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Abstract	This document contains recommended text for Section 4, General Recommendations, of the Coexistence practice document. It is the initial wording of the topics presented and discussed at Meetings 7 and 7.5
Purpose	Review the draft text and include in Coexistence Practice document if appropriate.
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Draft Text for Section 4 of Coexistence Practice

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4.0 Summary

This document would not be necessary if electromagnetic waves actually respected the same geographic and spectral boundaries which are used by regulators for making assignments to BWA operators. In the real world, regrettably, radio waves permeate through legislated (and even national) boundaries and emissions spill outside spectrum allocations. These two facts conspire to make coexistence issues between multiple operators inevitable.

The authors believe that resolving coexistence issues is a prerequisite for achieving a sustainable BWA industry. Ten specific Recommendations are presented below which we believe will promote coexistence. In reviewing these Recommendations, it should be understood that this document contains no concept of coexistence “protection.” That is because, during the document’s preparation, there emerged no single set of Recommendations that guaranteed coexistence without squandering either spectrum or the opportunity for economical deployments. Moreover, the authors feel that it would not contribute to fostering a BWA industry to suggest rules which might inhibit either innovation or aggression in deployments. In support of this view, this document does not find it appropriate to make recommendations which touch on intra-system matters such as frequency plans, frequency reuse patterns, etc. The consequence of these decisions is that coexistence, then, becomes as much a state of mind as it is a technological activity, relying heavily on the good-faith collaboration between spectrum holders for economical solutions to be implemented.

The document analyzes coexistence using two scenarios:

i) A Co-channel (CoCh) scenario in which two operators are in proximate location (either adjacent territories or territories within radio line of sight of each other) and have the same spectrum allocation, and
ii) An Adjacent Channel (AdjCh) scenario in which the licensed territory of two operators overlaps and they are assigned proximate (in the limit, side-by-side) spectrum.

It must be realized that separating coexistence issues to these two scenarios is just an analytical convenience. In an actual deployment, one should expect coexistence issues to arise simultaneously from both scenarios as well as from multiple operators having the same scenario.

Chapter 8 provides a toolkit of interference mitigation measures which can be marshaled to solve coexistence problems. Because of the wide variation in the geometric distribution of users/base stations, of radio emitter/receiver parameters, of localized rain patterns and the statistics of overlapping emissions in frequency and time, it is impossible to prescribe in this document which mitigation measures are appropriate to resolving a particular coexistence challenge. In the application of these mitigation measures, the authors feel that there should be a bias toward isolating individual terminals or groups of terminals for modification rather than the imposition of pervasive restrictions.

Following are the specific recommendations:

1) Recommendation 1: <u>Adopt a “6 dB below noise in the victim receiver criteria” as being a value of interference from each interfering operator which is “acceptable.”</u> The document institutes this value in recognition of the fact that it is not practical to insist upon and

"interference-free" environment. Having once adopted this value, there are some important consequences:

a) Each operator acknowledges that he is willing to accept a 1 dB degradation in his receiver sensitivity from each other operator. In some regard, the –6 dB value becomes the definition of "coexistence."
b) Depending upon the particular deployment environment, an operator may have a –6 dB contribution form multiple CoCh and AdjCh operators. Each operator should include design margin in his system which is capable of simultaneously accepting the compound effect of interference from all other relevant operators, each at the –6 dB level.
c) The design margin in (b) above should be included preemptively at initial deployment, even if the operator in question is the first to deploy in a region and is not experiencing interference.
d) It should be recognized by all parties that, in predicting signal levels which result in the –6 dB interference value, it is difficult to be precise in including the aggregating effect of multiple terminals, the effect of uncorrelated rain, etc. Therefore, all parties should be prepared to acknowledge claims of interference even if the particular prediction method which was used substantiate the –6 dB value suggests that there should not be any.

2) Recommendation 2: Each operator should take the initiative to collaborate with other known operators prior to initial deployment and at every relevant system modification. This recommendation should be followed even if an operator is the first to actually deploy in a region. To encourage this behavior, the document introduces the concept of using power spectral flux density values to "trigger" different levels of initiatives taken by an operator to give notification to other operators. The specific trigger values and their application to the two deployment scenarios are discussed in Recommendations 5 and 6 below. In some regulatory environments, the fact that the "triggers" were properly analyzed and that the proper cooperative initiative was made can be used as evidence of operating in good faith to promote coexistence.
3) Recommendation 3: Each operator should design and deploy his own system for the maximum amount of frequency reuse. The logic behind this Recommendation is that the same techniques of base station site selection, antenna pattern management and emission control which must be employed to facilitate aggressive frequency reuse within a system will contribute to its coexistence with other systems. Recommendations 7, 8 and 9 below provide recommended minimum antenna patterns, spectral masks and maximum EIRP from the vantage point of coexistence. These do not, however, guarantee coexistence. Even the most dense frequency reuse system does not guarantee coexistence. However, starting from a foundation of a "better" engineered system can facilitate the later resolution of coexistence issues.
4) Recommendation 4: In the resolution of coexistence issues, incumbents/first movers should have the same status as operators who deploy at a later time. The logic behind this Recommendation is that some coexistence problems cannot be resolved simply by modifications to the system of a new entrant into a region. Rather, they require the willingness of an incumbent to make modifications as well. It is recognized that this Recommendation is especially challenging in the AdjCh scenario where the overlapping territories means the incumbent and the late-comer may be competing for the same clients. The reality of some spectrum allocations are such that AdjCh operators will be allocated side-by-side frequency channels. As is seen below, this is an especially difficult coexistence problem to resolve without co-location of the operators. In resolving coexistence issues, it is legitimate to weigh the capital investment an incumbent operator has made in his system. However, for the BWA industry to succeed, the incumbent must be willing to share relevant

parameters about his system and to constructively participate in the application of interference mitigation measures.

5) Recommendation 5: Adopt a power spectral flux density of –114 dBW/MHz/m^2 as the initial "trigger" value for collaborative initiatives. Recommendation 2 above introduced the concept of using power spectral flux density "triggers" as a stimulus for an operator to take certain initiatives to collaborate with his neighbor. The value of –114 dBW/MHz/m^2 is employed in this document in the initiative procedure described in Recommendation 6 below. The value was derived as that power spectral flux density value which, if present at an average base station antenna and average receiver, would result in approximately the –6 dB interference value cited in Recommendation 1. It should be emphasized that the –114 dBW/MHz/m^2 value is useful only as a threshold for taking certain actions with other operators; it does not make an absolute statement as to whether there is, or is not, interference potential.
6) Recommendation 6: Apply the "trigger" of Recommendation 5 prior to deployment and prior to each relevant system modification using the following procedure. In general, an operator should exercise both of the following procedures for the relevant CoCh and AdjCh operators:
   a) For the CoCh scenario:
      Using the analytical parameters of Recommendation 10 below, predict the power spectral flux density at the boundary of one's own territory:
      (1) If the value is less than –114 dBW/MHz/m^2, document the analysis and file it for future reference. Notification of other operators of the intent to deploy (or modify) is optional, and is only warranted in cases where it is believed that the trigger value was not an accurate criteria for assessing the potential of co-channel interference.
      (2) If the value is greater than –114 dBW/MHz/m^2 at any point on one's own boundary:
         (a) For every co-channel operator whose territory abuts one's own territory (in a portion of one's own border where the power spectral flux density is greater than –114 dBW/MHz/m^2), notify that operator of the intent to deploy (or modify.) If possible, notify even license holders who have yet to deploy. Provide to each operator relevant information about the radio parameters of the intended deployment so an assessment can be made by him of the potential for co-channel interference. If notified by him that the potential for interference exists, negotiate in good faith to resolve any coexistence issues using the mitigation techniques of Chapter 8. If resolution cannot be achieved, seek the help of an arbiter or the regulator. In weighing the respective arguments during the negotiations, normally most weight is given to interference which affects already deployed equipment. However, when the power spectral flux density at the border of the victim operator's territory exceeds –94 dBW/MHz/m^2, planned future deployments should be weighed more heavily. In any coexistence issue negotiation, the most weight should be given to making a permanent solution to the issue, whether it be related to current or future deployments.
         (b) For each relevant co-channel operator whose territory does not abut ones own territory, perform the power spectral flux density prediction at the boundary of the other operator. If it is less than –114 dBW/MHz/m^2, proceed as in (1)(a) above. If it is greater than –114 dBW/MHz/m^2, proceed as in (2)(a) above.
   b) For the AdjCh scenario:
      In this case, since the operational territories overlap and the location of subscribers and (possibly) base stations is unknown, an operator should always take the initiative to notify all other relevant AdjCh operators of the intent to deploy (or modify.) When

making that notification, the proposing operator should present to the existing operator a map plot of the contours where the power spectral flux density in the adjacent channel(s) is predicted to be –114 dBW/MHz/m^2. This map plot should include each frequency channel where the power in any 1 MHz segment outside the operators authorized band is predicted to be greater than –114 dBW/MHz/m^2. The existing operator should provide the same information to the new operator. In addition, both operators should be prepared to exchange relevant technical information about their deployments so the potential for interference can be accurately assessed. It is recognized that the resolution of AdjCh coexistence issues will require very careful work if frequency guard bands are not available. In the absence of guard bands, it is recommended that the parties consider co-location of facilities so as to minimize the range differential to subscribers.

7) Recommendation 7: Utilize antennas for the base station and subscriber terminals at least as good as shown in Annex B. The coexistence simulations which led to the Recommendations contained herein revealed that most coexistence problems are the result of main-beam interference. The side lobe levels of the Base Station antennas are of a significant, but secondary influence. The sidelobe levels of the subscriber antenna are of tertiary importance. In the context of coexistence, therefore, relatively unsophisticated antennas, such as those presented in Annex B are sufficient. It should be emphasized that utilizing antennas with sidelobe (and polarization) performance better than the minimum will not degrade the coexistence performance and, in fact, are an effective mitigation technique for specific instances.
8) Recommendation 8: Utilize an emissions mask at least as good as provided in Paragraph 5.1.4. The utility of emissions masks for controlling adjacent channel coexistence issues is strongly dependent upon the separation of the two emitters in space and in frequency. In the case where there is large spatial separation between emitters, the opportunity exists for an interfering emitter to be much closer to a receiver than the desired emitter. This unfavorable range differential can overwhelm even the best emissions mask. Likewise, emissions masks are largely ineffectual in cases where there is no guard band between allocated spectrum but become very useful when there is at least 1 guard channel between allocations. The emissions mask presented in Paragraph 5.1.4 is most appropriate for the case where there is one guard channel between allocations and a modest separation of emitters. For cases where there no guard band is provided, it is recommended that co-location of emitters be considered before trying to improve emissions masks.
9) Recommendation 9: Utilize maximum EIRP and Subscriber Power control in accordance with Paragraph 5.1.1 and 5.1.2, respectively. The interests of coexistence are served by reducing the amount of power emitted by base station and subscriber terminals. The recommended maximum EIRP values contained in Paragraphs 5.1.1 and 5.1.2 are significantly less than allowed by some regulatory agencies but are believed by the authors to be an appropriate balance between constructing robust BWA systems and promoting coexistence.
10) Recommendation 10: In conducting analyses to predict power spectral flux density, incorporate the following parameters:
    a) For the CoCh scenario:
        i) Clear air (no rain) plus relevant atmospheric absorption
        ii) Line of sight propagation to a point on the border which is 50 meters above the prevailing terrain
        iii) Intervening terrain blockage
        iv) The actual electrical parameters (e.g., EIRP, antenna patterns, etc.)
        v) Aggregation as follows:
            (1) All Base Stations

(2) The actual number of subscriber stations which can transmit simultaneously within a sector, each operating without power control and in a worst case (but realistic) location.

b) For the AdjCh scenario: All of (a) above plus the effect of uncorrelated rain.