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| Project | **IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>** |
| Title | **An Addendum to: "A Simplified Method for the Estimation of Rain Attenuation at 10.5 GHz"** |
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| Re: | Coexistence C/I Simulations in Support of 802.16a System Design |
| Abstract | This document extends a simplified method for the estimation of rain attenuation at 10.5 GHz to address both the CS to CS and TS to CS interference cases. An estimation of the rain loss differential between interference and victim links is necessary for same area-adjacent frequency coexistence studies. This procedure will be employed in subsequent 10.5 GHz coexistence studies. |
| Purpose | This document is provided to TG2a for consideration and inclusion in the amended Coexistence Practice Document for PMP systems operating below 11 GHz. |
| Notice |  |
| Release |  |
| Patent Policy and Procedures |  |

# An Addendum to: "A Simplified Method for the Estimation of Rain Attenuation at 10.5 GHz"

## 1.0 Introduction

In [1], a simplified rain computational procedure was described. However, it was only directly applicable to the outbound CS to TS interference case. This addendum expands on the procedure to deal with both CS to CS and TS to CS interference cases. All parameters remain as identified in [1].

## 2.0 Rain Attenuation Models

### 2.1 CS to CS Interference

Figure 1 illustrates the model. It is convenient to set the reference sector as victim and the overlay sector as interference. As before, there are 20 randomly located victim subscribers within the link, each at some distance $R_0$ and angle $\gamma$ . Also, as before, a rain cell of diameter $D_c$ is randomly positioned in the cell at distance $D_{rc}$ and angle $\beta$ . The rain cell is bounded by the distances $D_{min}$ to $D_{max}$ and by inclusion angles between $\varphi_{min}$ and $\varphi_{max}$ . Again, within the bounded area, it is assumed that the rain attenuation across $D_c$ equates to the required availability fade margin FM.

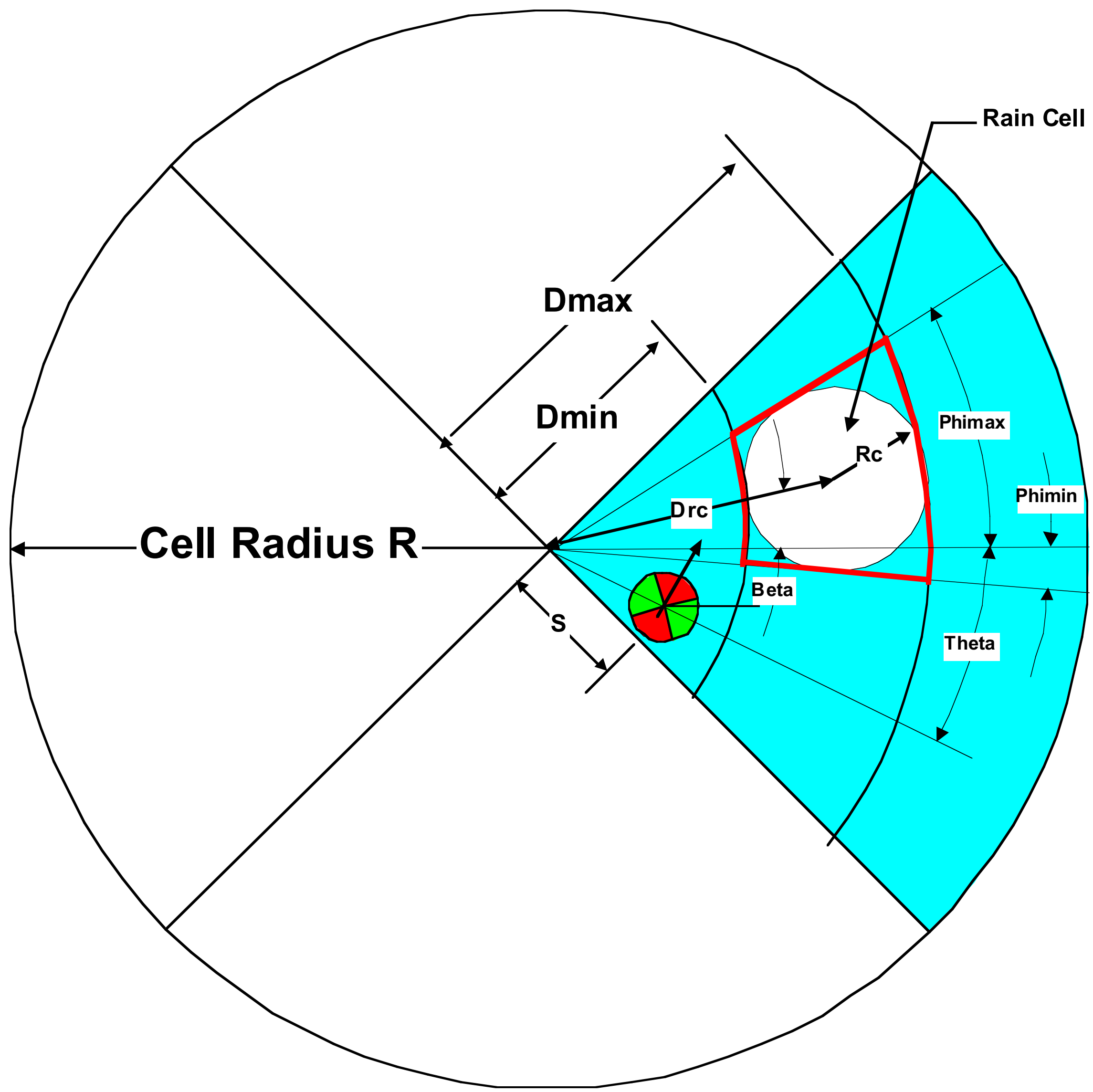



Figure 1. CS to CS Rain Simulation Model

For any one of the victim TS to CS links, the rain attenuation $R_{lv}$ remains as in [1]. It is repeated here as follows:

1. If $\gamma$ falls outside the angles bounded by $\varphi_{min}$ to $\varphi_{max}$, then $R_{lv} = 0$.

2. For $\gamma$ falling within the bounded angles, then

   - if $R_0 < D_{min}$ then $R_{lv} = 0$.
   - if $R_0 > D_{max}$ then $R_{lv} = FM$.
   - if $R_0$ is bounded between $D_{min}$ and $D_{max}$ then $R_{lv} = (R_0 - D_{min}) / D_c \leftrightarrow FM$

Now, the interference CS has been positioned at some parameterized distance S and at some random angle $\vartheta$ along the arc defined by S. So, with just a simple change of parameters, we can treat it's rain attenuation $R_{li}$ in a manner identical to the above. It is thus:

3. If $\theta$ falls outside the angles bounded by $\varphi_{min}$ to $\varphi_{max}$, then $R_{li} = 0$.

4. For $\theta$ falling within the bounded angles, then

   - if $S < D_{min}$ then $R_{li} = 0$.
   - if $S > D_{max}$ then $R_{li} = FM$.
   - if S is bounded between $D_{min}$ and $D_{max}$ then $R_{li} = (S - D_{min}) / D_c \leftrightarrow FM$

## 2.1 TS to CS Interference

When we examine the inbound interference TS to CS case, life becomes a bit more complicated. The simulation model is illustrated by Figure 2. Again, it is convenient to consider the primary cell as victim and the overlay cell as interference. Rain attenuation experienced on victim links (not illustrated), remains as previously described, except that we must now account for distance proportional ATPC, and adjustments to it, during rain fading.

As described in prior documents, it has been concluded that inbound links at 10.5 GHz would likely be 4-QAM. Using typical equipment parameters, this yields a fade margin of 16 dB. Quite by accident, this is the margin required in ITU-R rain region P for 99.99% availability. Due to the modest fade margin, it is assumed that cell edge TS would operate at full power without ATPC and achieve an RX signal power of $P_{cs}$. Under clear sky conditions, a TS at a lesser distance would employ distance proportional ATPC. Under rain fading conditions, a victim link may experience a rain loss $R_{lv}$. To adjust for this, the computational procedure increases the victim link TX power until it reestablishes a receive power of $P_{cs}$. If this is not obtainable, then TX power is set to the maximum level.

The interference CS has been positioned in the victim sector at distance S and random angle $\vartheta$ as illustrated on Figure 2. The relative boresight angle is at some spin angle $\alpha$ .We really do not care what rain loss an interference TS experiences into it's own CS, we are only concerned with the signal power that is directed towards the victim CS. So, for computational simplicity, all interference TS's are assumed to be at cell edge and operating at full power. The geometry for an example interference TS is illustrated on Figure 3. As all of the distance and angle relationships are "known", we can readily compute the interference distance $R_i$ and the reference angle $\vartheta_i$ . The distance and inclusion angles remain as before and hence we can compute the rain attenuation into the victim CS from an interference link.

Again, it is assumed that there are 20 interference TS's. As the access mode for both inbound links is assumed to be TDMA, an individual C/I calculation only needs to consider the relative signal relationships between one randomly located victim TS and one randomly located interference link, both assumed to be "talking" at the same time. For each spin angle $\alpha$ , this procedure is repeated 20 times.

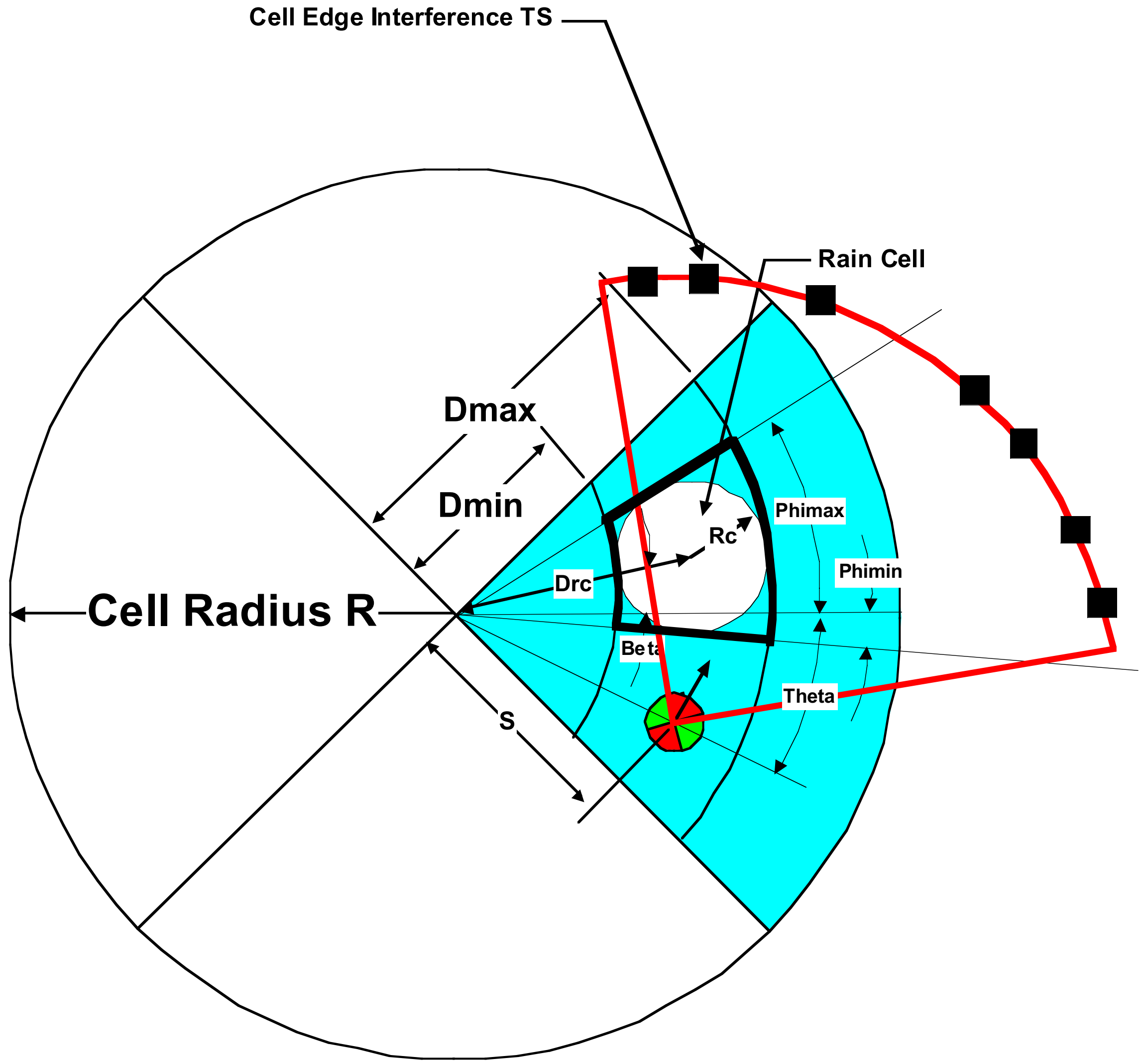
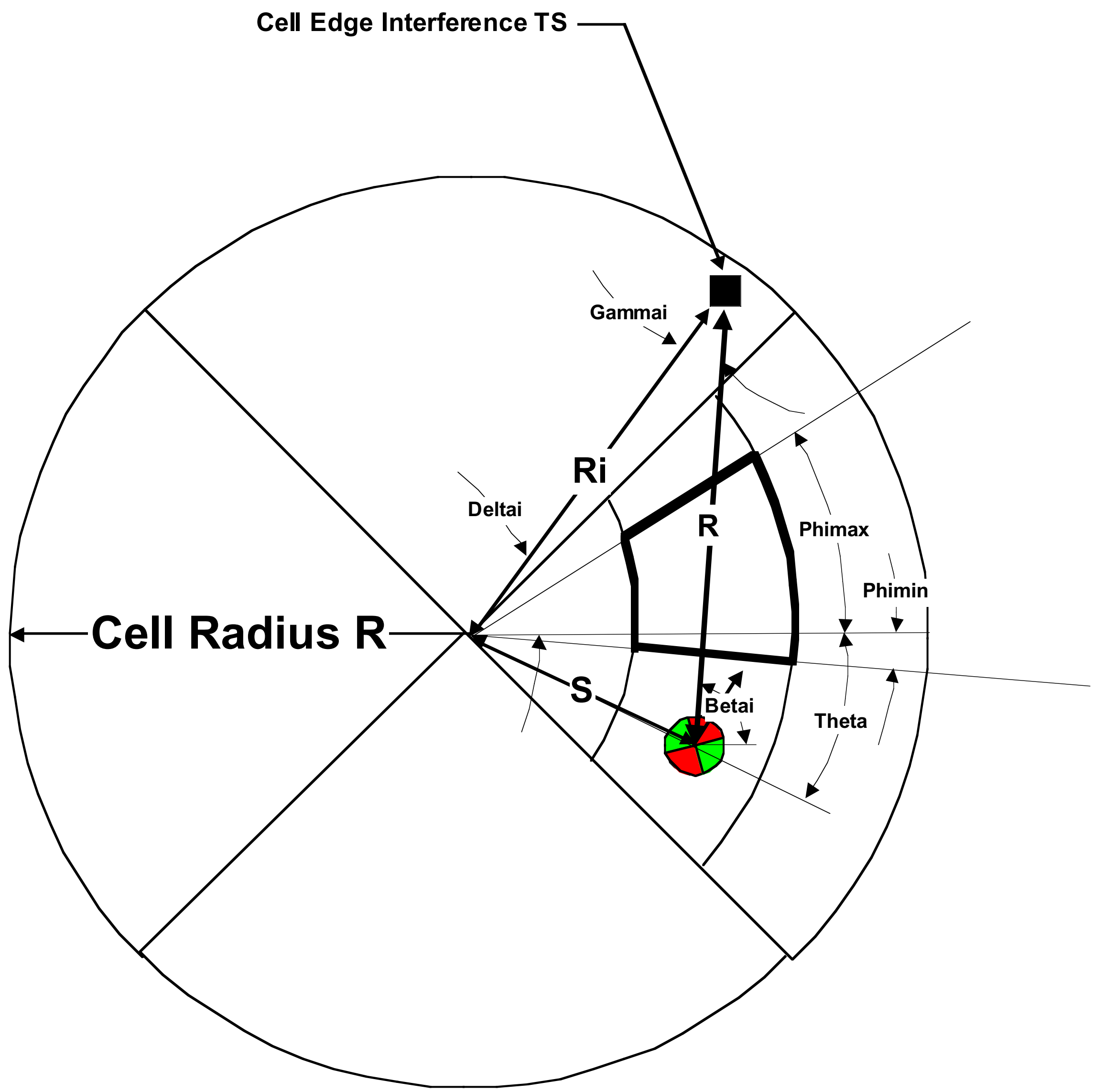



Figure 2. TS to CS Rain Simulation Model


Cell Edge Interference TS
Gammai
Ri
Deltai
R
Phimax
Phimin
Cell Radius R
S
Betai
Theta

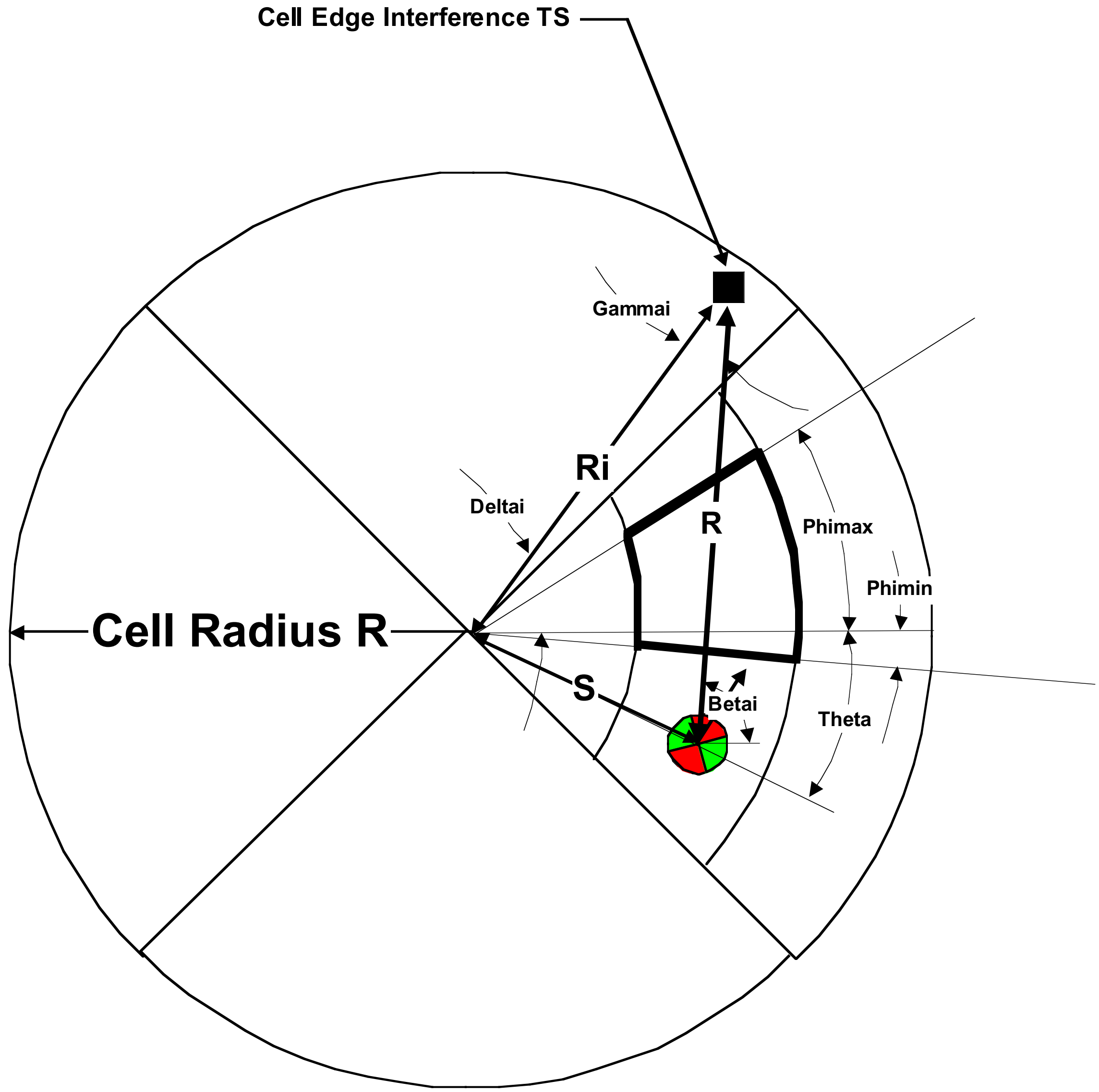



Figure 3. Geometrical Example for the Interference TS to CS Link.

## 3.0 Comments

The procedures described above will be employed to identify relative rain loss differential for subsequent CS to CS and TS to CS simulation estimates.

## 4.0 References

[1] A Simplified Method for the Estimation of Rain Attenuation at 10.5 GHz, C802.162a-02/15.