Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Draft Text for Section 7 "Deployment" for Coexistence Practice**
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Re:	IEEE PAR 802.16.2
Abstract	Discussions at the June 2000, Ottawa Interim meeting of IEEE 802.16.2 suggested textual changes to section 7. This contribution provides draft text for consideration by the committee.
Purpose	Review the draft text and include in Coexistence Practice if appropriate.
Notice	
Release	
Patent Policy and Procedures	

Draft Text for Section 7 “Deployment” for Coexistence Practice

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7 Deployment & Co-ordination

The following paragraphs provide a recommended structure process to be used to co-ordinate deployment of BWA systems in order to minimize interference problems.

Note that national regulation and / or international agreements may impose tighter limits than the following and will take precedence in this case.

This methodology should facilitate identification of potential interference issues and should minimize the impact in many cases, but compliance with this process will not guarantee avoiding interference problems.

It is recommended that the methodology apply to both co-frequency/adjacent area situations as well as adjacent frequency/same area situations. In both cases, the psfd limit applies to co-frequency emissions within the victim’s authorized band.
NOTE in the following, “coordination” as a minimum implies a simple assessment showing the likelihood of interference, AND it may imply a detailed bi-lateral negotiation between operators to mitigate problem areas for the benefit of both systems.

7.1 Co-Frequency / Adjacent Area

7.1.1 Methodology

Coordination is recommended between licensed service areas where both systems are operating co-channel, i.e. over the same BWA frequencies and where the service areas are in close proximity e.g., the shortest distance between the respective service boundaries is less than[1] 60 km . The rationale for 60 km is given in the next sub-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 in close proximity, the following coordination process should be employed (refer to Figure 7-1 for a graphical representation of the process).

BWA operators should calculate the power spectral flux density (psfd) at their own service area boundary. Power spectral flux density (psfd) should be calculated using good engineering practices, taking into account such factors as propagation loss, atmospheric loss, antenna directivity toward the service area boundary, curvature of Earth. It is the maximum value for elevation points up to 500 m above local terrain

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

elevation. Refer to the next section below for a rationale behind the psfd levels presented in this process.

The limits here refer to an operator's own service boundary, since that is known to the operator and will frequently be the same as the adjacent operator's service boundary. In cases where the two boundaries are separate (e.g., by a large lake), dialog between operators, as part of the coordination process, should investigate relaxing the limits by applying the limits at the adjacent service boundary. In cases where there is an intervening land mass (with no licensed operator) separating the two service areas, a similar relaxation could be applied, however in this case, caution is needed since both existing operators may have to re-engineer their systems, if a new licensee is awarded at a future time for this intervening land mass.

Deployment of facilities which generate a psfd less than or equal to -114 dBW/m^2 averaged over any 1 MHz (psfd A) at their own service area boundary are not subject to any coordination requirements. (It should be noted that the psfd values referred to in this section applies to systems operating in the 20-30 GHz frequency range. A table (Table 7-1), showing the corresponding psfd limits, is given below to address systems operating outside of this range.)

Deployment of facilities which generate a psfd greater than psfd A (-114 dBW/m^2 averaged over any 1 MHz), but less than or equal to -94 dBW/m^2 averaged over any 1 MHz (psfd B) at their own service area boundary are recommended to use the following coordination process:

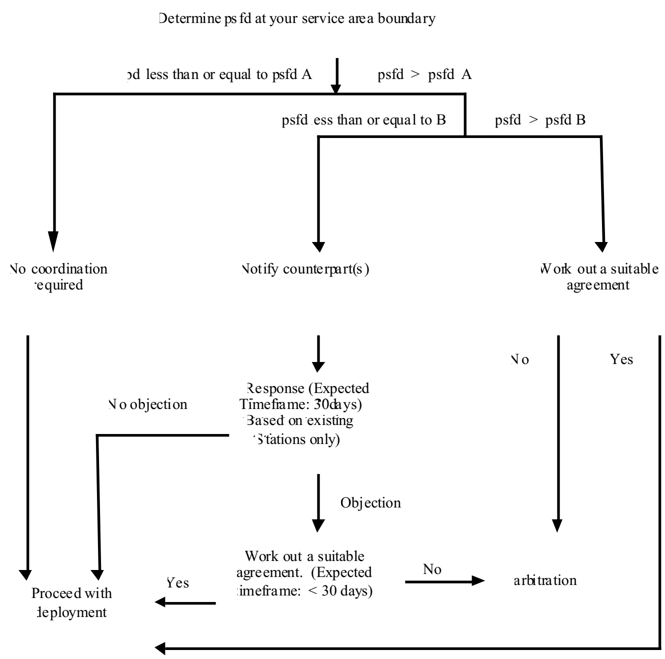
- The operator should notify the respective licensee(s) of its intention to deploy the facility(ies) along with the appropriate information necessary to conduct an interference analysis.
- The recipient of the notification should respond within 30 calendar days to indicate any objection to the deployment. 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.
- Proposed facilities should be deployed within 120 calendar days of the conclusion of coordination, otherwise, coordination should be reinitiated.

Deployment of facilities which generate a psfd greater than - 94 dBW/m^2 averaged over any 1 MHz) (psfd B) at their own service area boundary are subject to successful co-ordination 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 co-ordination of systems.

[2]Existing systems include systems that are operational prior to receipt of the notification, or systems that have previously been co-ordinated successfully.

Figure 1 - Coordination process for adjacent area co-channel BWA Systems



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

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

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

The table below summarizes the recommended psfd levels for systems operating in the 20-30 GHz and 30-40 GHz bands.

Table 1 - Maximum psfd Limits

quency Band	PSFD A (dBW/MHz-m^2)	PSFD B (dBW/MHz-m^2)
20-30 GHz	-114	-94
30-40 GHz	-114	-94

7.1.2 Co-ordination Trigger

As described above, distance is suggested as the first trigger mechanism for co-ordination between adjacent licensed operators. If the boundaries of two service areas are within 60 km of each other, then the co-ordination process is recommended.

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).

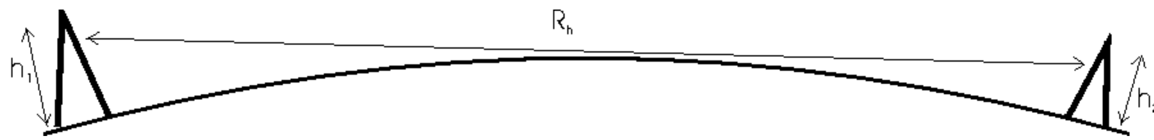


Figure xx Definition of Radio Horizon

The radio horizon, the maximum line-of-sight distance between two radios, is defined as (see Fig xx):

$$R_h=4.12(\sqrt{h_1} + \sqrt{h_2}) \quad (6)$$

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. Note that if the antenna is erected on a mountain (or building), then the “height of radio above clutter” will probably also include the height of the mountain (or building).

Table 2 - Horizon range for different radio heights AGL (in kilometers).

	Height of Radio 1 (m) above clutter								
Height of Radio 2 (m) above clutter	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 over the whole path length. 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.

7.2 Same Area / Adjacent Frequency

To estimate potential interference into other BWA systems in the same area, it is necessary to estimate the Unwanted (Spurious and Out-of-Band) emissions (see section 6.1.4) from one system, which are co-frequency with the another system operating in the same general area. It is recommended that around each base antenna, a map is drawn showing psfd contours where these out-of-band emissions are expected to exceed psfd's of –114 dBW/m^2 averaged over any 1MHz and of -94 dBW/m^2 averaged over any 1MHz. These maps should be passed to any operator using those frequencies in the same area and the process as in Section 7.1 and Figure 15 should be followed. Note that if these out-of-band psfd contours extend beyond the service area, then the process in section 7.1 should also be undertaken for adjacent areas.
It is recommended that any operator receiving such plots should:

- Reciprocally offer similar plots of his own emissions to the other operator
- Carefully assess the plots received to determine the severity of any interference
- Initiate a dialog with the other operator to minimize any impacts.

NOTE it is likely that, unless there is significant angular, time, frequency or distance separation between transmitters and receivers, there will be an area of interference close to a transmitter.

7.3 Use of Power Spectral Flux Density (psfd) as a Coexistence Metric

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 1 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:

$$N_o = 10 Log(kT_o) + N_F \qquad (7)$$
$$N_o = -144 + 6 = -138 \text{ dBW/MHz}$$

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 (psfd) at the antenna aperture is calculated as follows:

$$psfd = \frac{Pr}{Ae} = \frac{Pr}{\lambda^2 \frac{G}{4\pi}} = Pr - 10Log(\lambda^2) - G + 10Log(4\pi) \qquad (8)$$

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:

$Psfd_{BTS}$ = $-144 - 10Log(.011^2) – 20 + 10 Log(4\pi) = -144 + 39 – 20 + 11$
= -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 psfd A in the 20-30 GHz range of the co-ordination process described above.

The psfd limits for the 30-40 GHz frequency range were derived in a similar manner. A sample calculation is given below to determine the feasibility of meeting the psfd limit between a BTS transmitter and BTS victim receiver. The formula for psfd is as follows:

$$psfd_{victim} = P_{TX} + G_{TX} - 10log(4\pi) - 20log(R) - A_{losses} \qquad (9)$$

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 BWA parameters.

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

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

The –120 dBW/MHz-m^2 value is lower than the –114 dBW/MHz-m^2 tolerable level, therefore, the 60 km range is considered reasonable as a first level trigger point. Note that the above psfd calculation assumes free space propagation and clear line of sight, i.e. complete first Fresnel zone clearance.

While spectral psfd A (-114 dBW/MHz-m^2) allows for quick deployment, it is based on fairly conservative assumptions that may unnecessarily limit system performance. Spectral psfd 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.

7.4 Deployment Procedure

This section describes a process for an operator to follow in deploying an BWA system to promote coexistence. The process is essentially a ‘turn-on’ procedural list that should be followed before the operators activate their transmitter(s) to ensure they do not inadvertently interfere with or cause performance degradation to an existing system operating either co-located or in an adjacent area. The operator is highly encouraged to communicate with other known operators who may be potentially affected, since the slightest interference could severely affect their business.

The ‘turn on’ procedure is as follows:

- Follow the coordination procedure described above and where applicable, take the necessary mitigation steps accordingly.
- From a rooftop with good visibility over the target cell area, scan the surroundings with a radio detector and spectrum analyzer to determine if any interference is present that may adversely affect the performance of the system to be deployed.
- Ensure the antennas are properly installed in terms of main beam direction (AZ and El) and polarization (for the latter, labeling on the antenna to clearly indicate polarization is highly recommended). The antennas should also be sufficiently mechanically supported to withstand the worst case local wind conditions such that the antennas only deviate from their original alignment to within [+/- 0.5] degrees.
- Before turning on the transmitter verify the proper tests have been performed to ensure EIRP and OOB emissions fall within the regulated/ recommended limits.
- Verify the transmitter EIRP does not exceed safety limits as specified by local regulations.
- Verify the transmitter or its IF cables do not interfere with IF cables or receivers from other co-located systems.
- Verify the transmitter will automatically turn off in the event that it becomes rogue i.e. it loses lock and begins to transmit randomly in power and spectrum.