Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**P-P and PMP coexistence calculations based on ETSI TR 101 853 v1.1.1**
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Re:	Completing action items identified in IEEE C802.16.2a-02/06 (Interim Considerations arising from Simulations)
Abstract	An Excel worksheet implementing the coexistence calculations for the P-P and PMP scenarios described in the ETSI published report TR 101 853 “Rules for the co-existence of point to point and point to multipoint systems using different access methods in the same frequency band”. Classes B1 to B4 are included only.
Purpose	For discussion in the TG2a task group meeting at Session 19.
Notice	
Release	
Patent Policy and Procedures	

P-P and PMP coexistence calculations based on ETSI TR 101 853 v1.1.1

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Introduction

In order to assist the Task Group in drawing conclusions and recommendations regarding the coexistence possibilities for P-P and PMP systems the spreadsheet embedded in this document has been developed from the work published by ETSI in Report TR 101 853. This report examines interference scenarios labelled classes B1 to B4 that reflect all the possible interference paths between a P-P link and a PMP system.

ETSI TR 101-853 is available for free download from the ETSI Web Site and is already summarized in the Recommended Practice IEEE Std 802.16.2-2001 Annex D.

TR 101-853 Interference Classes

In summary these are:
Class B1 = PMP Central Station (CRS) to P-P station. (See TR 101 853 clause 7.2.2)
Class B2 = P-P station to PMP Central Station (CRS). (See TR 101 853 clause 7.2.3)
Class B3 = PMP Terminal Station (TS) to P-P station. (See TR 101 853 clause 7.2.4)
Class B4 = P-P station to PMP Terminal Station (TS). (See TR 101 853 clause 7.2.5)

Classes B1 and B2 are tackled by calculating the required minimum separation distance between the P-P station and the CRS for a given range of P-P link offset angles. A minimum C/I is assumed.

Classes B3 and B4 are tackled differently since there are more variables due to TS positioning. In these cases the actual C/I is calculated for a range of TS to P-P decoupling angles and P-P link offset angles.

The scenarios are illustrated in detail in the report.

Notes regarding the Spreadsheet

Parameter values have been taken from published standards where available. All parameters can be varied and frequency offset can be applied through Net Filter Discrimination (NFD). Embedded notes help clarify the origins of data and the calculation process.

The Spreadsheet

The spreadsheet file is submitted as document C802162a-02_25.xls

Proposal text for the draft amendment:

Summary of P-P and PMP Coexistence Scenarios published in ETSI Technical Report TR 101-853.

Introduction

ETSI Technical Report TR 101 853 [ref?] examines coexistence scenarios associated with P-P and PMP systems operating in the **same area and in adjacent frequency** blocks. It derives expressions that can be used to evaluate the coexistence potential for four possible interferer and victim system combinations classified as:

- Class B1 – PMP Central Station to P-P system.
- Class B2 – P-P system to PMP Central Station.
- Class B3 – PMP Terminal Station to P-P system.
- Class B4 – P-P system to PMP Terminal Station.

For classes B1 and B2 involving Central Stations, expressions are developed that can be used to calculate the minimum separation distance required between the P-P station and the PMP Central Station in order to meet a target minimum C/I ratio. For Classes B3 and B4, expressions are developed that calculate the C/I ratio specific to decoupling angles between the Terminal Station and the P-P station. See equations 28, 32, 37 and 40 in section 7 of the report [ref?].

These equations can be incorporated into calculation tools.

Example Calculations

The expressions developed in the technical report were used to assess coexistence between a PMP system operating in one frequency block adjacent to another frequency block dedicated to "protected" P-P links. Where available parameter values previously ratified in the task group were used. Where not available reference was made to appropriate ETSI standards EN 301-213, EN 301-215 and EN 300-431 .

Note: The calculation results are dependant on a large variety of possible parameter values. Definition of typical values is impractical since these will be different for any given scenario. Factors like P-P link length, planned availability, PMP cell size, to name a few, can impact the parameter values chosen.

Classes B1 and B2:

Table [x] below shows an example of minimum separation distance (Dmin) between a P-P station and a PMP CS when the P-P station is the victim (B1). The calculated distances are in kilometers and given for a range of Net Filter Discrimination (NFD) values corresponding to frequency offset between the two systems and P-P to CS pointing angle offset. An indication of appropriate NFD columns are shown for co-channel (although not an issue here) and for first and second adjacent channels representing the case where no guard channel is inserted between the system operating frequencies and where a single guard channel is inserted.

NFD (dB)	0 (Co-channel)	10	20	25 (1st adjacent ch. Region.)	30	35	40	45 (2nd adjacent ch.region.)	50	55
Angle										
0	1455.3	460.2	145.5	81.8	46.0	25.9	14.6	8.2	4.6	2.6
1.5	1455.3	460.2	145.5	81.8	46.0	25.9	14.6	8.2	4.6	2.6
2.0	1070.5	338.5	107.1	60.2	33.9	19.0	10.7	6.0	3.4	1.9
2.5	787.5	249.0	78.8	44.3	24.9	14.0	7.9	4.4	2.5	1.4
3.0	579.3	183.2	57.9	32.6	18.3	10.3	5.8	3.3	1.8	1.0
4.5	258.8	81.8	25.9	14.6	8.2	4.6	2.6	1.5	0.8	0.5
5.8	163.3	51.6	16.3	9.2	5.2	2.9	1.6	0.9	0.5	0.3
7.4	154.1	48.7	15.4	8.7	4.9	2.7	1.5	0.9	0.5	0.3
9.0	145.5	46.0	14.6	8.2	4.6	2.6	1.5	0.8	0.5	0.3
9.3	134.8	42.6	13.5	7.6	4.3	2.4	1.3	0.8	0.4	0.2
9.7	124.8	39.5	12.5	7.0	3.9	2.2	1.2	0.7	0.4	0.2
10.0	115.6	36.6	11.6	6.5	3.7	2.1	1.2	0.7	0.4	0.2
11.0	105.4	33.3	10.5	5.9	3.3	1.9	1.1	0.6	0.3	<200m
12.0	96.1	30.4	9.6	5.4	3.0	1.7	1.0	0.5	0.3	<200m
13.0	87.7	27.7	8.8	4.9	2.8	1.6	0.9	0.5	0.3	<200m
14.0	80.0	25.3	8.0	4.5	2.5	1.4	0.8	0.4	0.3	<200m
15.0	72.9	23.1	7.3	4.1	2.3	1.3	0.7	0.4	0.2	<200m
16.0	65.0	20.6	6.5	3.7	2.1	1.2	0.7	0.4	0.2	<200m
17.0	57.9	18.3	5.8	3.3	1.8	1.0	0.6	0.3	<200m	<200m
18.0	51.6	16.3	5.2	2.9	1.6	0.9	0.5	0.3	<200m	<200m
19.0	46.0	14.6	4.6	2.6	1.5	0.8	0.5	0.3	<200m	<200m
20.0	41.0	13.0	4.1	2.3	1.3	0.7	0.4	0.2	<200m	<200m

Table [x]: Class B1 separation distances in kilometers

For Class B2 the separation distances were less for the same parameter set leading to a presumption that the interference into the P-P system from the PMP CS is the driver when considering the PMP CS.

The results indicate that even a single guard channel between the systems is insufficient to allow fully uncoordinated deployment. Separation distances of several kilometers are needed if bore-sight alignment is possible. It is interesting also to consider the impact within a grid of Central Stations as depicted in the Figure [y] below. In Figure [y] for illustrative purposes, the P-P station is operating in the adjacent channel to the CS stations (of course a realistic frequency re-use plan may preclude all CS operating on the same frequency). Examination of Table [x] shows that in the adjacent channel and at a distance of 5km then a pointing angle offset of 13degrees is required. This leads to the range of pointing angles shown (in one quadrant only) that could be possible.

Alternatively the P-P station could be operated closer to the CS with a greater minimum offset angle. If limited to an offset of 45 degrees then the P-P link need be only 1.5km from the CS.

Examination of Table [x] shows that if a single guard channel is inserted (second adjacent channel region) then the P-P link could be operated anywhere within the grid so long as care is taken to respect the required minimum separation distance for low offset angles.

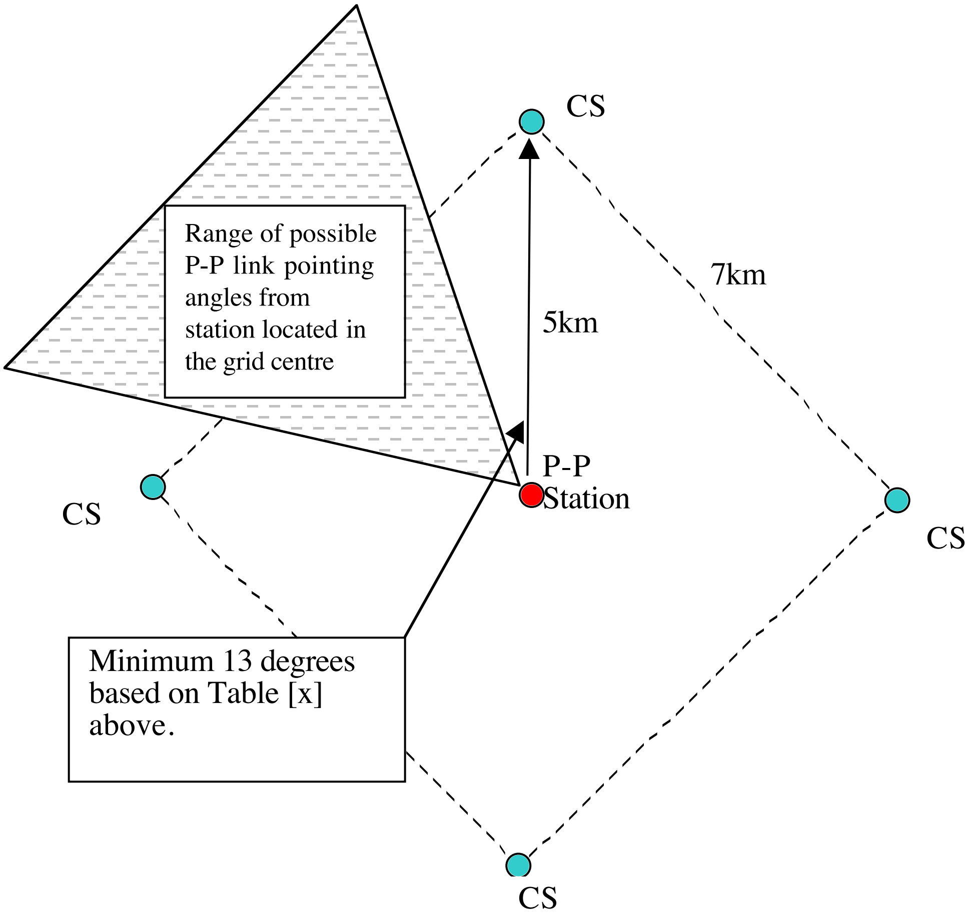


Figure [y]: Interpretation of Table [x] Results

Classes B3 and B4:
These classes tackle interference between the P-P station and PMP Terminal Stations. Care should be taken to understand the decoupling angles alpha and beta by reference to Figures 12 and 13 in the technical report [ref?].

The table [z] below is an extract of results for PMP Terminal Station interference into a P-P station. In this example the P-P link was sited 5km away from the CS and the table gives the C/I values that are less than 30dB at the P-P receiver for a range of P-P decoupling angles and Terminal Station decoupling angles. Additionally the frequency offset is one channel being bconsistent with a NFD assumption of 27dB.

Although the table here is truncated, the C/I for alpha equal to zero degrees becomes greater than 30dB at a beta angle of 52 degrees. This shows that in the situation where the TS decoupling angle is zero, the P-P link must point away by at least 52 degrees if operating in the adjacent channel to the PMP TS. Considering that TS could be located in any position in a sector facing the P-P link this could place considerable constraints on the P-P pointing angle illustrated in figure [h]. The problem becomes more severe when a full deployment of PMP cells is considered, employing a frequency re-use plan. If the P-P link is situated at 10km from the CS, the decoupling angle required drops to 24 degrees.

CRS to TS	Distance	d2=	3700	metres
CRS to P-P	Distance	d=	5000	metres

Max			
Alpha =		54	degrees

								TS Decouple Angle		(Alpha)			
	Alpha	0	5	10	15	20	25	30	35	40	45	50	55
P-P Decouple	Gain at Alpha	32	26.8	15	12.5	10	8.75	7.4	6.1	4.9	3.6	2.3	2
Beta	d1 (metres)	8700	8686	8644	8574	8477	8353	8204	8031	7834	7616	7378	7122
		P-P C/I		NFD=	27	dB							
0.0		-5.6	-0.4	11.4	13.8	16.2	17.3	18.5	19.6	20.6	21.7	22.7	22.7
1.5		-5.6	-0.4	11.4	13.8	16.2	17.3	18.5	19.6	20.6	21.7	22.7	22.7
2.0		-2.9	2.3	14.0	16.5	18.9	20.0	21.2	22.3	23.3	24.3	25.4	25.4
2.5		-0.2	4.9	16.7	19.1	21.5	22.7	23.9	25.0	25.9	27.0	28.0	28.0
3.0		2.4	7.6	19.4	21.8	24.2	25.3	26.5	27.6	28.6	29.7	-	-
4.5		9.4	14.6	26.4	28.8	-	-	-	-	-	-	-	-
5.8		13.4	18.6	-	-	-	-	-	-	-	-	-	-
7.4		13.9	19.1	-	-	-	-	-	-	-	-	-	-
9.0		14.4	19.6	-	-	-	-	-	-	-	-	-	-
9.3		15.1	20.3	-	-	-	-	-	-	-	-	-	-
9.7		15.8	20.9	-	-	-	-	-	-	-	-	-	-
10.0		16.4	21.6	-	-	-	-	-	-	-	-	-	-
11.0		17.2	22.4	-	-	-	-	-	-	-	-	-	-
12.0		18.0	23.2	-	-	-	-	-	-	-	-	-	-
13.0		18.8	24.0	-	-	-	-	-	-	-	-	-	-
14.0		19.6	24.8	-	-	-	-	-	-	-	-	-	-
15.0		20.4	25.6	-	-	-	-	-	-	-	-	-	-
16.0		21.4	26.6	-	-	-	-	-	-	-	-	-	-
17.0		22.4	27.6	-	-	-	-	-	-	-	-	-	-
18.0		23.4	28.6	-	-	-	-	-	-	-	-	-	-
19.0		24.4	29.6	-	-	-	-	-	-	-	-	-	-
20.0		25.4	-	-	-	-	-	-	-	-	-	-	-
22.0		25.7	-	-	-	-	-	-	-	-	-	-	-

Table [z]: Class B3, NFD=27dB, C/I at the P-P receiver from the PMP TS

Table [z2] is an extract from calculations in the same scenario but with the P-P link operating with one guard channel separation from the PMP TS station. This is reflected in a NFD figure of 50dB.

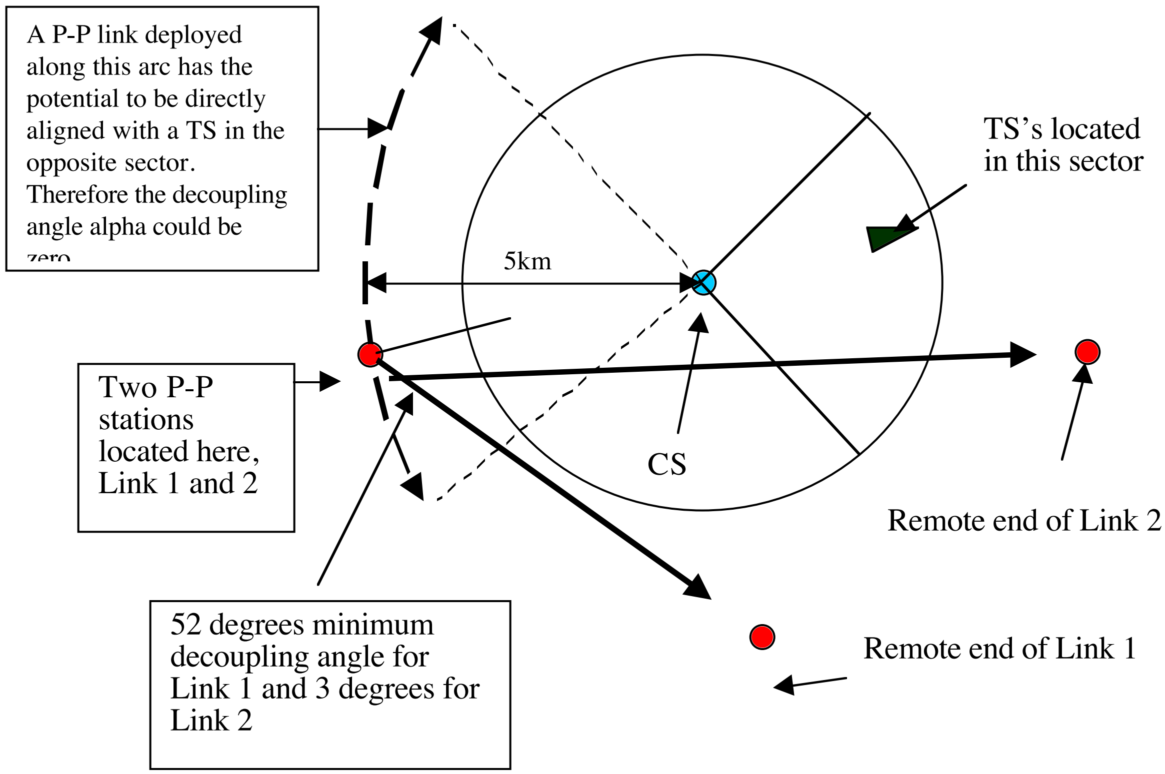
CRS to TS	Distance	d2=	3700	metres
CRS to P-P	Distance	d=	5000	metres

	Alpha	0	5	10	15	20
P-P Decouple	Gain at Alpha	32	26.8	15	12.5	10
Beta	d1 (metres)	8700	8686	8644	8574	8477
		P-P C/I		NFD=	50	dB
0.0		17.4	22.6	-	-	-
1.5		17.4	22.6	-	-	-
2.0		20.1	25.3	-	-	-
2.5		22.8	27.9	-	-	-
3.0		25.4	-	-	-	-
4.5		-	-	-	-	-
5.8		-	-	-	-	-
7.4		-	-	-	-	-
9.0		-	-	-	-	-
9.3		-	-	-	-	-

Table [z2]: Class B3, NFD=50dB, C/I at the P-P receiver from the PMP TS

The excluded decoupling angles are now considerably less being virtually limited to avoidance of bore-sight coupling. However this can still impose considerable constraints on the positioning of the P-P link considering again the fact that PMP TS can be located at any point in a facing sector thereby increasing the chance of bore-sight coupling.

For Class B4 the C/I values were less for the same parameter set leading to a presumption that the interference into the P-P system from the PMP TS is the driver when considering the PMP TS.



Link 1 is operating in the adjacent channel to the PMP TS and is constrained by the need to maintain the 52 degree decoupling angle.
Link 2 is operating on the second adjacent channel to the PMP TS thereby inserting one guard channel . In this case the constraint is reduced to around 3 degrees decoupling angle and 5 degrees decoupling between TS and the P-P link.

Figure [h]:Impact of the results displayed in Tables [z] and [z2]

Figure [h] shows an example of two P-P links with one end located on the arc 5km away from the CS (5km was assumed in the specific calculation in Table [z]). It illustrates the constraint on pointing angle brought about by the need to maintain at least 52 degrees of decoupling angle when no guard band is in place and the reduced constraint with a single guard channel. These results are specific to the calculation results reported in the tables above.

Conclusions / Considerations

The expressions derived in Technical Report TR 101-853 form a good basis for these coexistence calculations. However it is obvious that virtually every parameter used is variable and scenario specific but the following broad conclusions can be drawn when considering the operation of protected P-P links in frequency blocks adjacent to PMP systems in the same geographic area:

- Regarding P-P system and PMP Central Stations, operation in immediately adjacent channels may be possible despite the fact that calculations suggest minimum separation distances in the range of several kilometers even at offset angles moderately removed from main lobe coupling. However when considered in a wide-scale PMP deployment there will be considerable constraints on possible positioning and pointing angles that may be difficult to resolve.
- If a single guard channel is inserted then minimum separation distances reduce to hundreds of metres so long as the P-P link avoids main lobe alignment with a PMP CS receiver. This could be more manageable.
- Improvements in Net Filter Discrimination directly reduce the minimum separation required between P-P stations and PMP CS.
- Regarding P-P system and PMP Terminal Stations, operation in the immediately adjacent channel will impose considerable constraints upon pointing angle that could preclude pointing towards any adjacent channel TS in a PMP sector for P-P to CS separation distances well in excess of normal link lengths. This problem will be exacerbated by multi-cell PMP deployment.
- If a single guard channel is imposed then the P-P system and PMP Terminal Station constraints reduce to a need to avoid direct main beam coupling.

Generally:

- The best possible Net Filter Discrimination and lower EIRP in either system reduces deployment constraints and levels of interference.

Recommendations:

- A single guard channel at least as wide as the widest system between a PMP frequency block and a P-P system frequency block is virtually essential to avoid extremely detailed co-ordination and excessive deployment constraints.
- When assigning both PMP frequency blocks and P-P links/blocks in the same frequency band it will be useful to begin assignments from opposite ends of the band.