Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	Interference from a PP link system to a BFWA PMP system (same area, adjacent channel case).
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Re:	Amendment to Coexistence Recommended Practice IEEE 802.16.2-2001
Abstract	This paper provides the results of an analysis of scenarios in which a PMP system may receive interference from a point- to- point link, operating in the same geographical area on adjacent or near – adjacent channels. The point- to- point link is assumed to be individually licensed and to have “protected” status. However, the PMP system will not normally have the same degree of protection, so that occasional interference above the normal threshold level may be acceptable.
Purpose	To provide simulation results and draft coexistence guidelines for scenarios 7 and 8 in IEEE C802/16.2a-02/06 (interim considerations from simulations).
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Interference from a PP link system to a BFWA PMP system (same area, adjacent channel case).

This paper provides the results of an analysis of scenarios in which a PMP system may receive interference from a point- to- point link, operating in the same geographical area on adjacent or near – adjacent channels. The point-to- point link is assumed to be individually licensed and to have "protected" status. However, the PMP system will not normally have the same degree of protection, so that occasional interference above the normal threshold level may be acceptable.

The interference scenarios correspond to nos. 7 and 8 in IEEE C802.16.2a-02/06 [7]. The analysis is carried out at two frequencies; 25 GHz and 38 GHz. System parameters are taken from [2].

PP to PMP interference scenarios

In this case, the interferer is one end of a PP link and the victim is a BS or SS forming part of a BFWA PMP system. A worst-case analysis is appropriate to these scenarios.

In the case of a typical PMP BS, the antenna beam-width and height above surrounding terrain are such that terrain losses (over and above free space) cannot be relied on, so that all paths for the worst-case analysis should be assumed to be clear, line of sight.

The interference model for the BS case is shown in fig 1. The corresponding model for the SS case is shown in fig.2.

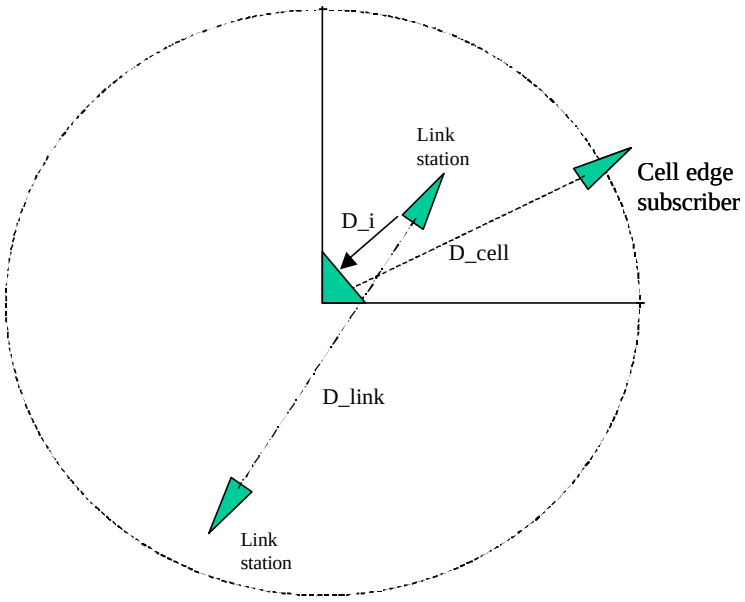

Fig. 1 Interference geometry (PP link to PMP BS)

The PMP cell is shown as a circle. A nominal cell radius of 5km is assumed, although this is not important in the calculations, since the interference limit criterion is a level of −114.5dBm/ MHz in the victim BS or SS receiver. The distance from the BS to the victim link station is D_i.

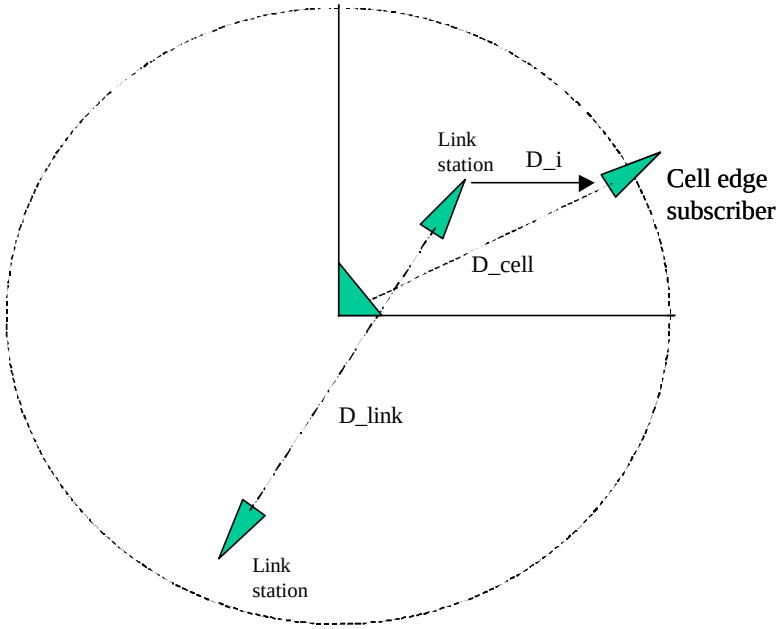

Fig. 2 Interference geometry (PP link PMP SS)

The interfering station in fig.2 is one end of a PP link and the victim is an SS, placed at the cell edge. The distance from the victim SS to the link station is D_i.

The following parameters are assumed for the analysis:

Parameter	**Value**	**Note**
PMP cell radius (D_cell)	5km	Larger radius leads to worse interference scenario
Typical PP link length	Up to 5km (25 GHz) Up to 3km (38 GHz)	From [2]
Frequency	25 GHz / 38 GHz	Antenna patterns for these frequencies are available in [3]
BS antenna gain	19dBi / 20 dBi	Typical for 90 degree sector antenna
SS antenna gain	36dBi / 38dBi	Typical values for narrow beam antennas
Link antenna gain	40 dBi / 42dBi (Note 2)	From [2]
Nominal Rx input level	-73dBm	Assuming 16 QAM modulation
Isolation (Note 1)	25dB	Typical value for adjacent channel operation
Isolation (Note 1)	49 dB	Typical value, from ETSI tables, for 1 guard channel

Isolation (Note 1)	70 dB	Typical value, from ETSI tables, for 2 guard channels
Note 1: The isolation may be achieved by use of guard bands or by other means. The values chosen correspond to typical NFD (net filter discrimination) data. NFD is a measure of the additional isolation between a transmitter and receiver that are on near-adjacent channels, compared with the on – channel case. There is little available data from actual systems and no standardised method of measurement (In the UK, there is a proposal from the RA to study this topic). Note 2: The range of values proposed in [2] is 40 - 42dB.		

Table 1: Parameters for PP to PMP interference scenarios

Results

The results of the analysis are summarised in tables 2 and 3 (BS interference) and tables 4 and 5 (SS interference).

interference from PP link station to BS Rx			int path 50m	100m	200m	300m	400m	500m	1km	2km	3km	5km	5km
adjacent channel, same area case													
Frequency GHz		25											
Tx power, max	dBm	26											
wanted PP link path length km			5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	10.0
wanted path loss dB		-123-20log d	-137.0	-137.0	-137.0	-137.0	-137.0	-137.0	-137.0	-137.0	-137.0	-137.0	-143.0
interference path length, km			0.05	0.1	0.2	0.3	0.4	0.5	1.0	2.0	3.0	5.0	5.0
interference path loss dB			-97.0	-103.0	-109.0	-112.5	-115.0	-117.0	-123.0	-129.0	-132.5	-137.0	-137.0
Link antenna gain dBi		40	40	40	40	40	40	40	40	40	40	40	40
BS antenna gain dBi		19	19	19	19	19	19	19	19	19	19	19	19
SS antenna gain dBi		36	36	36	36	36	36	36	36	36	36	36	36
wanted Rx input, 16 QAM, dBm		-73	-73	-73	-73	-73	-73	-73	-73	-73	-73	-73	-73
PP link Tx power, no fade, dBm			-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-10.0
interference power, no fade, dBm			-54.0	-60.0	-66.0	-69.6	-72.1	-74.0	-80.0	-86.0	-89.6	-94.0	-88.0
Less NFD for adjacent channel dB		25	-79.0	-85.0	-91.0	-94.6	-97.1	-99.0	-105.0	-111.0	-114.6	-119.0	-113.0
Less off axis RPE factor	3 degrees	-8	-87.0	-93.0	-99.0	-102.6	-105.1	-107.0	-113.0	-119.0	-122.6	-127.0	-121.0
	5.8 degrees	-19	-98.0	-104.0	-110.0	-113.6	-116.1	-118.0	-124.0	-130.0	-133.6	-138.0	-132.0
	10 degrees	-22	-101.0	-107.0	-113.0	-116.6	-119.1	-121.0	-127.0	-133.0	-136.6	-141.0	-135.0
Less NFD for 1 guard channel dB		49	-103.0	-109.0	-115.0	-118.6	-121.1	-123.0	-129.0	-135.0	-138.6	-143.0	-137.0
Less off axis RPE factor	3 degrees	-8	-111.0	-117.0	-123.0	-126.6	-129.1	-131.0	-137.0	-143.0	-146.6	-151.0	-145.0
	5.8 degrees	-19	-122.0	-128.0	-134.0	-137.6	-140.1	-142.0	-148.0	-154.0	-157.6	-162.0	-156.0
	10 degrees	-22	-125.0	-131.0	-137.0	-140.6	-143.1	-145.0	-151.0	-157.0	-160.6	-165.0	-159.0
Less NFD for 2 guard channels dB		70	-124.0	-130.0	-136.0	-139.6	-142.1	-144.0	-150.0	-156.0	-159.6	-164.0	-158.0
Less off axis RPE factor	3 degrees	-8	-132.0	-138.0	-144.0	-147.6	-150.1	-152.0	-158.0	-164.0	-167.6	-172.0	-166.0
	5.8 degrees	-19	-143.0	-149.0	-155.0	-158.6	-161.1	-163.0	-169.0	-175.0	-178.6	-183.0	-177.0
	10 degrees	-22	-146.0	-152.0	-158.0	-161.6	-164.1	-166.0	-172.0	-178.0	-181.6	-186.0	-180.0

Table 2 : PP link to BS Interference (25 GHz)

interference from PP link station to BS Rx			int path 50m	100m	200m	300m	400m	500m	1km	2km	3km	5km	5km
adjacent channel, same area case													
Frequency GHz		38											
Tx power, max	dBm	26											
wanted PP link path length km			5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	10.0
path loss dB		-126.43-20log d	-140.4	-140.4	-140.4	-140.4	-140.4	-140.4	-140.4	-140.4	-140.4	-140.4	-146.4
interference path length, km			0.05	0.1	0.2	0.3	0.4	0.5	1.0	2.0	3.0	5.0	5.0
interference path loss dB			-100.4	-106.4	-112.4	-115.9	-118.4	-120.4	-126.4	-132.4	-135.9	-140.4	-140.4
Link antenna gain dBi		42	42	42	42	42	42	42	42	42	42	42	42
BS antenna gain dBi		20	20	20	20	20	20	20	20	20	20	20	20
SS antenna gain dBi		38	38	38	38	38	38	38	38	38	38	38	38
wanted Rx input, 16 QAM, dBm		-73	-73	-73	-73	-73	-73	-73	-73	-73	-73	-73	-73
PP link Tx power, no fade dBm			-16.6	-16.6	-16.6	-16.6	-16.6	-16.6	-16.6	-16.6	-16.6	-16.6	-10.6
interference power, no fade, dBm			-55.0	-61.0	-67.0	-70.5	-73.0	-75.0	-81.0	-87.0	-90.5	-95.0	-88.9
Less NFD for adjacent channel dB		25	-80.0	-86.0	-92.0	-95.5	-98.0	-100.0	-106.0	-112.0	-115.5	-120.0	-113.9
Less off axis RPE factor	2 degrees	-8	-88.0	-94.0	-100.0	-103.5	-106.0	-108.0	-114.0	-120.0	-123.5	-128.0	-121.9
	4 degrees	-19	-99.0	-105.0	-111.0	-114.5	-117.0	-119.0	-125.0	-131.0	-134.5	-139.0	-132.9
	7 degrees	-25	-105.0	-111.0	-117.0	-120.5	-123.0	-125.0	-131.0	-137.0	-140.5	-145.0	-138.9
Less NFD for 1 guard channel dB		49	-104.0	-110.0	-116.0	-119.5	-122.0	-124.0	-130.0	-136.0	-139.5	-144.0	-137.9
Less off axis RPE factor	2 degrees	-8	-112.0	-118.0	-124.0	-127.5	-130.0	-132.0	-138.0	-144.0	-147.5	-152.0	-145.9
	4 degrees	-19	-123.0	-129.0	-135.0	-138.5	-141.0	-143.0	-149.0	-155.0	-158.5	-163.0	-156.9
	7 degrees	-25	-129.0	-135.0	-141.0	-144.5	-147.0	-149.0	-155.0	-161.0	-164.5	-169.0	-162.9
Less NFD for 2 guard channels dB		70	-125.0	-131.0	-137.0	-140.5	-143.0	-145.0	-151.0	-157.0	-160.5	-165.0	-158.9
Less off axis RPE factor	2 degrees	-8	-133.0	-139.0	-145.0	-148.5	-151.0	-153.0	-159.0	-165.0	-168.5	-173.0	-166.9
	4 degrees	-19	-144.0	-150.0	-156.0	-159.5	-162.0	-164.0	-170.0	-176.0	-179.5	-184.0	-177.9
	7 degrees	-25	-150.0	-156.0	-162.0	-165.5	-168.0	-170.0	-176.0	-182.0	-185.5	-190.0	-183.9

Table 3: PP link to BS Interference (38 GHz)

The value of interference at the victim PP receiver is calculated for a range of distances and variations in the isolation and PP antenna pointing offset. The isolation values used are typical for systems which have frequency offsets equivalent to adjacent channel operation, one guard channel or two guard channels, although the intention is not to specify the actual guard band required, only the necessary amount of isolation. The target interference level is less than or equal to –100 dBm (28 MHz channel). This corresponds to –114.5dBm/ MHz.

In the case where the BS is the interferer and with 25 dB of isolation (typically achieved with adjacent channel operation), the interference is too high unless there is a coordination zone of approximately 500m around the PP link station. Within this zone, a BS can only operate if its antenna pointing direction is suitably restricted. Some guidance on the pointing restrictions can be determined from tables 2 and 3. With a single guard channel (or equivalent amount of isolation), the coordination zone reduces to significantly less than 50m radius, with no pointing restrictions.

interference from PP link station to BS Rx			int path 50m	100m	200m	300m	400m	500m	1km	2km	3km	5km	5km
adjacent channel, same area case													
Frequency GHz		25											
Tx power, max	dBm	26											
wanted PP link path length km			5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	10.0
wanted path loss dB		-123-20log d	-137.0	-137.0	-137.0	-137.0	-137.0	-137.0	-137.0	-137.0	-137.0	-137.0	-143.0
interference path length, km			0.05	0.1	0.2	0.3	0.4	0.5	1.0	2.0	3.0	5.0	5.0
interference path loss dB			-97.0	-103.0	-109.0	-112.5	-115.0	-117.0	-123.0	-129.0	-132.5	-137.0	-137.0
Link antenna gain dBi		40	40	40	40	40	40	40	40	40	40	40	40
BS antenna gain dBi		19	19	19	19	19	19	19	19	19	19	19	19
SS antenna gain dBi		36	36	36	36	36	36	36	36	36	36	36	36
wanted Rx input, 16 QAM, dBm		-73	-73	-73	-73	-73	-73	-73	-73	-73	-73	-73	-73
PP link Tx power, no fade, dBm			-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-16.0	-10.0
interference power, no fade, dBm			-54.0	-60.0	-66.0	-69.6	-72.1	-74.0	-80.0	-86.0	-89.6	-94.0	-88.0
Less NFD for adjacent channel dB		25	-79.0	-85.0	-91.0	-94.6	-97.1	-99.0	-105.0	-111.0	-114.6	-119.0	-113.0
Less off axis RPE factor	3 degrees	-8	-87.0	-93.0	-99.0	-102.6	-105.1	-107.0	-113.0	-119.0	-122.6	-127.0	-121.0
	5.8 degrees	-19	-98.0	-104.0	-110.0	-113.6	-116.1	-118.0	-124.0	-130.0	-133.6	-138.0	-132.0
	10 degrees	-22	-101.0	-107.0	-113.0	-116.6	-119.1	-121.0	-127.0	-133.0	-136.6	-141.0	-135.0
Less NFD for 1 guard channel dB		49	-103.0	-109.0	-115.0	-118.6	-121.1	-123.0	-129.0	-135.0	-138.6	-143.0	-137.0
Less off axis RPE factor	3 degrees	-8	-111.0	-117.0	-123.0	-126.6	-129.1	-131.0	-137.0	-143.0	-146.6	-151.0	-145.0
	5.8 degrees	-19	-122.0	-128.0	-134.0	-137.6	-140.1	-142.0	-148.0	-154.0	-157.6	-162.0	-156.0
	10 degrees	-22	-125.0	-131.0	-137.0	-140.6	-143.1	-145.0	-151.0	-157.0	-160.6	-165.0	-159.0
Less NFD for 2 guard channels dB		70	-124.0	-130.0	-136.0	-139.6	-142.1	-144.0	-150.0	-156.0	-159.6	-164.0	-158.0
Less off axis RPE factor	3 degrees	-8	-132.0	-138.0	-144.0	-147.6	-150.1	-152.0	-158.0	-164.0	-167.6	-172.0	-166.0
	5.8 degrees	-19	-143.0	-149.0	-155.0	-158.6	-161.1	-163.0	-169.0	-175.0	-178.6	-183.0	-177.0
	10 degrees	-22	-146.0	-152.0	-158.0	-161.6	-164.1	-166.0	-172.0	-178.0	-181.6	-186.0	-180.0

Table 4: PP link to SS Interference (25 GHz).

interference from PP link station to SS Rx			int path 50m	100m	200m	300m	400m	500m	1km	2km	3km	5km	5km
adjacent channel, same area case													
Frequency GHz		38											
Tx power, max	dBm	26											
wanted PP link path length km			5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	10.0
path loss dB		-126.43-20log d	-140.4	-140.4	-140.4	-140.4	-140.4	-140.4	-140.4	-140.4	-140.4	-140.4	-146.4
interference path length, km			0.05	0.1	0.2	0.3	0.4	0.5	1.0	2.0	3.0	5.0	5.0
interference path loss dB			-100.4	-106.4	-112.4	-115.9	-118.4	-120.4	-126.4	-132.4	-135.9	-140.4	-140.4
Link antenna gain dBi		42	42	42	42	42	42	42	42	42	42	42	42
BS antenna gain dBi		20	20	20	20	20	20	20	20	20	20	20	20
SS antenna gain dBi		38	38	38	38	38	38	38	38	38	38	38	38
wanted Rx input, 16 QAM, dBm		-73	-73	-73	-73	-73	-73	-73	-73	-73	-73	-73	-73
PP link Tx power, no fade dBm			-16.6	-16.6	-16.6	-16.6	-16.6	-16.6	-16.6	-16.6	-16.6	-16.6	-10.6
interference power, no fade, dBm			-37.0	-43.0	-49.0	-52.5	-55.0	-57.0	-63.0	-69.0	-72.5	-77.0	-70.9
Less NFD for adjacent channel dB		25	-62.0	-68.0	-74.0	-77.5	-80.0	-82.0	-88.0	-94.0	-97.5	-102.0	-95.9
Less off axis RPE factor	2 degrees	-8	-70.0	-76.0	-82.0	-85.5	-88.0	-90.0	-96.0	-102.0	-105.5	-110.0	-103.9
	4 degrees	-19	-81.0	-87.0	-93.0	-96.5	-99.0	-101.0	-107.0	-113.0	-116.5	-121.0	-114.9
	7 degrees	-25	-87.0	-93.0	-99.0	-102.5	-105.0	-107.0	-113.0	-119.0	-122.5	-127.0	-120.9
Less NFD for 1 guard channel dB		49	-86.0	-92.0	-98.0	-101.5	-104.0	-106.0	-112.0	-118.0	-121.5	-126.0	-119.9
Less off axis RPE factor	2 degrees	-8	-94.0	-100.0	-106.0	-109.5	-112.0	-114.0	-120.0	-126.0	-129.5	-134.0	-127.9
	4 degrees	-19	-105.0	-111.0	-117.0	-120.5	-123.0	-125.0	-131.0	-137.0	-140.5	-145.0	-138.9
	7 degrees	-25	-111.0	-117.0	-123.0	-126.5	-129.0	-131.0	-137.0	-143.0	-146.5	-151.0	-144.9
Less NFD for 2 guard channels dB		70	-107.0	-113.0	-119.0	-122.5	-125.0	-127.0	-133.0	-139.0	-142.5	-147.0	-140.9
Less off axis RPE factor	2 degrees	-8	-115.0	-121.0	-127.0	-130.5	-133.0	-135.0	-141.0	-147.0	-150.5	-155.0	-148.9
	4 degrees	-19	-126.0	-132.0	-138.0	-141.5	-144.0	-146.0	-152.0	-158.0	-161.5	-166.0	-159.9
	7 degrees	-25	-132.0	-138.0	-144.0	-147.5	-150.0	-152.0	-158.0	-164.0	-167.5	-172.0	-165.9

Table 5: PP link to SS Interference (38 GHz).

In the case where the SS is the interferer, the level of interference is greater. Although the SS antenna beam-width is narrower, there are many stations distributed across the cell/ sector, so that the probability of interference may still be high.

With adjacent channel operation, the coordination area will be large. Because there are many SSs and new stations are added regularly, adjacent channel operation is not likely to be viable.

With a single channel guard band (or equivalent isolation), a coordination zone of around 250m radius is required around the interfering PP station. In this zone, an SS can only be placed if antenna pointing directions are favourable. As there are usually many SSs, coordination may be a significant task.

With a 2 channel guard- band (or equivalent isolation) the interference zone reduces to a very small area (much less than 50m radius around the PP station.

Conclusions for the PP to PMP scenarios

Interference Scenario (Note 1)	Frequency	Guideline	Notes
PP link station to BS	25 GHz	Single guard channel OR Adjacent channel operation plus 500m coordination zone	Operation in the coordination zone can be achieved by using antenna pointing restrictions
PP link station to BS	38 GHz	Single guard channel OR Adjacent channel operation plus 500m coordination zone	Operation in the coordination zone can be achieved by using antenna pointing restrictions
PP link station to SS	25 GHz	Single guard channel plus 250m coordination zone OR 2 channel guard band	Operation in the coordination zone can be achieved by using antenna pointing restrictions
PP link station to SS	38 GHz	Single guard channel plus 250m coordination zone OR 2 channel guard band	Operation in the coordination zone can be achieved by using antenna pointing restrictions
Note 1: The interference from PP to PMP systems is generally less severe than the reciprocal case.			

Table 6 Summary of results

In order to assure interference - free operation with a low level of coordination, a two - channel guard band is needed for the SS case and a single channel guard band is required for the BS case.

If only a single guard channel is available, coordination of SSs within a zone around the interfering PP link station is needed. Alternatively, it may well be the case that terrain and buildings reduce the level of interference, especially for the SS case. However, this is less probable than for the co-channel, adjacent area interference scenarios and should not be assumed.

References

[1] IEEE 802.16.2p-00/13: “Coexistence analysis at 26 GHz and 28 GHz” (This paper contains an explanation of NFD and provides NFD values derived from an ETSI report)
[2] IEEE C802.16.2a-01/06; “System parameters for point to point links for use in Coexistence Simulations (revision 1)”
[3] IEEE 802.16.2-01/14; “Proposed Antenna Radiation Pattern Envelopes for Coexistence Study”.
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[5] IEEE 802.16.2-2001; “Recommended Practice for coexistence of Fixed Broadband Wireless Access Systems.”
[6] ETSI Technical Report TR 101 853 v1.1.1 (2000-10); “Fixed Radio Systems; Point to point and point to multipoint equipment; Rules for the coexistence of point to point and point to multipoint systems using different access methods in the same frequency band.”
[7] IEEE C802.16.2a-02/06; “Interim considerations from simulations”

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