Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Co-ordination Criteria for BWA Systems**
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Re:	Outline for the co-ordination criteria section of the coexistence recommended practices document, as discussed at the Montreal interim meeting.
Abstract	This document includes an (incomplete) section, for consideration as part of the Recommended Practices for Coexistence of BWA Systems document. It provides guidance on the minimum geographical and channel spacings needed for various types of BWA system operating in the same and nearby geographical areas. The information is derived from calculations and simulations contributed by members of the Coexistence task group. Many of the figures are subject to final agreement by the task group
Purpose	The document is provided as a basis for a section of the recommended practices document, giving guidance to the reader on frequency and geographical spacings necessary for satisfactory operation of BWA systems deployed by different operators. It is intended that the various recommendations be discussed during the Washington meeting.
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Co-ordination Criteria for BWA Systems

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1. Summary

This document is proposed for consideration as part of section [tba] of the Recommended Practices document. It provides guidance on the minimum geographical and channel spacings needed for various types of BWA system operating in the same and nearby geographical areas. The information is derived from calculations and simulations contributed by members of the Coexistence task group. Since not all the cases have been discussed and agreed in the group, a number of entries are either provisional [brackets] or blank at this stage.

2. General recommendations (all cases)

It is recommended that systems be planned so that the sum of interference sources on a given channel be lower than [–114dBm / MHz] under normal conditions of propagation. In some cases, a single interferer will dominate. In other cases, multiples sources of interference must be considered.

[In the case of FDD hub to FDD hub interference, it is recommended that systems operating in the same or nearby geographical areas adopt the same block arrangement (i.e. all hubs transmit in the same frequency block). Further, it is recommended that the spacing between transmit and receive blocks be [approximately?] the same for all systems in the area.]

In the case of TDD systems or where there is a mix of FDD and TDD systems, the above recommendation can not apply. In this case, other measures must be taken to minimize inter-system interference.

3. Co-channel case

3.1 Hub to Hub co-polar, single and multiple interferers

The hub to hub interference is not necessarily the worst case but, when interference occurs, it affects a large number of users at the same time. Mitigation, by moving or re-pointing the hub or by changing frequency is very disruptive to a system. Therefore, a relatively "safe" value should be applied to co- channel, co-polar geographical spacing. Shorter distances are possible but it is recommended that these be verified by actual signal measurement. Occasionally, the normal recommended spacing will not be sufficient, due to adverse terrain. Where one station is on a local high point, which is much higher than the mean level of the surrounding terrain, it is recommended that a specific calculation be made of the interference level.

The results in this section are derived from worst case analysis (for a single interferer and a typical set of system parameters) and from simulation. The IEEE 802.16.1 standard is still evolving and results of the analysis may need to be reviewed when final systems parameters are known. Meanwhile, we have used parameters that are typical of BWA systems.

For systems with multiple hubs, typical frequency reuse arrangements can lead to multiple sources of interference on a given channel/ polarization. The level of interference can therefore be higher than that for a single interferer.

[The results of Leland's simulations, when completed, should be considered here].

System Types	Minimum recommended Hub Spacing without co-ordination [note 1]	Rationale
FDD to FDD (single interferer)	60km	Worst case analysis – see[ ]
FDD to FDD (multiple interferers)	[>60km ???]	Simulation results – see [Crosspan input]
TDD to TDD (single interferer)	60km	Worst case analysis – see[ ]
TDD to TDD (multiple interferers)	[>60km??]	Simulation results – see [Crosspan input]
Mixed FDD – TDD (single interferer)	60km	Worst case analysis – see[ ]
Mixed FDD – TDD (multiple interferers)	[>60km??]	Simulation results – see [Crosspan input]
Mesh to TDD/ FDD	Not applicable	There are no hubs in mesh systems

Note 1: The figures are guidelines, based on a horizon - grazing path for typical hub antenna heights. In rare cases, greater spacing could be necessary.

3.2 Subscriber to Hub, co – channel case

In this case, single and multiple subscribers must be considered. Dependent on the system design, the number of subscribers which transmit at any one time may be low (or only one) from a given cell sector. However, interference can often arise from several cells, especially when rain fading occurs selectively (i.e. where a localized storm cell attenuates some radio paths but not others). In the case of mesh systems, there may be several interferers on a given channel, although only a small number will transmit simultaneously and very few will be visible at a particular hub. Simulation (Monte Carlo modeling) is needed to analyse this case of multiple interferers.

[GJG's simulation results to be considered here]

[PW simulation results to be considered here]

System Types	Minimum recommended Sub to Hub Spacing without co-ordination [note 1]	Rationale
FDD to FDD (single interferer)	[??]	Worst case analysis – see[ ]
FDD to FDD (multiple interferers)	[from GJG's simulations]	Simulation results – see [GJG input]
TDD to TDD (single interferer)	[??]	Worst case analysis – see[ ]
TDD to TDD (multiple interferers)	[from GJG's simulations]	Simulation results – see GJG input
Mixed FDD – TDD (single interferer)	[??]	Worst case analysis – see[ ]
Mixed FDD – TDD (multiple interferers)	[from GJG's simulations]	Simulation results – see GJG input
Mesh to TDD/ FDD	12km (note 2)	Simulation Results - see PW input

Note 2: Less when the system uses automatic interference mitigation procedures

3.3 Subscriber to subscriber, co-channel case

Interference between subscribers in adjacent areas has, in general, a low probability of occurrence. Its level could be low or high, depending on circumstances. If co-channel PMP cells are at or beyond the minimum recommended "safe" distance, subscriber interference has low probability but could be at a higher level than that experienced by a hub (due to the higher gain antenna of the subscriber station). For the mesh to PMP case, the results are similar to PMP to PMP, except that interference is generally lower due to the use of lower gain mesh subscriber antennas.

System Types	Minimum recommended Sub to Sub Spacing without co-ordination [note 1]	Rationale
FDD to FDD	[??]	Simulation results – [??]
TDD to TDD	[??]	Simulation results – [??]
TDD to FDD	[??]	Simulation results – [??]
Mesh to TDD/ FDD	12km or less	Simulation results – [PW input

4. Overlapping Area Case

4.1 Hub to hub interference

System Types	Guard band required	Rationale
Hub to Hub, single interferer	[One guard channel equal to that of the wider of the 2 systems]	Worst case analysis [tba]
Hub to Hub, multiple interferers	[??]	Simulation [??]
Mesh to PMP	Not applicable	No hubs in mesh networks

4.2 Hub to sub interference

The interference experienced depends on the system configuration. In PMP systems, there are certain parts of the cell areas that are strongly affected and others that are not affected at all. In general, the proportion of the cell area(s) affected is small but where interference does occur, it is at a high level. It can be reduced by the use of guard bands and more highly specified subscriber antennas. However, antennas alone do not solve the problem.

[An analysis of this problem is also presented in CEPT input documents]

System Types	Minimum recommended Frequency Spacing	Rationale
FDD to FDD (single interferer)	None or 1 guard channel??	Worst case analysis – see[ ]
TDD to TDD (single interferer)	1 or 2 guard channels	Worst case analysis – see[ ]
Mixed FDD – TDD (single interferer)	1 or 2 guard channels	Worst case analysis – see[ ]
Mesh to TDD/ FDD	Not applicable	There are no hubs in mesh systems

4.3 Subscriber to subscriber, same area case

This problem has to be analysed by use of simulations (Monte Carlo modelling). In general, the probability of interference occurring is low but, when it does occur, the level can be high. Unlike the hub to subscriber case, the high levels of interference are not in predictable parts of the cell(s). Mitigation is by use of guard bands, improved antennas and (in mesh systems) by re-routing so as to avoid the worst pointing directions of antennas.

System Types	Minimum recommended Frequency Spacing	Rationale
FDD to FDD	[one guard channel??]	Simulation results – [??]
TDD to TDD	[one guard channel??]	Simulation results – [??]
TDD to FDD	[one guard channel??]	Simulation results – [??]
Mesh to TDD/ FDD	Zero to one guard channel	Simulation results – [PW input

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