Contributions to SE43 Group – 10th Meeting

SE43(11)32 – Further analisis on EIRP limits for WSDs
SE43(11)33 – Maximum EIRP calculation method

Nokia Institute of Technology - INdT

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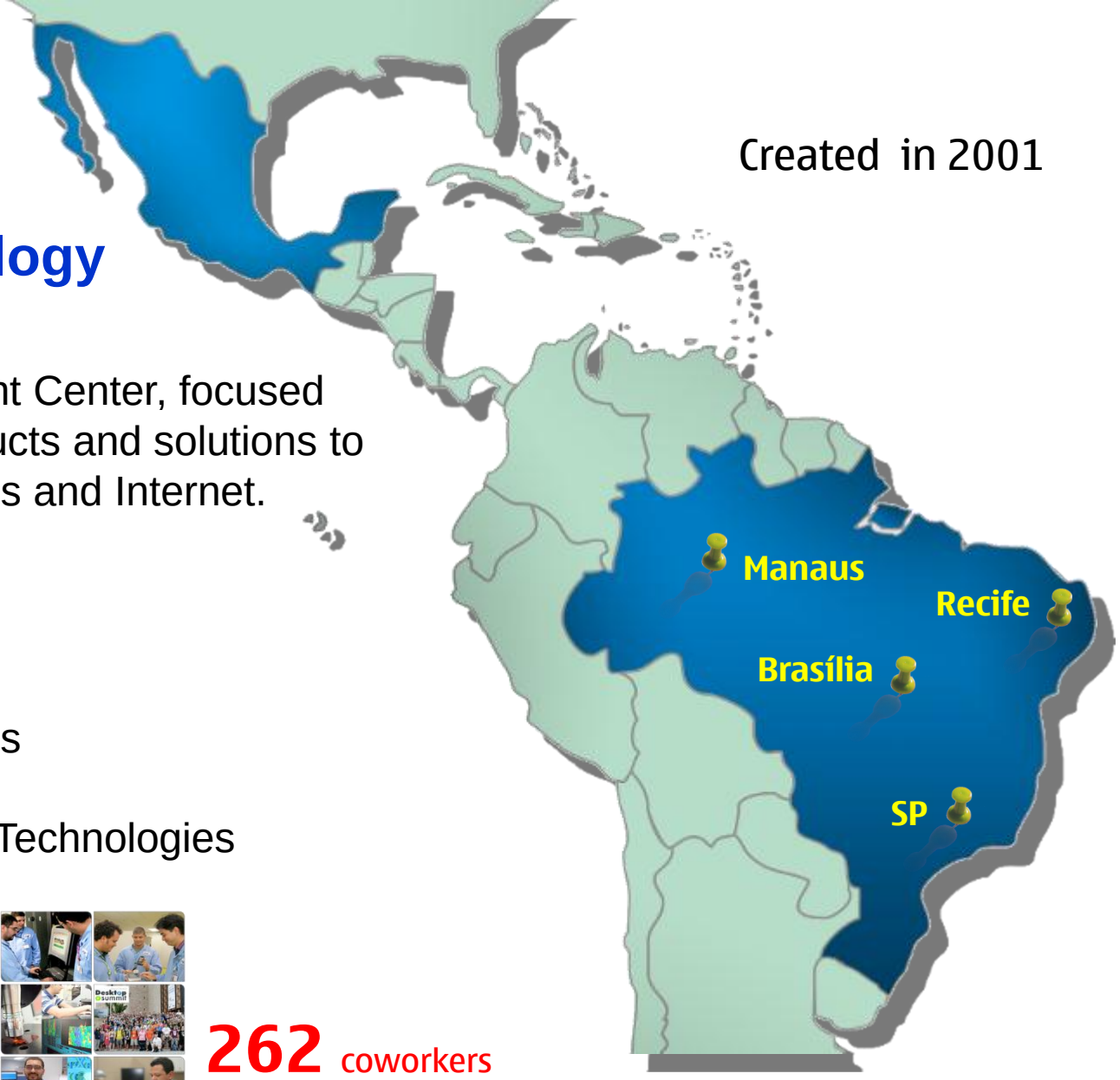


Our key areas are:

- Software and User Interfaces
- Network Technologies
- Product and Manufacturing Technologies
- Service Experiences

262 coworkers

SE43(11)32 – Further analisis on EIRP limits for WSDs

- Considerations on document SE43(11)12
  - Protection criteria
  - Multiple WSD interferers
  - Interference modeling
- Proposal
  - The attachment of the contribution is attached to the working document and Section 5 is placed into Section 3 of the working document
    - Location specific emissions of WSDs are limited by a determined level of **location probability degradation**, where a reference **protection ratio** is considered and an **overloading threshold** is respected
    - Need for further investigation on: path loss model for short distances, modeling of interference signal at DTT receiver, suitable levels of location probability degradation, reference values of protection ratio, reference values of overloading threshold
    - Two scenarios that resemble the traditional fixed service point-to-point usage allow high WSD transmit powers
    - Simultaneous multiple WSD interferers is a worst case over a worst case assumption and it is suggested that statistics of reference scenarios are taken into account

SE43(11)32 – Further analisis on EIRP limits for WSDs – Study methodology in document SE43(11)12

- Wanted signal and interference signal at the DTT receiver are random variables

$$\boldsymbol{E_{wmed}}\ [\mathrm{dB\mu V/m}] \sim N(E_{wmed}, \sigma_w = 5.5)$$
$$\boldsymbol{E_{imed}}\ [\mathrm{dB\mu V/m}] \sim N(E_{imed}, \sigma_I = 3.5)$$

- Monte-Carlo simulations
  - Location probability

$$LP = \Pr\{\boldsymbol{E_{wmed}} > E_{wmed\_ref}\}$$

  - Location probability under WSD interference

$$LP_{WSD} = \Pr\{\boldsymbol{E_{wmed}} > E_{wmed\_ref} + \boldsymbol{E_{imed}}\}$$

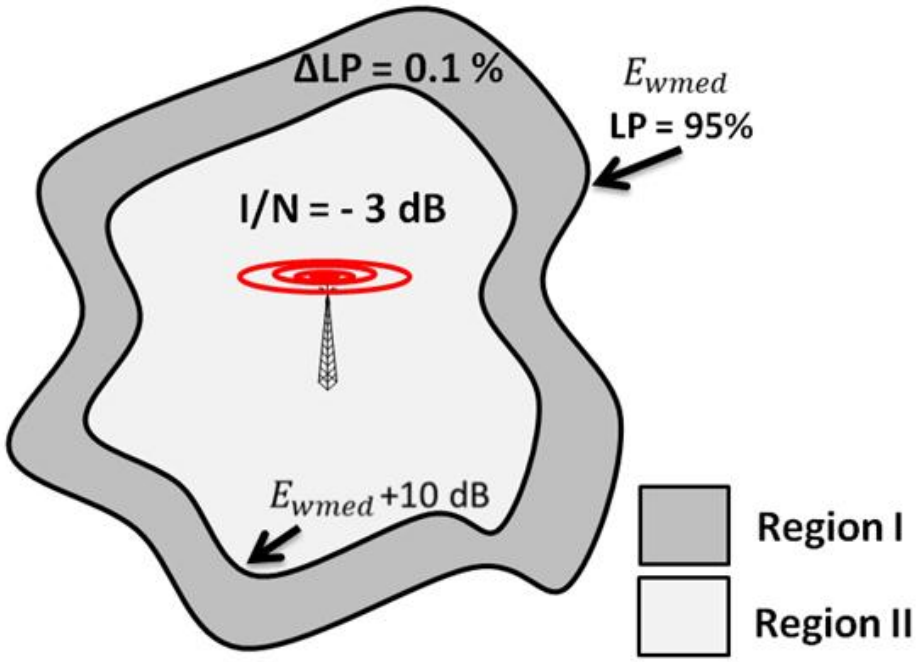
  - Location probability degradation

$$\Delta LP = LP - LP_{WSD}$$

SE43(11)32 – Further analisis on EIRP limits for WSDs – Document SE43(11)12

- Assumptions and methodology in document SE43(11)12

Two distinct regions



- Claim
  - New approved Recommendation ITU-R BT. 1895 states
    - **I/N <= - 20 dB** for all radiations and emissions without a corresponding frequency allocation in the Radio Regulations
- Proposal
  - **I/N <= - 3 dB**
    - For $E_{w\_med\_ref}$ + 10 dB, 0.1% location probability degradation is observed to be equivalent to I/N ≈ - 3 dB
- Maximum WSD EIRP calculation
  - Region I
    - 0.1% location probability degradation
  - Region II
    - 0.1% location probability degradation at $E_{w\_med\_ref}$ + 10 dB

SE43(11)32 – Further analisis on EIRP limits for WSDs – Validation results

- Relationship between E_{wmed}, LP, and E'_{imed} for fixed outdoor DTT reception and $\Delta LP = 0.1\%$
  - Results are similar to those in document SE43(11)12

Location	E_{wmed} $[dB\mu V/m]$	LP [%] (calculated)	LP [%] (simulated)	$E'_{imed}[dB\mu V/m]$
Coverage edge (E_{wmed})	65.26	95.01	94.96	5.408
$E_{wmed} + 1$ dB	66.26	96.62	96.61	7.008
$E_{wmed} + 2$ dB	67.26	97.77	97.74	8.408
$E_{wmed} + 3$ dB	68.26	98.58	98.56	10.01
$E_{wmed} + 4$ dB	69.26	99.12	99.11	11.71
$E_{wmed} + 5$ dB	70.26	99.47	99.46	13.61
$E_{wmed} + 6$ dB	71.26	99.69	99.69	15.41
$E_{wmed} + 7$ dB	72.26	99.82	99.83	17.11
$E_{wmed} + 8$ dB	73.26	99.90	99.90	19.01
$E_{wmed} + 9$ dB	74.26	99.95	99.95	20.91
$E_{wmed} + 10$ dB	75.26	99.97	99.97	22.51

SE43(11)32 – Further analisis on EIRP limits for WSDs – Validation results

- Relationship between E_{wmed}, LP, and E'_{imed} for <u>portable outdoor DTT reception</u> and $\Delta LP = 0.1\%$
  - Discrepancy of about 7 dB from results in document SE43(11)12 ($G_F = 9.15$ dBi, $G_P = 2.15$ dBi)

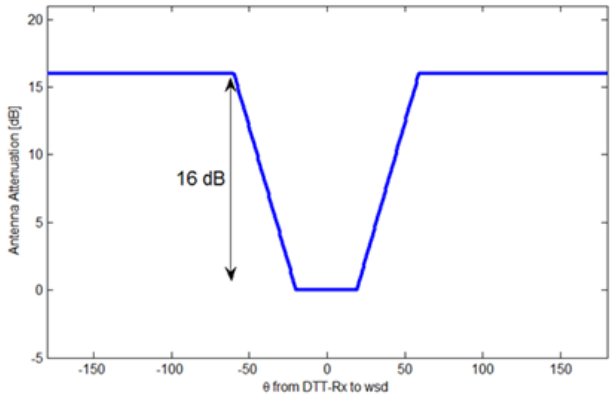
Location	E_{wmed} $[dB\mu V/m]$	LP [%] (calculated)	LP [%] (simulated)	$E'_{imed}[dB\mu V/m]$
Coverage edge (E_{wmed})	70.26	95.01	94.98	19.51
$E_{wmed} + 1$ dB	71.26	96.62	96.60	21.01
$E_{wmed} + 2$ dB	72.26	97.77	97.78	22.31
$E_{wmed} + 3$ dB	73.26	98.58	98.58	24.01
$E_{wmed} + 4$ dB	74.26	99.12	99.11	25.71
$E_{wmed} + 5$ dB	75.26	99.47	99.46	27.41
$E_{wmed} + 6$ dB	76.26	99.69	99.69	29.21
$E_{wmed} + 7$ dB	77.26	99.82	99.83	31.21
$E_{wmed} + 8$ dB	78.26	99.90	99.90	33.11
$E_{wmed} + 9$ dB	79.26	99.95	99.95	34.91
$E_{wmed} + 10$ dB	80.26	99.97	99.97	36.41

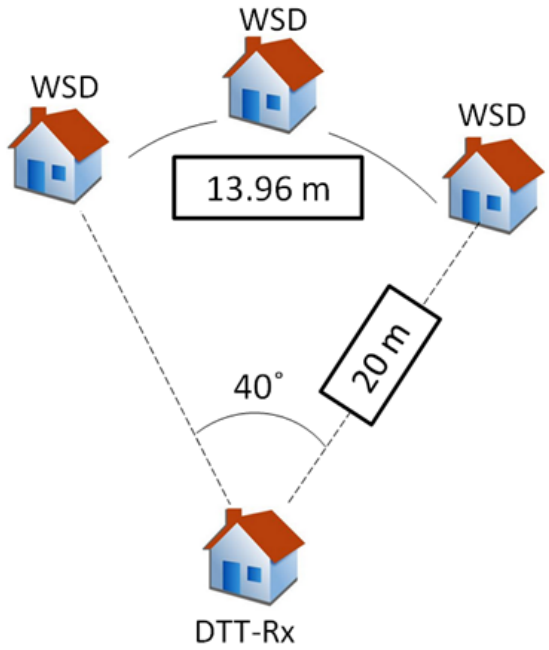
SE43(11)32 – Further analisis on EIRP limits for WSDs – Protection criteria

- I/N based protection criterion for DTT service is adopted in document SE43(11)12
  - Limitation of interference to broadcasting systems is recommended in ITU-R BT.1895
  - Studies consider as interference sources non-broadcasting radiocommunication devices like ultra-wideband (UWB) devices and short-range FM modulators (Recommendation ITU-R SM. 1757 and Report ITU-R SM 2050)
- Are I/N based protection criteria suitable to TV white spaces ?
  - Protection of the primary DTT service should be defined according to specific studies on the impact of interference on the DTT receiver and on the DTT reception quality
- Protection criterion jointly considering three elements
  - Location probability degradation
  - Protection ratio
  - Overloading threshold

SE43(11)32 – Further analisis on EIRP limits for WSDs – Multiple WSD interferers

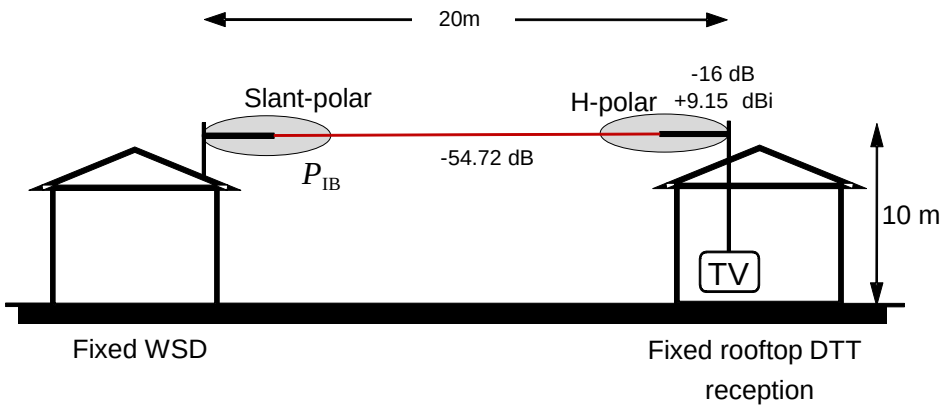
- Reference scenarios are the worst case interference situations (distance and angle between WSD transmitter and DTT receiver)
- Considering 3 equivalent WSDs interferers in these scenarios (SE43(11)12) is a worst case over a worst case assumption
- For fixed outdoor WSD: improbable worst case interference configuration (Scenarios 4 and 5)



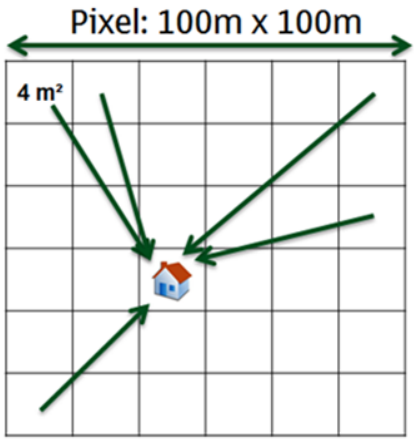


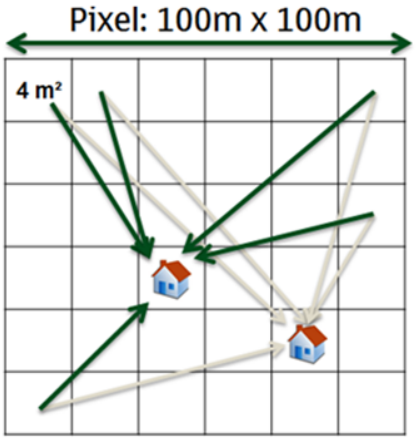
Attenuation diagram of DTT receive antenna (ITU-R BT.419-3) and the spatial composition of the worst case interference configuration with 3 WSDs interferers

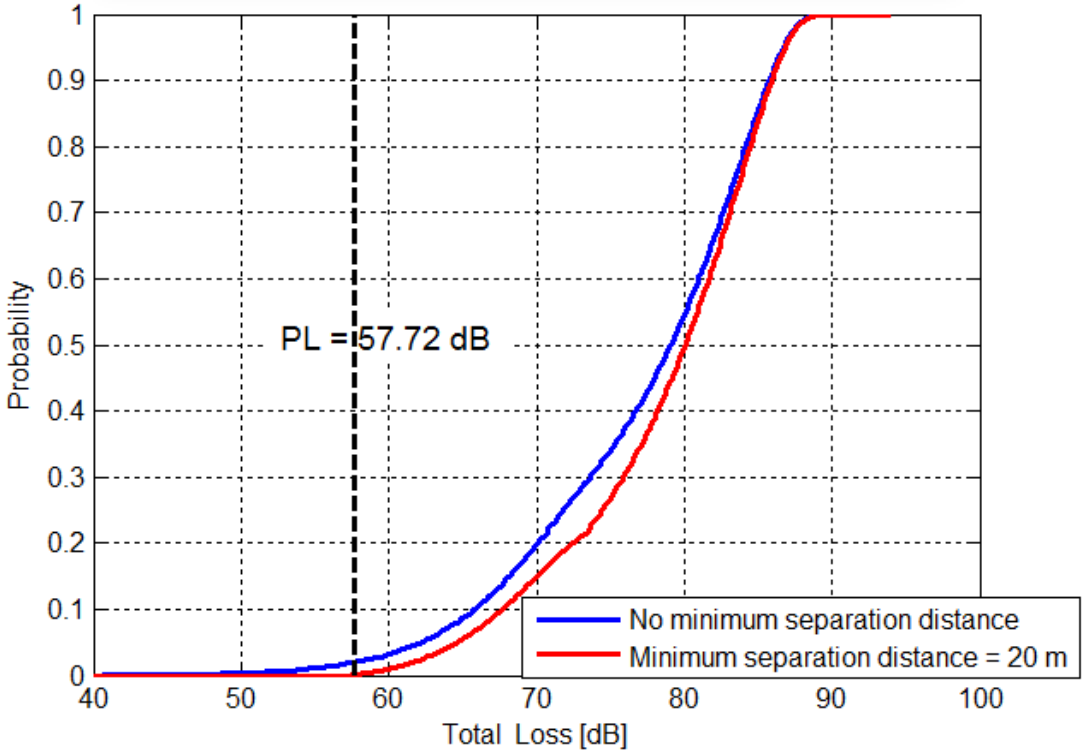
SE43(11)32 – Further analisis on EIRP limits for WSDs – Probability of occurrence of Scenario 4



Probability of occurrence of scenario 4 are close to 0.5% and 2% for respectively considering and not considering the minimum separation distance (20 m).



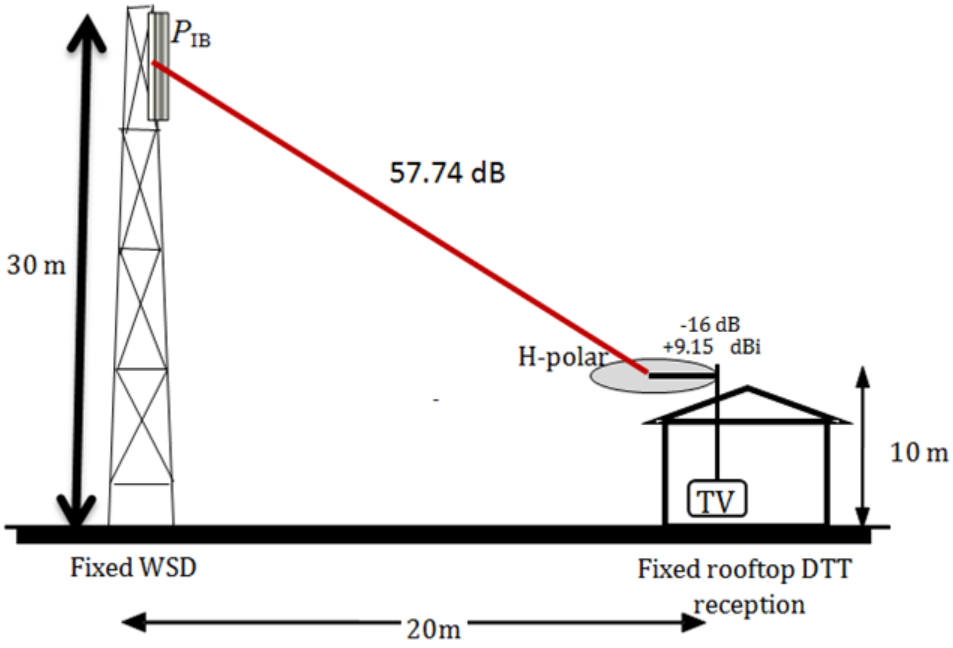




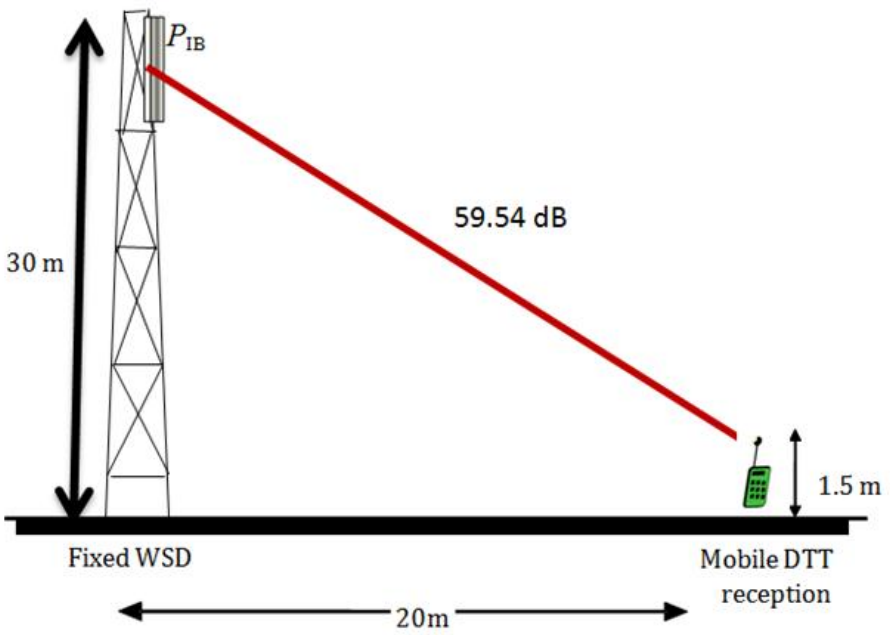
SE43(11)32 – Further analisis on EIRP limits for WSDs – Composition of scenarios

- Scenarios that resemble the traditional fixed service point-to-point usage
  - High WSD power limits

Scenario 6



Scenario 7



SE43(11)32 – Further analisis on EIRP limits for WSDs – Modeling of interference

- In SE43(11)12
  - Loss between WSD and DTT receiver is the most conservative (free space path loss)
  - Interference signal is modeled as a Gaussian random variable with standard deviation $\sigma_I = 3.5\ \mathrm{dB}$
  - Both aspects deserve further investigation

SE43(11)32 – Further analisis on EIRP limits for WSDs – Simulation configuration

- Interference modeling
  - No multi-interferers are considered
  - Interference signal as a Gaussian random variable with standard deviation $\sigma_I = 1$ dB
- Protection criterion
  - Location probability degradation: 0.1%
  - Protection ratio (as in SE43(11)12):

	Co-channel	1st adj. channel	2nd adj. channel
Fixed DTT receiver	21 dB	-30 dB	-40 dB
Portable DTT receiver	19 dB	-30 dB	-40 dB

  - Overloading threshold (ECC Report 148)

	Fixed DTT receiver		Portable DTT receiver	
	1st adj. channel	2nd adj. channel	1st adj. channel	2nd adj. channel
Fixed WSD transmitter	-13 dBm	-7 dBm	-26 dBm	-22 dBm
Portable WSD transmitter	-20 dBm	-25.5 dBm	-27 dBm	-47 dBm

SE43(11)32 – Further analisis on EIRP limits for WSDs – Simulation results

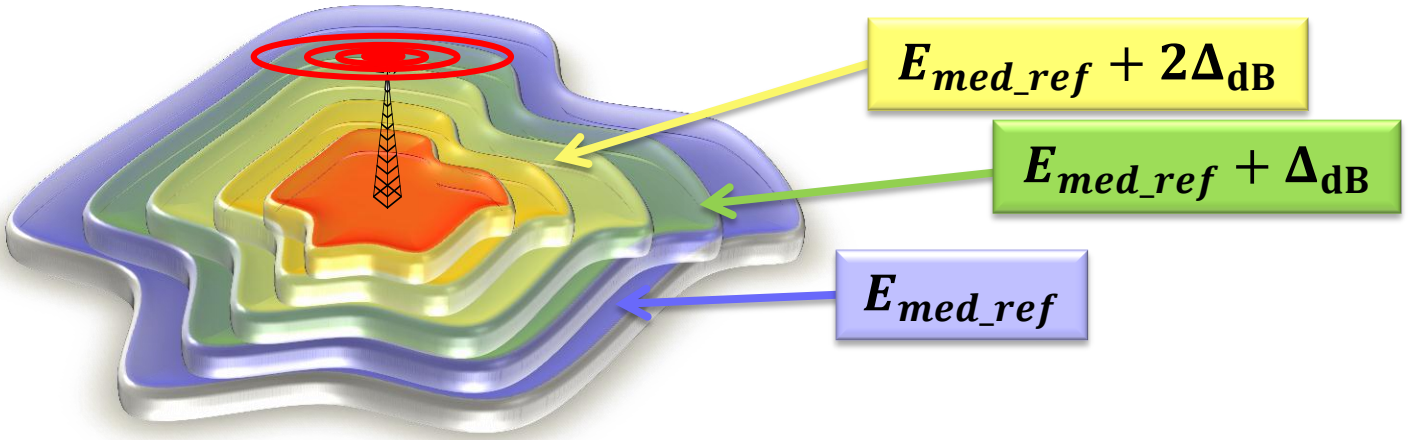
- WSD EIRP limits [dBm]

Location	Portable WSD transmitter		Portable WSD transmitter		Portable WSD transmitter		Fixed WSD transmitter		Fixed WSD transmitter		Fixed WSD transmitter		Fixed WSD transmitter	
	Fixed DTT receiver		Fixed DTT receiver		Portable DTT receiver		Fixed DTT receiver		Portable DTT receiver		Fixed DTT receiver		Portable DTT receiver	
	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		Scenario 6		Scenario 7	
	1st adj	2nd adj	1st adj	2nd adj	1st adj	2nd adj	1st adj	2nd adj	1st adj	2nd adj	1st adj	2nd adj	1st adj	2nd adj
Coverage edge (E_{wmed})	-19.0	-9.0	-20.8	-10.8	-28.8	-18.8	-17.8	-7.8	1.9	11.9	22.9	32.9	35.1	45.1
E_{wmed} + 1 dB	-17.6	-7.6	-19.4	-9.4	-27.6	-17.6	-16.4	-6.4	3.1	13.1	24.3	34.3	36.3	46.3
E_{wmed} + 2 dB	-16.3	-6.3	-18.1	-8.1	-26.1	-16.1	-15.1	-5.1	4.6	14.6	25.6	35.6	37.8	47.8
E_{wmed} + 3 dB	-14.7	-4.7	-16.6	-6.6	-24.5	-14.5	-13.6	-3.6	6.2	16.2	27.1	37.1	39.4	49.4
E_{wmed} + 4 dB	-12.6	-2.6	-14.5	-4.5	-22.7	-12.7	-11.5	-1.5	8.0	18.0	29.2	39.2	41.2	51.2
E_{wmed} + 5 dB	-10.8	-0.8	-12.7	-2.7	-20.5	-12.3	-9.7	0.3	10.2	20.2	31.0	41.0	43.4	53.4
E_{wmed} + 6 dB	-8.9	1.1	-10.8	-0.8	-18.5	-12.3	-7.8	2.2	12.2	22.2	32.9	42.9	45.4	55.4
E_{wmed} + 7 dB	-7.0	3.0	-8.9	1.1	-16.8	-12.3	-5.9	4.1	13.9	23.9	34.8	44.8	47.1	57.1
E_{wmed} + 8 dB	-4.9	5.1	-6.8	3.2	-14.7	-12.3	-3.8	6.2	16.0	26.0	36.9	46.9	49.2	59.2
E_{wmed} + 9 dB	-3.0	7.0	-4.9	5.1	-12.8	-12.3	-1.9	8.1	17.9	27.9	38.8	48.8	51.1	61.1
E_{wmed} + 10 dB	-1.2	8.8	-3.1	6.9	-10.9	-12.3	-0.1	9.9	19.8	29.8	40.6	50.6	53.0	63.0
E_{wmed} + 20 dB	11.7	21.7	9.8	19.8	1.9	-12.3	12.8	22.8	32.6	42.6	53.5	63.5	65.8	75.8

SE43(11)33 – Maximum EIRP calculation method

SE43(11)33 – Maximum EIRP calculation method – Proposal

- We propose to divide the coverage area in layers, according to the mean received DTT field strenght

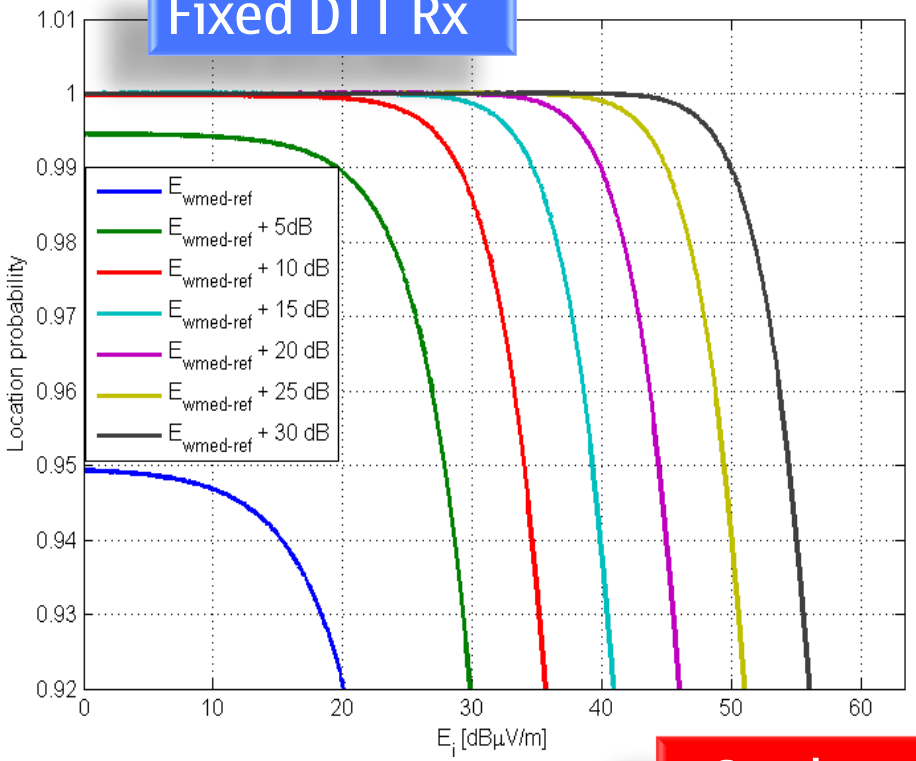


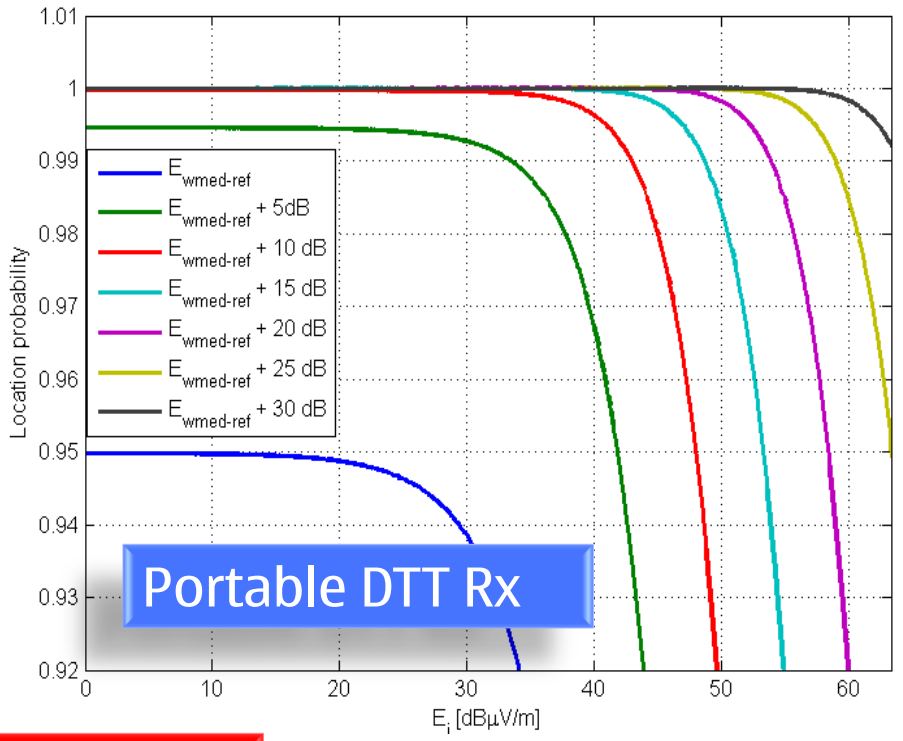
- In each layer, we apply the **protection criteria of 0.1% degradation in location probability** and calculate the maximum interference that can be caused.
- The upper limit is set by **overloading thresholds** for each type of WSD.
- The maximum EIRP is calculated according to **reference geometries**

Location probability as a function of the maximum interference field strength at the DTT receiver

$$LP_{\mathrm{WSD}} = \Pr(\boldsymbol{E_{wmed}} \geq E_{wmed\_ref} + \boldsymbol{E_{imed}})$$

Fixed DTT Rx





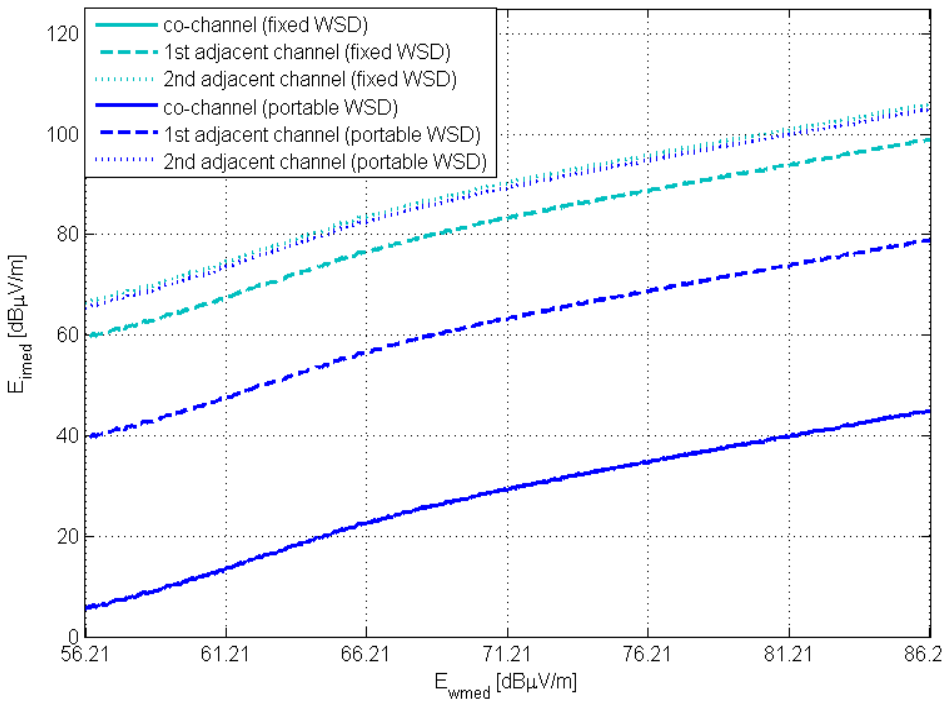
Portable DTT Rx

Co-channel operation

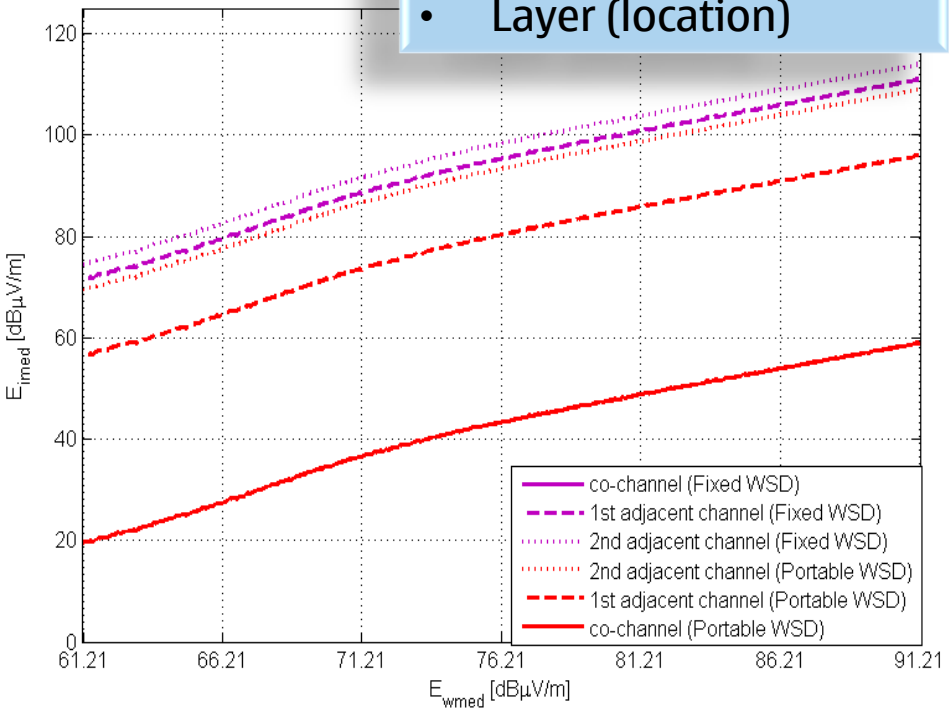
Interference field strength as a function of the wanted signal field strength for different layers

E_imed varies with:

- Channel
- Type of WSD
- Type of DTT Rx
- Layer (location)



Fixed DTT Rx



Portable DTT Rx

Note: Location probability degradation in 0.1%

Maximum permitted interference

$$I_{[dBm]} = E_{imed_{[dB\mu V/m]}} - 20\log_{10}(f_{[MHz]}) - 77.2$$

All values are bellow the overloading thresholds that protects 90% of the receivers

Fixed DTT Rx

	$I_{[dBm]}$ Fixed WSD		$I_{[dBm]}$ Portable WSD	
	1st adjacent channel	2nd adjacent channel	1st adjacent channel	2nd adjacent channel
E_{wmed_ref}	-74.05	-67.05	-94.05	-68.05
E_{wmed_ref} + 5 dB	-65.85	-58.85	-85.85	-59.85
E_{wmed_ref} + 10 dB	-56.95	-49.95	-76.95	-50.95
E_{wmed_ref} + 15 dB	-50.25	-43.25	-70.25	-44.25
E_{wmed_ref} + 20 dB	-44.75	-37.75	-64.75	-38.75
E_{wmed_ref} + 25 dB	-39.65	-32.65	-59.65	-33.65
E_{wmed_ref} + 30 dB	-34.55	-27.55	-54.55	-28.55
0th [dBm]	-13	-7	-20	-25.50

Maximum permitted interference

$$I_{[dBm]} = E_{imed_{[dB\mu V/m]}} - 20\log_{10}\left(f_{[MHz]}\right) - 77.2$$

Some values exceed the overloading threshold

Portable DTT Rx

	$I_{[dBm]}$ Fixed WSD		$I_{[dBm]}$ Portable WSD	
E_{wmed}	1st adjacent channel	2nd adjacent channel	1st adjacent channel	2nd adjacent channel
E_{wmed_ref}	-61.95	-58.95	-76.95	-63.95
E_{wmed_ref} + 5 dB	-54.05	-51.05	-69.05	-56.05
E_{wmed_ref} + 10 dB	-45.05	-42.05	-60.05	-47.05
E_{wmed_ref} + 15 dB	-38.15	-35.15	-53.15	-40.15
E_{wmed_ref} + 20 dB	-32.65	-29.65	-47.65	-34.65
E_{wmed_ref} + 25 dB	-27.45	-24.45	-42.45	-29.45
E_{wmed_ref} + 30 dB	-22.65	-19.65	-37.65	-24.65
0th [dBm]	-26	-22	-27	-47

Maximum permitted interference

Portable DTT Rx

	$I_{[dBm]}$ Fixed WSD		$I_{[dBm]}$ Portable WSD	
E_{wmed}	1st adjacent channel	2nd adjacent channel	1st adjacent channel	2nd adjacent channel
E_{wmed_ref}	-61.95	-58.95	-76.95	-63.95
E_{wmed_ref} + 5 dB	-54.05	-51.05	-69.05	-56.05
E_{wmed_ref} + 10 dB	-45.05	-42.05	-60.05	-47.05
E_{wmed_ref} + 15 dB	-38.15	-35.15	-53.15	-47
E_{wmed_ref} + 20 dB	-32.65	-29.65	-47.65	-47
E_{wmed_ref} + 25 dB	-27.45	-24.45	-42.45	-47
E_{wmed_ref} + 30 dB	-26	-22	-37.65	-47
0th [dBm]	-26	-22	-27	-47

Maximum WSD EIRP

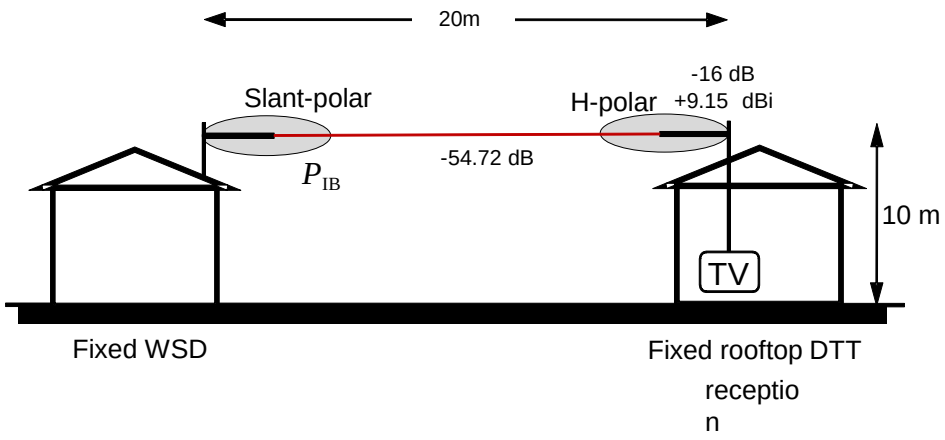
$$EIRP_{[dBm]} = I_{[dBm]} + LOSS$$

	Distance [m]	DTT height [m]	WSD height [m]	Polarization discrimination [dB]	Rx Antenna discrimination [dB]	Tx antenna attenuation [dB]	Total Loss [dB]
Scenario 1	22	10	1.5	-	0.45	-	56.6
Scenario 2	20	10	10	-	-	-	54.72
Scenario 3	2	1.5	1.5	-	-	-	34.72
Scenario 4	22	10	10	3	-	-	57.72
Scenario 5	20	1.5	10	-	-	10	65.45

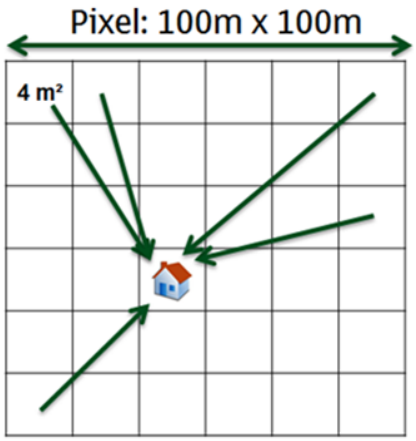
Layer	Fixed DTT		Fixed DTT		Portable DTT		Fixed DTT		Portable DTT	
	Portable WSD		Portable WSD		Portable WSD		Fixed WSD		Fixed WSD	
	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5	
	1st adj	2nd adj	1st adj	2nd adj	1st adj	2nd adj	1st adj	2nd adj	1st adj	2nd adj
E_{wmed_ref}	-37.4	-11.4	-39.3	-13.3	-42.2	-29.2	-16.3	-9.3	3.5	6.5
E_{wmed_ref} + 5 dB	-29.2	-3.2	-31.1	-5.1	-34.3	-21.3	-8.1	-1.1	11.4	14.4
E_{wmed_ref} + 10 dB	-20.3	5.7	-22.2	3.8	-25.3	-12.3	0.8	7.8	20.4	23.4
E_{wmed_ref} + 15 dB	-13.6	12.4	-15.5	10.5	-18.4	-12.3	7.5	14.5	27.3	30.3
E_{wmed_ref} + 20 dB	-8.1	17.9	-10.0	16.0	-12.9	-12.3	13.0	20.0	32.8	35.8
E_{wmed_ref} + 25 dB	-3.0	23.0	-4.9	21.1	-7.7	-12.3	18.1	25.1	38.0	41.0
E_{wmed_ref} + 30 dB	2.1	28.1	0.2	26.2	-2.9	-12.3	23.2	30.2	39.5	43.5

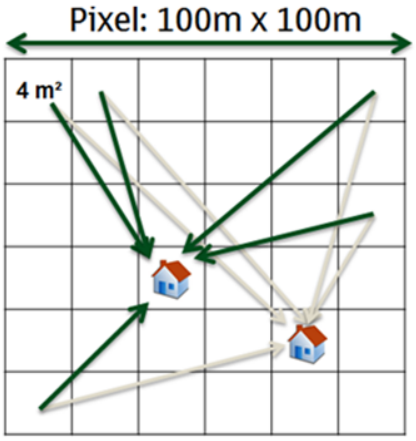
Maximum EIRP considering the 10th percentile of 0th

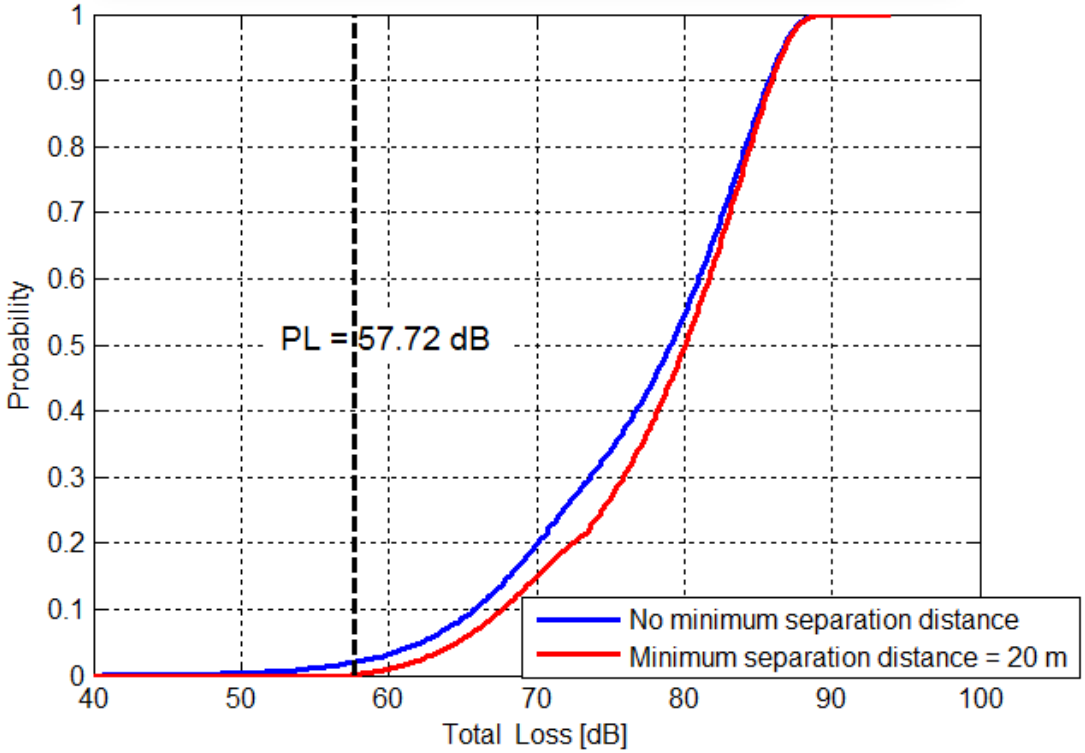
SE43(11)33 – Further analisis on EIRP limits for WSDs – Probability of occurrence of Scenario 4



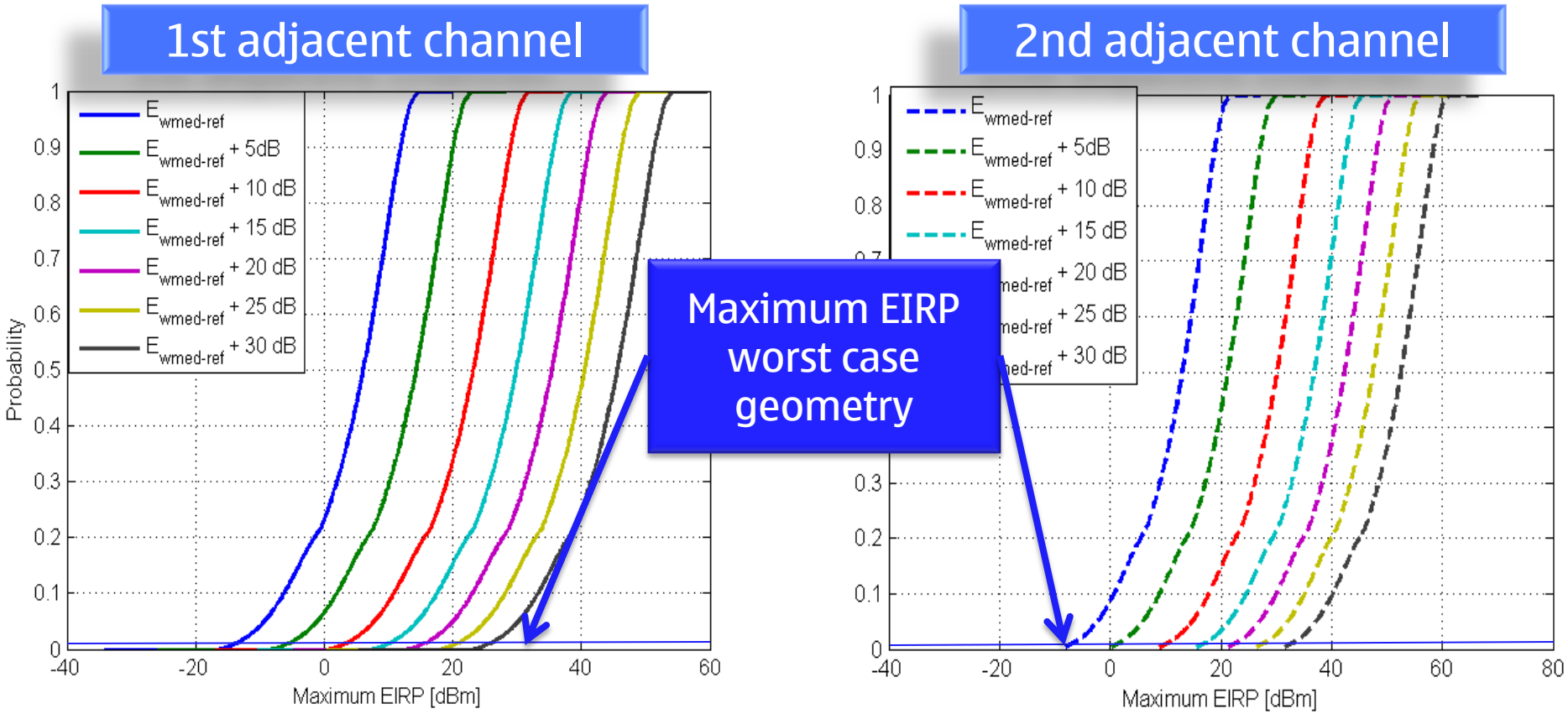
Probability of occurrence of scenario 4 are close to 0.5% and 2% for respectively considering and not considering the minimum separation distance (20 m).







Probability of occurence of scenario 4 and maximum EIRP Limits



Thank you!

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