

Cognitive radio systems for efficient sharing
of TV white spaces in European Context

DVB-T and Wireless Microphone Exclusion Area Computation through Interference Analysis

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3rd COST-TERRA meeting, 21 June 2011 Page 1

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- COGEU project
- Overview of SEAMCAT
- Exclusion area computation
 - Case study 1: Interference from LTE BS / UE to DVB-T
 - Case study 2: Interference from Cognitive LTE BS / UE to DVB-T
 - Case study 3: Interference from LTE UE to PMSE
- Final comments

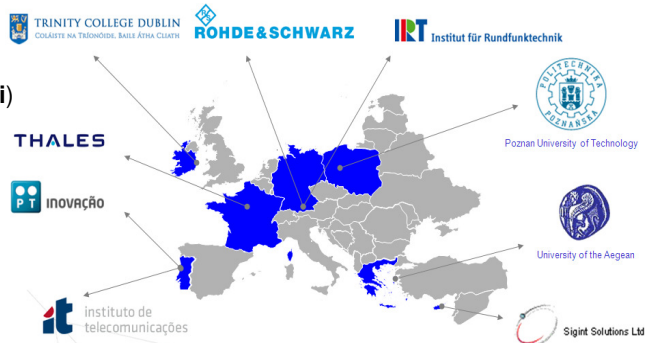


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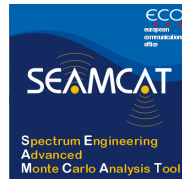


- STREP Project (www.ict-cogeu.eu)
- Duration: Jan 2010 – Dec 2012
- 9 partners
- EAB (RIM, Huawei)



Overview of SEAMCAT

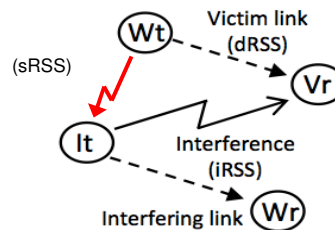
- **SEAMCAT** (Spectrum Engineering Advanced Monte Carlo Analysis Tool) is a statistical simulation model that uses a method of analysis called Monte Carlo to assess the potential interference between different radio communication systems.



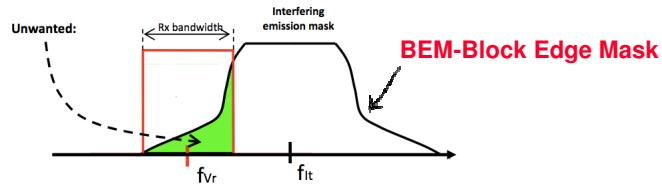
- Developed and maintained by **ECO**
- Build on a **Java** platform



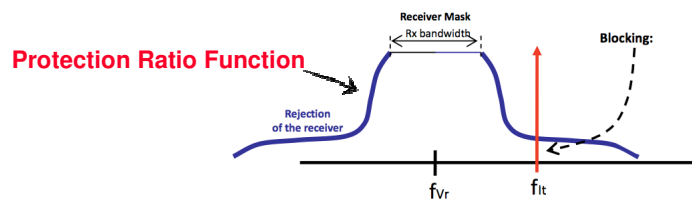
- **Wt**: Wanted transmitter
 - **Vr**: Victim receiver
 - **It**: Interfering transmitter
 - **Wr**: Wanted receiver
-
- **dRSS**: desired Received Signal Strength
 - **iRSS**: interfering Received Signal Strength
 - **sRSS**: sensing Received Signal Strength



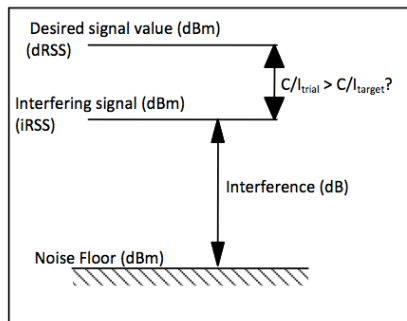
➤ Unwanted emissions:



➤ Receiver blocking:



- For each random event where
 $dRSS > \text{sensitivity}$:



- If $C/I_{\text{trial}} > C/I_{\text{target}}$: "good" event
- If $C/I_{\text{trial}} < C/I_{\text{target}}$: "interfered"

- Finally, after cycle of N_{all} events:
Overall $P_{\text{interference}} = 1 - (N_{\text{good}}/N_{\text{all}})$

Exclusion Area Computation:

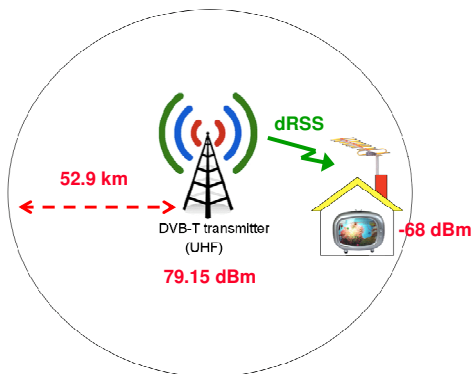
**How far away does a CR device transmitting
P [dBm] need to be from a primary receiver
to ensure no harmful interference?**

➤ DVB-T transmitter:

- Frequency: 658 MHz
- Power: 79.15 dBm
- Antenna height: 200 m
- antenna type: 0 dBi omnidirectional
- Antenna azimuth and elevation aligned with DVB-T receiver antenna

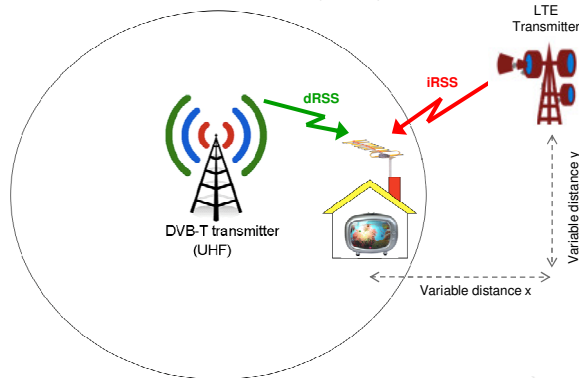
➤ DVB-T receiver:

- Antenna height: 10 m
- Antenna peak gain: 9.15 dBi
- Noise floor: -98.17 dBm
- Sensitivity: -77.17 dBm
- Reception bandwidth: 7,610 MHz

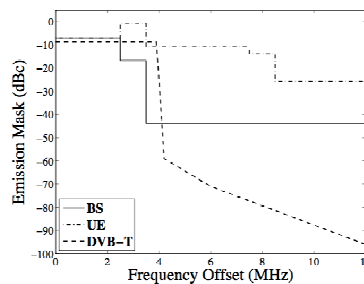


Propagation model: ITU-R P.1546

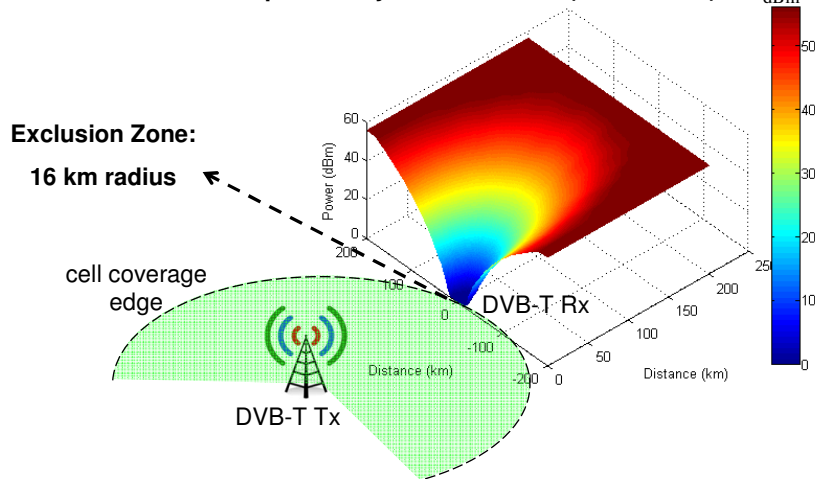
- For each Monte-Carlo trial:
 - Move the relative position (x,y) of the LTE BS / UE around the DVB-T receiver
- Propagation model LTE transmitter → DVB-T receiver (iRSS):
 - Extended Hata:**
 - Above roof for BS
 - Below roof for UE
- Co-channel interference



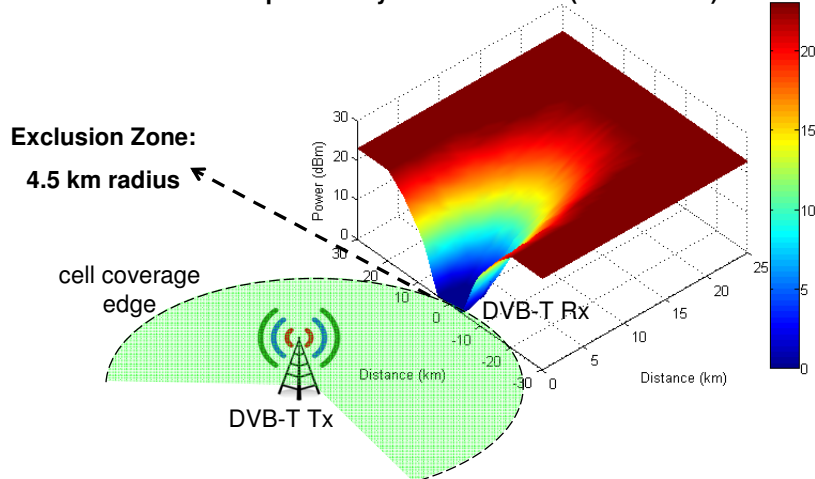
- | ➤ LTE BS transmitter: | LTE UE transmitter: |
|--------------------------------------|--------------------------------------|
| – Frequency: 658 MHz | – Frequency: 658 MHz |
| – Antenna height: 10 m | – Antenna height: 1.5 m |
| – Antenna: tri-sectored directional | – Antenna: Omnidirectional |
| – EIRPmax: 56 dBm | – EIRPmax: 23 dBm |
| – Spectral emission mask (5 MHz BW): | – Spectral emission mask (5 MHz BW): |



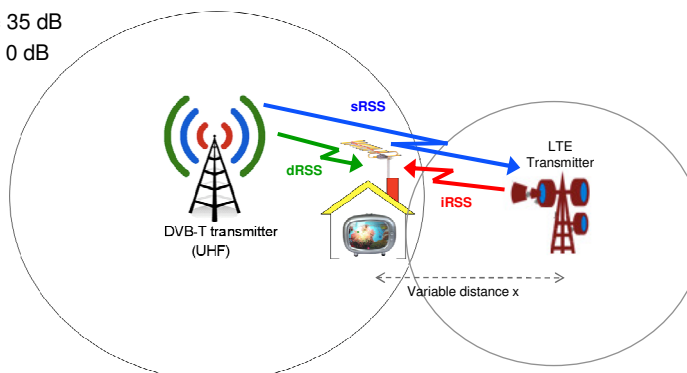
➤ Results for 1% of probability of interference ($C/N = 21$ dB):



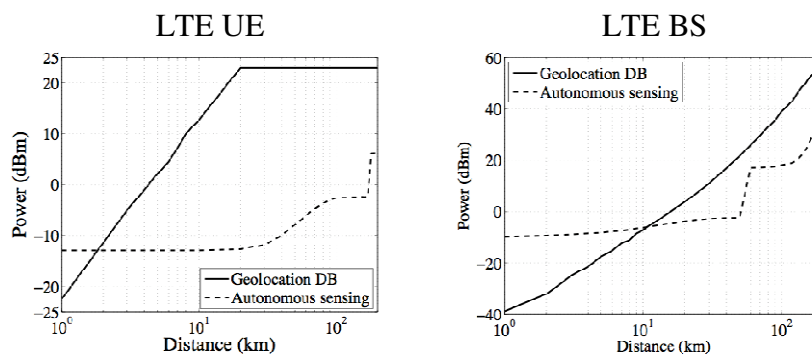
➤ Results for 1% of probability of interference ($C/N = 21$ dB):



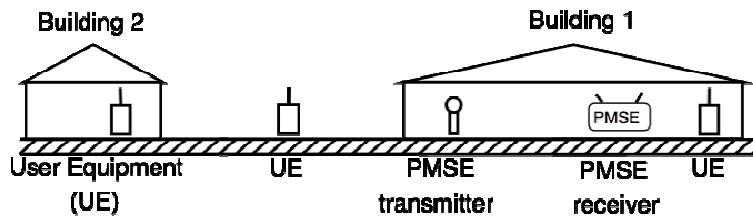
- Change the relative position (x,0) of the LTE interferer (BS or UE) from the DVB-T receiver.
 - Detection Threshold: -123 dBm
 - Sensing bandwidth: 8 MHz
 - UE: HNM = 35 dB
 - BS: HNM = 0 dB



- Results for 1% of probability of interference (C/N = 21 dB):



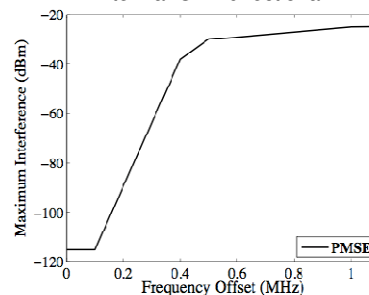
- PMSE system and TVWS Tx indoor
- PMSE system indoor and TVWS Tx outdoor
- PMSE system and TVWS Tx indoor in different buildings



- **PMSE Transmitter (W. Mic.):**
 - Frequency: 658 MHz
 - Power: 10 dBm
 - Antenna height: 1.5 m
 - antenna type: $\lambda/4$ or $\lambda/2$ dipole, 0dBi
 - Antenna azimuth and elevation aligned with PMSE receiver antenna.

PMSE receiver:

- Noise floor: -115 dBm
- Sensitivity: -95 dBm
- Reception bandwidth: 200 kHz
- Antenna height: 1.5 m
- Antenna peak gain: 2.15 dBi
- Antenna: Omnidirectional



➤ Interference criteria:

$$C/N = 21 \text{ dB}$$

$$\text{Sensitivity} = \text{Noise Floor} + C/(N + I)_{\text{dB}}$$

$$C/(N + I)_{\text{dB}} = -95 - (-115) = 20 \text{ dB}$$

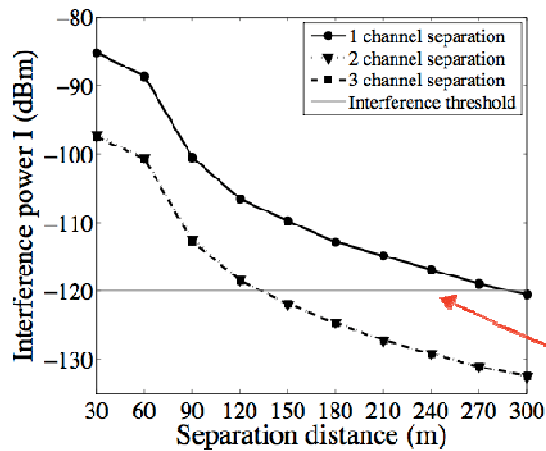
$$(N + I)/N_{\text{dB}} = C/N_{\text{dB}} - C/(N + I)_{\text{dB}} = 1 \text{ dB}$$

$$I/N_{\text{dB}} = 10\log((N+I)/N - 1) = 10\log(0.26) = -5.87 \text{ dB},$$

$$I_{\text{dB}} = -115 - 5.87 = -121 \text{ dB}$$

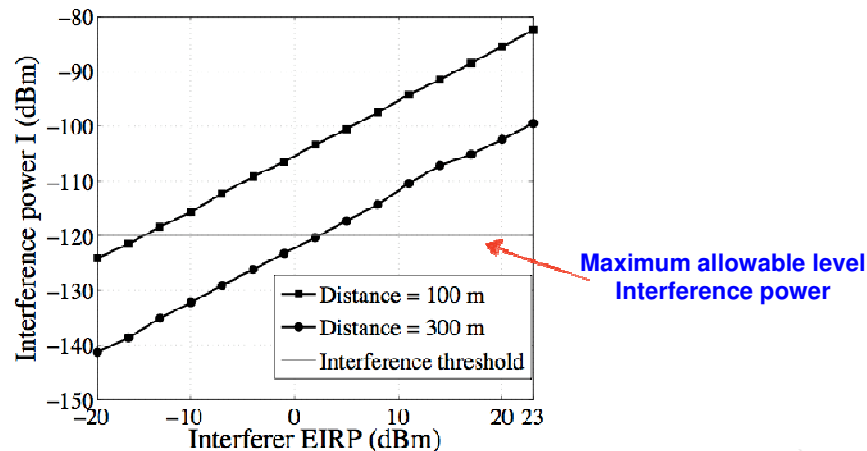
iRSSmax limit is -
121 dBm at the
PMSE receiver

➤ Adjacent channel interference



Maximum allowable level
Interference power

➤ Co-channel interference



➤ DVB-T exclusion area:

- LTE downlink limits the white space area (in LOS with the DVB-T aerial antenna)
- Exclusion distance is 16 km for LTE BS and 4.5 km for LTE UE.
- Autonomous sensing artificially limits the maximum transmit power allowed for TVWS Devices (hidden node margin).
- Geo-location database allows a more efficient use of TVWS.

➤ PMSE exclusion area:

- One channel separation (8 MHz): an LTE UE can transmit 22 dBm at 300 m from a PMSE receiver.
- Two channel separation (16 MHz): the exclusion distance can be decreased down to 145 m.
- No further improvements for channel separation above 16 MHz.

Thank you!

Questions?