Project	**IEEE 802.16 Broadband Wireless Access Working Group**	
Title	**Coexistence Same Area C/I Simulation Estimates at 3.5 GHz (CS to CS)**	
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Re:	Coexistence C/I Simulation Estimates in Support of 802.16 TGa Systems Design	
Abstract	This document examines base station to base station interference couplings at 3.5 GHz. These couplings are specific to TDD/TDD and TDD/FDD interference modes of transmission. The document identifies the coordination distance separation between base station locations that may be required between multiple same-area/adjacent frequency system operators. The conclusions are specific to the system model selected. Other system model parameters may modify the distance coordination requirements.	
Purpose	This document is provided to TG2a for consideration and inclusion in the amended Coexistence Practice Document for PMP systems operating below 11 GHz.	
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Coexistence Simulation C/I Estimates at 3.5 GHz (CS to CS)

1.0 Introduction

Previous same area/ adjacent frequency contributions [1], [2] have examined outbound (CS-TS) and inbound (TS-CS) interference couplings. These interference mechanisms apply equally to both FDD and TDD modes of transmission. This contribution examines the CS to CS interference coupling that occurs when one, or both, of the interference/victim links employs a TDD access mode of transmission.

TDD CS to CS interference couplings can be quite significant, as both CS antenna elevations may be *relatively high,* hence increasing the probability of a LOS interference coupling. As well, the assumption that both CS antennas are 90 degree-sectored, very much increases the probability of interference couplings of significance.

However, there are a number of interference techniques that can be employed to reduce the significance of CS to CS interference couplings. These are examined in the following.

2.0 Simulation Channel Model and Transmission Parameters

As with prior studies, outbound CS to TS transmissions are assumed to be 64-QAM and inbound victim link TS to CS transmissions are assumed to be 16-QAM. Both transmission directions are assumed to occupy a 7 MHz channel bandwidth and an excess Nyquist bandwidth of 25 % is assumed. A maximum cell radius of 7 km is also assumed. Antenna RPE patterns are those defined in [3].

Prior link budget studies indicate that most links will require a LOS transmission environment, given representative equipment parameters. Hence, both interference and victim links are assumed to be LOS. Anticipated system and typical equipment parameters are summarized in Table 1.

Propagation Models:	as per section 2
Maximum Cell Radius:	7 km
Channel Bandwidth:	7 MHz
Modulation Excess Bandwidth:	25 %
TS TX Power:	+21 dBm
CS TX Power:	+29.5 dBm
TS Antenna Gain:	+18 dBi
CS Antenna Gain:	+14.5 dBi
CS Antenna XPD:	>= 25 dB
Receiver Noise Figure:	5 dB
TX/RX RF Losses:	3 dB at each end
Link Availability Objective:	99.99% @ BER=10^{-6}
Modulation (Victim Link):	16-QAM
Receiver C/N Threshold:	18 dB
CS/TS Antenna RPE:	as specified in [3]
NFD:	
1'st Adjacent Channel:	27 dB
2'nd Adjacent Channel:	49 dB
3'rd Adjacent Channel:	53 dB

Table 1 Representative System and Equipment Parameters for 16-QAM.

3.0 Interference Mitigation

Prior same area/adjacent frequency studies have examined a number of system configuration variables that, taken either independently or jointly, impact on the expected levels of interference. Excluding distance separation, these are Relative Antenna Gain, NFD, XPD, Guard Band(s) and Relative Interference Link/Victim Link TX Power. This results in an endless number of potential combinations for interference mitigation. So, rather than trying to deal with all of these possible combinations, this contribution will examine CS to CS separation distance requirements based on a parametric estimate of Interference Protection Ratio (IPR). The lowest value of IPR considered is just that of the specified NFD for a 1'st adjacent/same-polarized flanking without a guard band, this being 27 dB. Increased values of IPR correspond to the inclusion of one or more of the mitigation techniques noted above.

4.0 System Models

The system models are described in detail in [1], [2]. The reader is referred to these references for a detailed description. In summary, they consider same-polarized/adjacent frequency operation with or without a guard band(s) as well as cross-polarized flanking.

Both two and four frequency plans are possible, the latter resulting in a factor of two reduction in the likelihood of a serious interference exposure. As well, TDD outbound transmissions are only active for a portion of each transmission frame period, thus reducing the time likelihood of an interference exposure accordingly. Only spatial alignment considerations are examined in the following.

5.0 Simulation Methodology

Figure 1 illustrates the simulation model selected for analysis. Within a victim sector, a victim CS is positioned at some parameterized distance S from the center of the interference cell. The relative position of the victim CS arc defined by S is set to be uniformly random within the 90 degree range of the arc. Within the victim sector, only one cell edge TS to CS victim link needs to be considered as distance proportional ATPC will set all inbound victim link signals to the same signal level.

For any one C/I estimate, the interference impact of each of the four interference cell sectors is computed and added in order to develop one C/I estimate. This estimate includes all of the relative geometry considerations, associated antenna RPE, distance differentials and, parameterized values for IPR.

As the simulation model assumes that there is no operator coordination, the relative boresight alignments of the two CS antennas are unknown. Consequently, the victim CS is spun in one degree increments from 0 to 360 degrees. Each time the victim CS spin is incremented, all of the specified random parameters are assigned a new random seed. Thus, a complete composite simulation run, for a specified CS separation distance S, consists of 360 interference estimates.

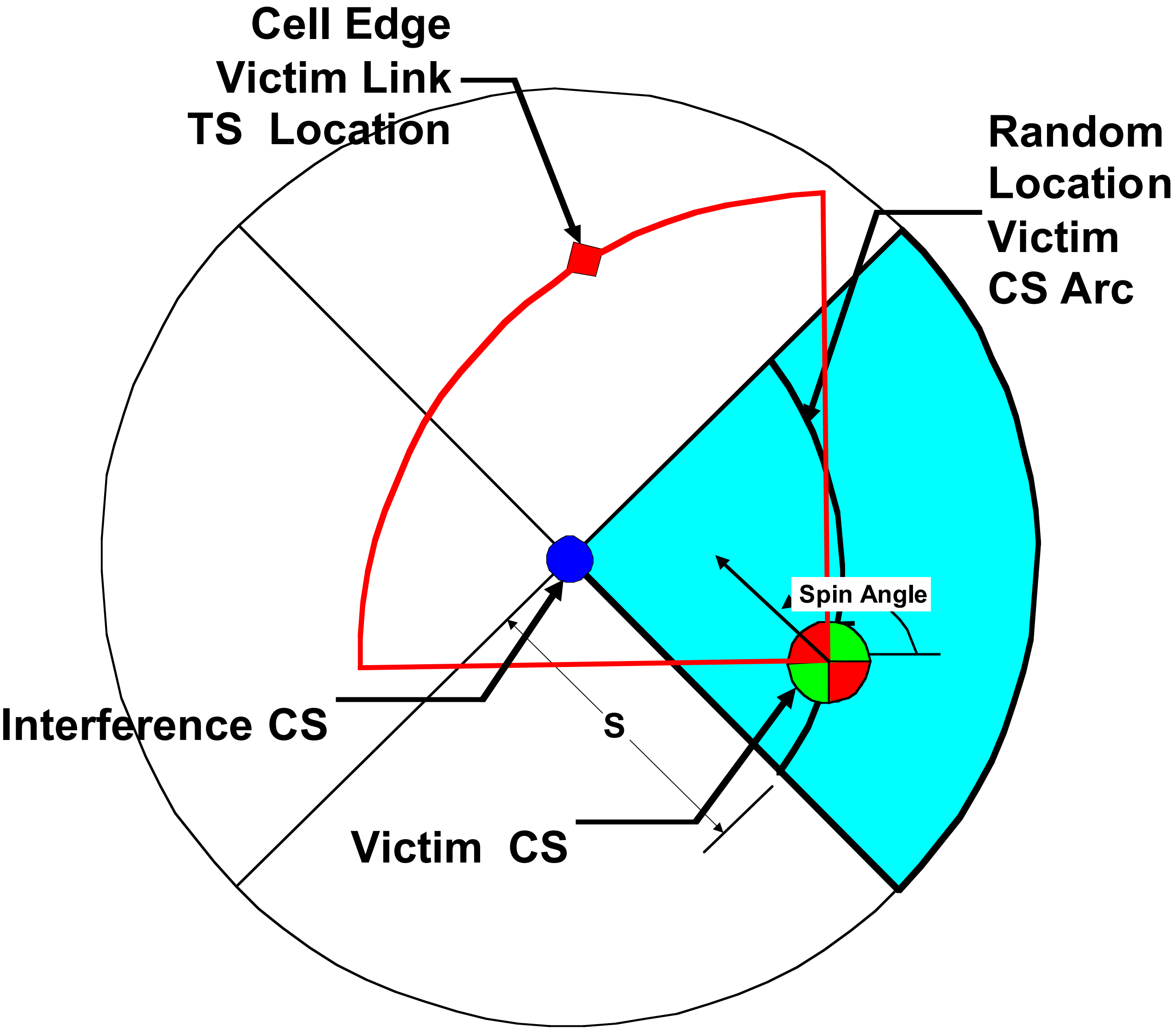

Figure 1. Simulation Model

6.0 Simulation Results and Discussion

Figures 1 and 2 illustrate the CDF vs C/I simulation estimates when the IPR is set equal to the NFD of a 1'st adjacent same polarized carrier. In this case, IPR = 27 dB. Figure 1 examines CS separation distances S from 0.1 to 2 km while Figure 2 examines separation distances from 3 to 6 km. It is quite apparent that successful operation under this scenario is unlikely unless the relative alignment of the two CS antennas can be coordinated a-priori to provide significant antenna discrimination.

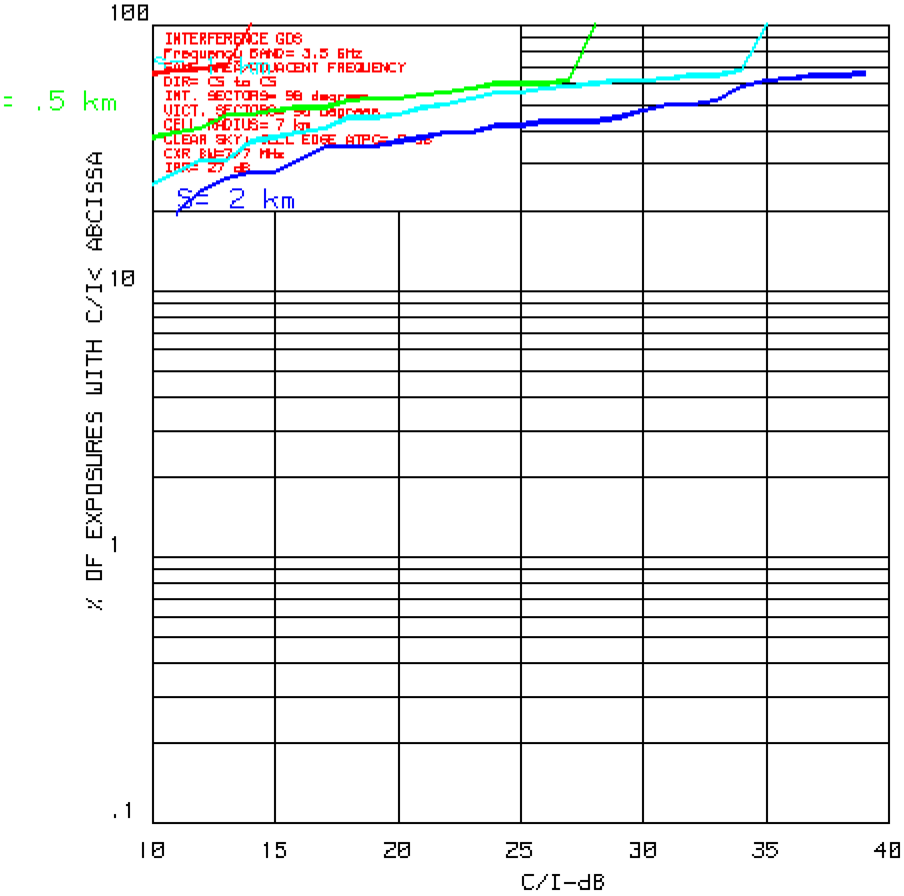

Figure 1 CDF for IPR = 27 dB (S < 2 km)

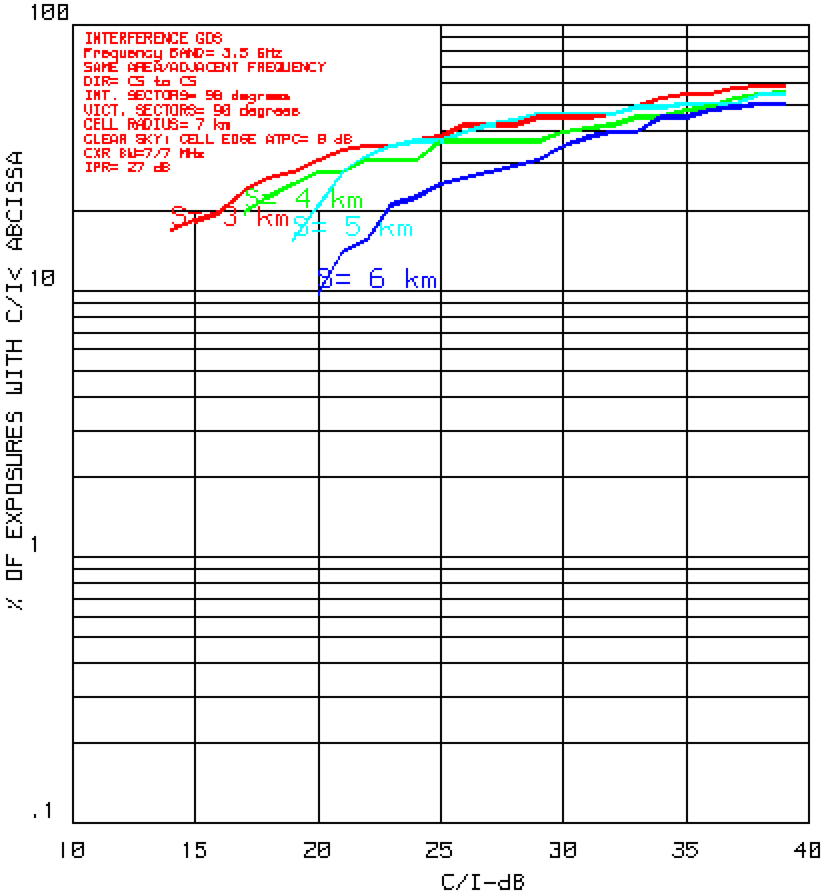

Figure 2 CDF for IPR = 27 dB (S > 3 km)

Figures 3 through 6 illustrate the CDF results when the IPR is parametrically varied from 35 to 65 dB. These, of course, involve the mitigation considerations discussed in Section 3. As the shorter separation distances from 0.1 to 2 km represent the most severe values for S, only these are illustrated.

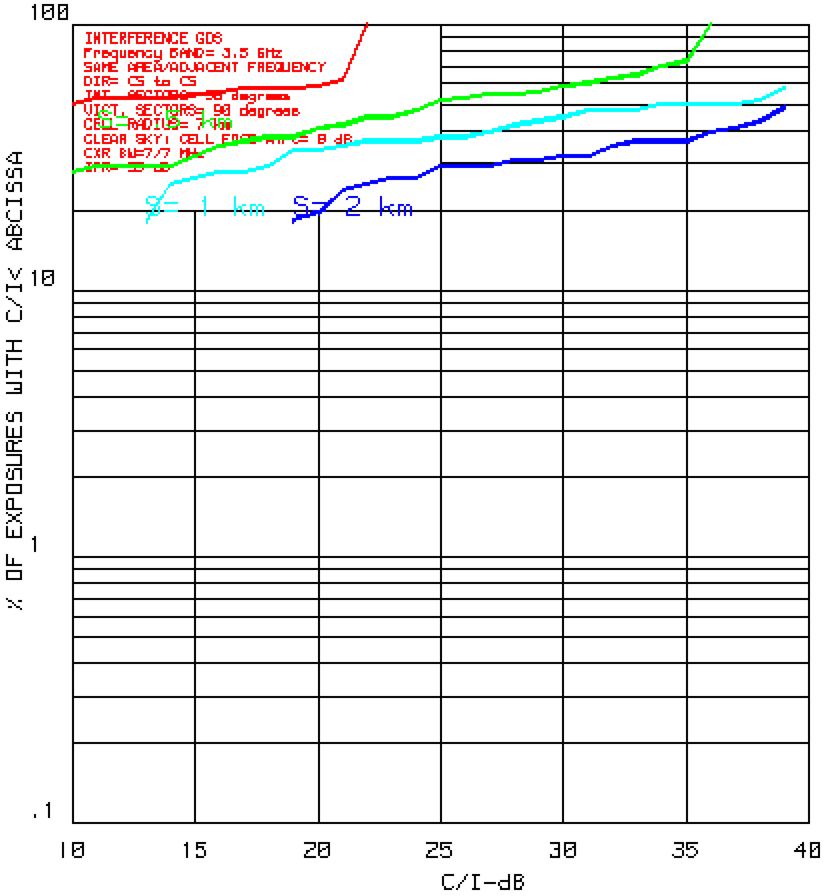

Figure 3 CDF for IPR = 35 dB (S < 2 km)

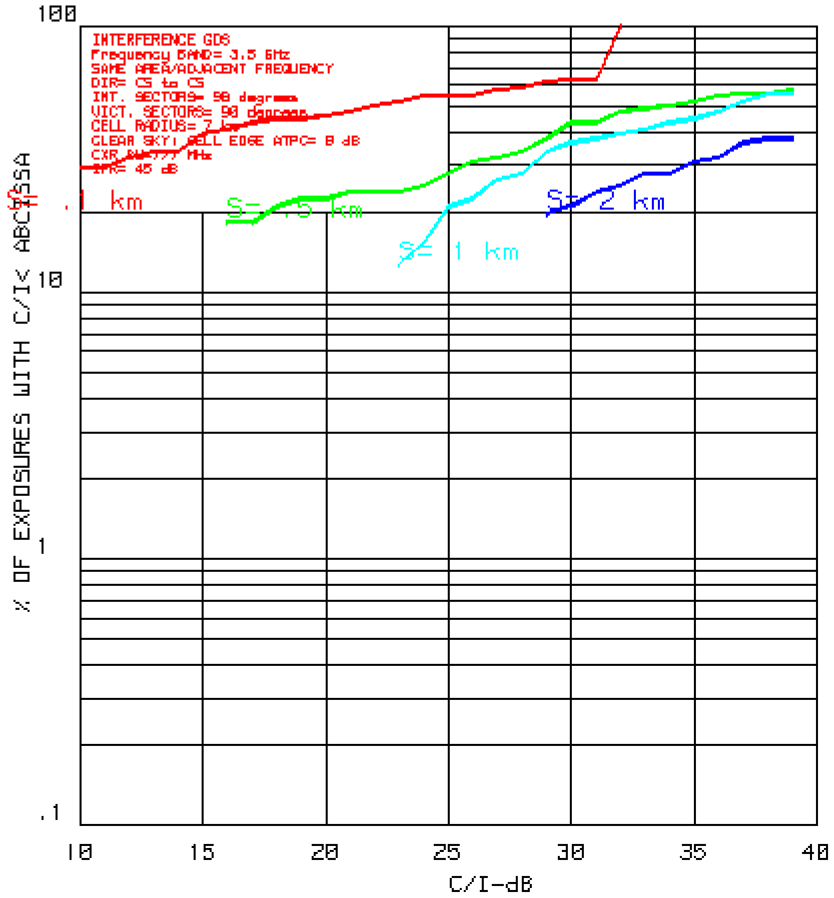

Figure 4 CDF for IPR = 45 dB (S < 2 km)

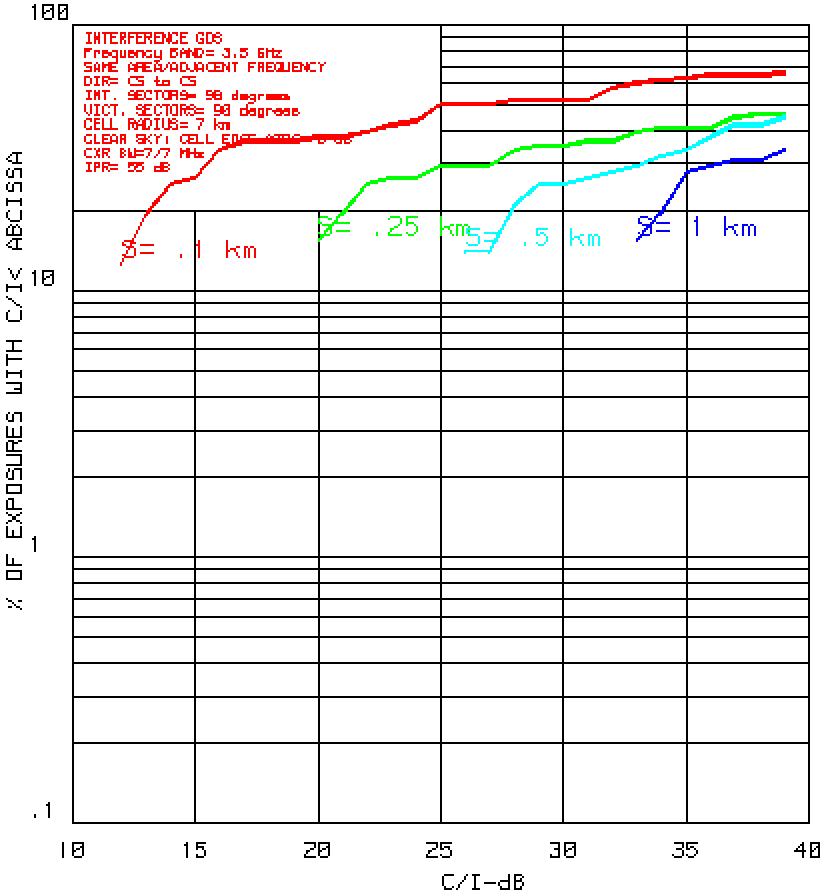

Figure 5 CDF for IPR = 55 dB (S < 1 km)

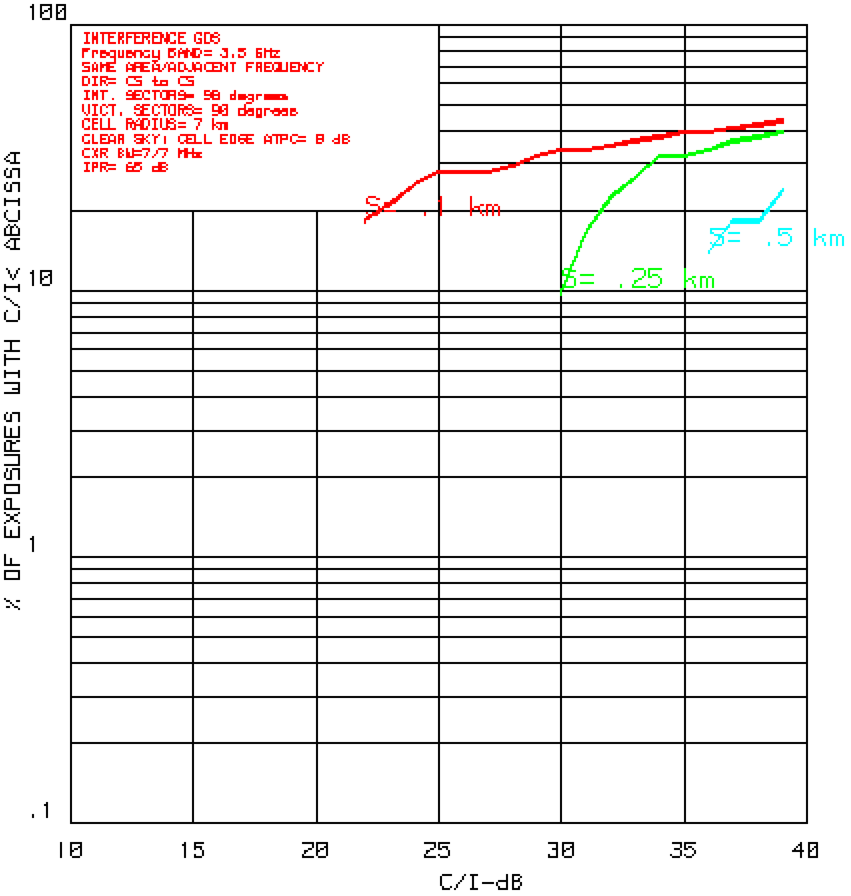

Figure 6. CDF for IPR = 65 dB (S < 0.5 km)

For 16-QAM inbound transmissions, performance threshold has been previously assumed to be a C/N = 18 dB. Correspondingly, a C/I = 24 dB represents a 1 dB hit on threshold performance. At an IPR of 45 dB, these objectives begin to be met at a separation distance of S = 1 km (see Figure 4).

As IPR increases, the requirements for separation distance S continues to reduce. At an IPR of 55 dB (Figure 5), there are no interference couplings that would exceed performance threshold for S = 0.25 km and there are no interference couplings for S = 0.5 km that are in excess of a 1 dB threshold impairment. If an IPR of 65 dB is achievable (Figure 6), then there are no interference couplings of significance for a separation distance that is greater than 0.25 km. While there remains a high % of couplings for S = 0.1km that are at, or exceed, a 1 dB threshold impairment, there are no C/I exposures that are worse than 22 dB.

At an IPR of 65 dB, we have pretty well exhausted the potential of mitigation techniques to reduce C/I. However, there are other performance enhancement techniques that could reduce the value for necessary C/N threshold. These have not been considered in this report.

7.0 References

[1] Coexistence Same Area Simulations at 3.5 GHz (Outbound) (IEEE C802.16.2a-02/07)

[2] Coexistence Same Area Simulations at 3.5 GHz (Inbound) (IEEE C802.16.2a-02/08)

[3] Coexistence Co-Channel Boundary pfd Simulations at 3.5 GHz (Inbound), Rev. 1 (IEEE C802.16.2a-02/02r1)