

ITU Workshop on “Practical measurement of EMF exposure”

(Gaborone, Botswana, 25-26 July 2011)

Use of EMF estimator for Base Station authorization in a multi-source environment

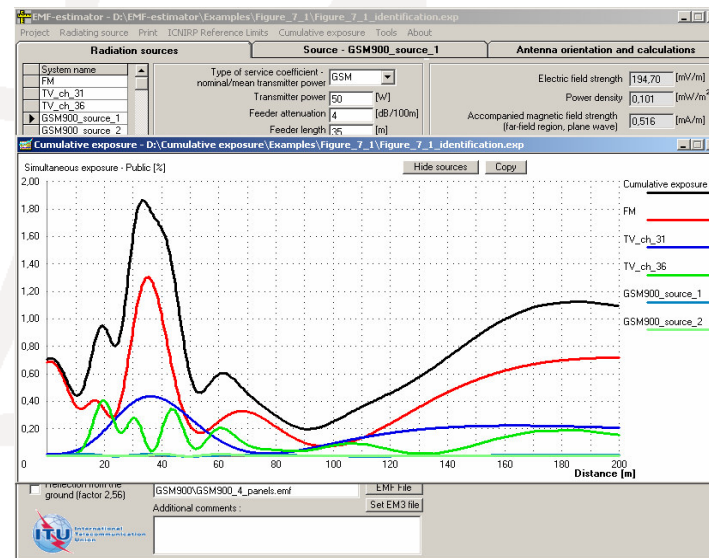
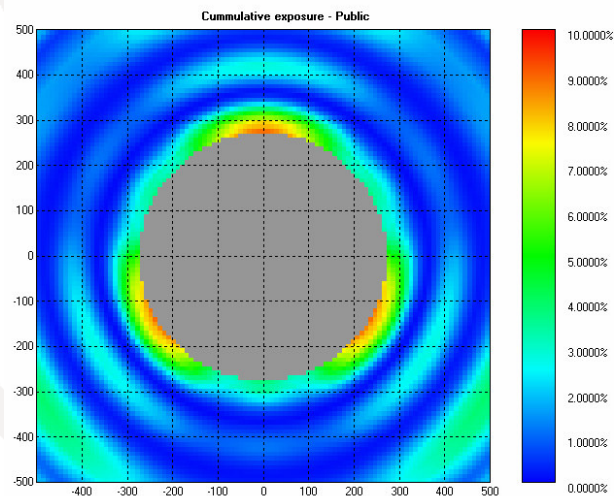
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ITU-T SG5, Rapporteur for Q 3/5
Telekomunikacja Polska
Orange Labs Poland**

Gaborone, Botswana, 25-26 July 2011



Introduction

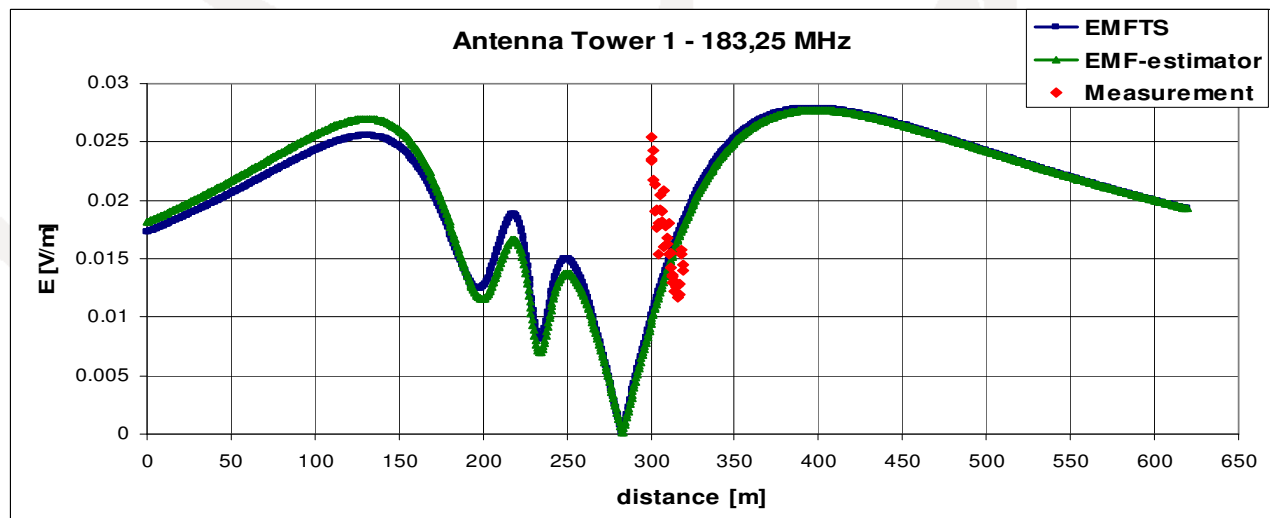
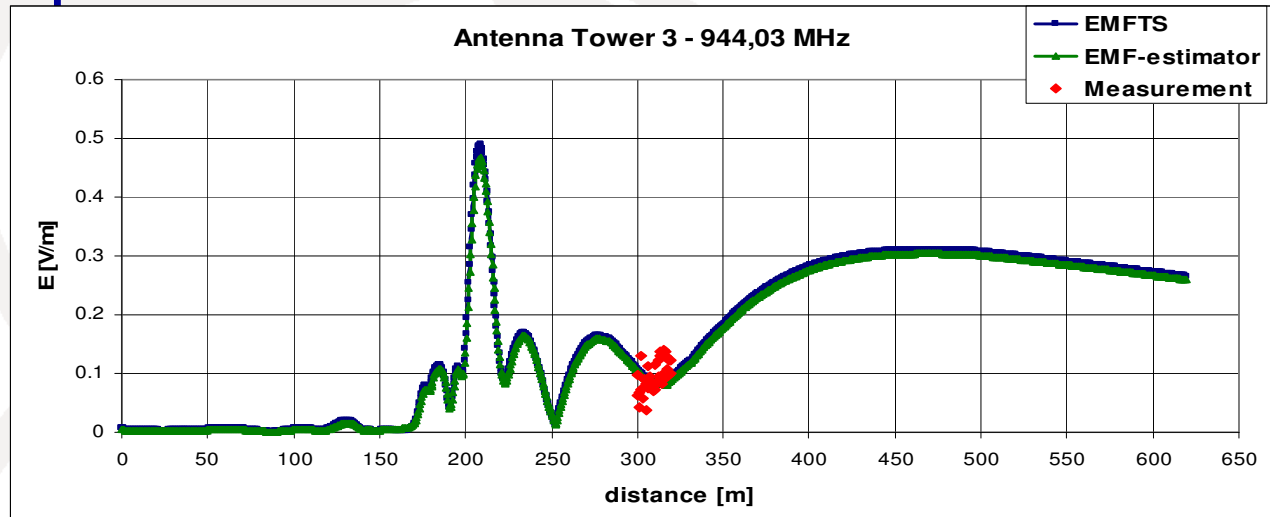
- Exposure assessment may be done by measurement or calculations
- Comparison measurement/calculation – see ITU-T Workshop in Nairobi 2010
- Calculation is much easier and cheaper to perform
- Current calculation methods give results very close to the measurement



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Introduction

Comparison measurement – calculation



Typical mobile base station

- Typical base station consists of 3 sectors (120° each) and operates in 2 or 3 bands (for example GSM900, GSM1800, UMTS)
- So it contains 6 to 9 independent sources of EMF



Multi sources environment

- Many base stations collocated at the same or neighboring towers
- Other radiating systems: broadcasting, radiocommunication, point-to-point fixed systems



Multi sources environment

- Contribution to the cumulative exposure is ERP dependent
- Typical ERP (K.70):
 - Cellular BS: 100-800W /per channel
 - FM: 50W – 120 kW
 - VHF TV: 0,1 – 200 kW
 - UHF TV: 0,1 – 1000 kW
 - AM/DRM: 0,1 – 4000 kW
 - WLAN: 0,01 – 1 W
 - radiocomm.: 10 – 1 kW

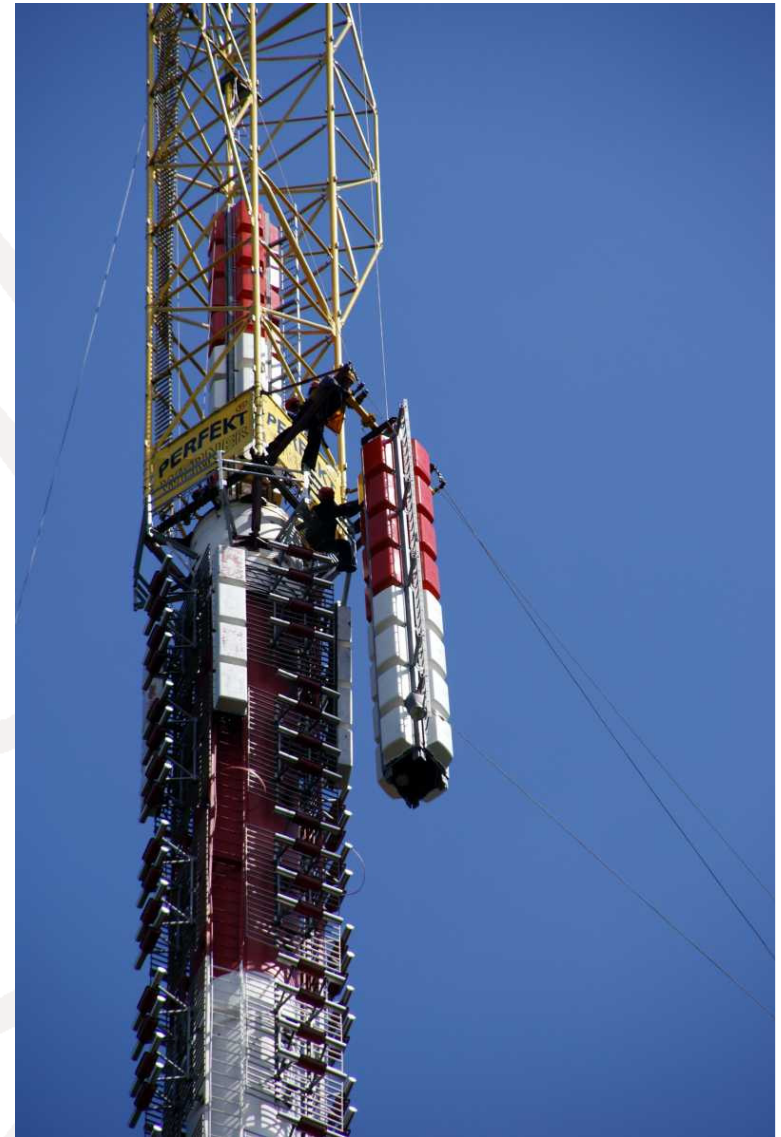


EMF-estimator

- EMF-estimator is the Annex I to the ITU-T Recommendation K.70
- The last version of the software (04.2011) may be loaded from the:
<http://www.itu.int/rec/T-REC-K.70-201105-I!Amd2>
http://www.itu.int/ITU-T/recommendations/index_sg.aspx?sg=5
- EMF-estimator is offered by ITU-T since 06.2007
- It is periodically updated / expanded according to the needs (in 2009 and 2011)

EMF-estimator

- EMF-estimator applies the point source model so it is fully valid for the far field region
- It may be used in the region of the radiating near-field but with lower accuracy
- It allows for the evaluation of the exposure to the EMF and the comparison with the exposure limits



EMF-estimator – validity area

EMF-estimator - D:\EMF_Estimator_ITU\Other_Examples\Base_Station_UMTS_3G.exp

Project Radiating source Print Reference Limits Cumulative exposure Calculations Tools About

Radiation sources	Source - UMTS_3G	Antenna orientation
System name ▶ UMTS_3G	Type of service coefficient - nominal/mean transmitter power: GSM	Electric field strength: 42.01 [mV/m]
	Transmitter power: 25 [W]	Power density: 0.005 [mW/m ²]
	Feeder attenuation: 5.2 [dB/100m]	Accompanied magnetic field strength (far-field region, plane wave): 0.111 [mA/m]
	Feeder length: 35 [m]	
	Additional attenuation: 0.7 [dB]	Exposure limits:
	Total attenuation: 2.52 [dB]	Electric field limit: Public 61.00 [V/m], Occupational 137.00 [V/m]
	Gain referred to isotropic antenna: 16.70 [dBi]	Power density limit: Public 10.00 [W/m ²], Occupational 50.00 [W/m ²]
	Gain referred to λ/2 dipole: 14.56 [dBd]	Compliance distance: Public 2.21 [m], Occupational 1.01 [m]
ERP: 399.9 [W]	HRP(φ): 0.0000 [dB]	Compliance distance(s) may be overestimated
EIRP: 655.8 [W]	VRP(θ): 0.0100 [V/V]	Simultaneous exposure to multiple sources:
EIRP (after type of service correction): 655.8 [W]	F(θ, φ): 0.010 [V/V]	Mainly thermal effect: 100 kHz - 300 GHz
Mechanical downtilt: 0 [deg]		This source: Public 0.00 [%], Occupational 0.00 [%]
Transmitting antenna height: 35 [m]		All sources simultaneously: Public 0.00 [%], Occupational 0.00 [%]
Distance from the start to the observation point: 1 [m]		Mainly electrical stimulation effect: 1 Hz - 10 MHz
Distance from the antenna to the observation point: 33.51 [m]		This source: Public [] [%], Occupational [] [%]
Elevation angle from transmitting antenna to the observation point: 178.3 [deg]		All sources simultaneously: Public 0.00 [%], Occupational 0.00 [%]
Azimuth from the antenna to the observation point: 0 [deg]		
Frequency [MHz]: 2140	Field Regions:	
Maximum size of the antenna [m]: 1.302	Reactive near-field: (0, λ)	from [m] to [m]
Limit [Hz]:	Radiating near-field: (λ; max(3λ, 2D ² /λ))	0 0.14
	Far-field: (max(3λ, 2D ² /λ); ∞)	0.14 24.20
	EMF-estimator validity: (0.62D ² /λ; ∞)	24.20 ∞
		7.50 ∞
<input type="checkbox"/> Reflection from the ground (factor 2.56)	File with HRP and VRP: D:\00ESTYMATOR\EMF_Estimator_ITU\Przykł	Show / Set EMF File
	Additional comments:	Set EM3 file

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EMF-estimator - Radiation sources

EMF-estimator - D:\EMF_Estimator_ITU\Other_Examples\B5_GSM900_GSM1800_UMTS.exp

Project Radiating source Print Reference Limits Cumulative exposure Calculations Tools About

Radiation sources Source - GSM900_az_120° Antenna orientation

System name	Type of service coefficient - nominal/mean transmitter power	GSM	Electric field strength	43.13 [mV/m]
GSM900_az_0°	Transmitter power	50 [W]	Power density	0.005 [mW/m ²]
▶ GSM900_az_120°	Feeder attenuation	4 [dB/100m]	Accompanied magnetic field strength (far-field region, plane wave)	0.114 [mA/m]
GSM900_az_240°	Feeder length	35 [m]	Exposure limits	
GSM900_az_60°	Additional attenuation	0.1 [dB]	Public	Occupational
GSM900_az_180°	Total attenuation	1.50 [dB]	Electric field limit	42.32 [V/m] 92.34 [V/m]
GSM1800_az_0°	Gain referred to isotropic antenna	17.00 [dBi]	Power density limit	4.74 [W/m ²] 23.69 [W/m ²]
GSM1800_az_120°	Gain referred to λ/2 dipole	14.86 [dBd]	Compliance distance	5.48 [m] 2.51 [m]
GSM1800_az_240°	ERP	1083.9 [W]	Compliance distance(s) may be overestimated	
GSM1800_az_300°	HRP(φ)	-15.4938 [dB]	Simultaneous exposure to multiple sources	
UMTS_3G_az_0°	EIRP	1777.5 [W]	Mainly thermal effect: 100 kHz - 300 GHz	
UMTS_3G_az_120°	EIRP (after type of service correction)	1777.5 [W]	Public	Occupational
UMTS_3G_az_240°	VRP(θ)	0.0371 [V/V]	This source	0.00 [%] 0.00 [%]
UMTS_3G_az_300°	F(θ, φ)	0.006 [V/V]	All sources simultaneously	0.02 [%] 0.00 [%]
	Mechanical downtilt	0 [deg]	Mainly electrical stimulation effect: 1 Hz - 10 MHz	
	Transmitting antenna height	35 [m]	Public	Occupational
	Distance from the start to the observation point	1 [m]	This source	0.00 [%] 0.00 [%]
	Distance from the antenna to the observation point	33.51 [m]	All sources simultaneously	0.00 [%] 0.00 [%]
	Elevation angle from transmitting antenna to the observation point	178.3 [deg]	Field Regions:	
	Azimuth from the antenna to the observation point	0 [deg]	Reactive near-field: (0, λ)	from [m] to [m]
	Frequency [MHz]	947.5	Radiating near-field: (λ ; max(3λ, 2D ² /λ))	0 0.32
	Maximum size of the antenna [m]	2.574	Far-field: (max(3λ, 2D ² /λ) ; ∞)	0.32 41.88
	Limits file		EMF-estimator validity: (0,62D ² /λ ; ∞)	41.88 ∞
				12.98 ∞

Reflection from the ground (factor 2.56)

File with HRP and VRP: D:\EMF-estimator\EMF_estimator_v1_2_0\Other Show / Set EMF File

Additional comments: Set EM3 file

Receiving point located in radiating near-field region. The field calculation does not take into account the antenna size (point-source model is used). Results of calculations may overestimate or underestimate real values !

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EMF-estimator - Source description

EMF-estimator - D:\EMF_Estimator_ITU\Other_Examples\BS_GSM900_GSM1800_UMTS.exp

Project Radiating source Print Reference Limits Cumulative exposure Calculations Tools About

Radiation sources **Source - GSM900_az_120*** **Antenna orientation**

Horizontal distance [m]	Power density [mW/m ²]
32.00	0.0095
32.50	0.0110
33.00	0.0121
33.50	0.0132
34.00	0.0138
34.50	0.0144
35.00	0.0145
35.50	0.0143
36.00	0.0140
36.50	0.0131
37.00	0.0122
37.50	0.0111
38.00	0.0099
38.50	0.0088
39.00	0.0072
39.50	0.0058
40.00	0.0046
40.50	0.0033
41.00	0.0023
41.50	0.0014
42.00	0.0008
42.50	0.0004
43.00	0.0002
43.50	0.0002
44.00	0.0002
44.50	0.0002
45.00	0.0005
45.50	0.0009
46.00	0.0013
46.50	0.0018
47.00	0.0022
47.50	0.0027
48.00	0.0031
48.50	0.0034

Type of service coefficient - nominal/mean transmitter power: GSM

Transmitter power: 50 [W]

Feeder attenuation: 4 [dB/100m]

Feeder length: 35 [m]

Additional attenuation: 0.1 [dB]

Total attenuation: 1.50 [dB]

Gain referred to isotropic antenna: 17.00 [dBi]

Gain referred to $\lambda/2$ dipole: 14.86 [dBd]

ERP: 1083.9 [W] HRP(ϕ): -15.4938 [dB]

EIRP: 1777.5 [W] VRP(θ): 0.0379 [V/V]

EIRP (after type of service correction): 1777.5 [W] F(θ, ϕ): 0.006 [V/V]

Mechanical downtilt: [] [deg]

Transmitting antenna height: 35 [m]

Distance from the start to the observ. point: 46.5 [m]

Distan. from the antenna to the observ. point: 57.31 [m]

Elevation angle from transmitting antenna to the observation point: 125.8 [deg]

Azimuth from the antenna to the observ. point: 0 [deg]

Electric field strength: 25.74 [mV/m]

Power density: 0.002 [mW/m²]

Accompanied magnetic field strength (far-field region, plane wave): 0.068 [mA/m]

Exposure limits:

	Public	Occupational
Electric field limit	42.32 [V/m]	92.34 [V/m]
Power density limit	4.74 [W/m ²]	23.69 [W/m ²]
Compliance distance	5.48 [m]	2.51 [m]

Compliance distance(s) may be overestimated

Simultaneous exposure to multiple sources

Mainly thermal effect: 100 kHz - 300 GHz

	Public	Occupational
This source	0.00 [%]	0.00 [%]

Mainly electrical stimulation effect: 1 Hz - 10 MHz

	Public	Occupational
This source	[] [%]	[] [%]

Field Regions:

	from [m]	to [m]
Reactive near-field: (0, λ)	0	0.32
Radiating near-field: (λ ; $\max(3\lambda, 2D^2/\lambda)$)	0.32	41.88
Far-field: ($\max(3\lambda, 2D^2/\lambda)$; ∞)	41.88	∞
EMF-estimator validity: ($0, 62D^2/\lambda$; ∞)	12.98	∞

Frequency [MHz]: 947.5

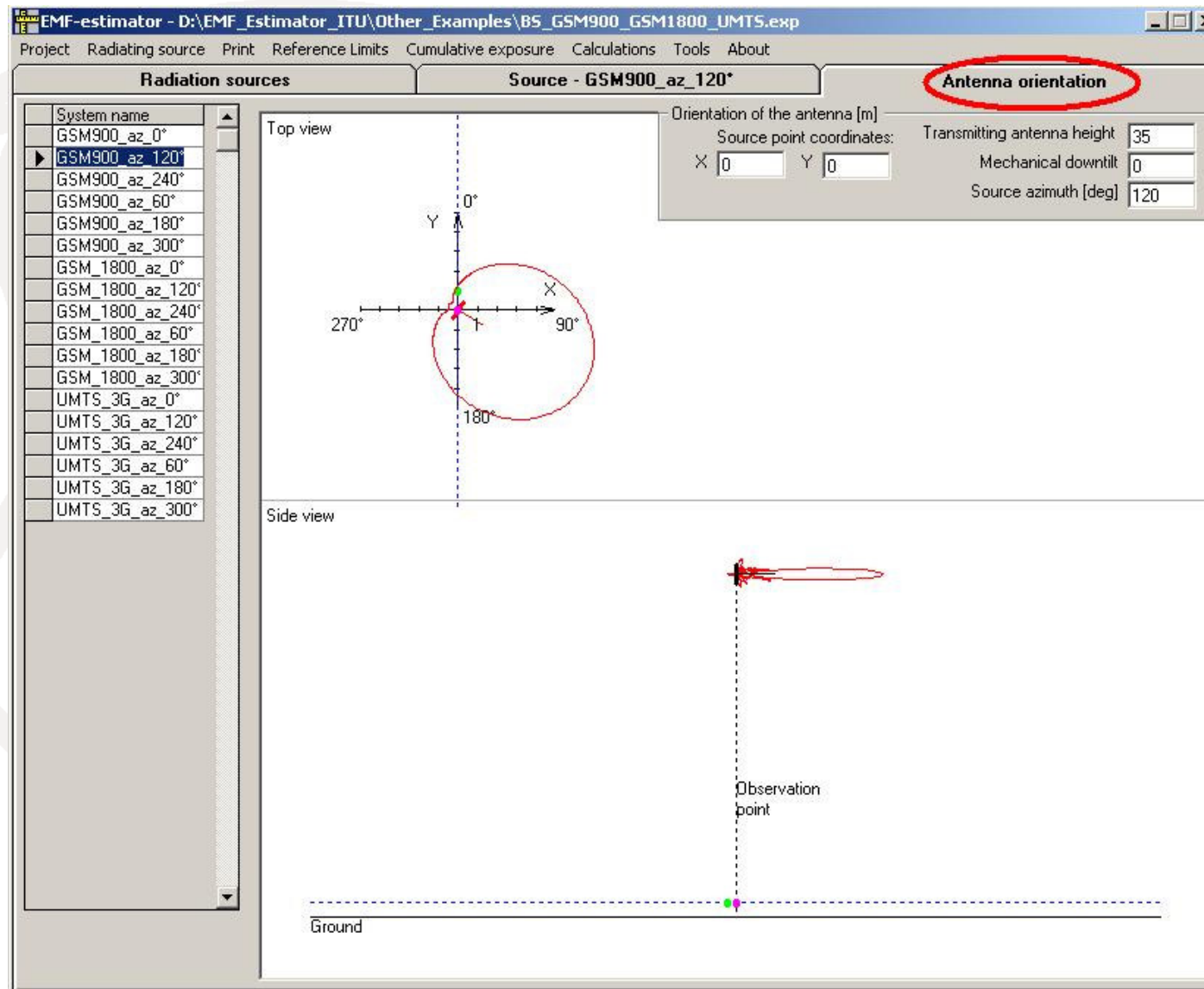
Maximum size of the antenna [m]: 2.574

Chart

Export

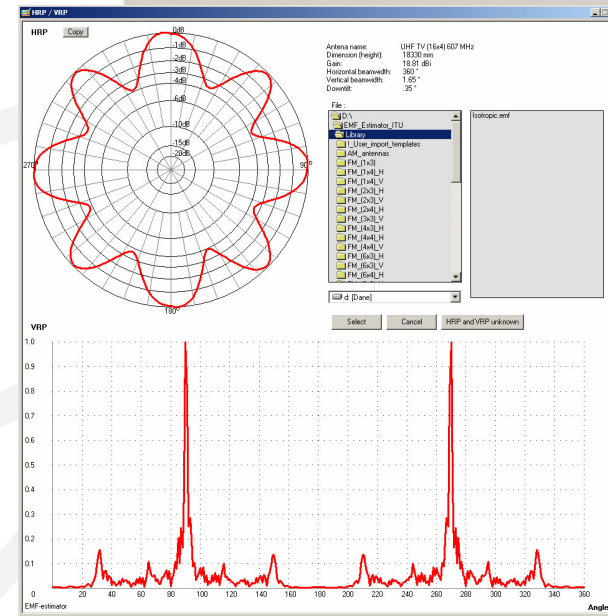
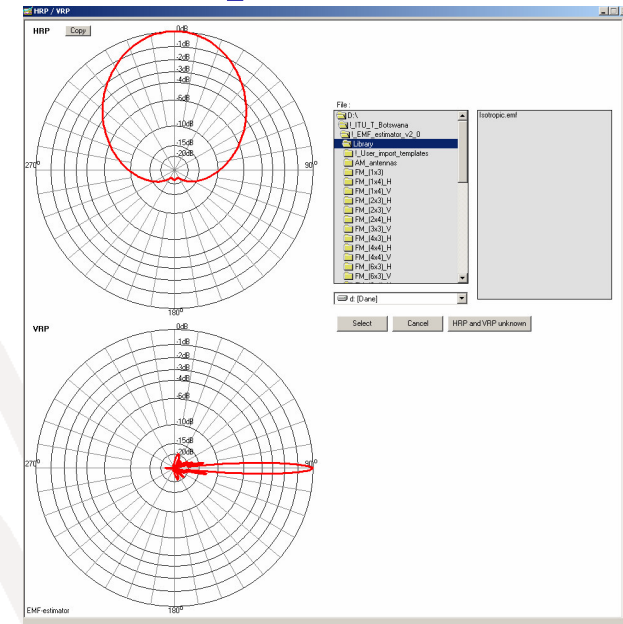
Reflection from the ground (factor 2.56)

EMF-estimator - Antenna orientation



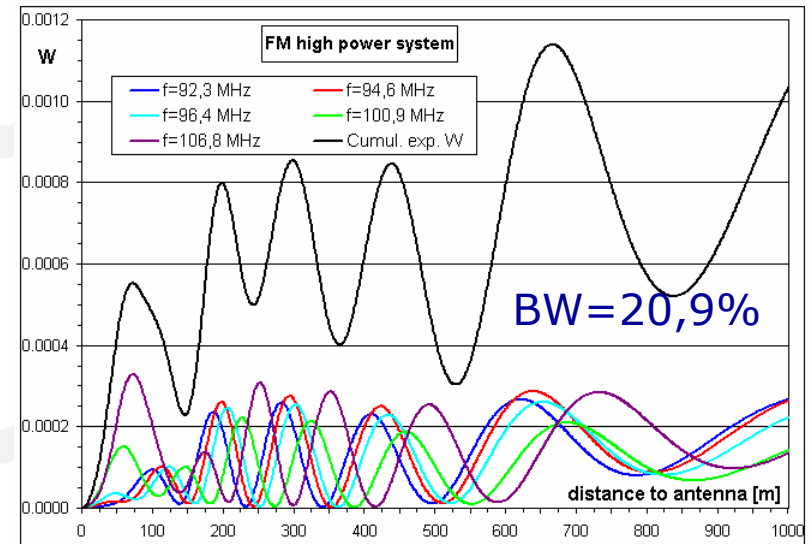
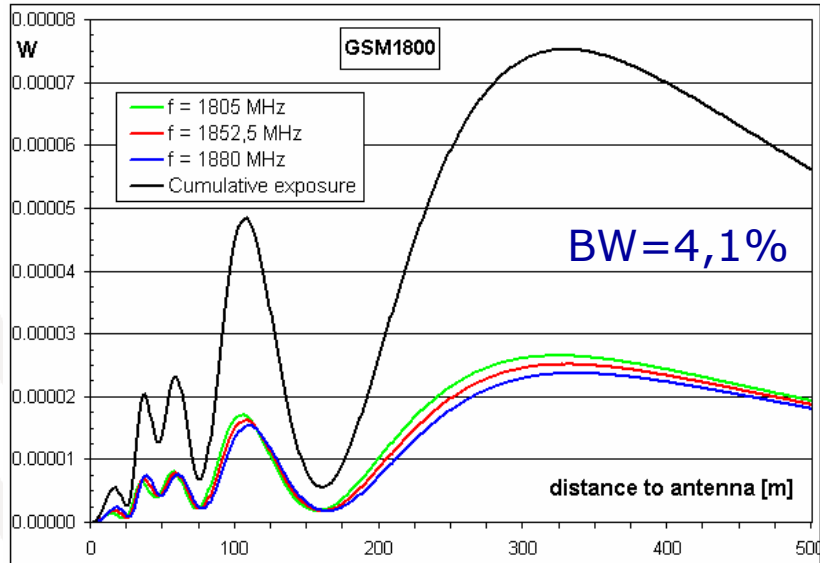
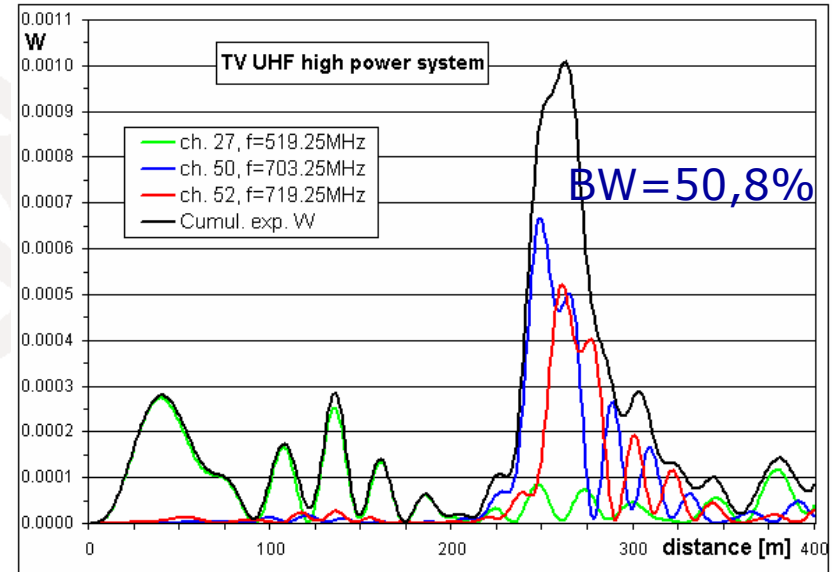
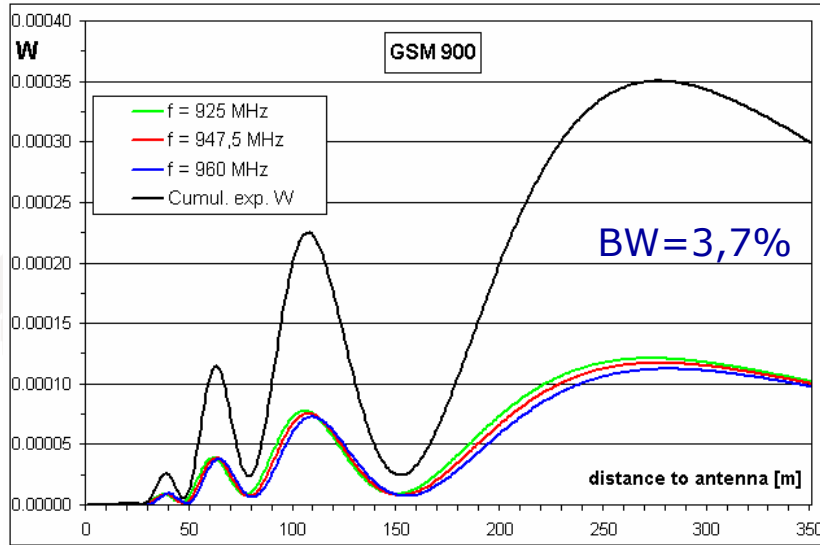
EMF-estimator Library

- Current library contains information concerning 124 antennas (56 mobile antennas)
- Examples on the right: Kathrein 739 418 and UHF TV (16x4) EAT402 = 64 panels
- Antenna data depend on frequency and downtilt



EMF-estimator

Operating frequency and connected parameters



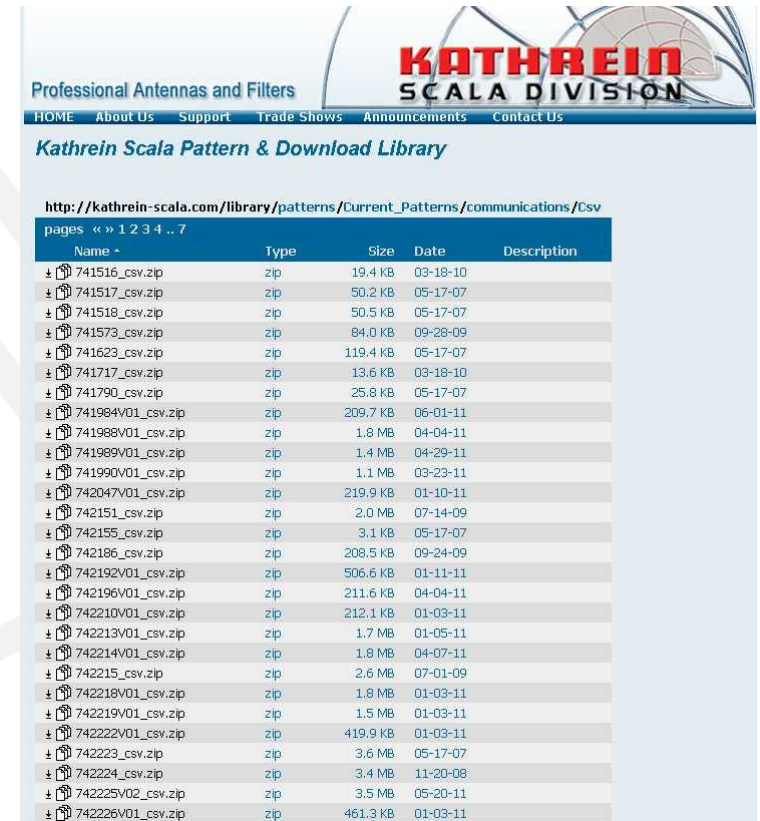
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New items in the Library

- User may introduce any new antenna to the library (using templates)
- Kathrein gives possibility to load numerical data concerning its antennas
- It requires registration at websites:

<http://www.kathrein.de/svg/index.cfm?sprache=en>

or: <http://kathrein-scala.com/>



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Kathrein Scala Pattern & Download Library

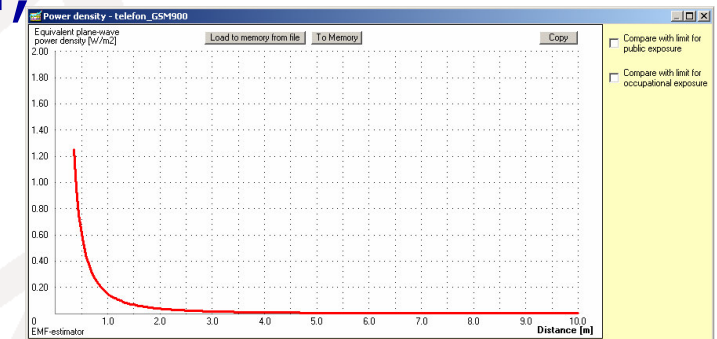
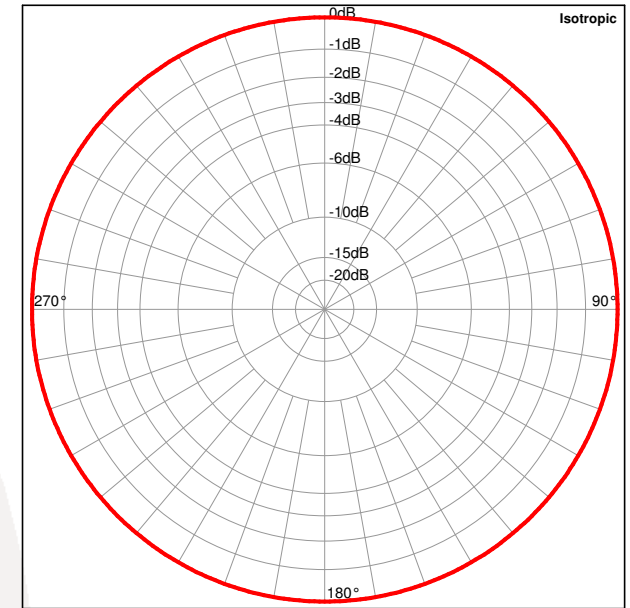
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pages « » 1 2 3 4 .. 7

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741717_csv.zip	zip	13.6 KB	03-18-10	
741790_csv.zip	zip	25.8 KB	05-17-07	
741984V01_csv.zip	zip	209.7 KB	06-01-11	
741988V01_csv.zip	zip	1.8 MB	04-04-11	
741989V01_csv.zip	zip	1.4 MB	04-29-11	
741990V01_csv.zip	zip	1.1 MB	03-23-11	
742047V01_csv.zip	zip	219.9 KB	01-10-11	
742151_csv.zip	zip	2.0 MB	07-14-09	
742155_csv.zip	zip	3.1 KB	05-17-07	
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742214V01_csv.zip	zip	1.8 MB	04-07-11	
742215_csv.zip	zip	2.6 MB	07-01-09	
742218V01_csv.zip	zip	1.8 MB	01-03-11	
742219V01_csv.zip	zip	1.5 MB	01-03-11	
742222V01_csv.zip	zip	419.9 KB	01-03-11	
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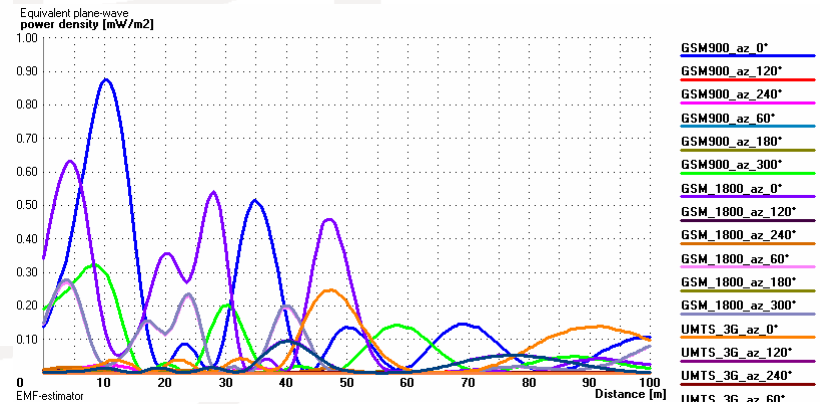
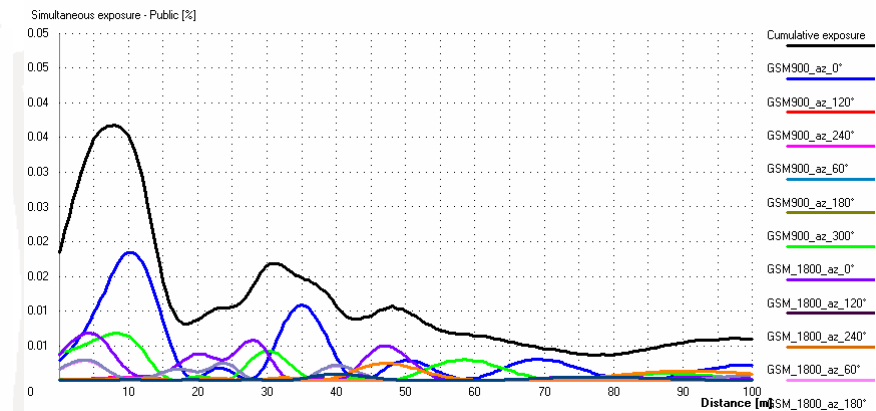
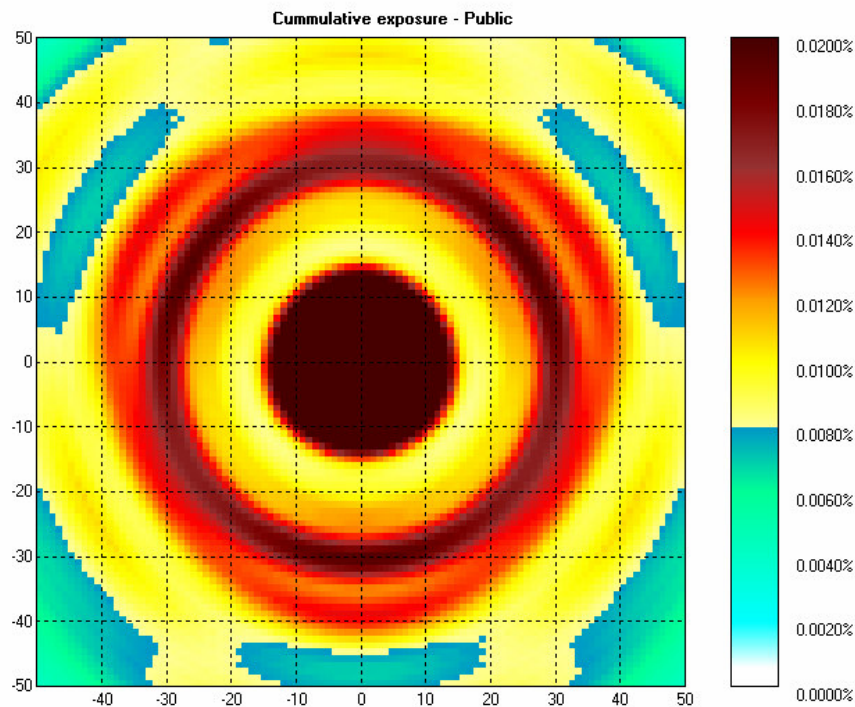
The simplest approach

- This method may be used for any antenna and without knowledge concerning its performance
- EIRP (maximum), operating frequency and antenna location are only required
- Isotropic antenna is assumed, the result is valid in any field region but usually with very high overestimation of EMF level
- In many cases it is satisfactory



EMF-estimator - examples

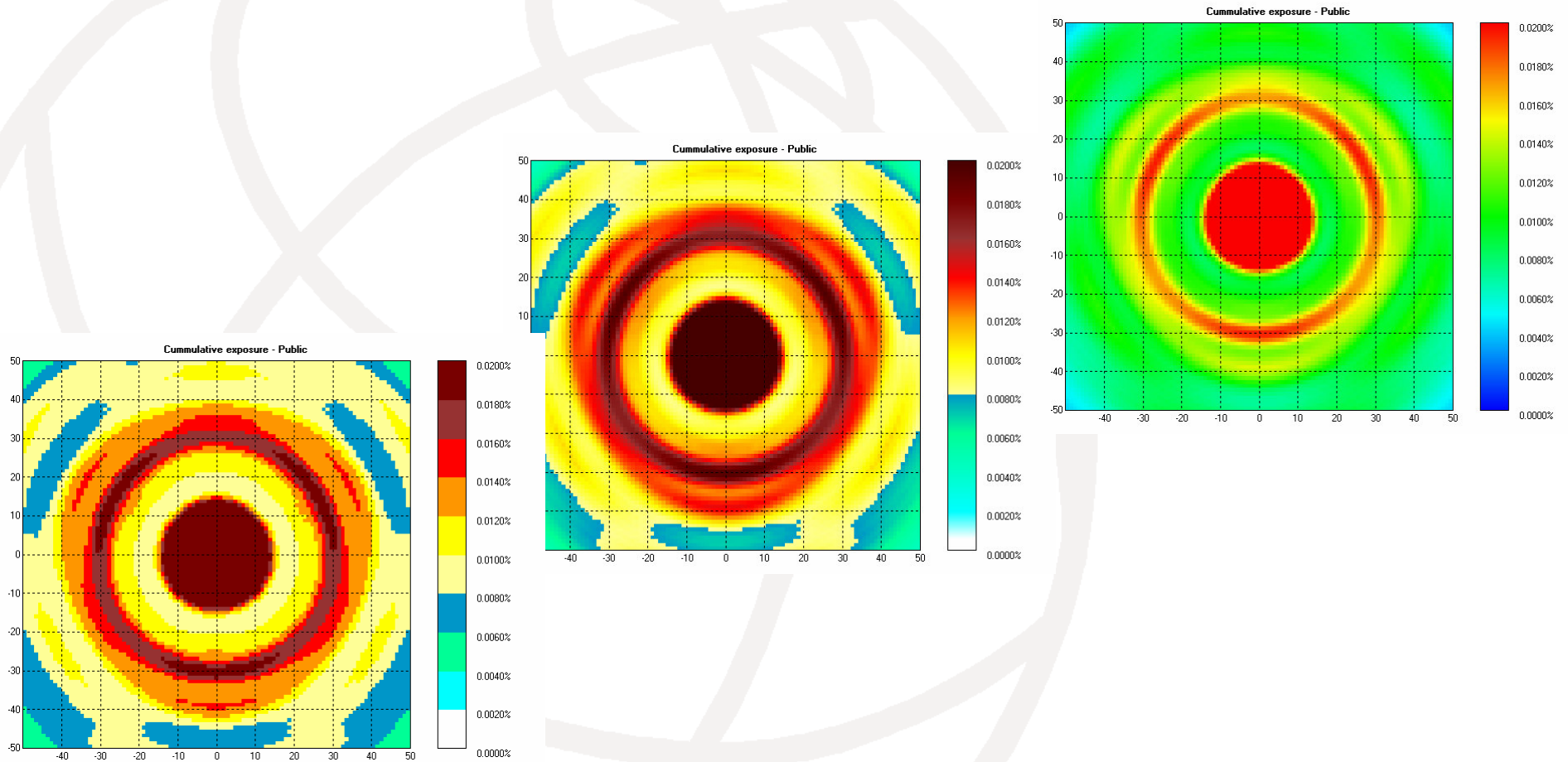
- Typical mobile base station (BS)
- 3-sectors, 3-bands, 2 operators
- Line calculation and grid calculation



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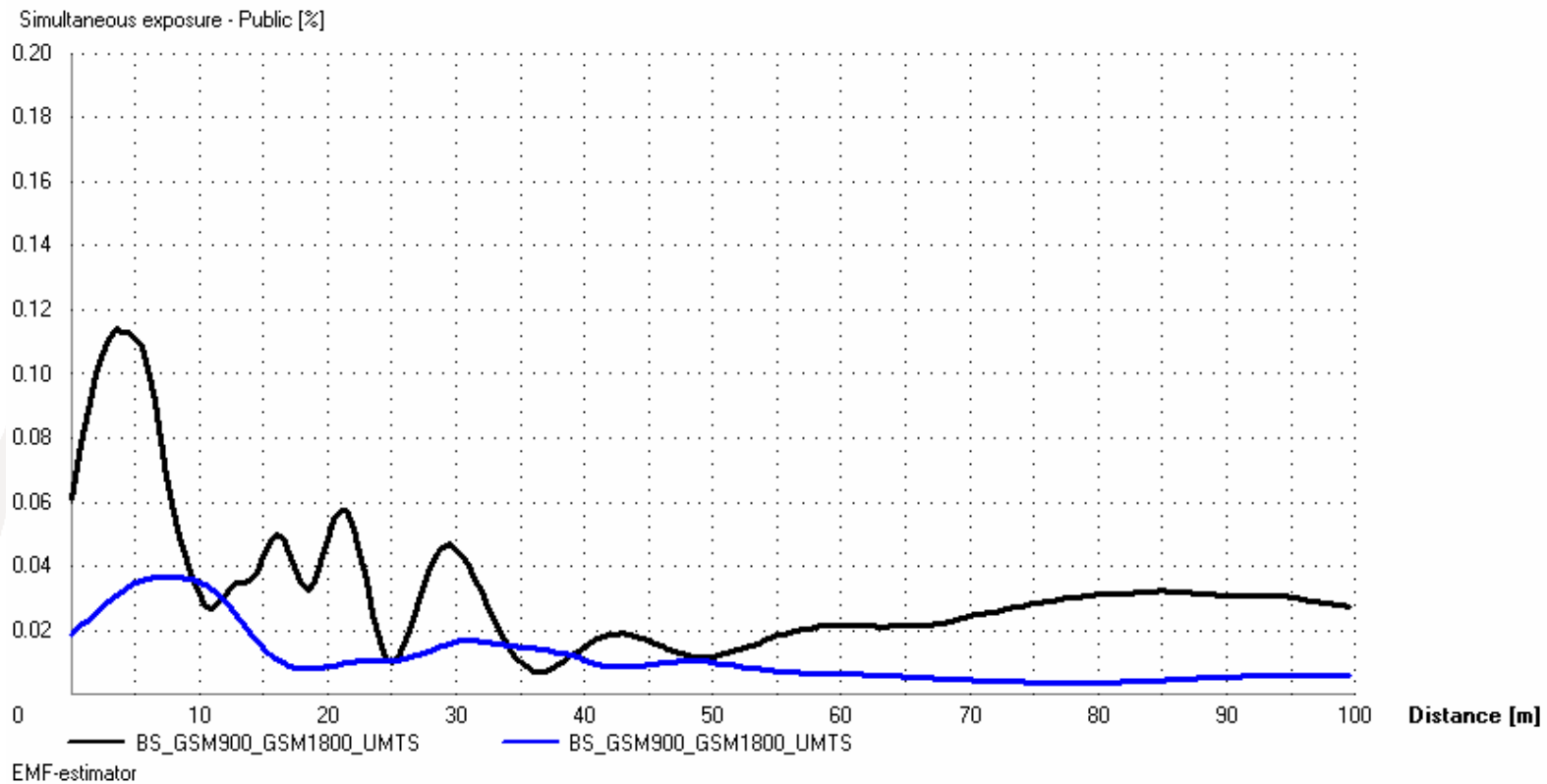
EMF-estimator - examples

Different 3D charts (different scales)



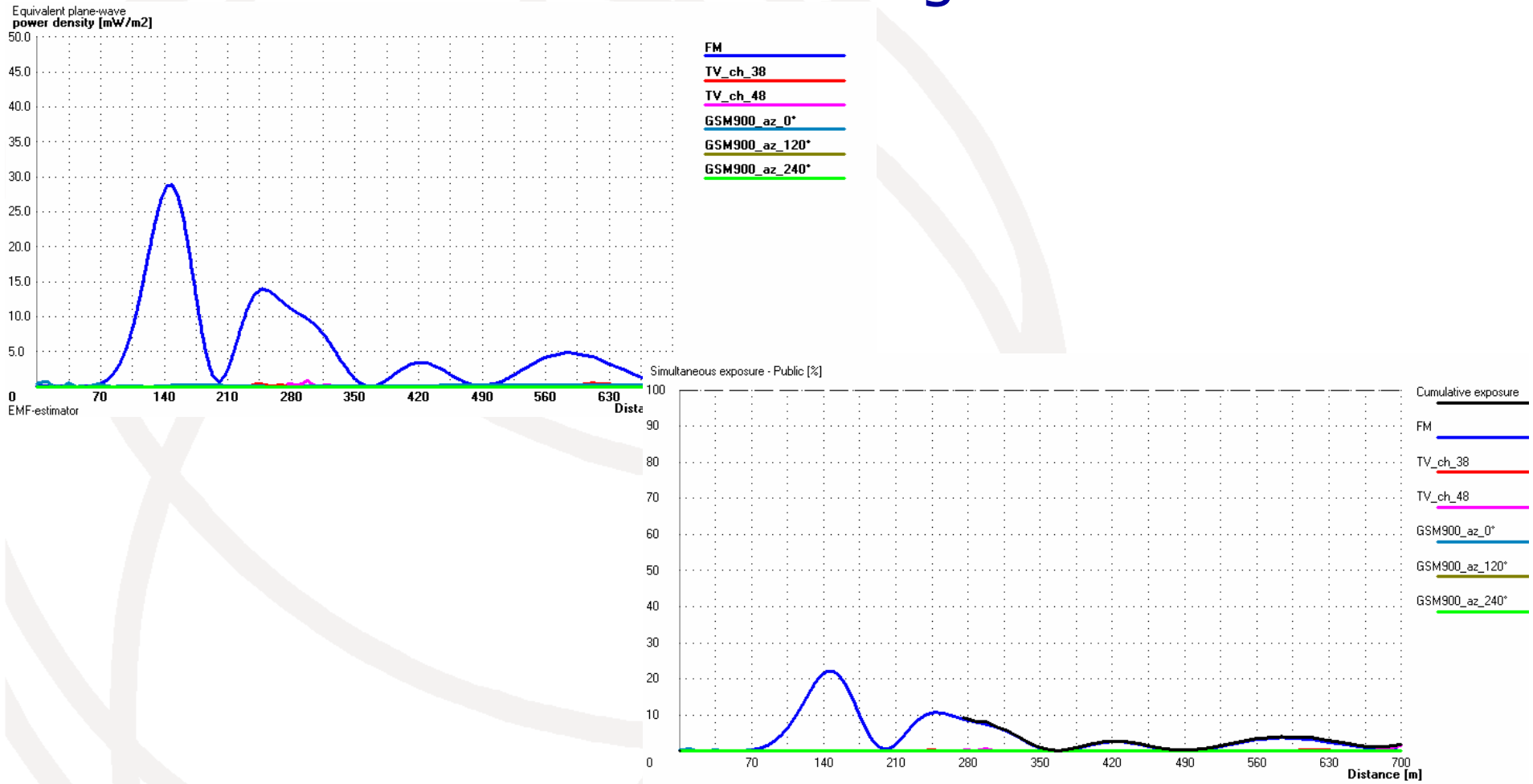
EMF-estimator

Comparison of considered cases (using memory) – two different heights: 1.5 m (blue) and 15 m (black) a.g.l.



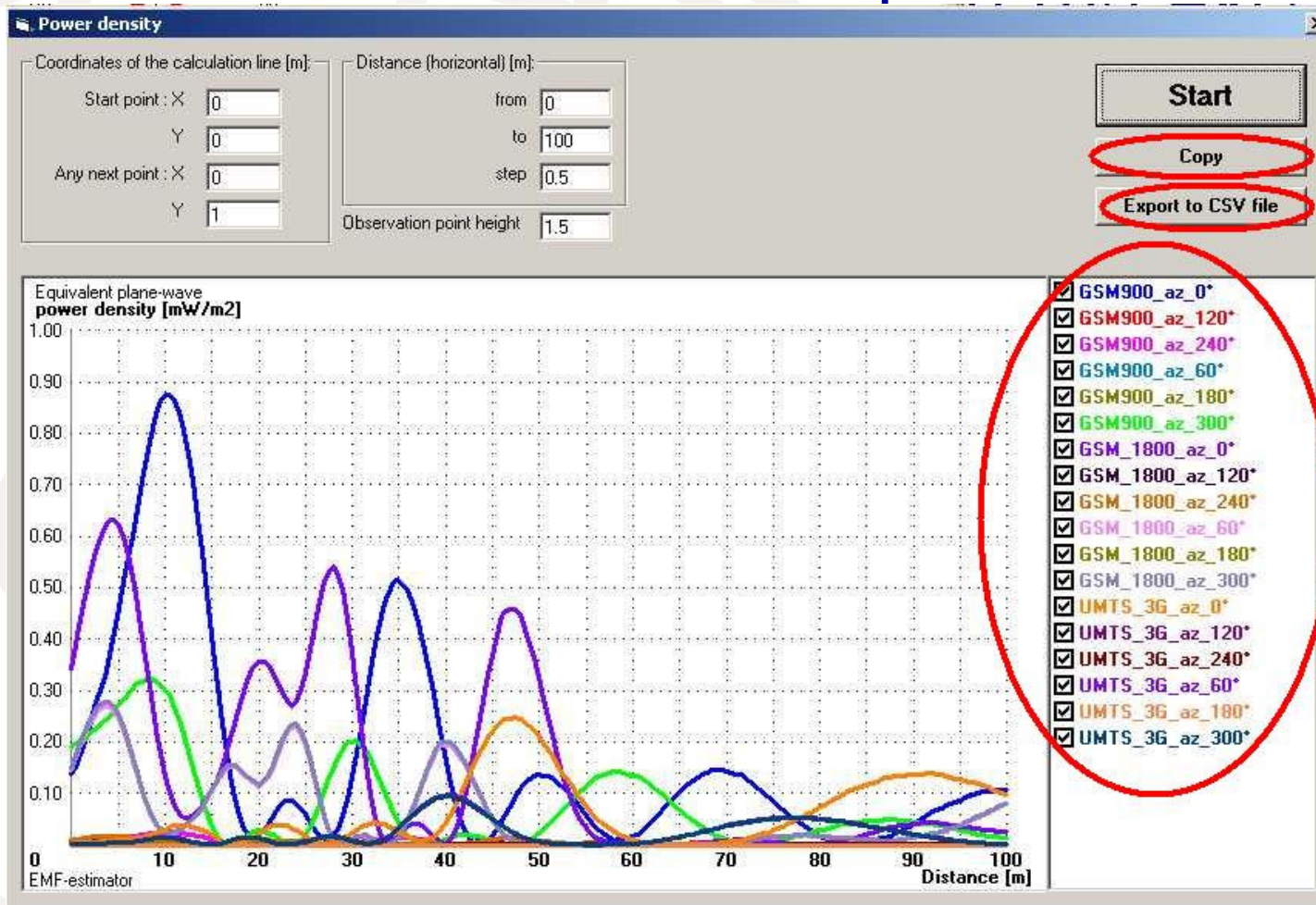
EMF-estimator

Collocation of the mobile BS and broadcasting TS



EMF-estimator

change of the colors, export to the Excel, charts to the Clipboard



EMF-estimator

- Transmitter power (RMS)
- Attenuation of the feeder and additional losses

EMF-estimator - D:\EMF_Estimator_ITU\Other_Examples\BS_GSM900_GSM1800_UMTS.exp

Project Radiating source Print Reference Limits Cumulative exposure Calculations Tools About

Radiation sources **Source - GSM900_az_0°** **Antenna orientation**

System name	Type of service coefficient	GSM
GSM900_az_0°	nominal/mean transmitter power	50 [W]
GSM900_az_120°	Transmitter power	50 [W]
GSM900_az_240°	Feeder attenuation	4 [dB/100m]
GSM900_az_60°	Feeder length	35 [m]
GSM900_az_180°	Additional attenuation	0.1 [dB]
GSM900_az_300°	Total attenuation	1.50 [dB]
GSM_1800_az_0°	Gain referred to isotropic antenna	17.00 [dBi]
GSM_1800_az_120°	Gain referred to $\lambda/2$ dipole	14.86 [dBd]
GSM_1800_az_240°	ERP	1083.9 [W]
GSM_1800_az_60°	EIRP	1777.5 [W]
GSM_1800_az_180°	EIRP (after type of service correction)	1777.5 [W]
GSM_1800_az_300°	HRP(ϕ)	0.0000 [dB]
UMTS_3G_az_0°	VRP(θ)	0.0371 [V/V]
UMTS_3G_az_120°	F(θ, ϕ)	0.037 [V/V]
UMTS_3G_az_240°	Mechanical downtilt	0 [deg]
UMTS_3G_az_60°	Transmitting antenna height	35 [m]
UMTS_3G_az_180°	Distance from the start to the observation point	1 [m]
UMTS_3G_az_300°	Distance from the antenna to the observation point	33.51 [m]
	Elevation angle from transmitting antenna to the observation point	178.3 [deg]
	Azimuth from the antenna to the observation point	0 [deg]

Frequency [MHz] 947.5
Maximum size of the antenna [m] 2.574
Limits file

Field Regions:

	from [m]	to [m]
Reactive near-field: (0, λ)	0	0.32
Radiating near-field: (λ ; $\max(3\lambda, 2D^2/\lambda)$)	0.32	41.88
Far-field: ($\max(3\lambda, 2D^2/\lambda)$; ∞)	41.88	∞
EMF-estimator validity: ($0.62D^2/\lambda$; ∞)	12.98	∞

Electric field strength 256.71 [mV/m]
Power density 0.126 [mW/m²]
Accompanied magnetic field strength (far-field region, plane wave) 0.691 [mA/m]

Exposure limits

	Public	Occupational
Electric field limit	42.32 [V/m]	92.34 [V/m]
Power density limit	4.74 [W/m ²]	23.69 [W/m ²]
Compliance distance	5.48 [m]	2.51 [m]

Compliance distance(s) may be overestimated

Simultaneous exposure to multiple sources

Mainly thermal effect: 100 kHz - 300 GHz

	Public	Occupational
This source	0.00 [%]	0.00 [%]
All sources simultaneously	0.00 [%]	0.00 [%]

Mainly electrical stimulation effect: 1 Hz - 10 MHz

	Public	Occupational
This source	0.00 [%]	0.00 [%]
All sources simultaneously	0.00 [%]	0.00 [%]

Receiving point located in radiating near-field region. The field calculation does not take into account the antenna size (point-source model is used). Results of calculations may overestimate or underestimate real values!

File with HRP and VRP: D:\EMF_Estimator_ITU\Library\GSM 900 Eurocode

Additional comments:

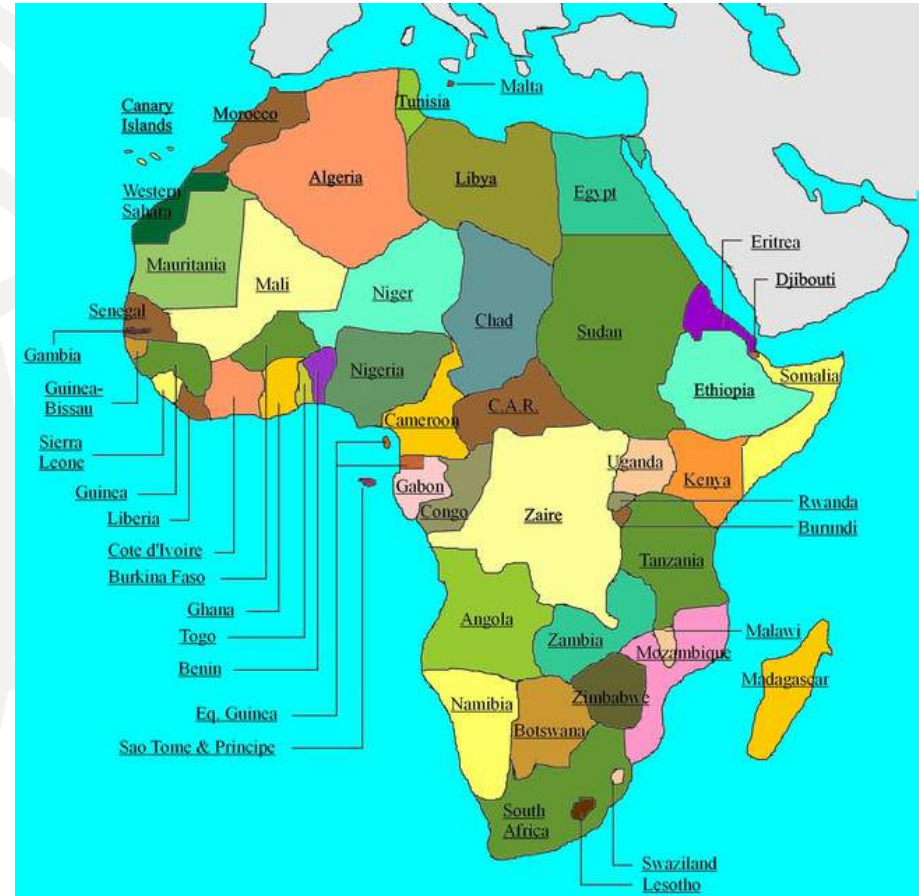
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Exposure limits

- WHO website:

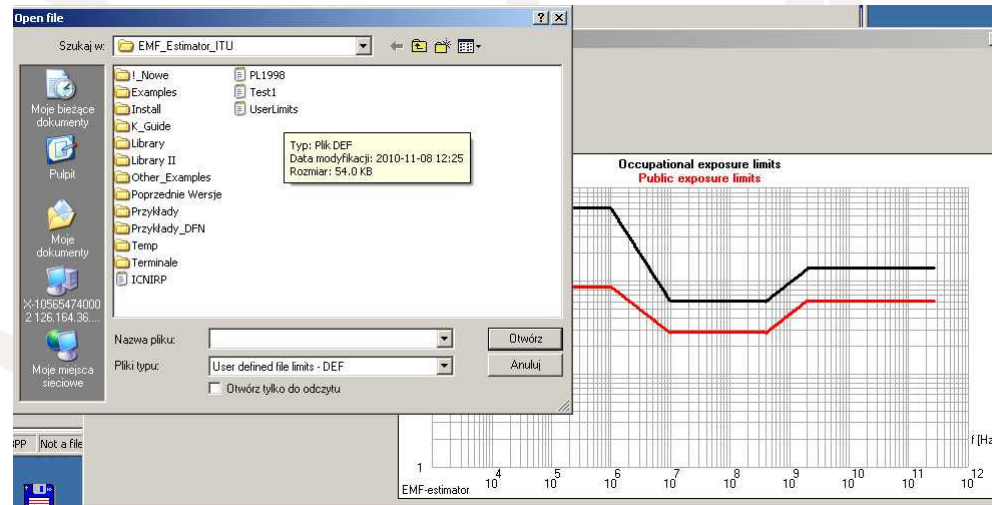
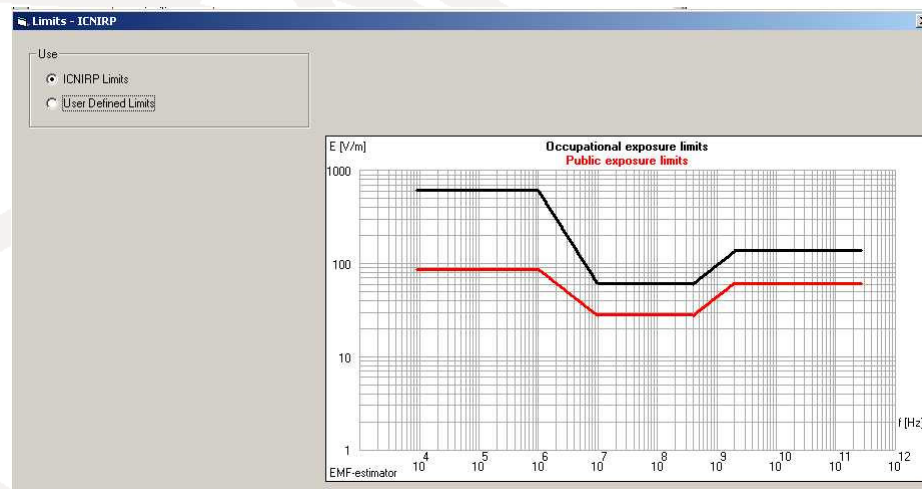
<http://www.who.int/docstore/p/eh-emf/EMFStandards/who-0102/Worldmap5.htm>

- On this website there is no information concerning exposure limits in Botswana



EMF-estimator

Introduction of the user defined limits



Conclusions

- In many cases the exposure assessment by calculation is a good choice and gives reliable results in a cost effective way
- EMF-estimator may be used for exposure assessment in many real cases





Thank you

**Questions,
Comments?**