Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Coexistence between point to point links and PMP systems (revision 1)**
Date Submitted	**2001–10-30**
Source(s)	Philip Whitehead Radiant Networks PLC The Mansion, Chesterford Park Little Chesterford Essex, CB10 1 XL UK Voice: +44 1799 533600 Fax: +44 1799 533601 mailto:pw@radiantnetworks.co.uk
Re:	Coexistence of point- to- point links and PMP systems – using revised antenna RPE
Abstract	This document is a revision of IEEE C802.16.2a-01/02, which described a series of simulations of point- to- point link systems interfering with PMP base stations and subscriber stations. The revisions take account of a new IEEE composite antenna RPE proposal.
Purpose	For discussion in TG2/a at session #16, Austin, Texas.
Notice	
Release	
Patent Policy and Procedures	

Coexistence between point to point links and PMP systems (revision 1)

Philip Whitehead
Radiant Networks PLC

1. Introduction

This document is a revised version of IEEE C802.16.2a-01/02 [1] using different antenna RPE data. The original paper studied coexistence scenarios between PP systems and PMP systems, in which the interfering system is a multi – link point to point system with moderate link density and the victim is either a PMP base station (BS) or a PMP subscriber station (SS) operating in an adjacent area and co-channel to the interfering system. The frequency range is 23.5 – 43.5 GHz.

In IEEE C802.16.2a-01/06 [2] system parameters for use in simulation work were derived. In IEEE 802.16.2-01/14 [3] antenna RPE information was compiled, derived from available commercial antenna data. A "composite" RPE was derived for 25 GHz and 38 GHz antennas, suitable for use in simulations and intended to be representative of practically available antennas. This paper uses the data for the 1ft 25 GHz composite antenna.

The point- to- point links are modeled using a simulation tool, adapted from a previously used model for interference between mesh systems and PMP systems. The code relating to the antenna RPE has been re – written (see section 6) and all the simulations performed in [1] have been repeated.

2. Simulation Methodology

The simulator computes the power received from a system comprising a number of point- to- point links at a PMP BS receiver or a PMP SS receiver, in a cell adjacent to the point to point system. The simulation program was described in [1] It can be applied to any frequency up to at least 43.5GHz (i.e. at least the whole of frequency range 2 of the IEEE coexistence recommended practice [4]).

2.1 System Modeling

A model has been created for a P-MP sector and for a corresponding system of multiple point to point links, using antenna patterns appropriate to each type of system, a model for wanted path length distribution and a propagation model. The geometry is shown in Fig.1.

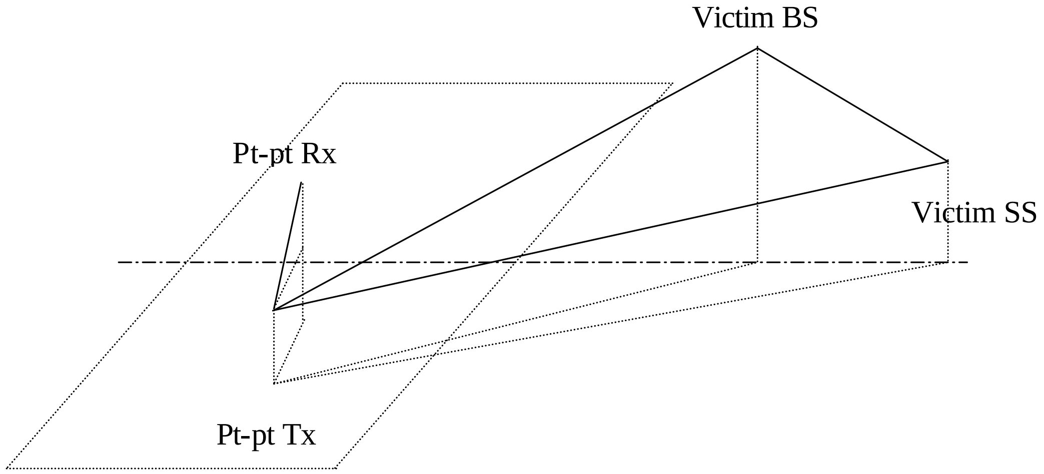

Fig.1 Interference Geometry

The main attributes of the model are:

- Monte-Carlo simulation with realistic point- to- point system parameters.
- Line-of-sight propagation probabilities calculated from Rayleigh roof height distribution function as per CRABS report D3P1B [5]
- Interfering power summed at PMP base or subscriber using full 3D geometry to compute distances and angles between lines of sight and antenna bore-sights.
- Effect of Automatic Power Control granularity (ATPC) included.
- PMP BS RPE for 24-28GHz band to EN 301 215-2 V1.1.1 [8] with elevation profile ignored for realistic worst case.
- Point to point antenna RPE model as per composite 1ft antenna (25 GHz) in [3].
- Atmospheric attenuation to ITU-R P.676-3 [6]
- Rain attenuation to ITU-R P.840-2 [7].
- Dry and rain storm weather patterns considered.

2.2 Rain Fading

Most of the scenarios have been simulated with no rain fading. A small number of examples of rain storm conditions were also simulated and found to have negligible impact on the results. All rain scenarios have only a small effect on the results

2.3 Point to Point System Characteristics

Some preliminary characteristics of point to point systems were derived in an output paper from session #14; IEEE 802.16.2-01/12, subsequently revised in [2]. These and some variations on them have been used in the simulations, to test the sensitivity of the results to various parameters.

The main characteristics are as follows:

- Frequency = 25 GHz
- Polarisation = Vertical
- APC on, with step size = 4 dB
- Link antenna gain = 40/ 42 dBi
- Link antenna RPE= composite 1ft antenna RPE from [3]
- % of links using same channel = 12.5
- Density of point to point links = 5/ 10 stations per sq km
- Area covered by links = 10 x 5 km
- Link length = 50 – 5000m
- Building density = 750/ sq km
- Fractional Building Area = 0.1
- Building Height Parameter = 0 to 7m

2.4 Propagation

Only line of sight paths for wanted signals and interference are considered, using line of sight probabilities and free-space propagation.

The probability of interference line of sight is calculated from a model in which building heights are assumed to have a Rayleigh distribution, as in [5], although the probability calculations follow a slightly different method.

2.5 Antenna Beam Profiles

The current modeling for the 24-28GHz band (nominal frequency of 25 GHz in the simulations) is based on an antenna with half power beam-width of 4.3° in both azimuth and elevation. The antenna RPE is as shown in figure 2. This was derived in [3], from a series of commercially available antennas and is considered to be a useful basis for planning purposes (and possibly for recommending minimum antenna performance requirements.)

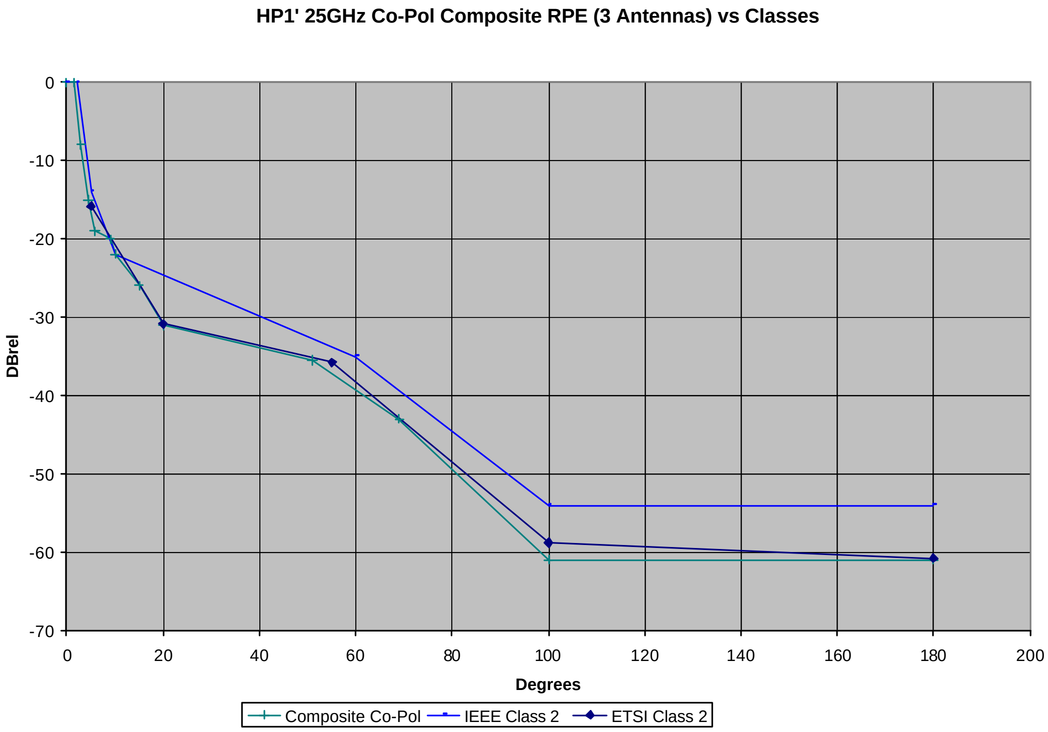

Fig. 2 Antenna RPE for Interfering Point to Point Links

2.6 Geometry

The basic arrangement of the model is shown in fig. 1. Given a point to point station density and the percentage of stations that can transmit simultaneously on a given channel, the simulator places the appropriate number of transmitters randomly within the prescribed system area at heights following the Rayleigh distribution.

For each transmitter, it then randomly places a receiver within the limits of link length and at an arbitrary angle. [Conditions near the edge of the system are satisfied by repeating any receiver placements that fall to the right of the system boundary].

The effects of buildings are modeled by their density and fractional area, and terrain (the result of both building and land height variation) is modeled with a Rayleigh distribution.

The BS receiver antenna is assumed to be a 90° sector aimed directly at the centre of the interfering system, with a gain which is flat to ±50°, falling off thereafter at 1dB every 4.5°.

2.7 Interfering Power Calculation

From each link transmitter and, taking account of the line of sight probability, the power received by the base station or subscriber station is computed. All these powers are summed, and the result rounded to the nearest dBm and assigned to a histogram bin, so that the relative probability of each power level can be estimated and cumulative probability distributions can be derived.

3 Simulation Results

3.1 Victim=PMP BS

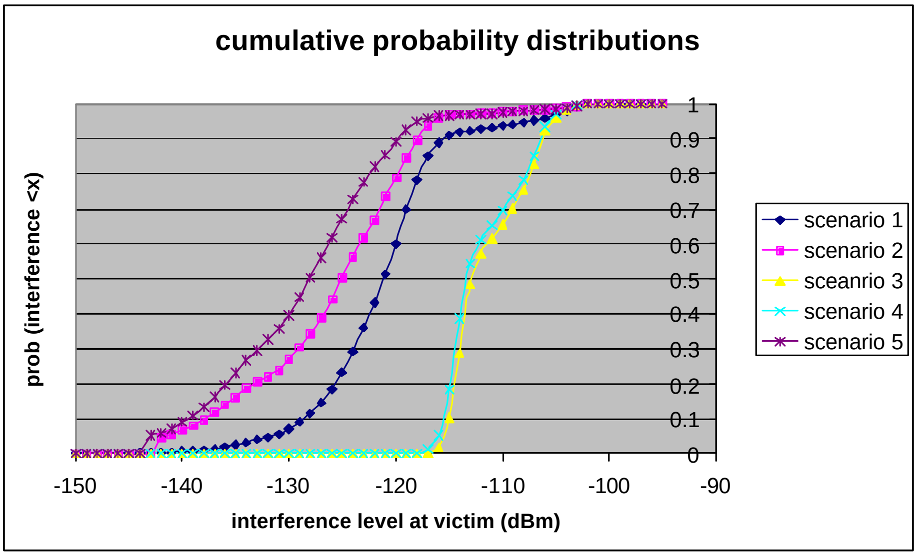

Figure 3a Cumulative probability distributions for BS interference (previous results)

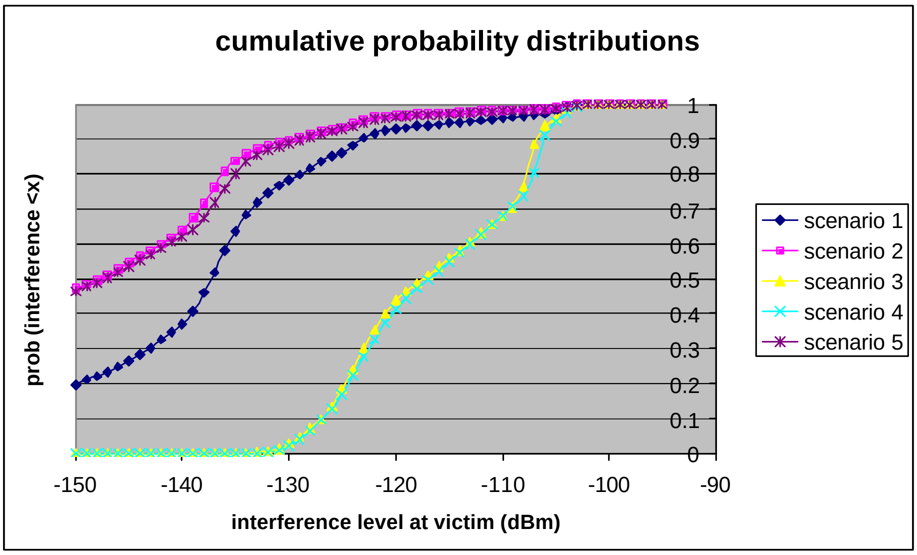

Figure 3b Cumulative probability distributions for BS interference (new results)

In figures 3a and 3b, the results of a series of simulation runs are shown as cumulative probability distributions. Figure 3a shows the previous results from [1] and fig 3b shows the results using the new antenna composite RPE. Each curve is derived from a series of 10,000 randomly generated system models, with each model simulating the required number of point- to- point links in the chosen coverage area. The cumulative probability at each point is that for which the total interference at the victim BS receiver will be less than a given value on the x axis.

In general, a value of –100dBm (equivalent to –114.5 dBm/ MHz) is low enough to be considered fully acceptable for planning purposes. Thus, where the cumulative probability has reached a value of 1 at the –100 dBm level, there are no cases above the interference threshold. The geographical spacing corresponding to such a value is then completely safe for planning purposes.

Even when there are a few cases above the –100dBm level, the situation may still be acceptable, since the probability of interference above the threshold level is very low and simple interference mitigation procedures may be available to mitigate these rare cases.

Scenario	**Building height parameter**	**Height of interferer above roof level**	**Links/sq km**	**Antenna gain dBi**	**Rain scenario**	**Distance to BS**	**% cases where threshold exceeded**
1	7m	3m	10	40	None	20km (previously 18km)	0
2	7m	1m	10	42	None	24km (previously 20km)	0
3	0m	4m	10	42	None	32km	0
4	0m	4m	10	42	Storm	30km	0
5	7m	3m	5	42	None	22km (previously 20km)	0

Table 1: Summary of BS Interference Scenarios using new antenna RPE

As can be seen from table 1, the previous conclusion that a system spacing of 18-20km is generally sufficient to eliminate all possibility of interference is now insufficient. The spacing should be increased to 20 –24km. The two scenarios where this spacing is insufficient have been included to show what happens when terrain and building obstructions are removed from the simulations. They are unrealistic of real deployment using moderate densities of point to point links, since such systems by their nature require buildings on which to place the equipment.

One example of the effects of rain- storm fading has also been included. As can be seen, the effects are negligible. Although not included here, there are many more results from the simulation that indicate a very low sensitivity of the results to rain fading.

3.2 Victim=PMP SS

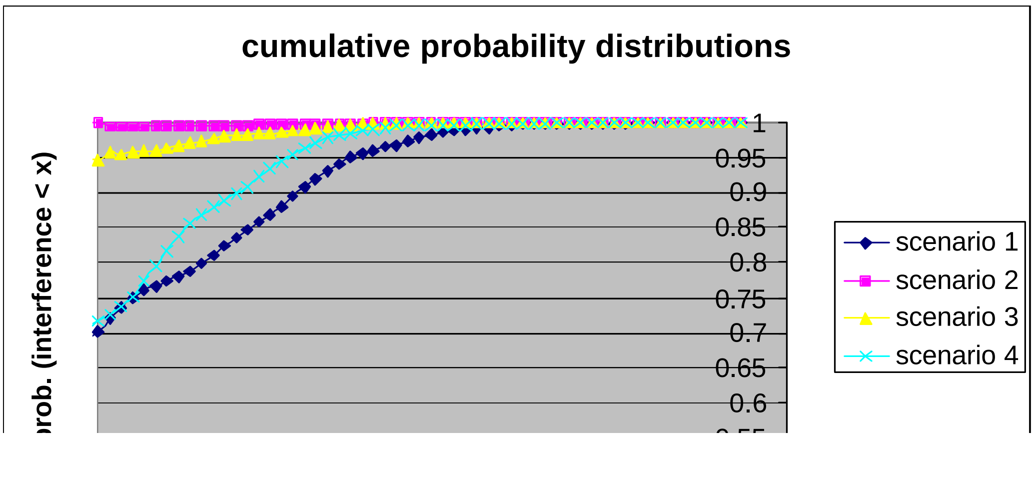

Fig. 4a: Cumulative Probability Distributions for SS Interference (previous results)

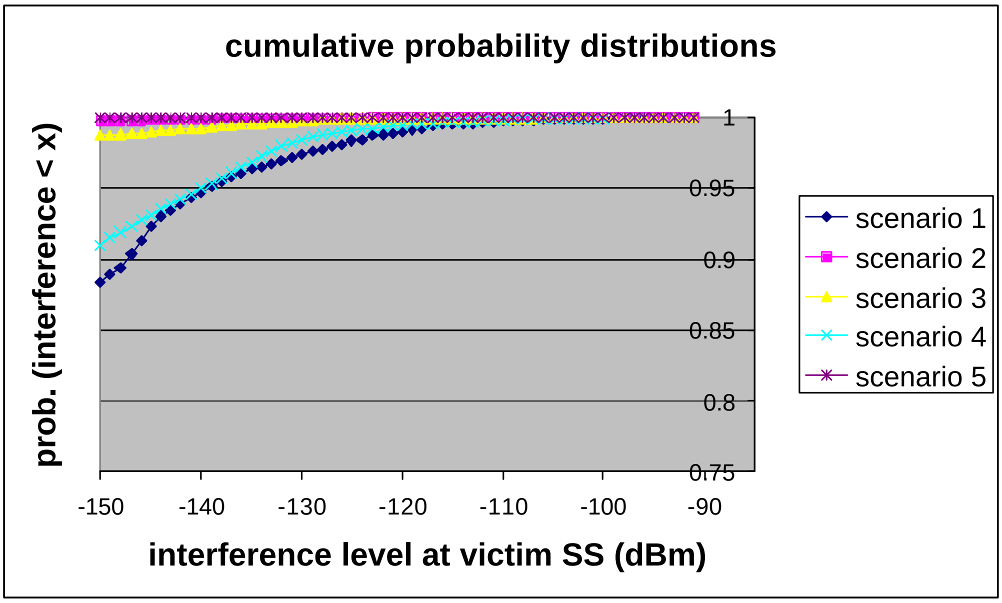

Fig 4b Cumulative Probability Distributions for SS Interference (new results)

In figures 4a and 4b, the results of are shown for the SS victim scenarios. As in fig.3 each curve is derived from a series of 10,000 randomly generated system models, with each model simulating the required number of point- to-point links in the chosen coverage area. The cumulative probability at each point is that for which the total interference at the victim base station receiver will be less than a given value on the x axis.

The same interference limit value of –100dBm (equivalent to –114.5 dBm/ MHz) is used as in the BS case.

Scenario	Building height parameter	Antenna Height above roof (interferers)	Links/sq km	Antenna gain	Victim antenna height	Rain scenario	Distance to SS	% threshold exceeded
1	7m	3m	5	40	20	None	15km	.05
2	7m	3m	5	40	15	None	15km (previously 17km)	0
3	7m	3m	5	40	20	None	40km	.01
4	7m	3m	5	40	25	None	50km	.06
5	7m	3m	5	40	10	None	10km	0

Table 2: Summary of SS Interference Scenarios using new antenna RPE

Note that in the case of a victim PMP SS, the level of interference depends strongly on the victim antenna height. Below about 15m, very little interference is experienced. Above 15m, the interference increases rapidly. Also, the probability distributions are much flatter than for the BS case, so that to eliminate the last few cases of interference above the threshold, the system spacing has to be increased significantly.

However, SS antenna heights above 15m have a relatively low probability, so that, in most cases, the base station distance required to reduce interference to the –100dBm threshold will dominate.

4. Conclusions

4.1 For most situations, interference to the BS victim station determines the required system spacing, which is in the range 20-24km.

4.2 Where SS antennas are on unusually high structures, the SS interference may dominate and the distance may then need to be increased to 40 – 50 km to reduce the probability of interference to a negligible level. Since the number of such cases is always a very low percentage of the total, it may be more reasonable to apply mitigation techniques than to resort to such large geographical separations

4.3 The conclusions are only slightly different from those in the previous analysis. The antenna RPE does have some impact but it is not a critical factor

4.3 Rain fading is not significant in determining the required geographical spacing

5. References

[1] IEEE C802.16.2a-01/02; “Coexistence between point to point links and PMP systems”

[2] IEEE 802.16.2-01/12; “System parameters for point to point links for use in Coexistence Simulations”; Phil Whitehead, 01/07/12

[3] IEEE 802.16.2-01/14; “Proposed Antenna Radiation Pattern Envelopes for Coexistence Study” by Robert Whiting, 01/07/12
[4] IEEE 802.16.2-2001; “Recommended Practice for Coexistence of Fixed Broadband Wireless Systems”
[5] ACTS Project 215, Deliverable Report D3P1B; “Cellular Radio Access for Broadband Services (CRABS)”.
[6] ITU-R P.676-3; Atmospheric attenuation
[7] ITU-R P.840-2; Rain attenuation
[8] ETSI EN 301 215-2,V1.1.1; “Antennas for use in PMP systems (24GHz to 30GHz)”

6 Appendix

Visual Basic sub – routine for IEEE Composite Antenna RPE

```
REM creates subscriber RPE as per IEEE 25 GHz composite 1ft antenna
REM creates sinsubs lookup table for first 90 degrees
REM and cossubs lookup table for next 90 degrees
REM tables are power relative to main beam
REM in this case sinref is the same as sinsubs (node antenna RPE same as PMP SS)
REM next line is 1170
step=0.001
temp1=180 / pi
For i=0 To 1000
If i < 1000 Then
v=step * i
Rem asin function not available:
temp = Atn(v / Sqr(1 - v * v)) * temp1
Else
temp = 90
End If
Rem sinsubs entry
If temp <1.5 Then
sinsubs(i) = 1
sinref(i) = sinsubs(i)
ElseIf temp < 3 Then
sinsubs(i) = 10 ^ (-8/1.5 * (temp – 1.5) / 10)
sinref(i) = sinsubs (i)
ElseIf temp < 4.5 Then
sinsubs(i) = 10 ^ ((-8 - 7/1.5 * (temp - 3)) / 10)
sinref(i) = sinsubs(i)
ElseIf temp<5.8 Then
sinsubs(i)=10-^((-15-4/1.3*(temp-4.5))/10)
sinref(i)=sinsubs(i)
ElseIf temp<9 Then
sinsubs(i)=10^((-19-1/3.1*(temp-5.8))/10)
sinref(i)=sinsubs(i)
ElseIf temp<10 Then
```

```
sinsubs(i)=10^((-20-2/1*(temp-9))/10)
sinref(i)=sinsubs(i)
Elseif temp<15 Then
sinsubs(i)=10^((-22-4/5*(temp-10))/10)
sinref(i)=sinsubs(i)
ElseIf temp<20 Then
sinsubs(i)=10^((-26-5/5*(temp-15))/10)
sinref(i)=sinsubs(i)
ElseIf temp<51 Then
sinsubs(i)=10^((-31-4.5/31*(temp-20))/10)
sinref(i)=sinsubs(i)
Elseif temp<69 Then
sinsubs(i)=10^((-35.5-7.5/18*(temp-51))/10)
sinref(i)=sinsubs(i)
Else
sinsubs(i)=10^((-43-12.2/21*(temp-69))/10)
sinref(i)=sinsubs(i)
EndIf
REM cossubs table starts here
Temp=temp+90
If temp<100 Then
cossubs(i)=10^((-55.2-5.8/10*(temp-90))/10)
Else cossubs(i)=10^(-61/10)
EndIf
Next i




END
```