
2. Advanced Designs Corporation
3. American Association of State Highway & Transportation Officials (AASHTO)
4. American Honda Motor Co., Inc.(Honda)
5. American Motorcyclist Association
6. ARRL, the national association for Amateur Radio
7. Association for the Advancement of Medical Instrumentation (AAMI)
8. Baron Services, Inc.
9. Bart Kus, (HamWAN)
10. BNetzA Germany
11. Broadcom
12. Cablevision Systems Corporation (Cablevision)
13. California Department of Transportation
14. Cambium Networks Ltd.
15. Cisco Systems, Inc. (Cisco)
16. Comcast Corporation (Comcast)
17. Consumer Electronics Association (CEA)
18. David Sparks
19. Delphi Automotive (Delphi)
20. Department of Commerce
21. Engine Advocacy
22. Enterprise Electronics Corp.
23. Ericsson
24. European Automobile Manufacturers' Association (ACEA)
25. European Space Agency (ESA)
26. Exalt Communications Inc.
27. Fastback Networks
28. First Step Internet, LLC (FSI)
29. Ford Motor Company (Ford)
30. General Motors Company (GM)
31. Globalstar, Inc. (Globalstar)
32. Google Inc. and Microsoft Corporation
33. Greg Larson, Department of Transportation, CA (CALTRANS)
34. Hans Klein Comments by ITSPAC - Intelligent Transportation Systems Program Advisory
35. Hubbard Broadcasting, Inc.
36. IEEE 802 LMSC
37. Information Technology Industry Council (ITIC)
38. Intelligent Transportation Society of America (ITS America)
39. Jackson Buddingh
40. Jay Joseph / Honda
41. Joe Cabrara, Safe America Foundation

42. Kurtis Morrison (on behalf of Don Hunt). Department of Transportation, State of Colorado.
43. Mercedes-Benz USA, LLC
44. Motorola Mobility LLC
45. Motorola Solutions, Inc. (MSI)
46. National Association of Broadcasters (NAB)
47. National Cable & Telecommunications Association (NCTA)
48. National Telecommunications and Information Administration (NTIA)
49. National Transportation Safety Board (NTSB)
50. Nickolaus E. Leggett
51. QUALCOMM Incorporated (Qualcomm)
52. Ruckus Wireless, Inc.
53. Sören Hess
54. SAE International
55. Savari, Inc. (Savari)
56. SES S.A. and Intelsat S.A.
57. Shared Spectrum Company
58. Spectrum Bridge
59. SPITwSPOTS, Inc.
60. Telecommunications Industry Association (TIA)
61. The Alliance of Automobile Manufacturers, Inc. and the Association of Global Automakers, Inc.
62. The National Association for Amateur Radio (ARRL)
63. Thomas Zorn, Volkswagen
64. Time Warner Cable Inc.
65. Toyota Motor North America, Inc.
66. Utah Department of Transportation
67. Wi-Fi Alliance
68. William Graff
69. Wireless Internet Service Providers Association (WISPA)

Parties filing reply comments:

1. American Association of State Highway & transportation officials (AASHTO)
2. American Cable Association (ACA)
3. Arizona Department of Transportation
4. Baron Services
5. Cablevision Systems Corporation
6. Cisco Systems (Cisco)
7. Comcast Corporation
8. Dr. Eli Yablonovitch
9. Fixed Wireless Communications Coalition (FWCC)
10. GlobalStar Inc. (Globalstar)
11. IEEE 802 LMSC
12. Intelligent Transportation Society of America (ITS America)
13. James E. Whedbee / Amateur
14. Mark Briggs

15. Mobile Satellite Users Association (MSUA)
16. National Association of Broadcasters (NAB)
17. National Cable & Telecommunications Association (NCTA)
18. National Public Safety Telecommunication Council (NPSTC)
19. PCIA - The Wireless Infrastructure Association and the HetNet Forum
20. Public Interest Organizations (The Open Technology Institute at the New America Foundation and Public Knowledge)
21. SAE International (Society of Automotive Engineers)
22. Satellite Industry Association (SIA)
23. SES S.A. & Intelsat S.A.
24. Shared Spectrum Company
25. The Alliance of Automobile Manufacturers, Inc. and the Association of Global Automakers (Alliance&Global)
26. The National Association for Amateur Radio (ARRL)
27. Toyota Motor North America (Toyota)
28. Utilities Telecom Council (UTC)
29. Wi-Fi Alliance
30. Wireless Internet Service Providers Association (WISPA)
31. Wisconsin Department of Transportation

Parties filing Ex-Parte Statements:

1. ADS-B Technologies, LLC
2. Alliance of Automobile Manufacturers and Association of Global Automakers (Alliance & Global)
3. Bright House Networks
4. Broadcom Corporation
5. Cisco Systems (Cisco)
6. Coastal Communications Consultants, Inc
7. Comcast Corporation (Comcast)
8. CTIA – The Wireless Association
9. Custom Cellular Concepts Corporation
10. Dynamic Spectrum Alliance
11. Eagle Eye Fishing Corp. et al.
12. Fastback Networks
13. Fixed Wireless Communications Coalition, Inc.
14. General Motors Company
15. Geochemical and Environmental Research Group, Texas AT&M University
16. GeoSonics Inc.
17. Globalstar, Inc. (Globalstar)
18. Globalstar Investors
19. Google Inc. (Google)
20. Intelligent Transportation Society of America (ITS America)
21. Microsoft Corporation
22. Mobile Future
23. National Cable & Telecommunications Association (NCTA)

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24. National Telecommunications and Information Administration (NTIA)
 25. New America Foundation
 26. OmniAir Consortium
 27. Openity, LLC
 28. Public Interest Organizations
 29. Public Interest Spectrum Coalition
 30. Public Knowledge
 31. Satellite Phone Solutions LLC
 32. SES S.A. and Intelsat S.A.
 33. Snodgrass, Inc.
 34. Telecommunications Industry Association
 35. The Hospital Council of Northwest Ohio
 36. United States Department of Transportation
 37. Wi-Fi Alliance
 38. Wireless Internet Service Providers Association (WISPA)

APPENDIX C**Final Rules**

For the reasons set forth in the preamble the Federal Communications Commission amends Parts 2 and 15 of the Code of Federal Regulations to read as follows:

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

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

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

2. Section 2.1033 is amended by adding paragraph (b)(13) to read as follows:

§ 2.1033 Application for certification.

(b) *****

(13) Applications for certification of U-NII devices in the 5.15-5.35 GHz and the 5.47-5.85 GHz bands must include a high level operational description of the security procedures that control the radio frequency operating parameters and ensure that unauthorized modifications cannot be made.

PART 15 – RADIO FREQUENCY DEVICES

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

Authority: 47 U.S.C. 154, 302a, 303, 304, 307, 336, 544a, and 549.

4. Section 15.37 is amended by adding new paragraph (h) to read as follows:

§ 15.37 Transition provisions for compliance with the rules.

(h) Effective (12-months after the effective date) devices using digital modulation techniques in the 5725-5850 MHz bands will no longer be certified under the provisions of Section 15.247. The technical requirements for obtaining certification after this date for digitally modulated devices and the digitally modulated portion of hybrid devices are found in Subpart E of this Part. The provisions for the frequency hopping spread spectrum portion of hybrid devices will remain in Section 15.247. Effective (2 years after the effective date) systems using digital modulation techniques in the 5725-5850 MHz band certified under the provisions of Section 15.247 may no longer be imported or marketed within the United States.

5. Section 15.215 is amended by revising paragraph (c) to read as follows:

§ 15.215 Additional provisions to the general radiated emission limitations.

(c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in Subpart E of this part, must be designed to ensure that

the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of Subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that Subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

6. Section 15.247 is amended by removing paragraphs (b)(4)(i), (ii) and (iii), and by revising paragraph (f) to read as follows:

§ 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

(b) ***

(4) ***

(i) [Remove]

(ii) [Remove]

(iii) [Remove]

(f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

NOTE TO PARAGRAPH (f): The transition provisions found in section 15.37(h) will apply to hybrid devices beginning (12-months after the effective date).

7. Section 15.401 is amended to read as follows:

§ 15.401 Scope.

This subpart sets out the regulations for unlicensed National Information Infrastructure (U-NII) devices operating in the 5.15-5.35 GHz, 5.47-5.725 GHz and 5.725-5.85 GHz bands.

8. Section 15.403 is amended by revising the definition in paragraphs (m), (o) and (s) to read as follows:

§ 15.403 Definitions.

(m) *Maximum Power Spectral Density.* The maximum power spectral density is the maximum power spectral density, within the specified measurement bandwidth, within the U-NII device operating band.

(o) *Power Spectral Density.* The power spectral density is the total energy output per unit bandwidth from a pulse or sequence of pulses for which the transmit power is at its maximum level, divided by the total duration of the pulses. This total time does not include the time between pulses during which the transmit power is off or below its maximum level.

(s) *U-NII devices.* Intentional radiators operating in the frequency bands 5.15-5.35 GHz and 5.470-5.850 GHz that use wideband digital modulation techniques and provide a wide array of high data rate mobile and fixed communications for individuals, businesses, and institutions.

9. Section 15.407 is amended by revising paragraphs (a)(1) through (a)(5), (b)(1) through (b)(4), (b)(8), (e), and (h)(2), and by removing paragraphs (a)(6), and by adding new paragraphs (i) and (j) to read as follows:

§ 15.407 General technical requirements.

(a) Power limits:

(1) For the band 5.15-5.25 GHz.

(i) For an outdoor access point operating in the band 5.15 – 5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 17 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. The maximum e.i.r.p. at any elevation angle above 30 degrees as measured from the horizon must not exceed 125 mW (21 dBm).

(ii) For an indoor access point operating in the band 5.15 – 5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 17 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(iii) For fixed point-to-point access points operating in the band 5.15 – 5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. Fixed point-to-point U-NII devices may employ antennas with directional gain up to 23 dBi without any corresponding reduction in the maximum conducted output power or maximum power spectral density. For fixed point-to-point transmitters that employ a directional antenna gain greater than 23 dBi, a 1 dB reduction in maximum conducted output power and maximum power spectral density is required for each 1 dB of antenna gain in excess of 23 dBi. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

(iv) For mobile and portable client devices in the 5.15 – 5.25 GHz band, the maximum conducted output power over the frequency band of operation shall not exceed 250 mW provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(2) For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum conducted output power over the frequency bands of operation shall not exceed the lesser of 250 mW or $11 \text{ dBm} + 10 \log B$, where B is the 26 dB emission bandwidth in megahertz. In addition, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(3) For the band 5.725-5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. In addition, the maximum power spectral density shall not exceed 30 dBm in any 500 kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. However, fixed point-to-point U-NII devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

NOTE TO PARAGRAPH (a)(3): The Commission strongly recommends that parties employing U-NII devices to provide critical communications services should determine if there are any nearby Government radar systems that could affect their operation.

(4) The maximum conducted output power must be measured over any interval of continuous transmission using instrumentation calibrated in terms of an rms-equivalent voltage.

(5) The maximum power spectral density is measured as a conducted emission by direct connection of a calibrated test instrument to the equipment under test. If the device cannot be connected directly, alternative techniques acceptable to the Commission may be used. Measurements in the 5.725-5.85 GHz band are made for a reference bandwidth of 500 kHz or the 26 dB emission bandwidth of the device, whichever is less. Measurements in the 5.15 – 5.25 GHz, 5.25 – 5.35 GHz, and the 5.47-5.725 GHz bands are made for a reference bandwidth of 1 MHz or the 26 dB emission bandwidth of the device, whichever

is less. A narrower resolution bandwidth can be used, provided that the measured power is integrated over the full reference bandwidth.

(6) [Remove]

(b) *Undesirable emission limits.* Except as shown in paragraph (b)(7) of this section, the maximum emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:

(1) For transmitters operating in the 5.15-5.25 GHz band: all emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of -27 dBm/MHz.

(2) For transmitters operating in the 5.25-5.35 GHz band: all emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of -27 dBm/MHz.

(3) For transmitters operating in the 5.47-5.725 GHz band: all emissions outside of the 5.47-5.725 GHz band shall not exceed an e.i.r.p. of -27 dBm/MHz.

(4) For transmitters operating in the 5.725-5.85 GHz band: all emissions within the frequency range from the band edge to 10 MHz above or below the band edge shall not exceed an e.i.r.p. of -17 dBm/MHz; for frequencies 10 MHz or greater above or below the band edge, emissions shall not exceed an e.i.r.p. of -27 dBm/MHz.

(8) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the upper and lower frequency band edges as the design of the equipment permits.

(e) Within the 5.725-5.85 GHz band, the minimum 6 dB bandwidth of U-NII devices shall be at least 500 kHz.

(h)***

(2) Radar Detection Function of Dynamic Frequency Selection (DFS). U-NII devices operating with any part of its 26 dB emission bandwidth in the 5.25-5.35 GHz and 5.47-5.725 GHz bands shall employ a DFS radar detection mechanism to detect the presence of radar systems and to avoid co-channel operation with radar systems. Operators shall only use equipment with a DFS mechanism that is turned on when operating in these bands. The device must sense for radar signals at 100 percent of its emission bandwidth. The minimum DFS detection threshold for devices with a maximum e.i.r.p. of 200 mW to 1 W is -64 dBm. For devices that operate with less than 200 mW e.i.r.p. and a Power Spectral Density of less than 10 dBm in a 1 MHz band, the minimum detection threshold is -62 dBm. The detection threshold is the received power averaged over 1 microsecond referenced to a 0 dBi antenna. For the initial channel

setting, the manufacturers shall be permitted to provide for either random channel selection or manual channel selection.

(i) *Device Security*: All U-NII devices must contain security features to protect against modification of software by unauthorized parties.

(1) Manufacturers must implement security features in any digitally modulated devices capable of operating in any of the U-NII bands, so that third parties are not able to reprogram the device to operate outside the parameters for which the device was certified. The software must prevent the user from operating the transmitter with operating frequencies, output power, modulation types or other radio frequency parameters outside those that were approved for the device. Manufacturers may use means including, but not limited to the use of a private network that allows only authenticated users to download software, electronic signatures in software or coding in hardware that is decoded by software to verify that new software can be legally loaded into a device to meet these requirements and must describe the methods in their application for equipment authorization.

(2) Manufacturers must take steps to ensure that DFS functionality cannot be disabled by the operator of the U-NII device.

(j) *Operator Filing Requirement*: Before deploying an aggregate total of more than one thousand outdoor access points within the 5.15-5.25 GHz band, parties must submit a letter to the Commission acknowledging that, should harmful interference to licensed services in this band occur, they will be required to take corrective action. Corrective actions may include reducing power, turning off devices, changing frequency bands, and/or further reducing power radiated in the vertical direction. This material shall be submitted to Laboratory Division, Office of Engineering and Technology, Federal Communications Commission, 7435 Oakland Mills Road, Columbia, MD, 21046 Attn: U-NII Coordination, or via website at <https://www.fcc.gov/labhelp> with the SUBJECT LINE: "U-NII-1 Filing".

**STATEMENT OF
CHAIRMAN TOM WHEELER**

Re: *Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*

Today's item to greatly increase the utility of 100 megahertz in the 5 GHz band is a big deal. Our action today will create new opportunities for entrepreneurs and innovators, and much-needed relief to the growing problem of congestion on Wi-Fi networks.

At the same time, it moves us another step closer to ending the analog-era debate of licensed vs. unlicensed spectrum.

In 2014, licensed and unlicensed spectrum are more complimentary than competitive. They are less oil & vinegar and more peanut butter & jelly. Today, virtually every smartphone has two unlicensed technologies, Wi-Fi and Bluetooth, with a third – near field communications – beginning to be added for mobile transactions. And wireless carriers are using Wi-Fi to offload more than 45% of smartphone traffic to fixed networks.

But Wi-Fi has become a victim of its own popularity, and now faces congestion issues of its own.

That's why the Commission is hard at work providing spectrum for both licensed and unlicensed use. Both are critically important to our mobile ecosystem.

In this order, the Commission is taking 100 MHz of unlicensed spectrum at 5 GHz that was barely usable – and not usable at all outdoors – and transforming it into spectrum that is fully usable for Wi-Fi.

To put this 100 MHz number into perspective, that's more usable spectrum than the 2.4 GHz band that gave birth to Wi-Fi in the first place.

This is a big win for consumers who will be able to enjoy faster connections and less congestion, as more spectrum will be available to handle Wi-Fi traffic. It will make it easier to get online wirelessly in public places like airports and convention centers, as well as in your living room.

This is also a big win for American innovators. The changes we are making will provide fertile ground for the growth of "Gigabit Wi-Fi" – the latest generation of ultra-high-speed, high-capacity Wi-Fi that can provide data speeds in excess of 1 Gigabit per second.

We are not stopping here when it comes to unlicensed spectrum. We are committed to making more spectrum available for unlicensed use in our incentive auction proceeding and our 3.5 GHz proceeding, and will continue to carefully study technical analyses that could further expand access to spectrum in up to 195 additional megahertz of spectrum in two other portions of the 5 GHz band.

Thank you also to OET for your hard and creative work on this item.

**STATEMENT OF
COMMISSIONER MIGNON L. CLYBURN**

Re: *Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*

Today's proceeding is just the latest example of smart government policy designed to promote industry innovation in unlicensed services in order to yield the greatest public benefit. The technical ingenuity, which ultimately has resulted in the explosive demand for Wi-Fi services, is several decades old and it is most fitting that, on this last day of Women's History Month, we are adopting an order to spur greater use of services that a woman helped to create. Many are familiar with how actress Hedy Lamarr invented frequency hopping technology in the 1940s. It is more than industry lore; she actually held a patent on the idea.

The federal government and commercial players eventually realized the benefits of Ms. Lamarr's idea, and beginning in the 1980's in response to petitions from federal agencies and industry, the Commission started promoting greater use of frequency hopping and spread spectrum in unlicensed services in the 2.4 and 5 GHz bands. Those policies together with the evolution of the 802.11 family of technical standards and Wi-Fi only tablets has resulted in the great consumer demand for Wi-Fi devices we see today.

Once criticized by licensed wireless providers; unlicensed spectrum is now being heavily used to off load data traffic. The economists who have studied the area have different estimates, but there is a consensus that Wi-Fi off load saves wireless companies tens of billions of dollars in network costs each year. Demand for unlicensed services, has spiked so much that the 2.4 GHz band is now congested particularly in major cities. We have to be ambitious in finding more ways to provide licensed and unlicensed spectrum for commercial services.

I commend the staff for working so efficiently to bring us an Order that makes 100 megahertz of spectrum, in the U-NII-1 band, available for both outdoor and indoor use of unlicensed services. This was not an easy process. A couple of months ago, advocates for the Wi-Fi and satellite industries seemed locked into their litigation positions. But thanks to the careful and creative work of Julie Knapp, Aole Wilkins, Karen Rackley, and other OET experts, we were able to narrow their differences and arrive at technical rules that both sides approve. Today's Order also has important device certification and security rules to prevent the interference that some U-NII devices were causing to federal operations a few years ago. I look forward to the staff's efforts to free up an additional 195 megahertz in the U-NII-2 and 4 bands. Thank you.

**STATEMENT OF
COMMISSIONER JESSICA ROSENWORCEL**

Re: *Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*

This proceeding sits at the intersection of two paradigm-shifting social and business trends. Call it a collision of cool.

The first trend is well known in these parts—the move to mobility. The statistics speak for themselves. In the next four years, mobile traffic is expected to increase by 11 times. By that time there will be more mobile devices than people on earth. But it is more than sheer volume that is at issue. It is the fact that wireless functionality will be built into everything around us and everything we do as we approach the coming Internet of Things.

The second trend is better known in technology and innovation corridors around the country—from Austin to Boston, from Seattle to Silicon Valley. It is the move toward sandboxes. Software developers often code sandboxes into their programs. This code allows others access to a portion of the program without harming the host platform. It provides a space to experiment within the program, minimizing risk before introducing ideas at a broader scale.

Up until now, sandbox culture has mostly resided within software applications. But I think it has application to a lot of what comes before us at this agency—and I've spoken before about how I think it is a useful framework for our technology transitions trials.

In fact, the sweetest spot for the sandbox could come from combining its experimental possibilities with the power of unlicensed spectrum. The innovative potential is big. By making more of our airwaves subject to access by rule rather than license, we reduce barriers to entry for innovators. We open up spaces for creative use and experimentation in the wireless network from the software layer to the equipment layer.

That is why what we do here is important. Today, we increase opportunities for unlicensed in the 5 GHz band. Critically, we take the flexible rules that have already made the 5.725-5.825 GHz band an unlicensed success story and we expand them to the 5.150-5.250 GHz band. While that sounds technical, this change will have real impact. Because we are doubling the unlicensed bandwidth in the 5 GHz band overnight.

So what does that mean? For starters, if you like Wi-Fi, that is a lot more. Cheers for that. But the power of unlicensed goes beyond onramps to the Internet and offloading for licensed services. It is the power of setting aside more of our airwaves for experiment and innovation without license. It is bound to yield new and exciting developments. It is also bound to be an economic boon. After all, the economic impact of unlicensed spectrum has been estimated at \$140 billion annually. By any measure, that is a lot.

So we should not stop here with the 5 GHz band. After all, good spectrum policy will always require a mix of licensed and unlicensed services. Treating them as competing is a relic from the past, because going forward they are complementary—and more and more devices and services are bound to incorporate the use of both.

That means we need to continue to seize unlicensed spectrum opportunities across other spectrum bands. In the near term, that means we should develop the possibilities of using unlicensed bandwidth in

the 3.5 GHz band. We also should find lawful ways to provide unlicensed services in the 600 MHz spectrum band now used by broadcasters.

But above all, we need to create more opportunities for combining the great power of mobility with the cool possibilities of sandbox experimentation—and I think unlicensed spectrum is the sweet spot where it starts.

**STATEMENT OF
COMMISSIONER AJIT PAI**

Re: *Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*

I love Wi-Fi. And so does the American public. Consumer demand for high-speed, wireless broadband is expected to increase nine-fold over the next four years, with 64 percent of mobile data traffic handled by Wi-Fi and small cell networks. That means our Wi-Fi routers will have to handle about 4.8 exabytes of data every month in 2018. I know what you're thinking—4.8 exabytes, carry the one— isn't that equivalent to 702 Libraries of Congress every month? And, yes, you'd be right. But you might not realize it's the same amount of data as 11.78 billion episodes of *Magnum, P.I.* Like Tom Selleck's mustache, that's impressive!

No doubt foreseeing a resurgence in the popularity of '80s television, Congress in 2012 told the Commission to consider additional unlicensed use in the 5 GHz band.¹ The band is tailor-made for the next generation of Wi-Fi. Its propagation characteristics minimize interference in the band. Its wide, contiguous blocks allow for extremely fast connections, with throughput reaching 1 gigabit per second, as I first saw when I visited Qualcomm's headquarters in San Diego in 2012. Because the 802.11ac technical standard is already set, liberalizing our 5 GHz rules can have an immediate impact on the speed and price of consumer devices. And taking this step will allow consumers to make greater use of the hundreds of thousands of Wi-Fi hotspots that the cable industry is deploying throughout the United States.

So I'm pleased to approve today's order, which allows greater unlicensed use of the 5 GHz band. And I'm especially pleased that we are moving forward with revisions to our rules now—on the easier issues presented in the 5 GHz proceeding—rather than waiting until the thornier questions can be resolved. This is precisely the path I outlined for the Commission last summer: raise the power limits for U-NII-1 devices, remove the indoor-only restriction, and harmonize some of our rules for the U-NII bands.² I'm glad that my colleagues agreed that it was the right way forward.

But we cannot rest on our laurels. If we're to keep pace with consumer expectations, we need *more* 5 GHz Wi-Fi spectrum, not just better use of existing 5 GHz Wi-Fi spectrum. We must redouble our efforts on making an additional 195 MHz of spectrum available for unlicensed use. Achieving this goal will not be without its challenges; for all the talk of spectrum sharing, the federal government has dragged out the process for evaluating new unlicensed use in the 5 GHz band. But I am confident that common sense will eventually prevail and that consumers at some point will enjoy the greater bandwidth, reduced congestion, and cheaper devices that increased use of the 5 GHz band can bring.

Finally, I would like to thank the Office of Engineering and Technology, especially Julius Knapp, Bruce Romano, Aole Wilkins, Geraldine Matise, Mark Settle, Karen Rackley, and Navid Golshahi. Thank you for your work on this item and for the work you do each day on behalf of the American people.

¹ See Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, § 6406, 126 Stat. 156, 231 (2012).

² Remarks of FCC Commissioner Ajit Pai, "Looking Back and Looking Ahead: The FCC and the Path to the Digital Economy," at 3 (July 25, 2013), available at <http://go.usa.gov/WRj4>.

**STATEMENT OF
COMMISSIONER MICHAEL O'RIELLY**

Re: *Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*

Today's item magnifies the importance of unlicensed spectrum in our modern communications landscape. In my time working for Senator John Sununu, I had the privilege of working with Senator Maria Cantwell and her great staff to advance a number of unlicensed measures, including opening up the television white spaces. The beauty of unlicensed spectrum, I learned, is that no one can predict with certainty what it will ultimately be used for, but it is a very safe bet that some uses will far exceed expectations or even become game changers.

If you want to meet the true innovators and entrepreneurs in spectrum policy, talk to the men and women in the unlicensed community. They can literally turn trash into treasure. Take, for example, the former so-called "garbage bands" at 900 MHz, 2.4 GHz, and 5.8 GHz. Once thought unusable, the FCC opened these bands up to unlicensed use in the 1980s and today they are some of the most valuable bands in the world, hosting popular wireless services, the most notable being Wi-Fi and Bluetooth, but also include baby monitors, cordless phones, garage door openers. Wireless broadband providers use these bands to expand broadband services to harder to reach parts of America, and some cable operators are devoting substantial funds to deploy Wi-Fi networks to provide consumers with fast, reliable broadband service.

To put these contributions into perspective, consider the following. By some estimates, unlicensed spectrum generates as much as \$220 billion in value annually to the economy.¹ And, in 2013, approximately .5 exabytes, or 57 percent, of mobile data was offloaded onto Wi-Fi networks each month. By 2018, this monthly offload is expected to reach 4.8 exabytes and make up 64 percent of all mobile data traffic.²

As Americans demand more mobile data at faster speeds, the Commission will have to find additional unlicensed spectrum to accommodate the growth in Wi-Fi. The 5 GHz band's propagation characteristics and new 802.11ac standard make it ideal for this purpose. That is why the Middle Class Tax Relief and Job Creation Act of 2012, which I joined others in some late nights working on, directed the Commission to advance unlicensed use in 5 GHz and that is why I am pleased to join my colleagues in approving this order.

The action we take today will permit outdoor use in the U-NII-1 band and harmonize power levels with those in the U-NII-3 band. This harmonization will allow consumers to benefit from the new Wi-Fi standard that will increase data speeds. Along with the enhanced use of the U-NII-1 band, the item provides safeguards that will facilitate corrective action should large deployments result in harmful interference to licensed services.

¹ *New study released by WifiForward finds unlicensed spectrum generated \$222 billion in value to the U.S. economy in 2013 and contributed \$6.7 billion to U.S. GDP*, WIFIFORWARD, <http://www.wififorward.org/wp-content/uploads/2014/01/Value-of-Unlicensed-Spectrum-to-the-US-Economy-overview.pdf> (last visited Mar. 26, 2014).

² *See Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update*; Letter from Paul J. Sinderbrand, Counsel to Cisco Systems, Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 13-49 (Mar. 7, 2014).

The order also takes additional steps to ensure that harmful interference does not occur to incumbent 5 GHz licensees. First, manufacturers are required to implement security measures to prevent unauthorized software changes to their equipment. We cannot allow rogue use of devices and everyone should be on notice that it will not be tolerated. Second, we modify certain technical requirements for devices operating in the U-NII-2 bands to provide additional protections to FAA weather and other radar systems.

It is important to remember that more work remains in other parts of the band to further increase unlicensed use, and I hope to see a separate order on this point soon. This will have to be done in cooperation with the primary federal and non-federal users, including the intelligent transportation systems program (ITS) at the Department of Transportation. I hope that we can count on them to work expeditiously with us to resolve any remaining hurdles.

Finally, I would like to express my appreciation to the staff in the Office of Engineering and Technology (OET). We ask a lot of OET in many different contexts. Here, OET acted as negotiator, mediator and referee, carefully analyzing, accepting, and dismissing, as appropriate, select arguments relating to the U-NII-1 band. For a number of months, there was a very contentious debate between parties presenting studies with conflicting technical parameters and assumptions. The dedicated staff was able to steer the parties to an acceptable outcome, as well as address other issues pertaining to the 5 GHz band, and I thank them for their work.