Project	**IEEE 802.16 Broadband Wireless Access Working Group**
Title	Contributions to main report
Date Submitted	1999-12-24
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Re:	This contribution is a response to the Call for Contributions from the 802.16 Coexistence Group regarding Broadband Wireless Access (BWA) systems.
Abstract	This contribution provides inputs to various sections of the main report
Purpose	This contribution provides inputs to various sections of the main report
Notice	
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Inputs into the main 802.16.2 Coexistence Report

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3.1.1.4 Inband Intercell Links

Inband intercell links (ICLs) are point to point (PTP) radios operating within the same LMDS/CS licensed band as the point to multipoint (PMP) systems. They provide a wireless backhaul capability between base stations at rates ranging from DS-3 to OC-3. The advantage of ICLs is that they can share a common infrastructure as the PMP systems, including the switch, to minimize overall network rollout costs. Additionally, ICL radios can operate under the auspices of a PMP license, thus avoiding the burden of additional licensing and cost associated with out of band PTP systems.

ICL radios typically employ high gain antennas to facilitate ranges that are at least twice the radius of a typical LMDS/CS PMP system, e.g. 8-10 km. Base on this, the following parameters are assumed for a 28 GHz ICL transmitter:

Gtx = 42 dBi
Ptx= 0 dBW/carrier
Carrier BW = 50 MHz
Modulation = 16 QAM (data rate~150 Mb/s)

Power density = Ptx – 10 Log (BW) = 0 – 10Log(50) = -17 dBW/MHz

e.i.r.p = Ptx + GTx = -17 + 42 = 25 dBW/MHz.

Allowing for some extra margin, the e.i.r.p. may be as high as 30 dBW/MHz.

Therefore, ICL radios conforming to the equipment requirements of this practice shall not produce an EIRP spectral density exceeding 30 dBW/MHz. This limit applies to the mean EIRP spectral density produced over any continuous burst of transmission. The spectral density shall be assessed with an integration bandwidth of not more than 1 MHz.

3.1.3 Frequency stability

The system must operate within a frequency stability of +/- 2 parts per million (ppm) over the temperature range for which the equipment is designed to operate. Note the CPE transmit frequency may be controlled by using a reference signal from the downstream signal. In this case, the CPE, under open loop (i.e. not controlled by the base station) may have a stability of +/- 10 ppm.

The RF frequency should be measured:

(a) at temperatures over which the system is designed to operate and at the manufacturer's rated supply voltage. The frequency stability can be tested to a lesser temperature range provided that the transmitter is automatically inhibited from operating outside the lesser temperature range. If automatic inhibition of operation is not provided the manufacturer’s lesser temperature range intended for the equipment is allowed provided that it is specified in the user manual.

(b) at 85% and at 115% of rated supply voltage, with temperature at +20^{o} C .

Minimum Standard :

The RF carrier frequency shall not depart from the reference frequency (reference frequency is the frequency at 20 o C and rated supply voltage) in excess of +/- 2 ppm.In lieu of meeting the above stability value, the test report may show that the frequencystability is sufficient to ensure that the occupied bandwidth emission mask (see section
3.1.2.3.1.1) stays within the licensee’s frequency band, when tested to the temperature
and supply voltage variations specified above. The emission tests shall be performed
using the outermost assignable frequencies which shall be stated in the test report.

3.2 Receiver

3.2.1 Selectivity

The receiver must be capable of operating at the specified BER in the presence of a co-channel interference signal that is 6 dB below the receiver’s noise floor, causing a total noise floor degradation of 0.5 dB.

The receiver must be capable of operating at the specified BER in the presence of an adjacent channel interference signal that is equal in power to the transmitted signal, i.e. C/I=0 dB.

A CW interferer, at a level of +30 dB with respect to the wanted signal and at any frequency up to 60 GHz, excluding frequencies within 500% of the center frequency of the wanted signal, shall not cause a degradation of more than 1 dB of the BER threshold.

<The following text is to replace the section currently in the report.

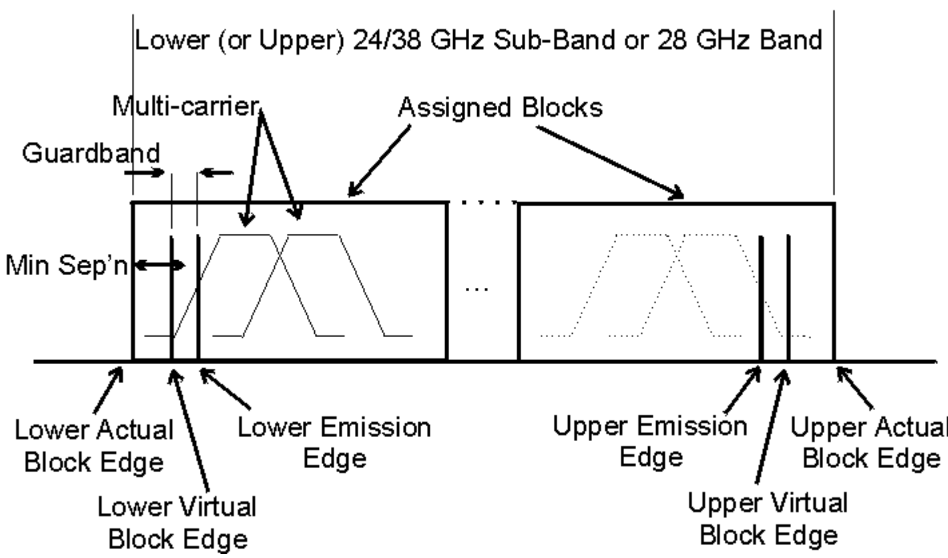
3.1.2.3.1.1 <u>Unwanted emissions:</u>

Unwanted emissions comprise of out-of-band emissions (emission on a frequency or frequencies immediately outside the occupied bandwidth), spurious emissions and harmonics. They are to be measured when the transmitter is operating at the manufacturer’s rated power and modulated as in section 6.2. Unwanted emissions are to be measured at the output of the final amplifier stage or referenced to that point. The occupied bandwidth (B_o) shall be stated in the test report by the certification applicant.

Single-carrier and multi-carrier tests are described below. If multicarrier operations are intended, then both tests are required.

Single carrier and multi-carrier tests are to be carried out relative to a virtual block edge (defined in the following table). The virtual block edge is located within the assigned band (see diagram below). When a transmitter is designed to only operate in part of a band (e.g. because of Frequency Duplexing), the virtual block edge shall be inside the designed band of operation. The occupied bandwidth of the carrier(s) must be closer to the centre of the block than the virtual block edge. The virtual block edge is only to be used for testing and does not impact an actual implementation in any way. One virtual block edge (at frequency f_{VL}) shall be inside the lower edge of the designed or assigned band and the other virtual block edge (at frequency f_{VU}) shall be inside the upper edge of the designed or assigned band.

Band	Minimum Separation between Actual and Virtual Block Edge
24 GHz	10 MHz
28 GHz	40 MHz
38 GHz	10 MHz



The purpose of specifying the tests relative to the virtual block edges is to avoid the attenuating effects of any RF filters that may be included in the transmitter design, so that the spectrum masks of section 6.3.3 are applicable to any channel block.

Note that although testing is specified relative to the virtual block edges, the transmitter is expected to perform similarly for all frequencies within the designed band. Therefore, to reduce the number of test runs, the Lower Virtual Block Edge can be in one assigned band and the Upper Virtual Block Edge can be in another (e.g. blocks A and E of Table 1, or even blocks A and E').

3.1.2.3.1.1.1 <u>Single Carrier Test</u>

For testing nearest the lower virtual block edge, set the carrier frequency f_L closest to the lower virtual block edge, taking into account any guardband used in the design of the equipment, record the carrier frequency f_L, the virtual block edge frequency f_{VL}, the guardband (f_{LG}) and plot the RF spectrum. Likewise, perform the highest frequency test with the carrier frequency, $f_{U,}$ nearest the upper virtual block edge. Record the carrier frequency, the virtual block edge frequency (f_{VU}) , the guardband (f_{UG}) and the RF spectrum plot. The guardband is the frequency separation between the virtual block edge and the edge (99%) of the occupied emission.

The user manual shall contain instructions, such as details on the minimum guardband sizes required to ensure that the radios remain compliant to the certification process.

It is to be noted that the SRSPs permit licensees to have more than one frequency block (Tables 1 and 3) for their systems. Equipment intended to have an occupied bandwidth wider than one frequency block per carrier shall be tested using such a wideband test signal for the section 6.3.3(1) requirement.

3.1.2.3.1.1.2 Multi-Carrier Test

This test is applicable for multi-carrier modulation. It applies equally to multi-transmitters into a common power amplifier. Note that the multi-carrier transmitter must be subjected to the single carrier testing, described above, in addition to the tests specified below.

For multi-carrier testing, the single carrier test method of 6.3.1 is to be used except that the single carrier is replaced by a multi-carrier modulated signal that is representative of an actual transmitter. The number of carriers should be representative of the maximum number expected from the transmitter, and be grouped side by side nearest the lower virtual block edge, with lower guardband, f_{LG}, if required by the design of the equipment. Likewise test nearest the upper virtual block edge. Record their spectrum plots, the number of carriers used and the guardband sizes (f_{LG}, f_{UG}), the carrier frequencies and the virtual block edge frequencies.

Notwithstanding the requirements in the table above in section 6.3 “Minimum Separation between Actual and Virtual Block Edge”, any equipment which uses the complete block or multiple blocks for a single licensee can include the attenuating effect of any RF filters in the transmitter design within the multi-carrier test , in which case the Virtual and Actual block edge frequencies will be the same.

The user manual shall contain instructions, such as details on the minimum guardband sizes required and the maximum number of carriers or multi-transmitters permitted, to ensure that the radios remain compliant to the certification process.

3.1.2.3.1.1.3 Minimum Standard:

Unwanted emissions spectral density shall be attenuated by at least A (dB) below the total mean output power as follows:

(1) For a single carrier transmitter (see section 6.3.1) :

In any 1.0 MHz reference bandwidth, outside the virtual block edge, and removed from the virtual block edge frequency by up to and including ±200% of the occupied bandwidth (i.e. 2 B_o): at least $A = 11 + 40 f_{offset}/B_o + 10 \log_{10}(B_o)$, dB, where B_o is in MHz and f_{offset} = frequency offset (in MHz) from the virtual block edge. Attenuation greater than $56 + 10 \log_{10}(B_o)$, dB, or to an absolute level lower than -43 dBW/MHz, is not required. For emissions in which the occupied bandwidth is less than 1 MHz, the required attenuation is to be calculated using $A = 11 + 40 f_{offset}/B_o$, dB.

(2) For a multi-carrier transmitter or multi-transmitters into a common final stage amplifier (see section 6.3.2) :

The mask is to be the same as in (1), using the occupied bandwidth that is defined for multi-carrier transmitters in section 5.6.1. The total mean power is to be the sum of the individual carrier/transmitter mean powers. Guardbands if used in the equipment design must also be used in testing the spectrum mask.

Note: Several transmitters into a common non-active antenna cannot use the multi-carrier mask for the composite signal. In this case the appropriate mask applies to the individual transmitter.

(3) In any 1.0 MHz band which is removed from the virtual block edge frequency by more than $\pm$200% of the occupied bandwidth : at least $43 + 10 \log_{10} (P_{mean})$ dB (i.e. –43 dBW), or 80 dB below P_{mean}, whichever is less stringent. P_{mean} is the mean output power of the transmitter (or, in the case of multi-carriers/multi-transmitters, the sum of the individual carrier/transmitter powers) in watts.

The search for unwanted emissions shall be from the lowest frequency internally generated or used in the device (local oscillator, intermediate or carrier frequency), or from 30 MHz, whichever is the lowest frequency, to the 5th harmonic of the highest frequency generated or used, without exceeding 40 GHz.

8. Deployment & Co-ordination

8.1 Co-ordination Process

Coordination is required between licensed service areas where the shortest distance between the respective service boundaries is less than[1] 60 km and both systems are operating co-channel, i.e. over the same LMDS frequencies. The rationale for 60 km is given in the next section. The operators are encouraged to arrive at mutually acceptable sharing agreements that would allow for the provision of service by each licensee within its service area to the maximum extent possible.

Under the circumstances where a sharing agreement between operators does not exist or has not been concluded, and whose service areas are less than 60 km apart, the following coordination process shall be employed (refer to Figure 1 for an graphical representation of the process):

> LMCS operators are required to calculate the power flux density (pfd) at the service area boundary of the neighboring service area(s) for the LMCS transmitting facilities. Power flux density is calculated assuming line-of-sight free space path loss, including such factors as atmospheric loss, antenna directivity toward the service area boundary, curvature of Earth, and it is the maximum value for elevation points up to 500 m above local terrain elevation. Refer to the next section below for a rationale behind the pfd levels presented in this process.
>
> Deployment of facilities which generate a pfd less than or equal to -114 dBW/m^2 in any 1 MHz (pfd A) at the other LMDS service area boundaries are not subject to any coordination requirements.
>
> Deployment of facilities which generate a pfd greater than pfd A (-114 dBW/m^2 in any 1 MHz), but less than or equal to -94 dBW/m^2 in any 1 MHz (pfd B) at the other LMCS service area boundaries are subject to successful coordination between the affected licensees in accordance with the following coordination process:
>
> The operator must notify the respective licensee(s) of its intention to deploy the facility(ies) along with the appropriate information necessary to conduct an interference analysis.
>
> The recipient of the notification must respond within 30 calendar days to indicate any objection to the deployment. Objection may be based on harmful interference to existing systems[2] only.
>
> If there is no objection raised, then the deployment may proceed.
>
> If an objection is raised, then the respective licensee(s) must work in collaboration to develop a suitable agreement between the licensee(s) before the deployment of facilities. It is expected that the time frame to develop such an agreement should not exceed 30 calendar days.

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[1] In the event an operator using sites of very high elevations relative to local terrain that could produce interference to LMCS service areas beyond 60 km, this operator shall coordinate with the affected licensee(s).

[2] Existing systems include systems that are operational, or systems that have been coordinated previously.

Any obligations as a result of the coordination are valid for 120 calendar days from the conclusion of coordination.

Deployment of facilities which generate a pfd greater than - 94 dBW/m^2 in any 1 MHz) (pfd B) at the other LMCS service area boundaries are subject to successful coordination between the affected licensees.

In any event, licensees are expected to take full advantage of interference mitigation techniques such as antenna discrimination, polarization, frequency offset, shielding, site selection, or power control to facilitate the coordination of systems.

All results of analysis on pfd, or agreements made between licensees must be retained by the licensees and be made available to the regulatory body upon request.

If a licence is transferred, the sharing agreement(s) developed between the former licensees shall remain in effect until superseded by a new agreement between licensees.

In the event a satisfactory agreement or a successful coordination between the licensees is not reached, the regulatory body should be informed.

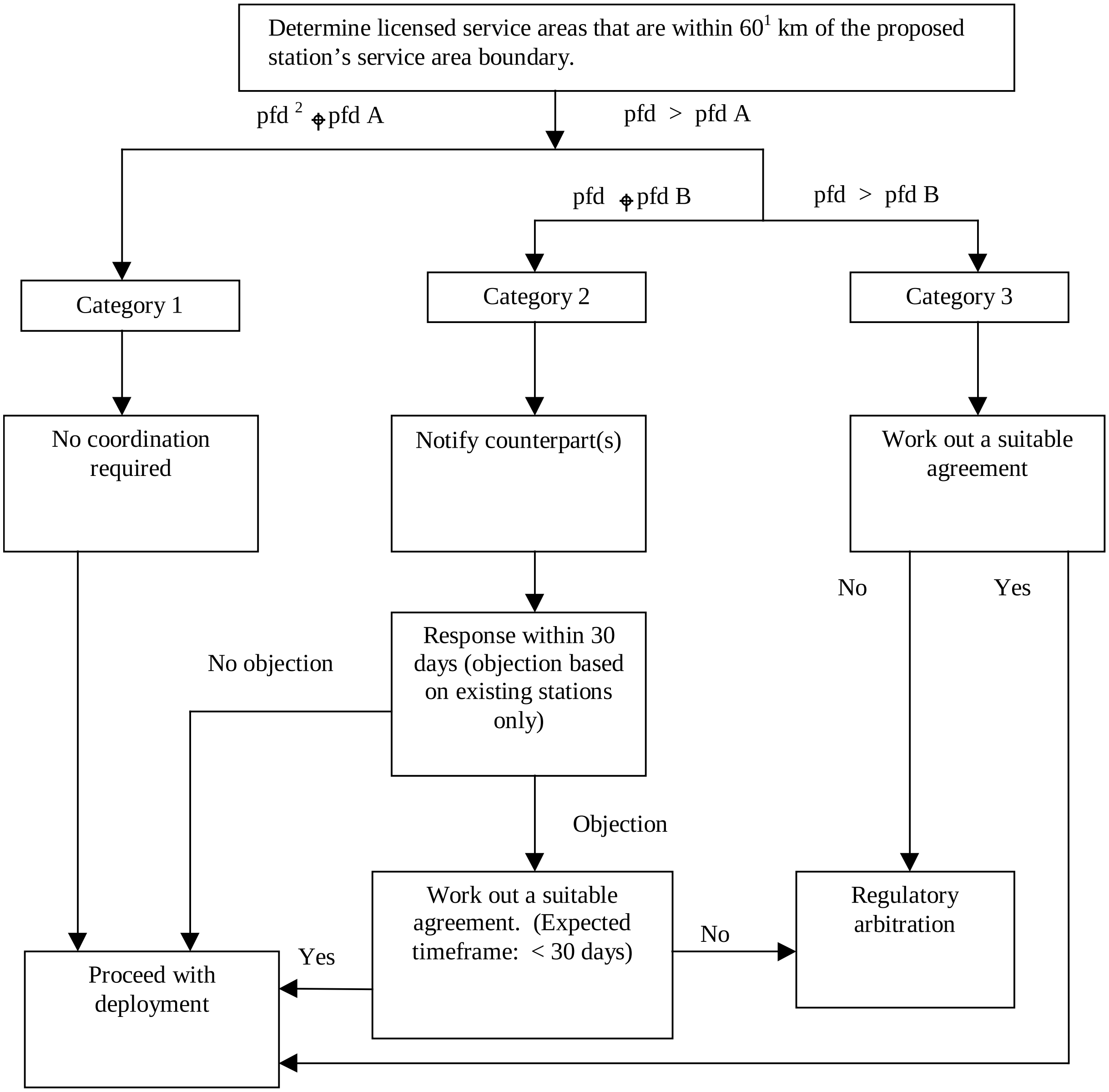

Figure 1 Coordination process for adjacent area co-channel LMDS systems.

8.1.1 Coordination Distance

As described above, distance is used as the first trigger mechanism for coordination between adjacent licensed operators. If the boundary of two service areas is within 60 km of each other, then the coordination process is invoked.

The rationale for 60 km is based upon several considerations including radio horizon calculations, propagation effects, and power flux density levels (the latter is discussed in the next section).

The radio horizon is defined as:

$$R_h=4.12(\sqrt{h_1} + \sqrt{h_2})$$

where:
R_h = Radio Horizon (km)
h_1 = Height of radio 1 above clutter (m)
h_2 = Height of radio 2 above clutter (m).

The table below presents the horizon range for different radio heights above average clutter.
Table XX.

Horizon range for different radio heights (in kilometers).

	Height of Radio 1 (m)								
Height of Radio 2 (m)	10	20	30	40	50	60	70	80	90
10	26	31	36	39	42	45	47	50	52
20	31	37	41	44	48	50	53	55	58
30	36	41	45	49	52	54	57	59	62
40	39	44	49	52	55	58	61	63	65
50	42	48	52	55	58	61	64	66	68
60	45	50	54	58	61	64	66	69	71
70	47	53	57	61	64	66	69	71	74
80	50	55	59	63	66	69	71	74	76
90	52	58	62	65	68	71	74	76	78

The worst case interference scenario involves two base stations, as they are typically located on relatively high buildings/infrastructures and hence have greater radio horizon distances. A typical height for a base station is 65 m above ground level, or 55 m above clutter, assuming an average clutter height of 10 m. This produces a radio horizon of 60 km. There will be cases where the base station equipment may be located on higher buildings which would produce a greater radio horizon. However, these base stations tend to tilt their antennas downward which effectively reduces the amount of power (interference) that can be directed towards the adjacent base station. The next section examines power levels in more detail.

8.1.2 Power Flux Density

This section addresses the maximum power flux density that can be tolerated as a result of co-channel interference originating from an adjacent licensed operator. The amount of interference generally considered acceptable or tolerable is one which produces a degradation of 0.5 dB to the system's C/N (this degradation is usually taken into consideration during the original link budget exercise). For the noise floor to increase by 0.5 dB, the interference power level must be 6 dB below the receiver's thermal noise floor. Assuming a typical receiver noise figure of 6 dB, then the thermal noise power spectral density of the receiver is calculated as follows:

$$N_o = 10 Log(kT_o) + N_F$$
$$N_o = -144 + 6 = -138 \text{ dBW/MHz}$$

where,
No = Receiver thermal noise power spectral density (dBW/MHz)
kT_o = Equipartition Law (-144 dBW/MHz)
N_F = Receiver noise figure (6 dB)

At 6 dB below N_o, the interference power level (I_{tol}) into the receiver is -144 dBW/MHz (-138 – 6).

The spectral power flux density (pfd) at the antenna aperture is calculated as follows:

$$pfd = \frac{\Pr}{Ae} = \frac{\Pr}{\lambda^2 \frac{G}{4\pi}} = \Pr - 10Log(\lambda^2) - G + 10Log(4\pi)$$

where:

Pr = interference power level into receiver (-144 dBW/MHz)
Ae = effective antenna aperture
λ = wavelength
G = antenna gain.

Assuming an operating frequency of 28 GHz (λ=.011m) and a typical base station antenna gain of 20 dBi, then the tolerable interference level is given as:

Pfd_{BTS} = -144 - 10Log($.011^2$) – 20 + 10 Log(4π) = -144 + 39 – 20 + 11 = -114 dBW/MHz-m^2

Note that the base station receiver is considered only in this analysis (not the subscriber). This is primarily due to the fact that BTS' are typically located on high buildings/structures with omni directional coverage which tend to increase their probability of achieving line of sight (LOS) to adjacent licensed area transmitters. Subscribers, on the other hand, tend to be situated at low altitudes (~15 m) which significantly reduces the probability of LOS (due to obstacles/clutter) to adjacent area systems. Furthermore, subscribers have highly directional antennas (narrow beamwidths) which further reduces the probability that they will align with an interference source from an adjacent area.

The –114 dBW/MHz-m^2 represents the first PFD trigger level of the coordination process described above.

A sample calculation is given below to determine the feasiblity of meeting the pfd limit between a BTS transmitter and BTS victim receiver.. The formula for pfd is as follows:

$$pfd_{victim} = P_{TX} + G_{TX} - 10\log(4\pi) - 20\log(R) - A_{losses}$$

where;

P_{TX} = transmitter power (- 25 dBW/MHz)
G_{TX} = transmitter antenna gain in the direction of the victim receiver (18 dBi)
R = range (60000 m)
A_{losses} = atmospheric losses, ~ 0.1 dB/km

The values given in brackets represent typical LMDS parameters.

Using the radio horizon range of 60 km from above, the pfd at the victim base station receiver antenna is:

$$pfd_{victim} = -25 + 18 - 10\log(4\pi) - 20\log(60000) - 60*.1$$
$$= -120 \text{ dBW/MHz-m}^2$$

The –120 value is lower than the –114 tolerable level, therefore, the 60 km range is considered reasonable as a first level trigger point. Note that the above pfd calculation assumes free space propagation and clear line of sight, i.e. complete first Fresnel zone clearance.

While spectral pfd A (-114) allows for quick deployment, it is based on fairly conservative assumptions that may unnecessarily limit system performance. Spectral pfd level B is set 20 dB higher on the basis that extra propagation losses will occur in reality, as much as 15 dB from diffraction, and that the operator will be able to resort to basic mitigation techniques including using cross-polarization, placing BTS transmitter at the same frequency as interfering BTS transmitter, etc.