Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radios	)))	ET Docket No. 03-108

COMMENTS OF THE WIRELESS BROADBAND OPERATORS COALITION

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May 3, 2004

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EXECUTIVE SUMMARY

The members of the Wireless Broadband Operators Coalition ("WBOC") are publicly and privately held companies that provide wireless broadband service over license-exempt spectrum to metropolitan, mid-size and rural markets. Through substantial capital investment and technological innovation, these providers are accelerating broadband deployment to areas that have no alternative to cable modem and/or DSL service, or who have no broadband service at all. As such, they are critical components of the Commission's plan to ensure rapid provision of advanced telecommunications services to all Americans, as mandated by Congress in the Telecommunications Act of 1996 (the "1996 Telecom Act").

While they differ somewhat as to size, markets and business mission, WBOC's members have demonstrated that it is possible to design, build and operate professional, carrier class wireless broadband systems over license-exempt spectrum, and that such systems are capable of providing a quality of service equal to or better than that of wired incumbents. Significantly, they have done so in the face of Part 15 rules that, largely due to the pace of technology, have become roadblocks to the continued development and deployment of wide-area, license-exempt broadband service. WBOC therefore endorses the Commission's ongoing efforts to update Part 15 as necessary to promote new technologies and services in the license-exempt space – with proper implementation, the Commission's proposals both here and in other proceedings will redound to the benefit of consumers, businesses, local governments, education, police/fire/emergency functions, and other sectors of the economy that need broadband service.

The *Notice of Proposed Rulemaking* ("*NPRM*") in this docket presents the Commission and the license-exempt industry with a unique opportunity to shed outdated technical limitations in Part 15, without increasing interference risks for other spectrum users. In particular, WBOC supports the Commission's attempt to promote rural deployments by permitting license-exempt, point-to-multipoint systems to transmit at higher power in rural areas where they use cognitive radio technology. At the same time, it is neither necessary, desirable nor practical to limit such higher power operations exclusively to rural areas, however the Commission defines them. WBOC believes there is a better solution that, using basic technical concepts already incorporated into Part 15, will give *all* consumers in *all* markets an opportunity to receive the benefits of license-exempt wireless broadband service in the near term, again without creating additional risks of interference to other spectrum users.

Presently, Section 15.247(b) generally limits point-to-multipoint transmissions in all markets to an output power of one (1) watt and an EIRP of four (4) watts (*i.e.*, 6 dBi antenna gain) at 100% duty cycle. In many cases, this effectively confines license-exempt broadband providers to line-of-site, relatively short range deployments. Further, because the EIRP limit remains the same regardless of beamwidth, point-to-multipoint systems have no incentive to directionalize their operations to protect other spectrum users – a classic model of spectral inefficiency.

Under certain conditions, however, transmission power for point-to-multipoint systems can be substantially increased while keeping general interference conditions constant. This is nothing more than a different application of the basic philosophy behind the Commission's rule permitting higher antenna gain for point-to-point systems – as license-exempt providers modify their systems to reduce the potential for interference (in this case by reducing duty cycle and/or directionalizing their signals), they should be afforded the ability to use higher power if no additional interference will result.

WBOC therefore recommends that the Commission do the following for all systems operating under Section 15.247 of the Commission's Rules in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands:

- Continue to limit transmitter output power, but *not* EIRP;

- Redefine the Section 15.247(b) power limit in terms of "maximum average interference power" ("MAIP") rather than "maximum peak output power";

- To retain consistency with the existing rule, limit MAIP to 1 watt;

- Define MAIP as the product of instantaneous transmitter power (the amount of power entering the antenna port), times transmitter ("TX") duty cycle, times horizontal beamwidth divided by 360 (*i.e.,* MAIP = ITX Power * TX Duty Cycle * (horizontal antenna beamwidth/360)). Impose no limit on ITX Power so long as the other two factors are adjusted as necessary to keep MAIP at no higher than 1 watt;

- Require use of cognitive radio technology to mitigate interference in the limited number of cases where operation under the MAIP formula increases interference to other users of the license-exempt bands.

It should be noted that WBOC's proposal is conservative – if cognitive radio technology is required for interference mitigation, WBOC believes that the MAIP limit could be set as high as ten watts or more without creating harmful interference. WBOC thus would not object to an MAIP limit of ten watts or higher – it has confined its proposal to 1 watt simply to maintain consistency with the existing rule, if that is what the Commission prefers.

The technical rationale for limiting MAIP rather than EIRP is relatively straightforward. First, the average amount of interference generated by a radio signal is independent of the antenna radiation pattern, and is dictated by the amount of TX power injected into the antenna port Thus, use of directional higher gain antennas does not change the overall amount of interference generated by the radio – it merely changes how different receivers within the antenna's range will be affected (i.e., receivers located in the path of the antenna's directional beam will receive a higher level of interference than they would have received if the antenna were omni-directional; by the same token, receivers outside the directional beam will receive no interference). As a result, the gain in signal strength from directional antennas can be used to increase range, building penetration, and/or system capacity, without increasing the overall interference injected into the RF environment. Furthermore, permitting unlimited ITX Power will not worsen the interference environment in the license-exempt bands, since its impact must be mitigated by reducing TX duty cycle (which shortens the amount of time during which a higher power transmission occupies its spectrum) and/or narrowing the antenna beamwidths.

Conversely, the Commission's proposal to limit higher power, point-to-multipoint license-exempt operations to "rural" areas only is rife with problems and ultimately may cause more harm than good. At bottom, the Commission's proposal is intended to ensure that broadband is deployed quickly to unserved and underserved areas of the country, which in this case the Commission defines to be "rural." However, while service to rural America should be a primary consideration in this proceeding, it is not the only factor in the public interest equation where broadband is concerned. Indeed, in Section 706 of the 1996 Telecom Act, Congress directed the Commission to speed deployment of advanced telecommunications services to *all* Americans, not just some of them. Likewise, the history of Part 15 is an inclusive one, promoting new technologies and services without geographic limitations.

Moreover, as a practical matter the concept of "rural vs. non-rural" is a non-starter for license-exempt services: as the Commission knows, license-exempt devices can operate anywhere provided they do not cause harmful interference. There is no feasible enforcement mechanism that can prevent this, and the Commission should not try to prevent it in any case -- wireless broadband systems are integrated facilities designed for ubiquitous coverage regardless of whether their service areas or portions thereof are rural or not, and system operators otherwise do not draw such geographic distinctions except when determining what technical facilities are best suited to serve their customers.

The Commission cannot mitigate these weaknesses by defining a rural area in terms of whether the license-exempt bands are "unused" at any given location, and permitting cognitive radios in the license-exempt bands to transmit at higher power at any location where they detect that spectrum is "unused." In this case, the Commission proposes to define "unused spectrum" as any frequency where aggregate noise plus interference power is no more than 30 dB above the noise floor within a measurement bandwidth of 1.25 MHz. However, as already pointed out in this docket by license-exempt equipment vendor WaveRider Communications Inc., permitting cognitive radios to transmit at higher power where they detect signal plus noise at a predetermined level above the noise floor necessarily raises serious interference problems for vendors who are developing receivers that are capable of operating at or below the noise floor. For those vendors and the system operators who use their equipment, the Commission's proposal will have the perverse effect of punishing spectrally efficient operations with no countervailing benefit for consumers.

Finally, limiting higher power, point-to-multipoint operation to rural areas will only render the Commission's Part 15 rules inconsistent and confusing. For example, the Commission's rule that permits higher power for point-to-point ("PTP") operation does not have a rural limitation, and, in ET Docket No. 03-201, the Commission has proposed to permit sectorized and phased array antennas to operate at higher PTP power levels, again without a rural limitation. Further, the Commission recently proposed to permit license-exempt devices to operate with as much as 25 watts output power in the 3650-3700 MHz band, once again without a rural limitation. If all of these proposals are adopted as is, license-exempt WISPs will be forced to comply with different power limits in different areas on different spectrum (all perhaps within the same system), making it extremely difficult for license-exempt providers to design networks that can deliver a uniform quality of service to consumers. The Commission can and should eliminate any potential for confusion once and for all by amending its point-to-multipoint power limits as proposed by WBOC, so that they apply uniformly to all markets without exception.

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COMMENTS OF THE WIRELESS BROADBAND OPERATORS COALITION

The Wireless Broadband Operators Coalition ("WBOC") hereby submits its comments in response to the Commission's *Notice of Proposed Rulemaking* ("*NPRM*") in the above-captioned proceeding.[1]

I. INTRODUCTION.

WBOC is a group of publicly and privately held companies that provide wireless broadband service over license-exempt spectrum to metropolitan, mid-size and rural markets in various regions of the United States. Through substantial capital investment and technological innovation, WBOC's members are accelerating broadband deployment to areas that have no alternative to cable modem and/or DSL service, or who have no broadband service at all. As such, they are critical components of the Commission's plan to ensure rapid provision of advanced telecommunications services to all Americans, as mandated by Congress in Section 706 of the Telecommunications Act of 1996 (the "1996 Telecom Act").

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[1] FCC 03-322 (rel. Dec. 30, 2003).

The following companies are members of WBOC:

- ***AMA Tech Tel Communications LLC*** (www.amatechtel.com) provides a variety of license-exempt broadband services with a wireless footprint covering over 20,000 square miles in and around Amarillo, Texas. The company currently has over 4,000 wireless broadband subscribers (making it one of the largest providers of wireless broadband service in the United States) and anticipates adding 8,000 more within the next 12-18 months. AMA's deployment is a sophisticated, contiguous network that provides carrier class broadband service to residential, corporate and educational campuses. Using multiple unlicensed bands, AMA has created private virtual environments for three college campuses, multiple school systems, law enforcement and public safety agencies, hospitals, and numerous banks within its expanding footprint. Last year the company announced its groundbreaking partnership with Texas Tech University to build and maintain a wireless broadband telecommunications backbone stretching from Amarillo to Hobbs, New Mexico. The backbone will provide access to high-speed telecommunications to the rural communities along its route. Principally, the backbone will be a wide-area network for delivery of content to be used in small business development, work force training, and other adult and K-12 educational programs.[2]

- ***Prairie INet LLC*** (www.prairieinet.net) provides license-exempt broadband service in the license-exempt 2.4 GHz and 5.8 GHz bands to approximately 4,000 subscribers in over 120 communities in Iowa and Illinois, with a waiting list of another 2,000 customers. In addition to residential and business customers, Prairie INet provides service to schools, medical clinics and municipal governments. The company estimates that it is the sole provider of broadband service in approximately 50% of its markets.[3]

- ***NextWeb, Inc.*** (www.nextweb.net) is the largest and fastest growing wireless Internet service provider in the United States. NextWeb provides service to more than 2,000 enterprise customers in the largest metropolitan markets in California including the San Francisco Bay Area, Silicon Valley, Los Angeles and Orange County. The company's service area encompasses over 175 cities across nearly 3,000 square miles and covers 50,000 small and medium-sized enterprises in population centers that include nearly 25 million households.

- ***US Wireless Online*** (www.uswo.net), based in Louisville, KY, is a publicly-held company that provides business and residential wireless broadband service over

[2] *See* "Texas Tech University Signs Agreement to Build Network to Improve Internet Access to Rural Areas," Joint Press Release of Texas Tech University and AMA Tech Tel (July 2, 2003), available at http://www.wcai.com/press_mem2001.htm.

[3] *See* http://www.wcai.com/interview.htm.

metro-area networks in Kentucky, Georgia, Ohio and Indiana. Approximately 24,000 users access the Internet with high-speed connections through the company's more than 500 enterprise customers. The company recently announced plans to implement a non-line of sight wireless overbuild in Louisville that will provide most of the city's metropolitan area with a portable wireless broadband alternative.

- ***Pixius Communications, LLC*** (www.pixius.com) provides wireless broadband service to 36 counties in the state of Kansas, encompassing 210,552 households and a population of 545,220, representing nearly half of the households and population in those counties. Since Pixius' service is not limited to the borders of a town or city, many of its customers are in rural areas where no one else offers broadband service. Initial funding for the network was provided by a group of local (Wichita, KS) investors. In March 2003, Pixius obtained funding from the USDA-RUS Pilot Broadband Loan Program, allowing the company to expand its network at a pace greater than that possible under the private investment model.

- ***StoneBridge Wireless, Inc.*** (www.sbwireless.net) provides wireless broadband service via approximately 45 transmission towers in Minneapolis, MN, western Wisconsin and surrounding suburban and rural communities, with additional facilities to be constructed this year in Michigan and Oklahoma. Many of StoneBridge's customers are beyond the reach of any cable modem or DSL service. The company recently received nearly $5M in RUS funding to support the continued expansion of its wireless broadband networks.

WBOC supports the Commission's attempt in the *NPRM* to promote license-exempt wireless broadband service by permitting point-to-multipoint Part 15 facilities to utilize higher power in rural areas if they use cognitive radios. However, WBOC believes it is neither necessary, desirable nor practical to limit such higher power operations exclusively to rural areas, however the Commission chooses to define them. As demonstrated below, there is a better solution that, using basic technical concepts already incorporated into Part 15, will give *all* consumers in *all* markets an opportunity to receive the benefits of license-exempt wireless broadband service in the near term, without creating additional risks of harmful interference to existing spectrum users in the license-exempt bands.

II. DISCUSSION.

A. There Is A Way For The Commission To Permit Point-to-Multipoint License-Exempt Wireless Broadband Systems To Operate At Higher Power Without Increasing The Risk Of Interference To Other Spectrum Users.

WBOC proposes to amend Section 15.247 of the Commission's Rules to allow license-exempt point-to-multipoint wireless broadband systems to use higher power under certain conditions but without geographic limitation. As explained below and in the attached engineering statement provided by Kiwi Networks, Inc., the proposed changes will expand or strengthen the coverage areas of license-exempt wireless broadband service providers nationwide, widen the availability of non-line of sight, portable wireless broadband service in the license-exempt bands, and promote efficient sharing of spectrum among license-exempt users without causing additional interference to (1) in-band licensed users, (2) adjacent band licensed users, and (3) license-exempt users of low-power devices.[4]

For a number of years, Section 15.247(b) has limited, point-to-multipoint license-exempt operations to an output power of 1 watt and an EIRP of 4 watts (reflecting a maximum permitted antenna gain of 6 dBi). This limitation (adopted well before license-exempt spectrum developed into an effective vehicle for wireless broadband service) effectively limits license-exempt broadband providers to line-of-site, relatively short range deployments. This has painted license-exempt WISPs into an economic corner – they must absorb additional infrastructure and service

[4] Kiwi Networks, Inc., based in Campbell, California, provides broadband wireless access systems for service providers operating in license-exempt spectrum. Kiwi systems utilize innovative interference mitigation and frequency use techniques, making carrier grade service levels achievable in the license-exempt bands, even where that spectrum is heavily occupied by other users.

costs to compensate for limited coverage, but are prohibited from expanding their service areas in a manner that would allow them to spread those costs over a larger subscriber base.

Under certain conditions, however, transmission power for point-to-multipoint systems can be increased substantially while keeping general interference conditions constant. This is nothing more than a different application of the basic philosophy behind the Commission's rule permitting higher antenna gain for point-to-point systems (Section 15.247(b)(4)(i)-(ii)) – as license-exempt providers modify their systems to reduce the potential for interference, they should be afforded the ability to use higher power if no additional interference will result.[5] WBOC thus recommends that the Commission amend Section 15.247 as follows:

- Continue to limit transmitter output power, but *not* EIRP;
- Redefine the Section 15.247(b) power limit in terms of "maximum average interference power" ("MAIP") rather than "maximum peak output power";
- To retain consistency with the existing rule, limit MAIP to 1 watt;
- Define MAIP as the product of maximum instantaneous transmitter power (the amount of power entering the antenna port), times transmitter ("TX") duty cycle, times horizontal beamwidth divided by 360 (*i.e.,* MAIP = ITX Power * TX Duty Cycle * (horizontal antenna beamwidth/360)). Impose no limit on ITX Power so long as the other two factors are adjusted as necessary to keep MAIP at no higher than 1 watt;[6]

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[5] *See Amendment of Parts 2 and 15 of the Commission's Rules Regarding Spread Spectrum Transmitters*, 12 FCC Rcd 7488, 7498 (1997) ("[T]he Commission believes that it is necessary to implement its proposal to decrease the output power of a [point-to-point] spread spectrum transmitter operating in the 2450 MHz band by 1 dB for every 3 dB that the antenna gain exceeds 6 dBi. This action will ensure that the area over which harmful interference can occur is equivalent to what would be caused by a spread spectrum system employing an omnidirectional antenna and operating at the current maximum EIRP of 6 dBW.") ("*1997 Spread Spectrum Report and Order*").

[6] For example, if a license-exempt wireless broadband provider wished to double its ITX power but use a fully omnidirectional antenna, TX duty cycle would have to be reduced a proportionate amount to maintain MAIP at one watt.

- Require use of cognitive radio technology to mitigate interference in the limited number of cases where operation under the MAIP formula increases interference to other users of the license-exempt bands.

It should be noted that WBOC's proposal is conservative – if cognitive radio technology is required for interference mitigation, WBOC believes that the MAIP limit could be set as high as ten watts or more without creating harmful interference. WBOC thus would not object to an MAIP limit of ten watts or higher – it has confined its proposal to one watt simply to maintain consistency with the existing rule, if that is what the Commission prefers.

The technical rationale for limiting MAIP rather than EIRP is relatively straightforward. First, the average amount of interference generated by a radio signal is independent of the antenna radiation pattern, and is dictated by the amount of TX power injected into the antenna port. That is, use of directional higher gain antennas does not change the overall amount of interference generated by the radio – it merely changes how different receivers within the antenna's range will be affected (i.e., receivers located in the path of the antenna's directional beam will receive a higher level of interference than they would have received if the antenna were omni-directional; by the same token, receivers outside the directional beam will receive less interference). As a result, the gain in signal strength from directional antennas can be used to increase range, building penetration, and/or system capacity, without increasing the overall interference injected into the RF environment.

Conversely, Section 15.247's current EIRP limitation may actually worsen interference conditions in the license-exempt bands. Because the EIRP limit remains the same regardless of the directionalization or beamwidth of the antenna, service providers who operate in the point-to-multipoint mode have no incentive to directionalize their operations. Moreover, operation under the more liberal power limitations for point-to-point service is not a viable economic alternative in many cases – point-to-multipoint is by far the superior means of delivering wide-area, carrier class wireless broadband service at the lowest possible cost. Thus, changing the rule as proposed herein will provide license-exempt broadband providers with an incentive to use more efficient antenna technologies in the point-to-multipoint mode, thus leading to decreased levels of interference without decreased quality of service to consumers.

WBOC recognizes that its proposal may increase interference levels in a limited number of cases. That is, although WBOC's proposal would not increase the average level of interference in the RF environment, there will be some probability that antenna beams will be directed at some unintended receivers and hence increase those receivers' level of interference. The result is increased "interference variability" among receivers, since they suffer different levels of interference depending on their location relative to the directional beam.[7] Cognitive radio technology could be used to mitigate this effect.[8] This is because cognitive radio technology benefits are greatest when reception conditions in the network vary -- the essence of cognitive operation is the radio's self-adjustment of its operating parameters based on location-specific and time-specific channel quality. Hence, the larger the variability in reception conditions, the more benefit cognitive radios will deliver.

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[7] *See 1997 Spread Spectrum Report and Order*, 12 FCC Rcd at 7495 ("When dealing with fixed radio applications, the use of directional antennas can be particularly important in allowing nearby fixed radio systems to co-exist within the same frequency band. Radio systems located outside the directional beam of the antenna pattern have a low probability of receiving interference. However, radio systems that are located in the main beam of the directional antenna will have a much higher potential for receiving interference, in particular because of the higher signal levels caused by the antenna gain.").

[8] This is not a new concept -- Wi-Fi devices already implement a simple form of cognitive radio, *i.e.*, a Wi-Fi receiver senses the environment and schedules transmissions based on acceptable interference conditions. Hence, for the reasons discussed herein, it is possible that even the performance of legacy Wi-Fi devices could be improved under WBOC's proposal.

While interference variability provides the optimal environment for cognitive radio technology, there remains the question of whether overall system performance under WBOC's proposal (higher power transmissions limited by duty cycle, directionalization and cognitive techniques) would be superior to that of a system operating under the existing Section 15.247 limitations. WBOC submits that under its proposal system performance does increase because of what is commonly known as "multi-user diversity." This means that if a particular radio experiences interference, it defers the transmit opportunity to another radio with superior channel conditions, and transmits only when channel conditions become more favorable for itself.[9] Conversely, under the current Section 15.247, interference conditions can be more pronounced and constant throughout a market (since the rule confines omnidirectional operation to a specified EIRP without exception), thereby leaving fewer opportunities for a cognitive radio to find spectral "space" within which to transmit.

Most important, however, the public interest benefits of WBOC's proposal are significant. If adopted, the new rule will afford license-exempt broadband providers with an increase in capacity, a dramatic reduction in interference, improved range, building penetration and coverage. The Kiwi Networks engineering statement quantifies those benefits based on simulation results. Specifically, Appendix A of the Kiwi statement presents a simulation model that illustrates the capacity benefits of Kiwi's proposal. The model examines performance of single radio that is receiving transmissions from (M + 1) sources. Only one of these transmissions is assumed to be the desired signal, and the other M transmissions are assumed to

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[9] Thus, an important distinction between WBOC's proposal and that in the *NPRM* is that WBOC believes service providers should use cognitive techniques to help *themselves* combat interference, rather than focus on minimizing harmful effects to others.

be undesired signals or interference. MAIP is assumed to be constant, while Instantaneous TX power is allowed to fluctuate based on duty cycle, and antenna beamwidth, per the relationship established by the MAIP formula discussed above.

Using this simulation model, Figure 1 of the Kiwi statement presents simulation results for the scenario where no cognitive techniques are deployed. Not surprisingly, Figure 1 shows that an increase in gain naturally leads to an increase in capacity. More interestingly, however, decreasing duty cycle does not have a corresponding impact on system capacity, which is reduced by only half when duty cycle is reduced from 100% to 20%. Even at 20% duty cycle, system capacity is superior to what is achievable under the existing Part 15 rules. And, as demonstrated by Figure 2, the overall capacity numbers are twice what is achievable under the existing Part 15 case once cognitive capabilities are added to the network.

For the same simulation model depicted in Appendix A, Kiwi next examined the impact of WBOC's proposal on the outage probability experienced by each potentially affected radio. Figure 3 illustrates outage probability for each radio as a function of antenna gain and TX duty-cycle, where the ITX power level is inversely proportional to TX duty-cycle, and no cognitive ability is assumed. Figure 4 illustrates the same scenario, but with cognitive capability. In both cases, increasing antenna gain and reducing TX duty-cycle while increasing ITX power reduces the outage probability. As expected, cognitive capabilities lead to much lower outage probability.

The Kiwi statement concludes that allowing an increase in ITX power under the WBOC proposal can easily increase an operator's link budget by 20dB, which, as demonstrated by Figures 5 and 6, would significantly improve coverage and in-building penetration. Indeed even a 12dB increase in EIRP will approximately double coverage distance or quadruple coverage in a suburban area. In turn, a large percentage of license-exempt broadband deployments could use indoor CPE units, thus obviating the need for costly external CPE devices, dramatically reducing residential broadband costs, and accelerating broadband deployments throughout the country. When weighed against their minimal interference impact, these benefits militate strongly in favor of WBOC's solution – they enhance rural broadband service without leaving underserved consumers in non-rural areas behind.

B. The Commission Should Remain Faithful To Its Policy Of Promoting New Wireless Services For All Consumers, Not Just Some Of Them.

As demonstrated below, WBOC's proposal also is entirely consistent with the Commission's mandate from Congress to accelerate broadband deployments nationwide, and advanced the Commission's historical policy of promoting the development of license-exempt services for all consumers, regardless of where they live.

Although the *NPRM* gives a nod to the public interest benefits of license-exempt services generally, it is clear that the Commission's proposal for higher power is intended primarily to stimulate usage of license-exempt spectrum to deliver broadband to unserved or underserved areas.[10] In that respect, then, the NPRM could be fairly viewed as the latest chapter in the Commission's overriding mission to accelerate broadband deployments as specifically directed by Congress in Section 706 of the Telecommunications Act of 1996.

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[10] *See NPRM* at ¶ 34 ("The lower population density and the greater distances between people in rural areas can make it difficult for certain types of unlicensed operations at the current Part 15 limits to provide adequate signal coverage. Such operations include Wireless Internet Service Providers (WISPs) and wireless LANS operated between buildings or other locations with a large separation between transmitters."); *id.* at ¶ 41 ("We seek comment on whether the increased levels we are proposing are sufficient to be of benefit to WISPs, wireless LANs or other unlicensed operations in areas with limited spectrum use . . . .").

Section 706, however, is not confined by geography – it directs the Commission to "encourage the deployment on a reasonable and timely basis of advanced telecommunications capability to all Americans . . . by utilizing . . . measures that promote competition in the local telecommunications market, or other regulating methods that remove barriers to infrastructure investment."[11] Likewise, Section 706 directs the Commission to determine on an annual basis "whether advanced telecommunications capability is being deployed to all Americans in a reasonable and timely fashion."[12] Thus, while service to rural areas certainly should remain a primary consideration, it is not the only factor in the public interest equation where broadband is concerned. Given that many Americans still do not have an alternative to wired broadband incumbents (if they even have access to those service providers at all), the Commission should strive to ensure aggressive broadband deployments in all areas of the country and in all sectors of the economy, as well as for educational, health, local government, public safety and other institutions that are becoming increasingly reliant on broadband to deliver services to the public.

Likewise, the history of Part 15 is an inclusive one, focusing on technology without geographic distinctions among license-exempt services. For example, in its 1989 overhaul of its Part 15 rules, geography was not the driving factor – rather, the Commission had the broader goal of "achiev[ing] more effective use of the radio frequency spectrum while providing additional technical and operational flexibility in the design, manufacture and use of non-licensed devices."[13] In that same proceeding the Commission reaffirmed that the need to keep

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[11] *See* § 706(a) of the Telecommunications Act of 1996, Pub. L. 104-104, 110 Stat. 56 (1996).

[12] *Id.* § 706(b).

[13] *Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices Without An Individual License*, 4 FCC Rcd 3493 (1989) ("*1989 Part 15 First Report and Order*").

pace with technology, not geography, is what motivates reform of Part 15.[14] Where, as here, the Commission is presented with a technical proposal that will benefit rural and non-rural areas alike, the relevant question therefore is not whether rural areas will benefit more than others – rather, the issue is whether the proposal "represent[s] a reasonable engineering compromise between the risks of increased interference and the desire to accommodate new technologies."[15] For the reasons discussed above and in Kiwi Networks' attached engineering statement, WBOC's proposal meets that standard.

C. The Commission's Proposal To Limit Higher Power License-Exempt Operations To Rural Areas Only Is Neither Practical Nor Enforceable, And May Actually Frustrate Technological Innovation In License-Exempt Broadband Services.

The Commission has long held that its Part 15 regulatory scheme should, *inter alia*, "establish uniformity between the technical standards for various non-licensed operations" and "clarify and simplify [the Commission's] administrative requirements."[16] Similarly, in their recent joint White Paper on license-exempt services, the Commission's Office of Strategic Planning and Policy and Office of Engineering and Technology recommended that "the FCC's [Part 15] rules should be as clear as practicable, strictly enforced, and maximize utility [of

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[14] *See id.* ("Early standards adopted to control interference are frequently significantly different from what is needed at the present time due to improvements in equipment, such as receiver sensitivity, the increased proliferation of both licensed and non-licensed operations, and changes to the frequency allocations of authorized radio services."); *Amendment of Part 15 of the Commission's Rules Regarding Spread Spectrum Devices*, 15 FCC Rcd 16244, 16249 (2000) ("[W]e contend that as technology evolves, we must amend our rules from time to time so that innovation is not discouraged"); *id.* at 16250 ("Generally, the Part 15 spread spectrum rules have continued to evolve in order to reflect changes in technology and consumer needs.") ("*2000 Spread Spectrum First Report and Order*")

[15] *Id.* At 16249.

[16] *1989 Part 15 First Report and Order*, 4 FCC Rcd at 3493-4.

spectrum]."[17] Unfortunately, the Commission's proposal to limit higher power license-exempt point-to-multipoint operations to rural areas will not achieve any of these objectives.

First and foremost, the Commission acknowledges that "unlicensed devices generally have no geographic restrictions on operation and can be used in any location."[18] In other words, license-exempt devices may operate anywhere in the country provided that they do not cause harmful interference. Moreover, unless equipped with GPS or other location monitoring technology (improvements that only add cost to what are supposed to be low-cost devices), a license-exempt device has no knowledge of its geographic location, and can easily wander in and out of rural areas (however they are defined) without knowing it. For these reasons alone, it is extremely difficult to design an efficient, reliable regulatory scheme that will restrict operation of license exempt devices to some areas and not others.

Second, it makes little sense to construct rules around a rural/non-rural distinction when the Commission remains uncertain as to what that distinction is. As the agency noted in its pending Notice of Proposed Rulemaking on enhancing rural wireless services generally (WT Docket No. 02-381), "[t]he federal government has multiple ways of defining "rural," reflecting the multiple purposes for which the definitions are used."[19] Moreover, for many carriers the rural/non-rural distinction is a non-starter – rather, they have built integrated, wide-area networks that are designed to offer the same quality of service to all of their customers regardless of where they live. For example, while AMA TechTel's 20,000 square mile service area encompasses the

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[17] Carter, Lahjouji and McNeil, "Unlicensed and Unshackled: A Joint OSP-OET White Paper on Unlicensed Devices and Their Regulatory Issues," OSP Working Paper Series No. 39, at 49 (May 2003).

[18] *NPRM* at ¶ 36.

city of Amarillo (not a "rural" area by any definition), it also encompasses large swatches of lightly populated areas in the North Plains of Texas that might easily qualify as "rural." Similarly, Pixius Communications' 36-county service area in Kansas encompasses a variety of mid-size, small and rural communities – for operational purposes, the rural/non-rural distinction really does not exist.[20]

The Commission cannot mitigate these weaknesses by defining a rural area in terms of whether the license-exempt bands are "unused" at any given location, and permitting cognitive radios in the license-exempt bands to transmit at higher power at any location where they detect that spectrum is "unused." In this case, the Commission proposes to define "unused spectrum" as any frequency where aggregate noise plus interference power is no more than 30 dB above the noise floor within a measurement bandwidth of 1.25 MHz.[21] However, as already pointed out in this docket by license-exempt equipment vendor WaveRider Communications Inc., permitting cognitive radios to transmit at higher power where they detect signal plus noise at a predetermined level above the noise floor necessarily raises serious interference problems for

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[19] *Facilitating the Provision of Spectrum-Based Services to Rural Areas and Promoting Opportunities for Rural Telephone Companies To Provide Spectrum-Based Services*, 17 FCC Rcd 25554, 25563 (2002).

[20] Even rural cellular carriers have questioned the validity of drawing regulatory distinctions between rural and non-rural areas. *See, e.g.,* Comments of Dobson Communications Corporation, WT Docket No. 02-381, at 5-6 (filed Feb. 3, 2003) ("In February 2002, Dobson's Chief Operating Officer, Doug Stephens, participated in a Commission Public Forum that was convened to explore ways for the Commission to better gather and analyze data for its annual CMRS Competition Reports to Congress. Mr. Stephens stressed that the competitive landscape that existed in rural markets in the mid-1990s bears no resemblance to the competition that exists in rural markets today. He argues that 'it is no longer useful for the Commission to apply an urban/rural distinction, applying different rules according to some artificial distinction between the two. There are only 'markets' – some are large and some are small.' . . . .") (footnotes omitted).

[21] *See NPRM* at ¶ 44.

vendors who are developing receivers that are capable of operating at or below the noise floor.[22] For those vendors and the system operators who use their equipment, the Commission's proposal will have the perverse effect of punishing spectrally efficient operations with no countervailing benefit for consumers.

Finally, limiting higher power, point-to-multipoint operation to rural areas will only render the Commission's Part 15 rules inconsistent and confusing. For example, the Commission's rule that permits higher power for point-to-point ("PTP") operation (Section 15.247(b)(4)(i)-(ii)) does not have a rural limitation, and, in its pending *Notice of Proposed Rulemaking* in ET Docket No. 03-201, the Commission has proposed to permit sectorized and phased array antennas to operate at the higher PTP power levels, again without a rural limitation.[23] Further, the Commission recently proposed to permit license-exempt devices to operate with as much as 25 watts output power in the 3650-3700 MHz band, once again without a rural limitation.[24] If all of these proposals are adopted as is, license-exempt wireless broadband providers will be forced to comply with different power limits in different areas on different spectrum (all perhaps within the same system), making it extremely difficult for license-exempt providers to design networks that can deliver a uniform quality of service to consumers. Also, a

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[22] *See* Comments of WaveRider Communications Inc., ET Docket No. 03-108, at 8 (filed Mar. 29, 2004). (stating that the Commission's proposal will "discourage the use of system wide Transmit Power Control (a key cognizant radio technology) since the very act of lowering the required signal powers can result in other users/operators increasing the interference levels, and negating the advantages of the improved [equipment] sensitivities that would otherwise allow the reduction of power levels. Attention will have to turn to making higher power the objective, with the attendant negative results of higher equipment costs and higher general interference levels. This appears to be a 'zero-sum' game.").

[23] *See Modification of Parts 2 and 15 of the Commission's Rules For Unlicensed Devices And Equipment Approval*, ET Docket No. 03-201, at ¶¶ 5-15 (rel. Sept. 17, 2003).

[24] *See Unlicensed Operation in the Band 3650-3700 MHz*, ET Docket No. 04-151, at ¶ 43 (rel. Apr. 23, 2004).

rural limitation on higher power will inevitably invite waiver requests to accommodate new technologies and other exceptional situations, returning the Commission to exactly the sort of piecemeal regulatory approach it has been trying to avoid in Part 15. The Commission can and should mitigate any potential for confusion once and for all by amending its point-to-multipoint power limits as proposed by WBOC, so that they apply uniformly to all markets and all the license-exempt bands covered under Section 15.247 without exception.

III. CONCLUSION.

WBOC's proposal achieves the Commission's objective of enhancing license-exempt broadband service in rural areas while remaining true to the Commission's desire to extend the benefits of license-exempt services to all consumers. It does so without aggravating the interference environment for other spectrum users in the license-exempt bands, in a relatively straightforward manner that is based on well-settled engineering principles and easy to apply. WBOC therefore respectfully urges that the Commission amend its Part 15 rules in accordance with the comments set forth above.

AMA TECHTEL COMMUNICATIONS LLC

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May 3, 2004

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Increasing TX Power in Licensed Exempt Spectrum

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1 Introduction

This document proposes updates to certain FCC Part 15 rule sections to allow license-exempt devices to use higher power under certain conditions, without geographic limitation.   The proposed changes will expand or strengthen the coverage areas of unlicensed wireless broadband service providers nationwide and promote efficient sharing of license-exempt spectrum, without causing additional interference to (1) in-band licensed users, (2) adjacent band licensed users, and (3) unlicensed users of low-power devices.

Specifically, Kiwi Networks, Inc. ("Kiwi") proposes that the FCC do the following

A) Amend Section 15.247 of the FCC's Rules to permit higher power transmission in the 902-928 MHz, 2400-2483.5 GHz, and 5.725-5.850 GHz bands;

B) Allow such higher power transmission in all geographic areas, as opposed to just rural areas;

C) define "maximum average interference power" or "MAIP" as:

MAIP *= Instantaneous Transmitter ("ITX")Power * TXduty cycle * HorizontalAntennaBeamwidth/360*

For purposes of this formula. InstantaneousTX Power= the amount of power entering the antenna at the antenna port

Note: Presently, Section 15.247 generally limits point-to-multipoint license-exempt transmissions in all markets at the antenna port to 1W at 100% duty cycle. Thus MAIP is presently set at 1W. Under Kiwi's formulation, MAIP would remain at 1W to maintain consistency with the current rule. However, higher Instantaneous TX power would be permitted so long as the MAIP (defined here as the product of Instantaneous TX power, the duty cycle and horizontal beamwidth) does not exceed the 1W limit.

Finally, in those extreme cases where interference could occur notwithstanding the above, Kiwi urges the FCC to encourage the use of cognitive radio technology in accordance with the recommendations below.

These proposals, if adopted, will benefit license-exempt service providers who are attempting to provide carrier grade wireless broadband services in all areas of the country, including those that have no alternative to incumbent cable modem or DSL providers, or have no broadband service at all. In turn, the availability of ubiquitous and competitive broadband communication services will benefit consumers, businesses, police/fire/emergency users, education and other segments of the economy that are becoming increasingly reliant on high-speed Internet access to deliver services to the public.

2 Proposal

2.1 General

For a number of years, Section 15.247(b)(1)-(4) has limited, point-to-multipoint license-exempt operations to an MAIP of 1 W and an EIRP of 4 watts (reflecting a maximum permitted antenna gain of 6 dBi). This limitation (adopted well before license-exempt spectrum became a viable broadband alternative) effectively limits license-exempt broadband providers to line-of-site, relatively short range deployments. This paints license-exempt WISPs into an economic corner – they must absorb additional infrastructure and service costs to compensate for limited coverage, but are prohibited from expanding their service areas and thereby spread those costs over a larger subscriber base.

Kiwi believes, however, that under certain conditions a license-exempt WISP's transmission power can be substantially increased while keeping general interference conditions constant. It should be noted that Section 15.247(b)(4)(ii) already permits higher EIRP for point to point license-exempt systems. In essence, Kiwi has used the underlying philosophy for that rule to devise a way for point-to-multipoint systems to enjoy the same benefits.

2.2 Conditions for Higher Power Transmissions

Kiwi Networks, Inc. proposes the following implementation principles:

1. Limit transmission power at the antenna port, not EIRP

2. Impose no limit on Instantaneous TX power under the following conditions:

    a. A limit is imposed on transmission duty cycle during higher power transmissions

    b. Define maximum contiguous channel activity (x msec) and interval statistics (for example: Poisson) during higher power transmission

3. Encourage use of directional antennas to increase performance of intended receivers and minimize interference to non-intended receivers

Higher power transmissions should be permitted so long as MAIP, as defined above, remains within the 1W limit.

2.3 Rationale

2.3.1 TX Power Limits vs. ERP

The average amount of interference generated by a radio signal is independent of the antenna radiation pattern, and is dictated by TX power injected into the antenna port That is, use of directional higher gain antennas does not change the overall amount of interference generated by the radio – it merely changes how different receivers within the antenna's range will be affected (i.e., receivers located in the path of the antenna's directional beam will receive a higher level of interference than they would have received if the antenna were omni-directional; by the same token, receivers outside the directional beam will receive no interference). As a result, the gain in signal strength from directional antennas can be used to increase range, building penetration, and/or system capacity, without increasing the overall interference injected into the RF environment.

Conversely, Section 15.247's current EIRP limitation may actually worsen interference conditions. Because the EIRP limit remains the same regardless of the directionalization (a.k.a. beamwidth) of the antenna, service providers who operate in the point-to-multipoint mode have no incentive to directionalize their operations (and operation under the more liberal power limitations for point-to-point service simply is not a viable economic alternative in many cases – point-to-multipoint is by far the superior means of delivering wide-area, carrier class wireless broadband service at the lowest possible cost). Changing the rule as proposed herein will provide license-exempt WISPs with an incentive to use more efficient antenna technologies in the point-to-multipoint mode, thus leading to decreased levels of interference without decreased quality of service to consumers.

Kiwi recognizes that increasing transmit power as proposed may increase interference levels in a limited number of cases, i.e., for those receivers that stand in the direct path of a WISP's directionalized transmissions. Hence, although the average level of interference in the RF environment does not increase, there will be some probability that antenna beams will be directed at some unintended receivers and hence increase those receivers' level of interference.

Kiwi believes, however, that the harmful impact of increasing interference to a smaller universe of receivers can be substantially mitigated by cognitive radio technology. It should be noted that Wi-Fi devices already implement a simple form of cognitive radio, i.e., a Wi-Fi receiver senses the environment and schedules transmissions based on acceptable interference conditions. Hence it is possible that even the performance of legacy Wi-Fi devices could be improved under Kiwi's proposal for reasons discussed in the next section.

2.3.2 Benefits of Cognitive Radio Technology

Cognitive radio technology benefits are greatest when reception conditions in the network vary. This is because the essence of cognitive operation is the radio's self-adjustment of its operating parameters based on location-specific and time-specific channel quality). The larger the variability in channel conditions, the more benefit cognitive radios will deliver.

Consider two environments, each containing the same number of non-cooperative radio systems communicating in a license-exempt band. Assume further that the absolute interference level for both environments is identical, though one has much higher interference variability than the other (or, put another way, the distribution of interference among receivers in the latter market is far more uniform).

Cognitive techniques can provide very limited benefits in the system where interference conditions are fairly constant. However, where interference levels have a high degree of variability, the system can use cognitive techniques to identify transmission opportunities when channel conditions are highly favorable.

While interference variability provides the optimal environment for cognitive radio technology, there remains the question of whether overall system performance under Kiwi's proposal (higher power transmissions limited by duty cycle, directionalization and cognitive techniques) would be superior to that of a system operating under the existing Part 15 limitations.

System performance does increase because of what is commonly known as multi-user diversity. If a particular radio experiences interference, it defers the transmit opportunity to another radio with superior channel conditions, and transmits only when channel conditions become more favorable for itself. In limited cases, if interference is both pronounced and constant, there may not be any opportunity for transmission under current Part 15 specifications

An important distinction between Kiwi's proposal and the NPRM is that Kiwi believes services providers should use cognitive techniques to help themselves combat interference, as opposed to focusing on minimizing harmful effects to others.

3 License Exempt Spectrum User Benefits

If the proposals contained in this document are adopted, users will experience an increase in capacity, a dramatic reduction in interference, improved range, building penetration and coverage. This section will quantify the benefits based on simulation results.

3.1 Increased Capacity

According to Shannon **Therom** the capacity of a system is given by:

$$Capacity = BW \cdot \log_2(1 + C/(I + N))$$

where BW is channel bandwidth, C is signal strength or power, and (I+N) are interference and noise, respectively. For example, if power (C) is increased by 20dB, the capacity can be increased by approximately 4.5X.

Appendix A presents a simulation model that illustrates the capacity benefits of Kiwi's proposal. The model examines performance of single radio that is receiving transmissions from (M + 1) sources. Only one of these transmissions is assumed to be the desired signal, and the other M transmissions are assumed to be undesired signals or interference. MAIP is assumed to be constant, while Instantaneous TX power is allowed to fluctuate based on duty cycle, and antenna beamwidth, per the relationship established by the equation given in Section 2.2.

Figure 1 presents simulation results for the scenario where no cognitive techniques are deployed. Note that the existing Part 15 scenario is depicted in the lower left hand edge of the graph: 100% duty cycle, no additional gain (also, in the following illustrations 0 gain condition depicts an omni directional antenna, and as gain is increased, narrower beamwidth is assumed).

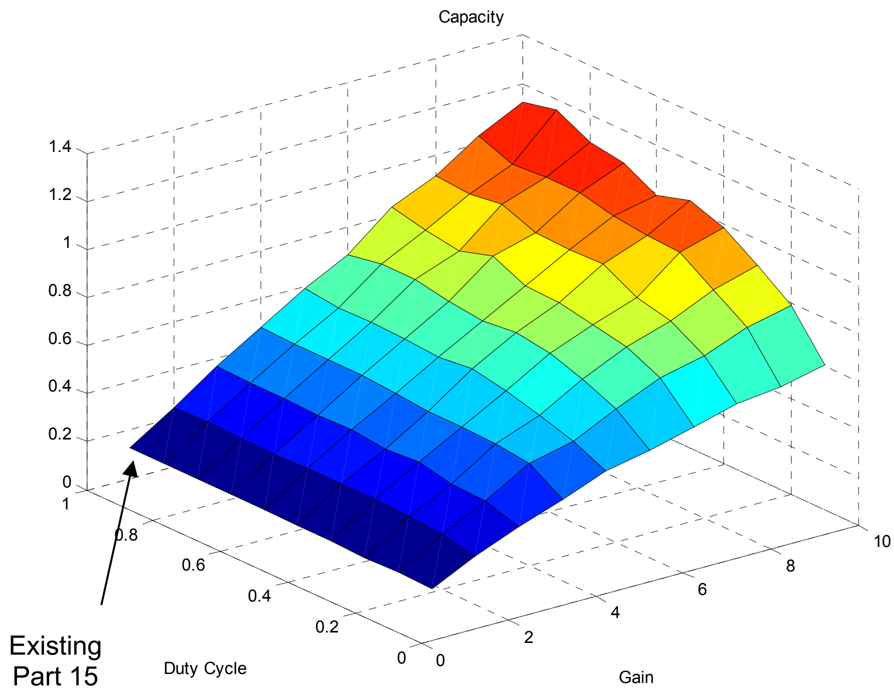

Figure 1: Capacity as function of antenna gain and TX duty cycle without cognitive functionality

As shown above, increase in gain naturally leads to increase in capacity. More interestingly, however, decreasing duty cycle does not have a material impact on system capacity, which is reduced by only half when duty cycle is reduced from 100% to 20%. Even at 20% duty cycle, system capacity is superior to the existing Part 15 case.

Figure 2 examines the case where cognitive capabilities are added to the network. Generally, the overall capacity numbers are 2x the existing Part 15 case.

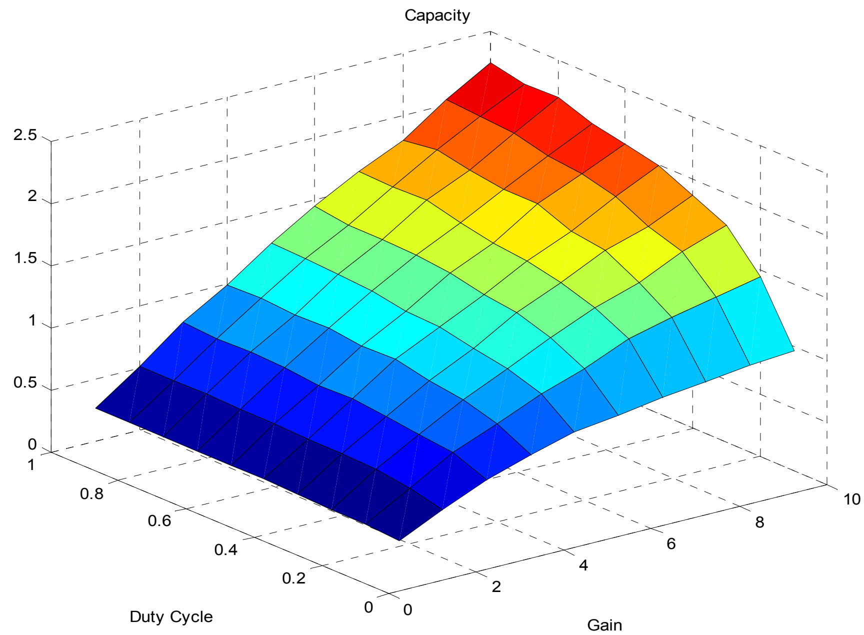

Figure 2: Capacity as function of antenna gain and TX duty cycle with cognitive functionality

3.2 Interference Reduction

For the same network model depicted in Appendix A hereto, we next examine outage probability experienced by each radio. Figure 3 illustrates outage probability for each radio as a function of antenna gain and TX duty-cycle (where the Instantaneous TX power level is inversely proportional to TX duty-cycle). No cognitive ability is assumed.

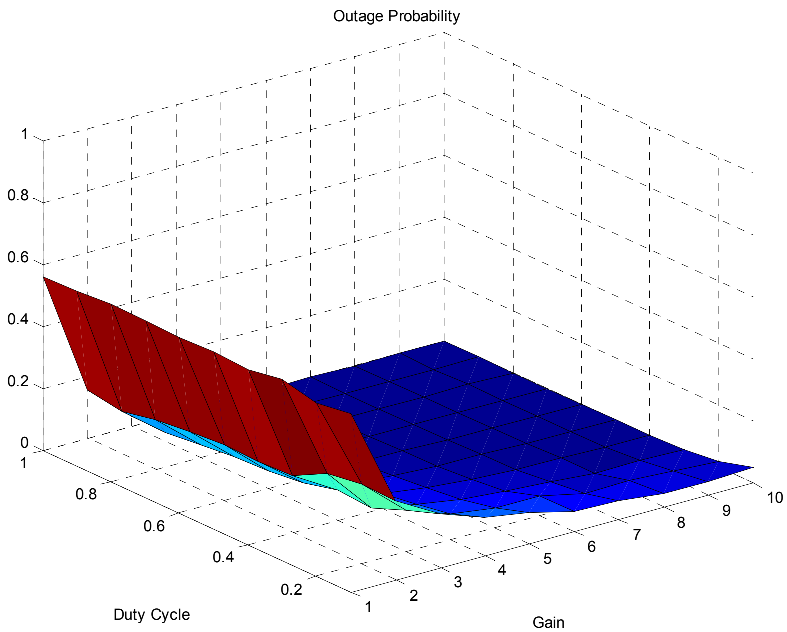

Figure 3: Interference related outage probability without cognitive functionality

Figure 4 illustrates the same scenario, but with cognitive capability. In both cases, with or without cognitive capability, increasing antenna gain and reducing TX duty-cycle while increasing Instantaneous TX power reduces the outage probability. As expected, cognitive capabilities lead to much lower outage probability.

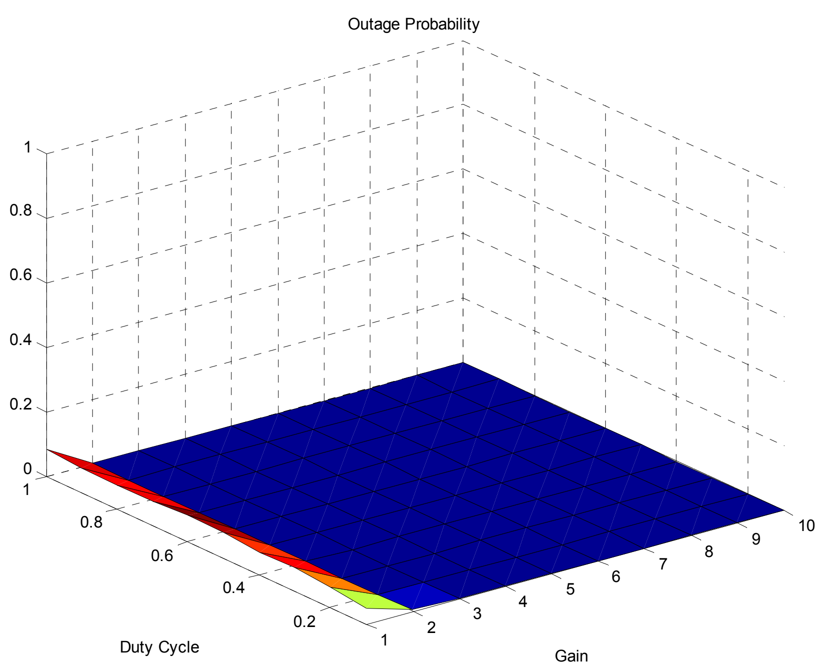

Figure 4: Interference related outage probability with cognitive functionality

3.3 Increase in Range and Coverage

Generally speaking, as discussed in previous section, allowing an increase in instantaneous power can esily increase the link budget by 20dB This will significantly improve coverage and help in building penetration. In that scenario, a significant percentage of license-exempt broadband deployments could use indoor CPE units, thus obviating the need for costly external CPE devices, dramatically reducing residential broadband costs, and helping proliferate broadband communications services across the U.S.

Figure 5 illustrates the benefits of instantaneous TX power increase at 2.4 GHz service in an urban environment: h_m = subscriber station's antenna height and h_b = base station's antenna height.

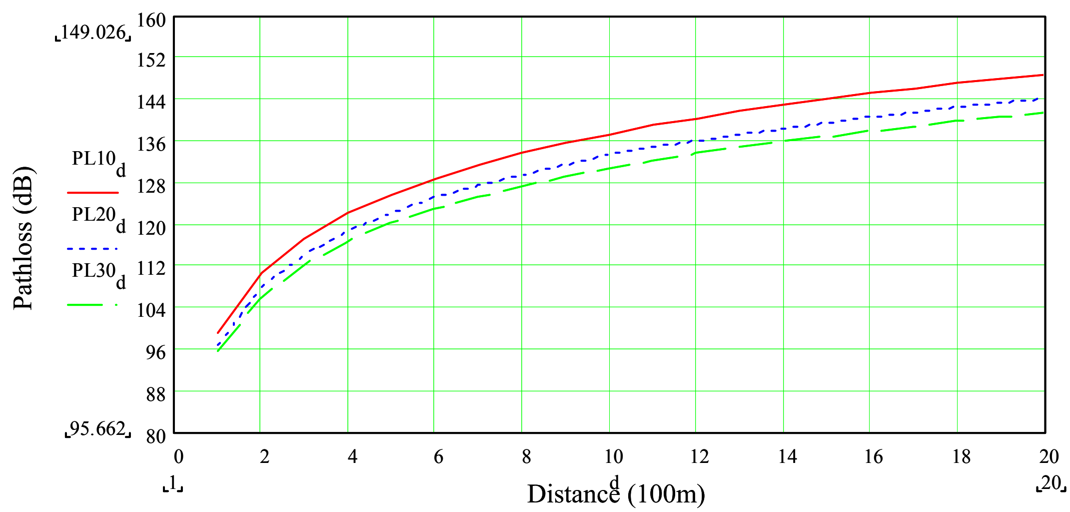

Figure 5: 2.4GHz path loss for h_b = 10, 20 and 30m, h_m = 5m, urban

Figure 6 illustrates the same scenarios for an suburban environment. There is no surprise to see that 12dB increase in ERP will approximately double coverage distance or quadruple the coverage area.

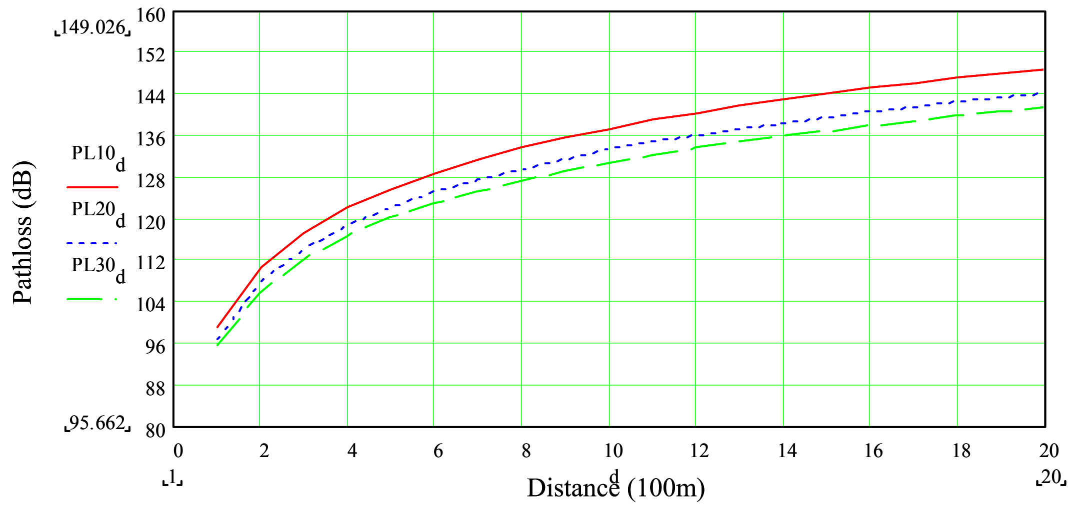

Figure 6: 2.4GHz path loss for h_b = 10, 20 and 30m, h_m = 5m, suburban

4 Summary

Kiwi proposes that the Commission can optimize the provision of wide-area point-to-multipoint license-exempt broadband service in *all* markets, without compromising the interference environment for other spectrum users. As discussed above, this can be accomplished by (1) redefining maximum average output interference power as a function of Instantaneous TX power, TX duty cycle and antenna beamwidth, 2) increasing allowable instantaneous transmission power (at the antenna port), but with corresponding reductions in transmission duty cycle and/or horizontal beamwidth, and 4) using cognitive radio techniques to greatly reduce outage probability. By implementing these guidelines, wireless broadband services can enjoy a 20dB increase in power delivery in the network without materially harming others.

5 Appendix A: Simplified model & simulation for signal and interference

Assume that the user receives transmissions from M + 1 sources. The strongest of these transmissions is assumed to be the desired signal, and the other M transmissions are assumed to be the interference. The values of the M+1 received transmissions are drawn from a lognormal distribution with a specified standard deviation.

Capacity calculations for the reference system [duty cycle = 1, omni antenna]

Let X[m] be these random values.

Then the signal S = max{X[m]} = X[mmax]

Interference I = sum X[m]   where the sum is over all m not equal to mmax

The capacity is given by:

$$C = \log_2(1 + SINR) \quad \text{where} \quad SINR = S/(N+I)$$

We compute the average capacity over many random drawings of X[m].

To "calibrate" the system we scale the signal and the interference so that the average SNR = S/N and INR = I/N equal some specified valued.

Capacity calculations for the system which uses antenna with gain, reduced duty cycle and multi-user diversity

Assume a duty cycle $0<D<1$ and an antenna gain G. Also assume that the antenna beam-width is approximately 360/G.

Pick binary random variables d[m] which is 1 with probability D and 0 with probability 1-D. Pick binary random variables g[m] which is 1 with probability 1/G and 0 with probability 1-1/G.

Then the signal and interference in this case will be given by

signal $S = (1/D)*G*\max\{X[m]\} = (1/D)*G*X[mmax]$

interference $I = (1/D)*\text{sum } d[m]*g[m]*X[m]$

where the sum is over all m not equal to mmax

The factor of (1/D) represents the increase in power due in proportion to the decrease in the duty cycle.

The capacity is given by

$C = D*\log(1 + SINR)$ where $SINR = S/(N+I)$

We compute the average capacity over many random drawings of X[m], d[m], g[m].

To take into account the effect of potential multi-user diversity using cognitive functionality we proceed as follows: Assume that the users are divided into K groups. At each time we pick one user from each group, check their SINR, and transmit to the one which had the best SINR. In the simulation this is accomplished by generated K random values of C each time, and picking the largest one.

In addition to computing the average capacity it is useful to look at the outage probability, i.e. the probability that the capacity will be below a specified level. In the simulation the outage probability is evaluated by counting the number of cases where the random capacity was below a threshold, and dividing that value by the total number of cases.