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Re:	Inputs into the coexistence practice document.
Abstract	This document addresses equipment design parameters, and coordination process.
Purpose	The contents of this paper is to be included in the coexistence practice document for formal submision to the IEEE 802.16 committee.
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Coexistence Practice Document (Inputs)

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Equipment Design Parameters

Frequency Stability Requirements

The system must operate within a frequency stability of +/- 15 parts per million over a temperature range of – 40 to +40 degrees.

Coordination Process

Coordination Distance

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. Refer to Annex A [Canadian paper on coordination] for a detailed description of the process.

A distance of 60 km is used based upon several considerations including radio horizon calculations and propagation effects. 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.

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 in the link budget analysis). 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:

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

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 in Annex A [Canadian paper on coordination].

A sample calculation is given below to determine the feasiblity of meeting the pfd limit described above. 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

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 much 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. In reality, partial penetration of the Fresnel zone at these distances will occur which will introduce as much as 6-15 dB of extra attenuation to the interfering signal towards the victim receiver, thus reducing the range at which potential interference can occur.