Unlicensed to kill: a brief history of the Part 15 rules

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Abstract

Purpose – *The purpose of this paper is to provide a brief history of the Part 15 rules.*

Design/methodology/approach – *The approach takes the form of a systematic overview of spectrum policy applied to rules governing unlicensed devices since 1938.*

Findings – *Much of the policy debate in the last decade has been couched in terms of how spectrum rights are defined. The jurisprudence underlying the Part 15 rules is that unlicensed spectrum is not spectrum at all. Rather, the rules concentrate on the effective power and modulation characteristic of the radio devices themselves. Perhaps this is the next great idea for all spectrum policy: spectrum does not really exist. It is merely an idea – a concept – a way of describing and organizing the physical world in people's minds and actions. Spectrum is a legal and engineering construct to control for an immutable fundamental physical property.*

Research limitations/implications – *Research limitations encompass typical limitations of a case study of a historical event.*

Practical implications – *The paper informs ongoing efforts to update and modernize spectrum policy.*

Originality/value – *The paper provides a retrospective view of spectrum policy.*

Keywords *Communication technologies, Technical regulations, Radio systems*

Paper type *Case study*

1. Introduction

One would think that a paper on history of unlicensed spectrum ought to be a very short. For one, with except for a very minor section of the Federal Communications Commission's Part 15 rules, there is no such thing as ''unlicensed spectrum''. Rather, the FCC's Part 15 rules permit radio operation on a sufferance basis in broad swaths of the spectrum which is not allocated specifically to unlicensed use. Second, when compared to other communications policies, the history of the unlicensed rules is rather brief. In the five decades between the establishment of the rules in 1938 and their major revision in 1989, the FCC issued only a handful of proceeding on the issue. The commission's actions on the subject begin to accelerate apace starting in the early 1990s.

While the unlicensed rules may lack a glorious and romantic past, licensed operation holds great interest for spectrum policy wonks as well as rich issues for the spectrum policy debate. With increasing intensity over the last decade, proponents and opponents in this debate have held forth unlicensed operation as being either pariah or paradigm. Having participated in this debate numerous conferences and events, it seems to me that following syllogism describes the view of spectrum policy researchers toward unlicensed operation. Namely, that unlicensed operation is for economists akin to what the bumblebee is for aeronautical engineers. As the legend goes, according to aerodynamic theory, the length of the bumble bee's wings is too short for its body and thus, it is not be able to fly. And, yet it does.

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Similarly, unlicensed operation should not work. Due to the immutable laws of nature and economics, without some form of regulation, it is impossible to exclude or limit the use of a common resource such as spectrum. Without exclusion, users consume the spectrum without regard to their usage's impact on the benefits obtained by other would-be users. They, therefore, tend to overuse the spectrum, causing interference to one another. This reduction in social welfare due to overuse is referred to as the ''tragedy of the commons''. Spectrum policy is the necessary and appropriate means of exclusion for spectrum in order to solve the tragedy of the commons.

Despite this widely held view, unlicensed operation does not simply get around the ''tragedy of the commons'' problem. Rather, by strictly limiting the power density of energy unlicensed devices can emit into the ether, the rules limit the likelihood of harmful interference to an acceptably low probability (Carter *et al.*, 2003). The overuse problem that is the tragedy of the commons still occurs, but the cost of trying to curtail every minute interfering emission is not outweighed by the benefit of eliminating interference or coordinating use. Simply put, unlicensed operation still sees the tragedy of the commons, but it is just more of an improvised sketch than a three-act Sophoclian opus, as would be the case if higher power operation were permitted.

Since Part 15 devices have historically represented a smaller part of radio services and given the richness of the current debate, an understanding of the history development of the Part 15 rules can serve to inform the future. This paper proceeds as follows: in section 2, I provide a description of the Part 15 rules governing unlicensed devices the US. Section 3 addresses the regulatory history and current FCC rulemaking for Part 15. Finally, in section 4, I address lessons to be learned and offer my conclusions. I now turn to a background on the rules governing such devices and their origins to offer a better understanding the implications of unlicensed operation.

2. Unlicensed rules generally

''It is generally easier to explain unlicensed devices in terms of what they are not, rather than in terms of what they are'' (Carter *et al.*, 2003). The FCC grants licenses to operators to emit radio frequency (RF) radiation, who can expect to be free from harmful interference that would disrupt the normal operation within the licensed service area. In contrast to licensed services, unlicensed devices, or ''Part 15 devices'', may emit radio frequency energy without first obtaining a station or user authorization, but are granted no protective rights[1]. Unlicensed devices are permitted to operate on a sufferance basis, subject to a few cardinal rules. Part 15 users:

- have no vested right to continue using any frequency;
- must accept any interference generated by all other users, including other unlicensed uses;
- may not cause harmful interference;
- must cease if notified by FCC that device is causing harmful interference; and
- equipment must be authorized (verification or certificated) to show compliance with FCC standards before marketing/importation of device[2].

With the exception of unlicensed PCS, there is really no such thing as ''unlicensed spectrum''[3]. Rather, unlicensed devices may emit RF radiation in almost any portion of the spectrum, even in frequency bands for which licenses have been granted. Since 1985, most operation shares the spectrum with other radio services in those bands which have been allocated to industrial, scientific and medical (ISM) equipment (see Marcus, 2009; Scales, 1980, p. 6)[4]. Unlicensed devices can only employ very low energy in comparison to the vast majority of licensed devices. As such, the likelihood of harmful interference to other radio operators is acceptably small, and therefore unlicensed devices can be freed from the restrictions of a licensing process necessary to prevent interference.

In addition to sidestepping the normal delays associated with the licensing process, the devices can enjoy spectrum that is not encumbered by license fees. Generally, unlicensed devices benefit from lower costs and more rapid development cycles. Until recently, the

scope of unlicensed devices was limited, providing only short-range applications such as toys, gadgets, and novelties. Driven by rapid advances in technology, entrepreneurship, and certain enabling government policies, unlicensed RF devices are increasingly able to offer applications in all areas of industry, government, and in private homes[5].

3. The history of the Part 15 rules

3.1 Origins of the rules governing unlicensed devices

In 1938, shortly after its founding, the FCC first permitted unlicensed devices to be sold and operated without a license[6]. The Part 15 rules stem from what is possibly an oversight of fundamental physical phenomenon by the Communications Act of 1934. Congress had intended to treat the regulation of spectrum in the way in which we traditionally think of it. Namely, the FCC was to award rights through licensing discrete individual entities, including such as radio broadcasters, the military, and the alike[7]. This, however, failed to recognize two facts. First, that nearly all devices that employ electricity leak or reradiate electromagnetic energy, albeit at very low power levels. Second, also at this time, radio device manufacturers started introduce short range, low duty cycle communication devices which operated employing low levels of energy over very short distances[8]. As a result, the FCC set about to promulgate rules to manage such devices based on the jurisprudence that if RF emissions that were sufficiently weak and short ranged so as to not be considered measurable, they would, therefore, not rise to the level of harmful interference. This was explained by then-FCC Chief Engineer, Ewell Jett in 1938:

> What we are concerned with immediately is the problem of interference. If certain low power devices can be used without interfering with radio communications, there would appear to be no engineering reason for suppressing their use[9].

In the subsequent rulemaking, conditions were set to ensure that the devices would not generate emissions or field strength levels greater than a specified maximum[10]. At that time, typical qualifying devices included wireless record players, carrier current communication systems[11], and remote control devices[12]. With the adoption of the original 1938 rules, ''most unlicensed devices were designed to operate in the medium frequency (0.3-3 MHz) and high frequency (3-30 MHz) frequency bands, and compliance with FCC regulations was relatively easy to achieve''[13].

3.2 The evolution of the Part 15 rules

The story of the regulation of unlicensed devices is similar to a Westward Migration. Initially, unlicensed operation was permitted only in select bands. As these bands filled up with competing applications and the functional ability to use higher frequency ranges became technically feasible, stakeholders such as equipment manufacturers petitioned the FCC to allow operation across additional bands[14]. In the more than seven decades that the FCC has permitted unlicensed spectrum devices, it has continually modified the operational rules and open new bands in which unlicensed devices can operate to accommodate new applications for unlicensed devices.

Because higher frequency waves propagate for shorter distances than lower frequency waves and as the industry developed new products intended for operation on higher frequencies, it became increasingly difficult for manufacturers to design useful devices and still comply with the maximum field strength limit imposed in this early standard. Accordingly, over the years the FCC amended and expanded the Part 15 rules to permit the use of higher power for unlicensed operation in higher frequency bands where it deemed that the mass-marketing of such products would not result in harmful interference to authorized radio services. In 1949, the FCC issued an NPRM in which it set forth the general principles it proposed to regulate, so-called, ''restricted radiation devices''[15], codified in Part 15 of its rules. Five years later, it issued an FNPRM, culminating in an order in December 1955[16]. This order addressed operation between 30 and 890 MHz[17] and exempted receivers operating above 1000 MHz from field strength requirements, since the FCC found no satisfactory standard technique on which measuring field strength could be based. This unlicensed use of the spectrum came with the caveat that no radio device would be allowed to cause harmful interference[18]. Part 15 was then based on the rationale that if radiation

could be kept within certain fixed limitations, RF energy emitted from the device would not cause harmful interference within the purview of section 301 of the Communications Act requiring a license[19]. From the 1960s through the 1980s, the FCC permitted the operation of emerging new equipment such as wireless microphones, telemetry systems, garage door openers, video cassette recorders, field disturbance sensors, anti-pilferage systems for retail stores, auditory assistance devices, control and security alarm devices, and cordless telephones by making additional modifications to the Part 15 rules[20]. Each time, the FCC incrementally adopted device-specific regulations.

However, because the Part 15 rules had been revised on an *ad hoc* basis in response to petitions for rule making that requested authorization only for the specific device in question, Part 15 had become a lengthy patchwork of rules, difficult for the public to understand. Further by the 1980s, as technology made possible the introduction of devices designed to operate at higher frequencies than the rules had contemplated, the general field strength limit was again becoming too restrictive. Parties before the commission argued that the rules were:

- overly complex;
- unnecessarily restrictive;
- internally inconsistent in terms of the technical standards between Part 15 devices with similar interference potentials;
- outmoded due to improvements in equipment, such as receiver sensitivity, which mitigated the need to control interference;
- outmoded due to the proliferation of both licensed and non-licensed operations, and
- outmoded due to the changes in frequency allocations of authorized radio services.

It was generally accepted that under the state of the rules, manufacturers often were reluctant to incur the legal expenses and delays associated with the rule making process in order to market a new product, especially when their competitors can manufacture similar products without expending resources on satisfying the regulatory burdens. In response in 1985, the FCC initiated an omnibus revision of its technical and administrative provisions for the operation of Part 15 devices in order to remedy its shortcomings[21].

This rulemaking culminated in a 1989 Report and Order which established new general emission limits in order to create more flexible opportunities for the development of new unlicensed devices. These more generalized rules allowed the operation of unlicensed devices for any application provided that the device complies with specified emission limits. In this rulemaking the FCC standardized the emission limits in various bands and established a number of general usage frequency bands placing limits on peak emissions[22]. This revision also established new ''restricted bands'' to protect certain sensitive radio operations, such as satellite downlink bands, and federal government operations. The new rules prohibited transmissions by unlicensed devices in those bands. Nonetheless, the omnibus revision enabled more effective use of the spectrum by improved technical and operational flexibility.

Perhaps most importantly, the FCC expanded its Part 15 rules to encompass the operation of low power, unlicensed spread spectrum systems in the 900-928 MHz, 2,400-2,483.5 MHz, and 5,725-5,850 MHz bands[23]. Spread spectrum techniques, developed in the 1940s for military applications, are characterized by high immunity to interference and low probability of interception by other radio operators (i.e. harmful interference). The spread spectrum technical standards contained in Part 15 set emission limits and defined frequency hopping parameters designed to ensure that there is a low probability that these unlicensed devices will cause harmful interference to other users of the radio spectrum[24].

3.3 The operation of the Part 15 rules

The 1989 revision of the rules also gave the current structure to the Part 15 rules. This revision re-classified unlicensed devices into three broad categories:

1. *Unintentional radiators*. Devices that generate RF energy internally, or sends RF signals to associated equipment via connecting wiring, but which are not intended to radiate RF energy through the air. Examples include computer CPU boards and power supplies. The components and enclosures of these devices must be shielded sufficiently to limit the amount of RF energy that escapes[25].
2. *Incidental radiators*. Devices, like electric motors, that generate radio frequency energy during the course of operation although the devices are not intentionally designed to generate or emit RF energy[26].
3. *Intentional radiators*. Devices that intentionally generate and emit RF energy by radiation or induction[27].

The FCC requires that Part 15 devices be pre-approved through an authorization procedure prior to their sale to the public[28]. This authorization process ensures that devices will not be marketed and available to the public unless they comply with the commission's technical standards. Authorization can take either of two forms, verification or certification[29]. Verification is a statement made by the manufacturer or importer, attesting that the device complies with FCC rules. This form of authorization is generally employed for those devices whose engineering is well understood. Device certification, on the other hand, is a more formal process. Certification requires a written application to the FCC stating that the device complies with the FCC rules along with specific information, including technical specifications for the device. Under this procedure, the Commission reviews documentation regarding such characteristics as transmitter frequency, occupied bandwidth, and output power. In addition, where necessary, manufacturers must supply supplementary measurements to show that users of a device will not be exposed to excessive amounts of RF radiation. The FCC then certifies the devices solely based on an engineering review, or it may request actual samples and perform its own tests on the device. To help expedite the certification process, the FCC has authorized private organizations known as Telecommunication Certification Bodies (TCB's) to perform equipment authorizations on behalf of the FCC[30].

The revision also created general categories that allow intentional radiators to operate at very low powers in any band except where expressly prohibited. Greater emissions were permitted in certain bands where the FCC deemed such operation would not result in production of harmful interference[31]. Part 15 intentional radiators, *i.e.* radio transmitters, are permitted to operate under a set of general emission limits[32] or under provisions that allow higher emission levels in certain frequency bands[33]. Part 15 radio transmitters, other than ultra-wideband devices[34], generally are permitted to operate in any band, save certain sensitive[35] or safety-related frequency bands that are designated as restricted bands[36]. Only out-of-band[37] or spurious[38] emissions from Part 15 transmitters are permitted in these restricted bands[39].

After the 1989 re-write, the FCC continued to modify the Part 15 rules in a more orderly fashion as advances in technology dictated.

3.4 More room for unlicensed operation – into the future

The 1990s saw the rise of devices that use digital modulation techniques to transmit information. In 1993, the FCC first permitted Unlicensed Personal Communications Services (''U-PCS''). U-PCS devices operate in the 1,910-1,920, 1,920-1,930, and 2,390-2,400 MHz bands[40]. The 1,910-1,920 portion of the band was allocated for high-speed data transfer applications while the 1,920-1,930 MHz portion was reserved for voice communication such as wireless intra-office telephone systems like wireless PBX systems[41]. In 1995, the FCC made the 59-64 GHz band, commonly referred to as the millimeter wave band, available for use by unlicensed devices[42]. An additional two gigahertz of spectrum was later made available, widening the band to 57-64 GHz. The FCC noted that the spectrum would be appropriate for novel broadband applications such as wireless computer-to-computer communications. The commission also noted that interference potential to licensed services would also be limited by both high propagation loss at these frequencies and the narrow beamwidth of point-to-point antennas normally operating in this range[43]. The FCC again

amended the Part 15 rules in 1997[44], this time to provide for operation of Unlicensed National Information Infrastructure (U-NII)[45] devices in the 5 GHz Frequency Range (5.15-5.35 GHz and 5.725-5.825 GHz)[46]. Once more, the FCC recognized that developments in a number of different digital technologies greatly increased the need to transfer large amounts of data from one network to another. In making this spectrum available, the FCC concluded that providing additional spectrum for unlicensed wideband operation would benefit a vast number of medical, educational, business, and industrial users[47].

In February 2002, the FCC adopted an Order authorizing devices that use ultra-wideband (''UWB'') technology[48]. UWB devices operate by employing very narrow pulses that spread energy over a broad swath of spectrum, sometimes as much as several gigahertz wide. Because, UWB devices operate across such wide reaches of spectrum, they must share spectrum with an extensive variety of non-government licensed and Federal Government services. The UWB Order defined workable technical standards and emission restrictions in order to permit UWB devices to operate without causing interference to primary users of the spectrum. To achieve this objective, the FCC adopted very conservative standards based in large measure on limits that the NTIA deemed necessary to protect against interference to existing Federal Government uses such as global positioning systems (''GPS''). The FCC established specific technical standards and operating restrictions for three distinct UWB applications: imaging systems including ground penetrating radars (GPRs), through-wall, medical imaging, and surveillance devices; vehicular radar systems; and communications and measurement systems.

As part of its ongoing effort to update and modernize its spectrum policy, the FCC has undertaken several proceedings relating to the revision of Part 15 of its rules. A subcommittee of the FCC's Spectrum Policy Task Force, the Unlicensed Devices and Experimental Licensing Working Group (UEWG) found that it is not currently practical to develop estimates of the optimal amount of spectrum that should be provided for unlicensed operations; however, it appears that additional spectrum is needed[49]. Such newly available spectrum would facilitate the growth of wireless networking and new applications[50]. The Spectrum Policy Task Force sought comment from the industry about whether additional spectrum should be set aside for unlicensed use. In response to its July 2002 Public Notice (PN) seeking comments on a number of issues regarding spectrum regulation[51], more than 200 comments were filed. Commenters generally expressed support for the allocation of additional unlicensed access to the spectrum. Based on the comments filed in response to the PN, there was a general lack of specific recommendations on how the FCC should create such unlicensed bands and what priority they should be given relative to other spectrum requests.

Nonetheless, the FCC made an additional 255 megahertz of spectrum in the 5.47-5.725 GHz band spectrum available for Unlicensed National Information Infrastructure (U-NII) devices[52], including Radio Local Area Networks (RLANs)[[53]]. The movement to significantly increase the spectrum available for unlicensed devices comes in response to a petition for rule making submitted by the Wireless Ethernet Compatibility Alliance[54] and negotiations at the World Radiocommunication Conference at the ITU[55], to harmonize the frequency bands used by U-NII devices with those in other parts of the world[56].

In a further attempt to seek opportunities for shared-spectrum unlicensed operation, the FCC initiated a proceeding[57] to explore the possibility of permitting unlicensed devices to operate in the bands reserved for television broadcasting and also in newly available spectrum at 3,650-3,700 MHz[58]. In December 2002, the Commission released a Notice of Inquiry (NOI) seeking comment on the feasibility of such a proposal[59]. Specifically, the NOI sought comments on ''the feasibility of allowing unlicensed devices to operate in TV broadcast spectrum at locations and times when spectrum is not being used, and on the technical requirements that would be necessary to ensure that such devices do not cause interference to authorized services operating within the TV broadcast bands''[60]. The sometime heated debate over unlicensed use of the TV broadcast band has continued to date.

4. Spectrum policy lessons from its history

For nearly a century, lawyers and engineers have struggled to make workable behavioral rules for the complicated and, literally, ethereal problem of interference and its negative impact on value of the spectrum resource to all. One countercurrent has been the Part 15 rules governing unlicensed operation. Over the past 70 years, the FCC's Part 15 rules have, with increasing success, achieved a balance among stability, flexibility, and development. Much of the evolution of the rules has been somewhat organic in nature. They are, therefore, ugly in their technical complexity but beautiful in their honesty. The rules have been effective due to the fact they focus on fundamental property: irradiated power that is the direct cause of harmful interference. The rules establish parameters, not standards, allowing market forces to be free to operate within these constraints.

By contrast, much of the policy debate in recent decades has been couched in terms of how spectrum rights are defined. The regulatory change since the early part of this decade has been a deliberate review of policy options, fuelled by theoretical economics and multidisciplinary research. The results forced a false dichotomy in terms of a ''property rights'' approach versus a ''commons approach'' to spectrum management. The property rights debate between licensed and unlicensed operation is not so simplistic an inquiry to result in only one regime prevailing. Licensed and unlicensed spectrum regimes both are important policy tools for governing radio communications and are likely to continue to be symbiotic.

However, the origin and evolution of unlicensed rules has eschewed such an esoteric discussion. The Part 15 rules were not created or operate on such a theoretical level[61]. Rather, the rules concentrate on the effective power and modulation characteristic of the radio devices themselves. These rules have not tried to describe or predict the service that will be offered. When the services offered by wireless communications are not well defined or are not knowable at the time rules are created (and they never are), an unlicensed regime holds certain advantages, such as competitive entry, product innovation, and user investment in wireless networks.

The jurisprudence underlying the Part 15 rules is that unlicensed spectrum is not spectrum at all. Perhaps this is the next great idea for all spectrum policy: spectrum does not really exist. It is merely an idea – a concept – a way of describing and organizing the physical world in our minds and in our actions. Spectrum is a legal and engineering construct to control for an immutable fundamental physical property: when multiple electromagnetic waves, used as carriers to transmit information are incident in time, harmonic in frequency, and alight on the same reception antenna, they degrade one another's ability to transmit information. If we can accept that spectrum does not exist, then perhaps we can free ourselves from a century of thinking and search for more modern, more nibble solutions. More flexible modes of regulation might focus on dealing with interference, not necessarily avoiding it, and coordinating concurrent usage.

Notes

1. 47 C.F.R. § 15.1 *et sequation*.
2. 47 C.F.R. § 15.5 (emphasis added). It is oftentimes mistakenly assumed that unlicensed devices operators and manufacturers have no rights under Part 15. This is not precisely correct. Under a careful reading of the Rules, operators are permitted to continue normal use unless they are notified by the commission to cease, subject, of course, to due process concerns. Manufacturers of unlicensed devices obtain permission to market and import such devices upon its certification that the particular device complies with the rules. In addition to limiting the technical constraints, one of the primary operating conditions under Part 15 is that the operator must accept whatever interference is received and must correct whatever interference is caused. Should harmful interference occur, the operator is required to immediately correct the interference problem, even if correction of the problem requires ceasing operation of the Part 15 system causing the interference. See Id.
3. See Table of Allocations 47 C.F.R. § 2.101. Other than an allocation for Part 15D Unlicensed PSC, one will not find the Part 15 rules reference for a spectrum allocation. Id.

4. See also 47 C.F.R. §18 *et sequation.*
5. Unlicensed devices now ranges from remote control toys, wireless computer networking systems, telephones and inventory control systems (OSP Working Paper Number 39).
6. See Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices Without An Individual License, *Notice of Proposed Rule Making*, 2 FCC Rcd. 6135, para. 2 (1987). See also, FCC, Spectrum Policy Task Force, *Report of the Unlicensed Devices and Experimental Licenses Working Group 7-8* (November 15, 2002) available at: www.fcc.gov/sptf/files/E&UWGFinalReport.pdf [hereinafter Report of the Unlicensed Devices Working Group].
7. For an excellent review of the intellectual underpinnings to these rules (see Snider, 2006, pp. 8-12).
8. *Ibid*, p. 9.
9. Informal Hearing Before the Chief Engineer In the Matter of Proposed Rules and Regulations Governing the Operation of Low Power Radio Frequency Devices, FCC Docket No. 5335 (September 19, 1938) p. 5.
10. The limit applied to these early devices was 15 microvolts per meter (uV/m) at a distance equivalent to the wavelength of the operating frequency divided by 2π. *See In re* Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices without an Individual License, *First Report and Order*, 4 FCC Rcd. 3493, para. 3554 (1989).
11. ''Carrier current system. A system, or part of a system, that transmits radio frequency energy by conduction over the electric power lines. A carrier current system can be designed such that the signals are received by conduction directly from connection to the electric power lines (unintentional radiator) or the signals are received over-the-air due to radiation of the radio frequency signals from the electric power lines (intentional radiator)'' 47 C.F.R. § 15.3(f).
12. ''Legend has it that the original unlicensed device was a 'couch potato'-like remote control for radio receivers'' (Marcus, 2009).
13. *See In re* Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices Without An Individual License, *First Report and Order*, 4 FCC Rcd. 3493 (1989). See also OSP Working Paper Number 39, p. 6.
14. See notes 23, 40, 42 and 46 and accompanying text, *infra*.
15. These included devices not regulated as industrial, scientific and medical (ISM) devices (then in Part 18) such as electrical motors, current carrier systems, electronic equipment, and very short-range radio devices. Part 15 – Incident and Restricted Radiation Devices, 20 Fed. Reg. 10,056 (Dec. 21, 1955). The ISM bands are located at 902-928 MHz, 2,400-2,483.5 MHz, and 5,725-5,850 MHz and are generally used for non-communications, industrial purposes, including heating materials, such as plastics to form seals or welds during manufacturing processes. All most all recent model microwave ovens use the 2400 MHz band for heating food. Report of the Unlicensed Devices Working Group, para. 8-9.
16. Part 15 – Incident and Restricted Radiation Devices, 20 Fed. Reg. at 10,056 (Dec. 21, 1955).
17. At the time, the field strength measurements are denoted as ''Mc'' or Mega Cycles.
18. *Id.* at 10,056-57.
19. Id.
20. Report of the Unlicensed Devices Working Group.
21. See *In re* Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices Without An Individual License, *First Report and Order*, 4 FCC Rcd. 3493, 4 (1989).
22. Id.
23. See Authorization of Spread Spectrum Systems Under Parts 15 and 90, *First Report and Order*, 50 Fed. Reg. 25234, 25,237 (June 18, 1985).
24. In addition to limiting the technical constraints, one of the primary operating conditions under Part 15 is that the operator must accept whatever interference is received and must correct whatever interference is caused. Should harmful interference occur, the operator is required to immediately

correct the interference problem, even if correction of the problem requires ceasing operation of the Part 15 system causing the interference. See 47 C.F.R. § 5.5.

25. 47 C.F.R. § 15.3(z); see also, Part 15, Subpart B §§ 15.101-15.122.
26. 47 CFR § 15.3(n).
27. 47 CFR § 15.3(m); see also Part 15, Subpart C §§ 15.201-15.255
28. Devices are permitted to operate after they have been verified to comply with existing operational restrictions. See 47 C.F.R. Chapter 2, Subpart J and 15 C.F.R. § 15.101(a).
29. Id.
30. 47 C.F.R. § 2.960.
31. See 4 FCC Rcd. 3493, 4 (1989).
32. See 47 C.F.R. § 15.209.
33. See 47 C.F.R. §§ 15.215-15.407. In some cases, operation at the higher emission levels within these designated frequency band is limited to specific applications.
34. See note 48 and accompanying text, *infra.*
35. The sensitive bands referenced here are bands employed by radio services that must function, as a nature of their operation, using extremely low received signal levels. These systems may be passive, such as radio astronomy, or active, such as satellite down links and wildlife tracking systems.
36. See 47 C.F.R. § 15.205. Ultra-wideband devices can operate in the restricted bands, subject to restrictions on applications and must meet the Section 15.209 limits, or lower. *In re* Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, *First Report and Order*, 17 FCC Rcd. 7435 (2002).
37. ''Out-of-band Emission. Emission on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process, but excluding spurious emissions'' 47 C.F.R. § 2.1.
38. ''Spurious Emission. Emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions'' Id.
39. 47 C.F.R. § 15.205.
40. See Amendment of the Commission's Rules to Establish New Narrowband Personal Communications Services, *First Report and Order*, 8 FCC Rcd. 7162, 2 (1993).
41. 47 C.F.R. § 15.303(g) (1993). For a thorough treatment of the U-PCS rules and their application, see Carter (2006).
42. In the Matter of Amendment of Parts 2, 15, and 87 of the Commission's Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications, 11 FCC Rec. 4481, para. 1 (1985).
43. *Id.*, para. 42.
44. *See In re* Amendment of the Commission's Rules to Provide for Operation of Unlicensed NII Devices in the 5 GHz Range, *Report and Order*, 12 FCC Rcd. 1576 (1997).
45. U-NII devices provide short-range, high-speed wireless digital communications such as wireless local area networks (''W-LANs''), and to facilitate wireless access to the National Information Infrastructure. With the use of a high-gain directional antenna, these devices may be used to complete point-to-point links of over 1 kilometer ''The National Information Infrastructure, or NII, is a group of networks, including the public switched telecommunications network, radio and television networks, private communications networks, and other networks not yet built, which together will serve the communications and information processing needs of the people of the US in the future.'' See 12 FCC Rcd. 15,796, para. 1, fn. 2.
46. *Id.* See also 47 C.F.R. § 15.401. It is important to note that the 5 GHz band is also used on an unlicensed basis in Europe. However, the available spectrum, referred to as the HiperLAN2 bands, is slightly different than the US U-NII bands. While the two share the 5.15-5.25 GHz portion, the

HiperLAN2 upper band is 5.470-5.725 GHz. In view of this difference, the Wi-Fi Alliance (formerly known as WECA) has petitioned the FCC to modify its rules to permit operation in the 5.470-5.725 GHz band. The FCC has not yet acted on that request. A recent agreement between the Department of Defense, NTIA, and the FCC to promote co-existence of unlicensed devices and government radar may help to speed action on the Wi-Fi alliance petition. The commission has initiated a rulemaking proceeding (RM-10371) to determine the best method to implement proposals contained in the Wi-Fi Alliance petition and the agency agreement.

47. *See In re* Amendment of the Commission's Rules to Provide for Operation of Unlicensed NII Devices in the 5 GHz Range, *Report and Order*, 12 FCC Rcd. 1576, para. 7 (1997).

48. *In re* Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, *First Report and Order*, 17 FCC Rcd. 7435, para. 1 (2002).

49. Report of the Unlicensed Devices Working Group, para. 11-12.

50. Id.

51. *See Spectrum Policy Task Force* Seeks Public Comment on Issues Related to Commission's Spectrum Policies, *Public Notice*, ET 02-135 (2002) (seeking, among other issues, public comment regarding policy changes that would useful in resolving anticipated congestion in the bands available for unlicensed operation).

52. *See* 47 C.F.R. Part 15 Subpart E – Unlicensed National Information Infrastructure Devices. U-NII devices are ''[i]ntentional radiators operating in the frequency bands 5.15-5.35 GHz and 5.725-5.825 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'' 47 C.F.R. § 15.403(i).

53. *In re* 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 (Nov. 2003). ''We also propose to modify certain technical requirements for U-NII devices in the Part 15 rules to protect various radio services against harmful interference. The rules we are proposing herein are those deemed necessary to protect incumbent users from interference. Industry standards being developed by IEEE or others may contain more detailed technical requirements.'' *Notice of Proposed Rulemaking*, ET Docket No. 03-122. The 5 GHz band increased the spectrum available to unlicensed operation by nearly 80 percent. *Id.*

54. *See Petition for Rulemaking* of WECA, RM 10371, Rept. No. 2527 (Jan. 29, 2002). ''WECA'' is now known as the Wi-Fi Alliance.

55. See Press Release, National Telecommunications and Information Administration, Agreement Reached Regarding US Position on 5 GHz Wireless Access Devices, at www.ntia.doc.gov/ntiahome/press/2003/5ghzagreement.htm (Jan. 31, 2003). The World Radiocommunication Conference 2003 (WRC-03) was held on June 9-July 4, 2003, in Geneva, Switzerland. In Agenda Item 1.5, WRC-03 the conference considered spectrum allocations for the mobile, fixed, EESS, and SRS, and the upgrade of the radiolocation service in the frequency range 5.15-5.725 GHz. *Id.*

56. ''Allowing RLANs to operate in the same spectrum used by products built to the European HIPERLAN standard will foster American industry's flexibility to create products for both markets, promote economies of scale in production, increase convenience for traveling users and facilitate seamless user applications.'' High Performance Radio Local Area Networks (HiperLANs), similar to Wi-Fi W-LANs, operate in the 5.15-5.35 GHz and 5.475-5.725 GHz bands and are prevalent in Europe. *In re* 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, *Notice of Proposed Rulemaking*, ET Docket No. 03-122, pg. 2 and fn. 1 (2003).

57. *In re* Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, *Notice of Inquiry*, ET Docket No. 02-380 (2002).

58. The 3,600-3,700 MHz band was previously allocated for use by the Federal Government on a primary basis for radiolocation services, and for non-government use in the Fixed Satellite Service. In 1993, the National Telecommunications and Information Administration identified the 3,650-3,700 MHz portion of the band for transfer from a Government/non-Government shared use statue to a mixed-use status. The 3,650-3,700 MHz band is currently not available for unlicensed use. The band falls within one of the restricted bands identified in 47 C.F.R. § 15.205(a).

59. *See generally In re* Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, *Notice of Inquiry*, ET Docket No. 02-380, 17 FCC Rcd. 25632 (2002).

60. ''The term 'TV broadcast bands' refers to the 402 MHz allocated to the broadcast services at 54-72 MHz, 76-88 MHz, 174-216 MHz, 470-608 MHz and 614-806 MHz. The band 470-512 MHz is allocated to the land mobile and commercial mobile radio services in 13 cities, and the broadcast auxiliary service also operates on certain channels in the TV broadcast bands. As of September 30, 2002, there were 1,714 TV stations, 4,739 TV translators, 2,127 low power TV stations and 568 Class A TV stations. There are over 1.4 million fixed and mobile stations authorized in the 470-512 MHz band, of which 96 percent are in the private land mobile service (equally shared between public safety and industrial/business services) and the remainder are in the commercial mobile radio and broadcast auxiliary services.'' *In re* Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket No. 02-380, note 1 (2002).

61. ''In summary, my research of Part 15 rulemakings from 1938 until 2002, confirmed by conversations with senior FCC engineers with responsibility for the Part 15 rules, has not revealed the FCC resorting to any grand economic theories to justify its unlicensed rules, which were primarily developed by engineers responding to immediate and practical concerns raised by manufacturers and users. Political forces heavily constrained what the engineers could propose, but even here the tradition was to phrase concerns in technical rather than grand theoretical economic terms'' (Snider, 2006, p. 11).

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