Project	**IEEE 802.16 Broadband Wireless Access Working Group**
Title	**Coexistence Same Area Simulations at 3.5 GHz (Inbound)**
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Re:	Coexistence C/I Simulation Estimates in Support of 802.16a System Design
Abstract	This document examines inbound C/I estimate at 3.5 GHz. It identifies the distance separation between CS locations for which coordination may be required between system operators. The impact of a guard band between multiple operator frequency assignments is also considered. The conclusions are specific to the system model selected. Other system model parameters may modify the distance coordination requirements.
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Coexistence Same Area C/I Simulation

Estimates at 3.5 GHz (Inbound)

1.0 Introduction

A companion contribution [1] examined coexistence C/I estimates for outbound transmission and victim TS receivers. This contribution examines the inbound reverse direction of transmission whereby victim links are from TS to CS. The reader is encouraged to first read [1] as it details the system model assumptions, many of which will not be repeated herein.

As in [1], C/I estimates are developed as a function of distance separation between interference and victim CS locations. Using Monte Carlo simulation techniques, C/I estimates are developed for operators who deploy on adjacent frequency - same polarization or opposite polarization carriers. C/I performance with a frequency guard band is also considered.

2.0 Simulation Channel Model

In [1], it was concluded that the outbound link could support 64-QAM modulation for a 7 km LOS transmission path. However, for the inbound link, the transmitter HPA power is likely to be significantly lower. Link budget estimates for this direction would likely be limited to 16-QAM and thus this is employed in the following. Based on assumed representative equipment parameters, unfaded C/N is approximately 29 dB. To a 16-QAM performance limit C/N of 18 dB, this results in a very modest fade margin of 11 dB.

3.0 Simulation Transmission Parameters

Anticipated system parameters and *typical* equipment parameters are summarized as follows 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:	16 QAM
Receiver C/N Threshold:	18 dB
CS/TS Antenna RPE:	as specified in [2]
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.

4.0 System Models

System models that describe multiple-operator flanking frequency/polarization assignments are detailed in [1]. These are summarized here as follows:

Figure 1 illustrates an aggressive frequency re-use plan where sector assignments are employed twice within a cell. As illustrated, the flanking carriers are set to the same polarization. The guard band C may or may not exist.

Figure 2 illustrates the same re-use plan but with a reversal of polarization assignments between the flanking carriers. Again, the guard channel may or may not exist.

Figure 3 illustrates a less aggressive re-use plan where frequency/polarization assignments are employed only once within a cell. In an uncoordinated operator deployment, this would be expected to reduce the probability of interference exposure by perhaps a factor of two.

All of these system models are considered in the following.

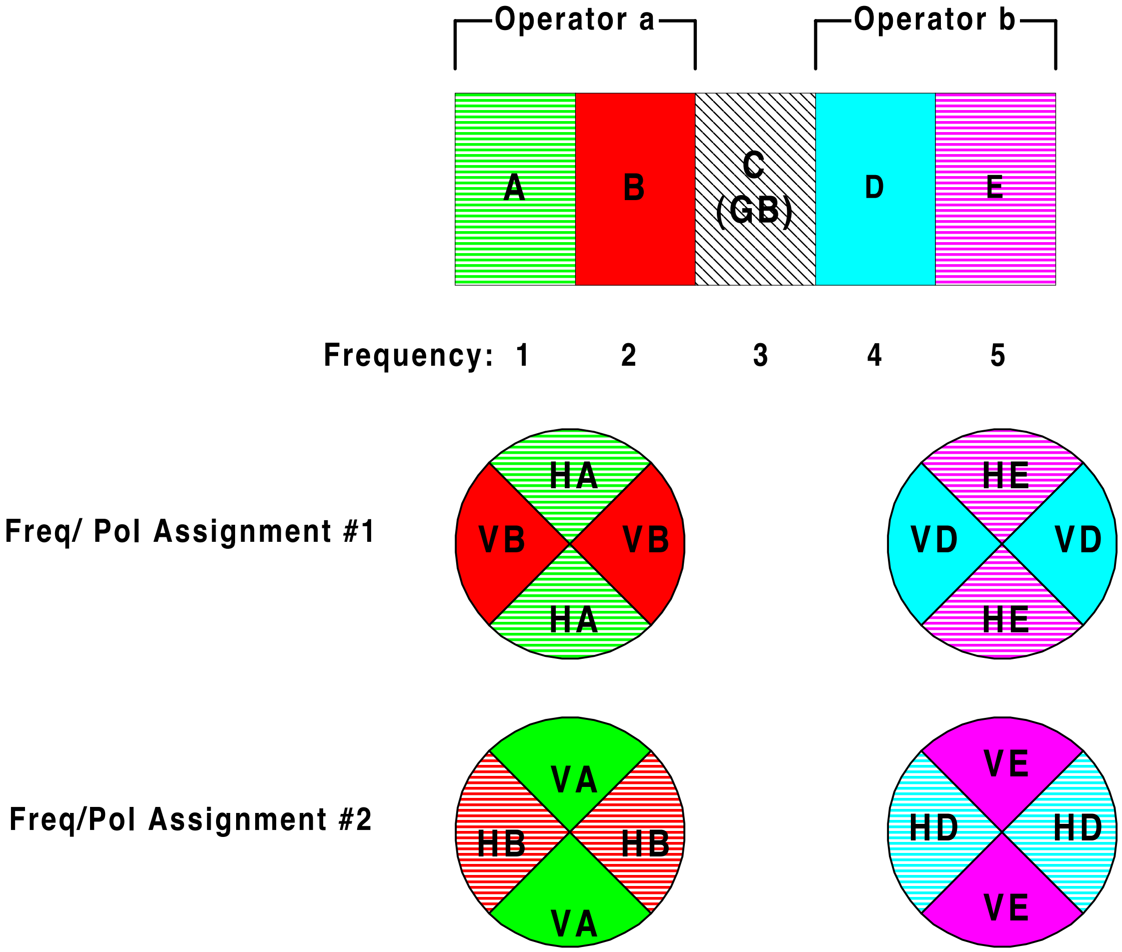

Figure 1. Two Frequency-Two Polarization Frequency Re-Use Plan

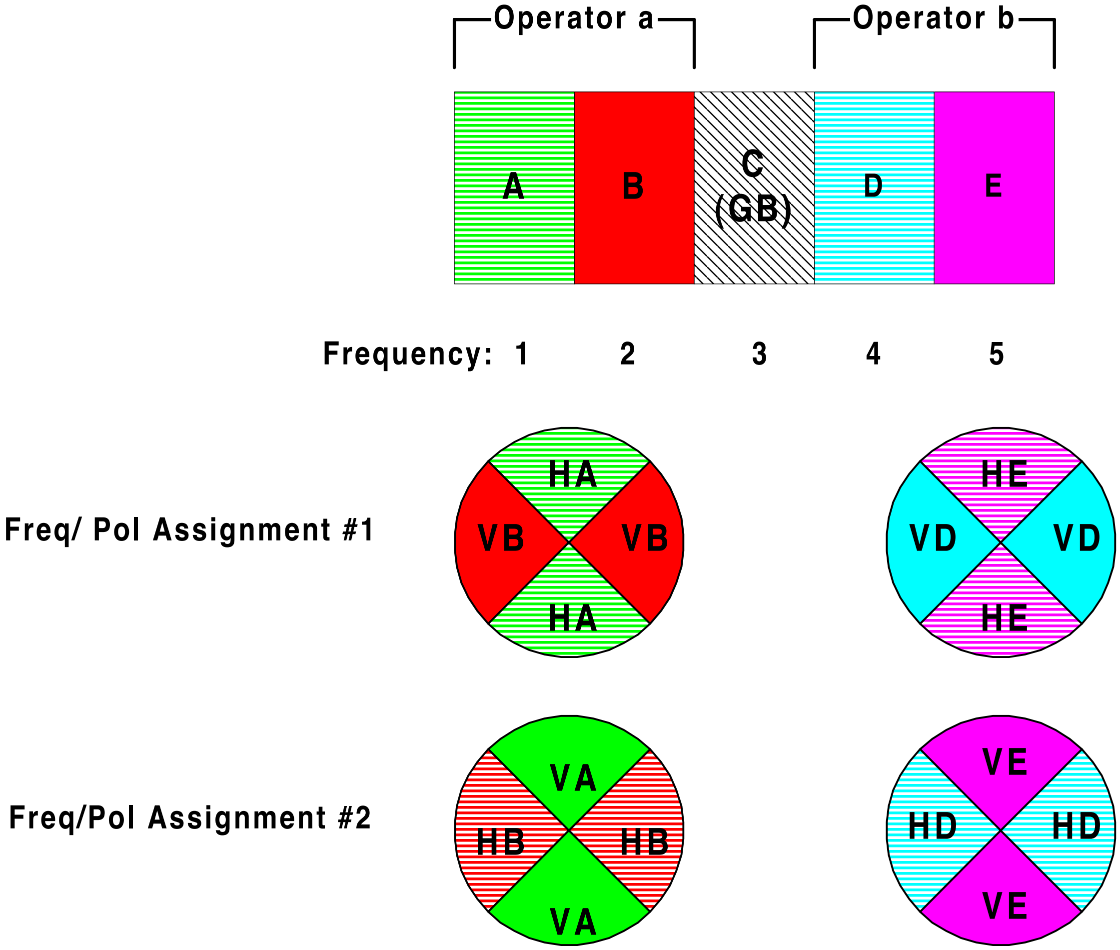

Figure 2. Two Frequency-Two Polarization Re-Use Plan with Polarization Reversal

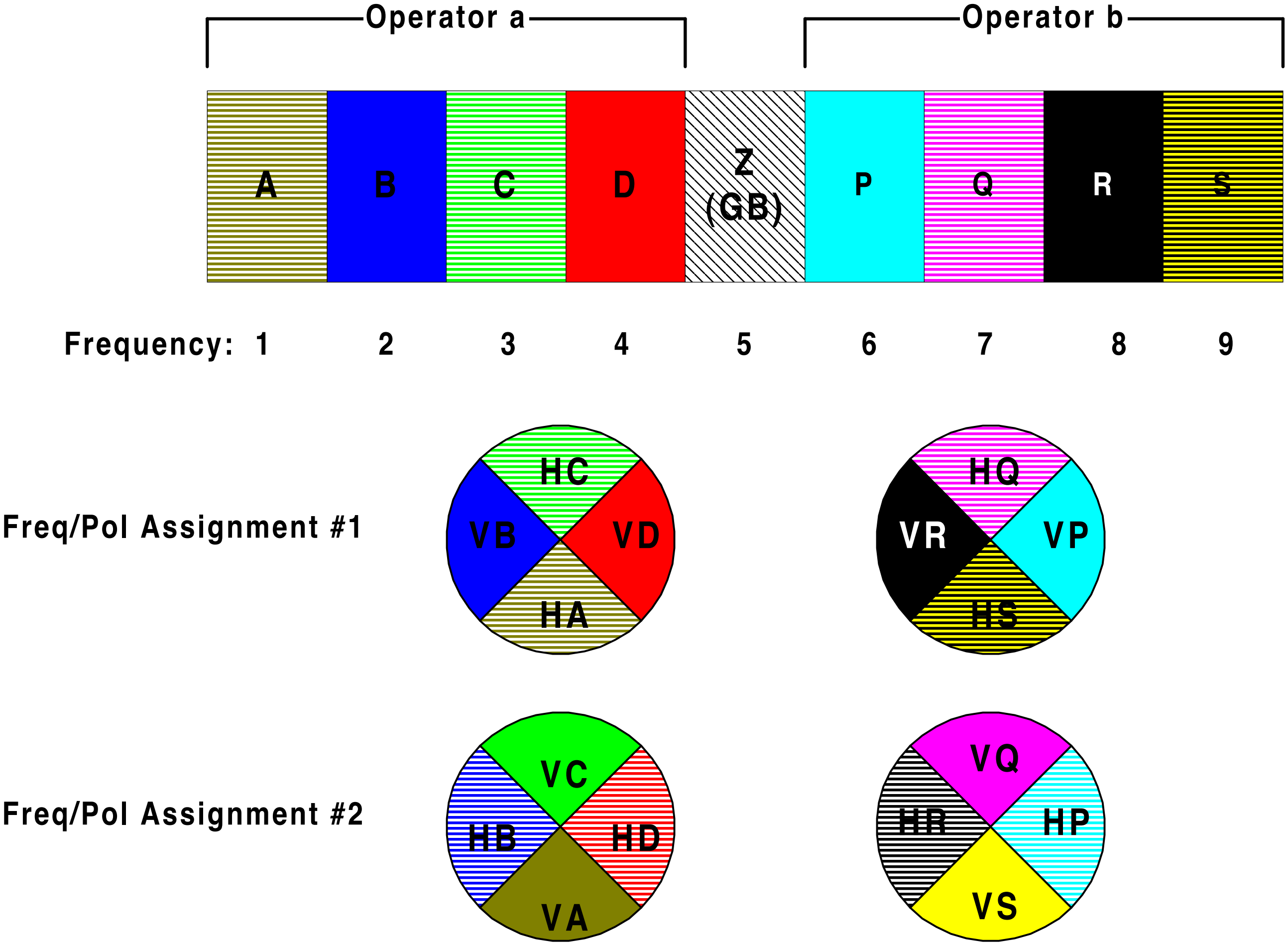

Figure 3. Four frequency-Two Polarization Frequency Re-Use Plan

5.0 Simulation Methodology

Figure 4 illustrates the simulation model for inbound interference. It differs from the outbound case [1], in that it is now computationally convenient to consider the overlaid sector/cell as being the victim. This is parameterized at some separation distance S between the two CS sites. Within the victim sector, all TS locations are assumed to employ distance proportional ATPC. Therefore, received signal levels from all of these locations would be expected to arrive at the victim CS at approximately the same level of signal strength. Thus, it is only necessary to set victim TS to CS signal level based on a single cell-edge victim link. Due to the modest link margin, no cell edge ATPC is assumed.

Twenty interference TS locations are assigned to be randomly located based on an area proportional basis. The transmit power of each of these is ATPC adjusted and set based on their relative distance from the interference CS.

To account for the assumption that there is no operator coordination, the relative boresight alignments of the two CS antennas are considered to be unknown. Hence, the victim CS boresight alignment is spun in 5 degree increments. A complete simulation run thus consists of 20(360/5) = 1440 interference estimates.

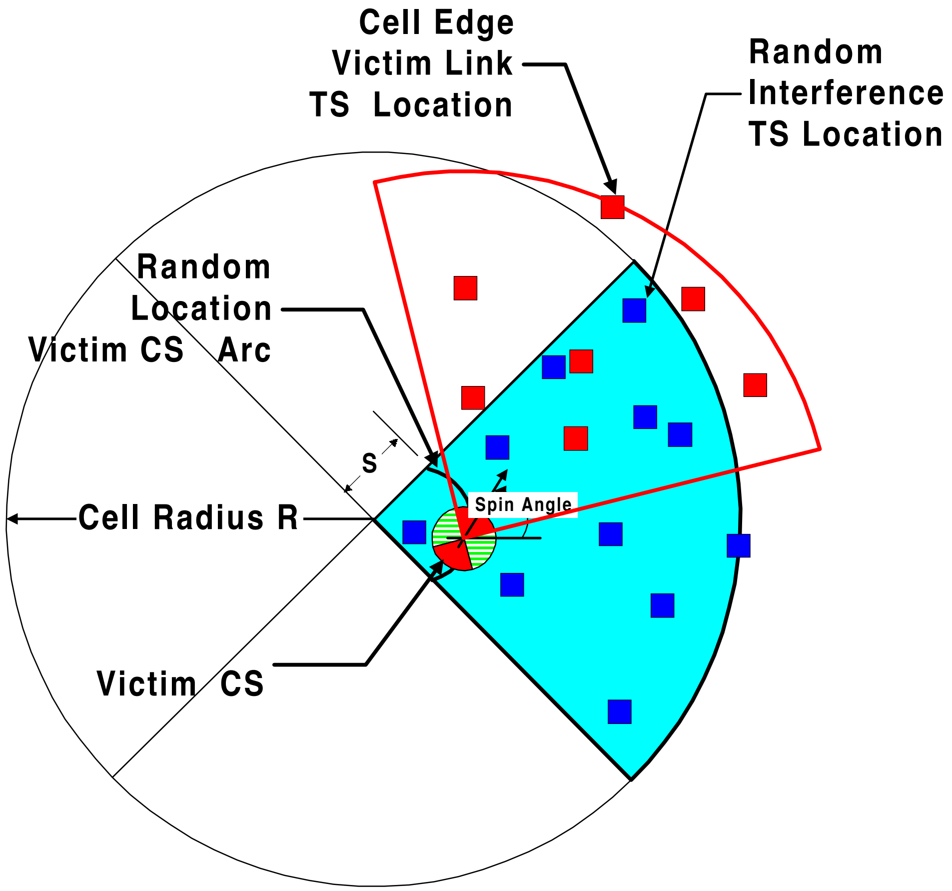

Figure 4. Simulation Model

6.0 Simulation Results

Referenced to the system model of Figure 1, a simulation for a CS separation distance between 0.1 and 2 km is illustrated in Figure 5. Here, NFD is only 27 dB and there is no XPD advantage. Figure 6 illustrates comparable results for S between 3 and 6 km.

6.1 Zero Guard Band - Same Polarization

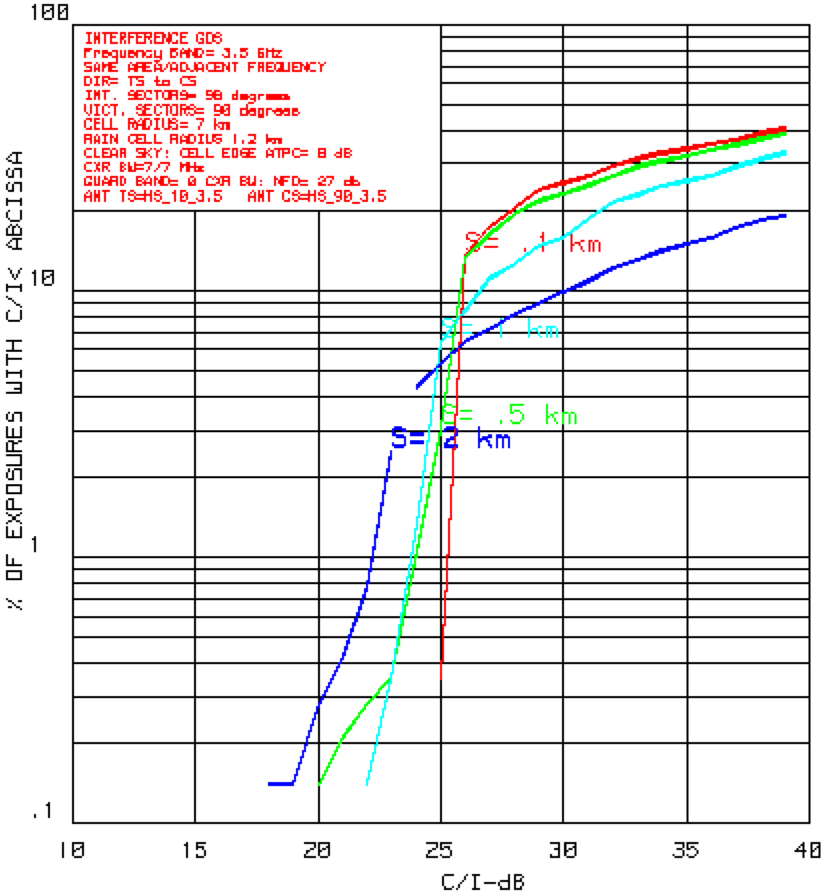

Figure 5. CDF for Zero Guard Band and Same Polarization (S < 2 km).

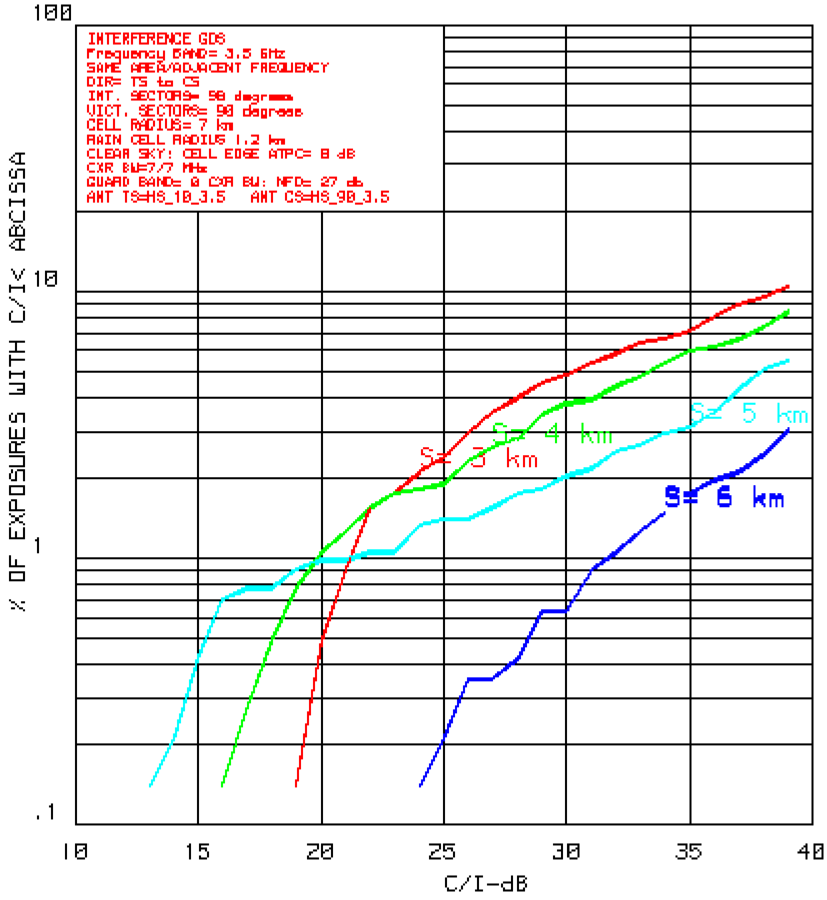

Figure 6. CDF for Zero Guard Band and Same Polarization (S > 3 km).

For the simulations of Figure 5 and Figure 6, only one interference sector has been considered, with the 20 interference random TS locations positioned in accordance with Figure 4. Hence, a totally accurate system model for the simulations is the four frequency re-use plan given by Figure 3. As a result of distance proportional ATPC, both outbound and inbound CDF vs C/I estimates should be the same. One may compare Figure 5 with Figure 9 of [1] to confirm that this is true. Any differences are in the detail and are the result of different random seed assignments.

However, in the outbound two-frequency re-use case, rotational symmetry exists between the victim sector and two interference sectors. Thus, outbound, the CDF probabilities for the two frequency plan were expected to be twice that of the four frequency plan. As described in [1], this assumption was confirmed. But for the inbound case, this symmetry does not apply and we do not expect there to be a factor of two difference between the two re-use plans.

Figure 7 illustrates the geometrical relationships for the inbound case. A simple boresight alignment of interference and victim sectors is illustrated. Figure 7-a illustrates the case when the victim CS is within the interference sector at some separation distance S from the interference CS. Some one interference TS is shown at a distance D_i from it's serving CS. The interference TS experiences distance proportional ATPC in accordance with the ratio $(D_i/R)^2$. The relative difference in FSL between the interference and victim links is given by the ratio of $[(D_i\text{-}S)/R]^2$. All other parameters assumed being equal, NFD and the previous two parameters set the value for C/I).

Figure 7-b illustrates the case where the victim CS is now in alignment with the opposite interference sector. Assuming an equivalent interference TS distance D_I, the ATPC level adjustment remains the same. However, relative FSL now involves D_i+S rather than D_i-S. The impact of the FSL level differential is thus reduced and C/I improves accordingly.

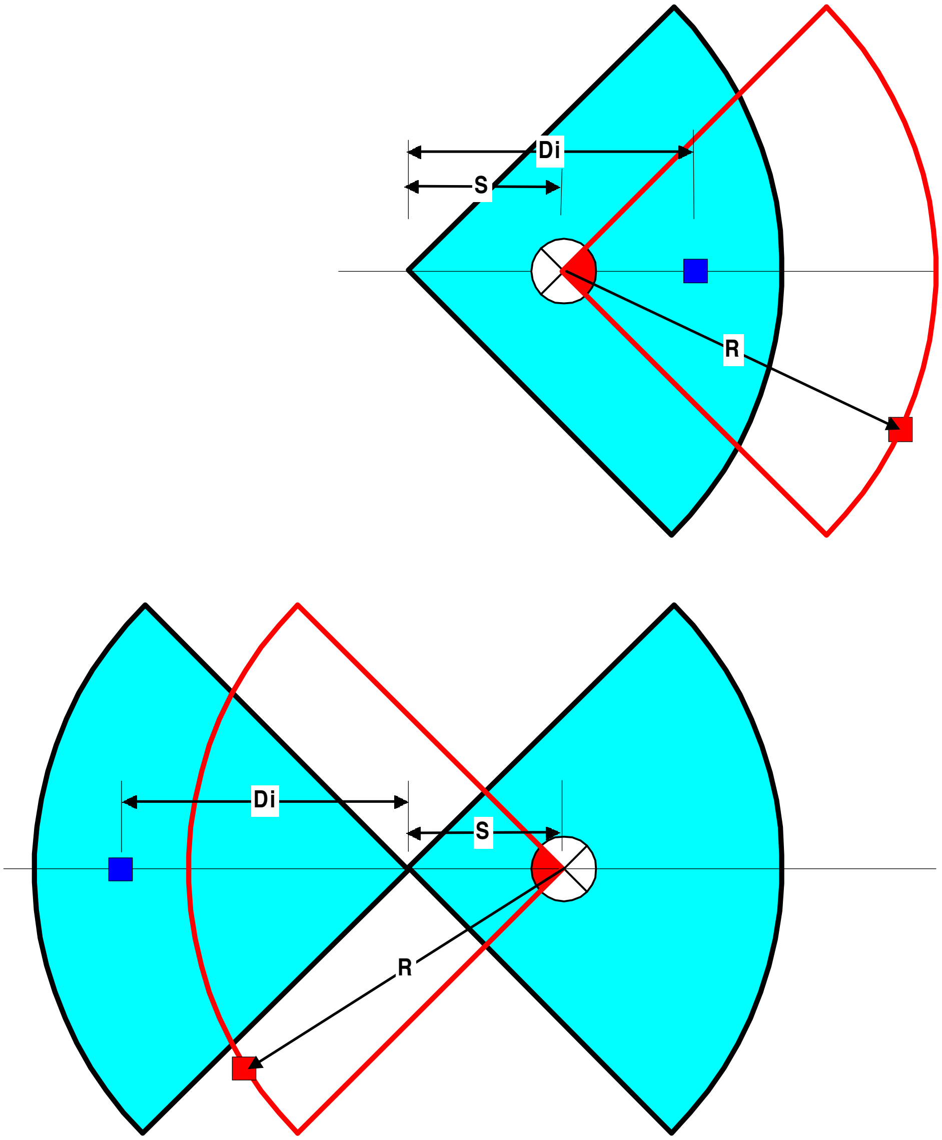

Figure 7 Inbound Rotational Asymmetry for a Two Frequency Re-Use Plan.

Figure 8 illustrates the C/I difference between same and opposite sector alignments for a range of interference TS distance D_i. Two CS separation distances S are shown, these being S= .5 and S= 3 km. It is apparent that the contribution of the opposite sector would not result in a doubling of the CDF probabilities between the two re-use plans under consideration. Composite simulations that assign interference TS locations to the opposite sector have not been attempted, however it is concluded that the results would be somewhat better than those given by Figures 5 and Figure 6 of [1].

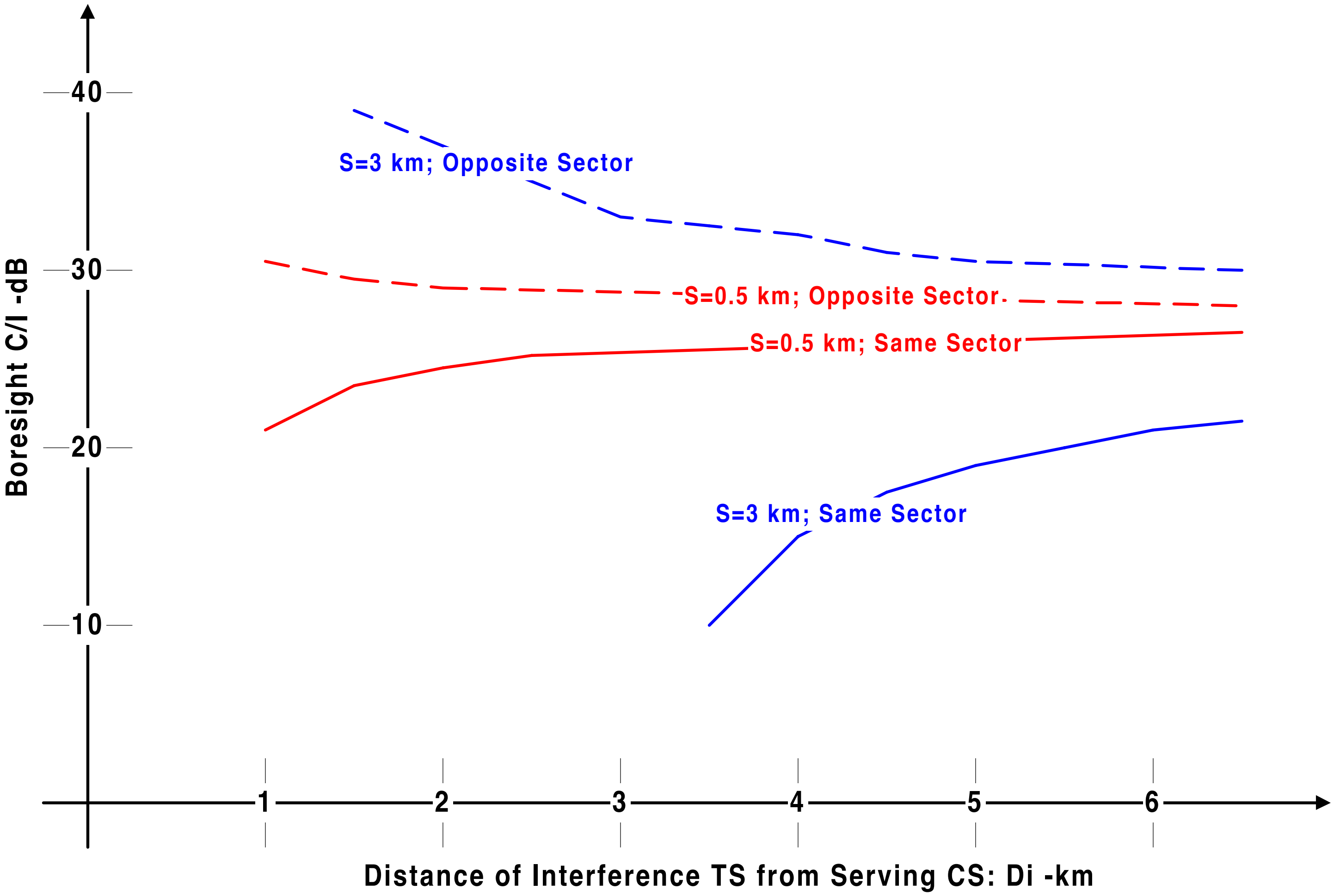

Figure 8. C/I Comparison for Same and Opposite Interference Sectors

6.2 Zero Guard Band - Opposite Polarization

Figures 9 and 10 are included "just for the record". They assume a very modest XPD allowance of 10 dB between flanking carriers. They correspond to the same range of CS separation distances under discussion. As expected, they simply move the C/I values 10 dB to the right.

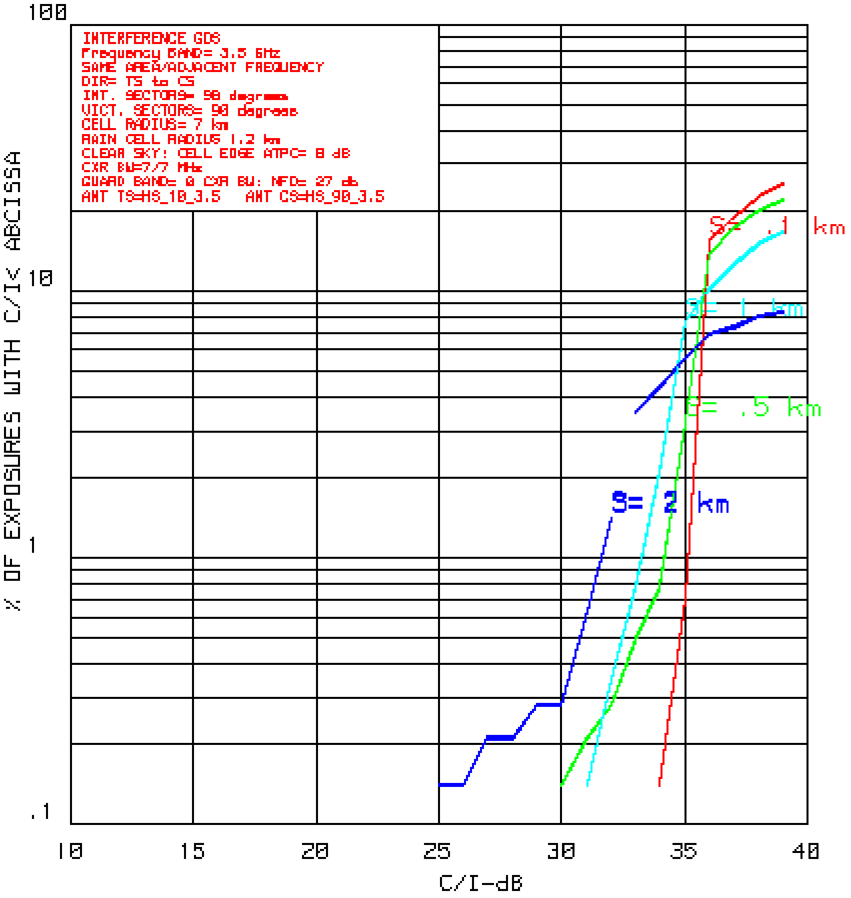

Figure 9. CDF for Zero Guard Band and Opposite Polarization (S < 2 km; XPD = 10 dB)

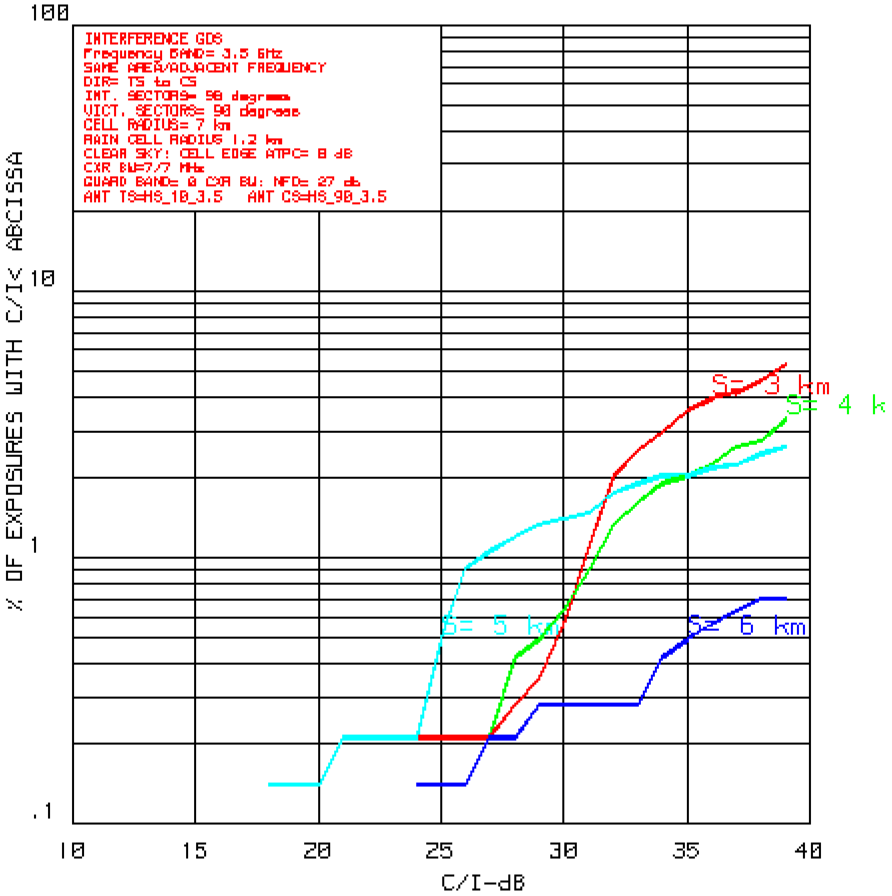

Figure 10. CDF for Zero Guard Band and Opposite Polarization (S > 2 km; XPD = 10 dB)

7.0 Summary and Discussion

The preceding simulations indicate that, with distance proportional ATPC, C/I impairments are essentially the same in both inbound and outbound transmission directions. Again, we conclude that 64-QAM operation would be questionable unless cross-polarized flanking or a guard band is employed. For the link budget parameters assumed, the maximum inbound modulation index has been concluded to be that of 16-QAM. This, of course, could change, with a different set of link budget assumptions.

From Figures 5 and 6, one could argue that 16-QAM performance is marginal at a 1 dB threshold impairment of 24 dB. However, actual threshold failure at 18 dB is quite respectable and is less than one percent. Of course all these problems go away if it is possible to deploy with a polarization change. Simulations with a guard band were not presented. The significant increase in NFD simply moves the coexistence problem off the graph.

8.0 References

[1] Coexistence Same Area Simulations at 3.5 GHz (Outbound).

[2] Coexistence Co-Channel Boundary pfd Simulations at 3.5 GHz (Inbound). Revision 1