Strategies for the calculation of location specific power limits for secondary devices operating on TV white spaces

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Introduction

- Increasing demand for wireless Internet access and rich multimedia services

- Switch off from analog to digital television
  - Free frequencies in the UHF band – the TV white spaces
  - Dynamic spectrum allocation for efficient use of spectrum

- Operation of white space devices (WSDs)
  - No harmful interference to licensed (primary) systems, especially the digital terrestrial television (DTT)
  - Identification of free channels
  - Determination of maximum permitted WSD transmit powers

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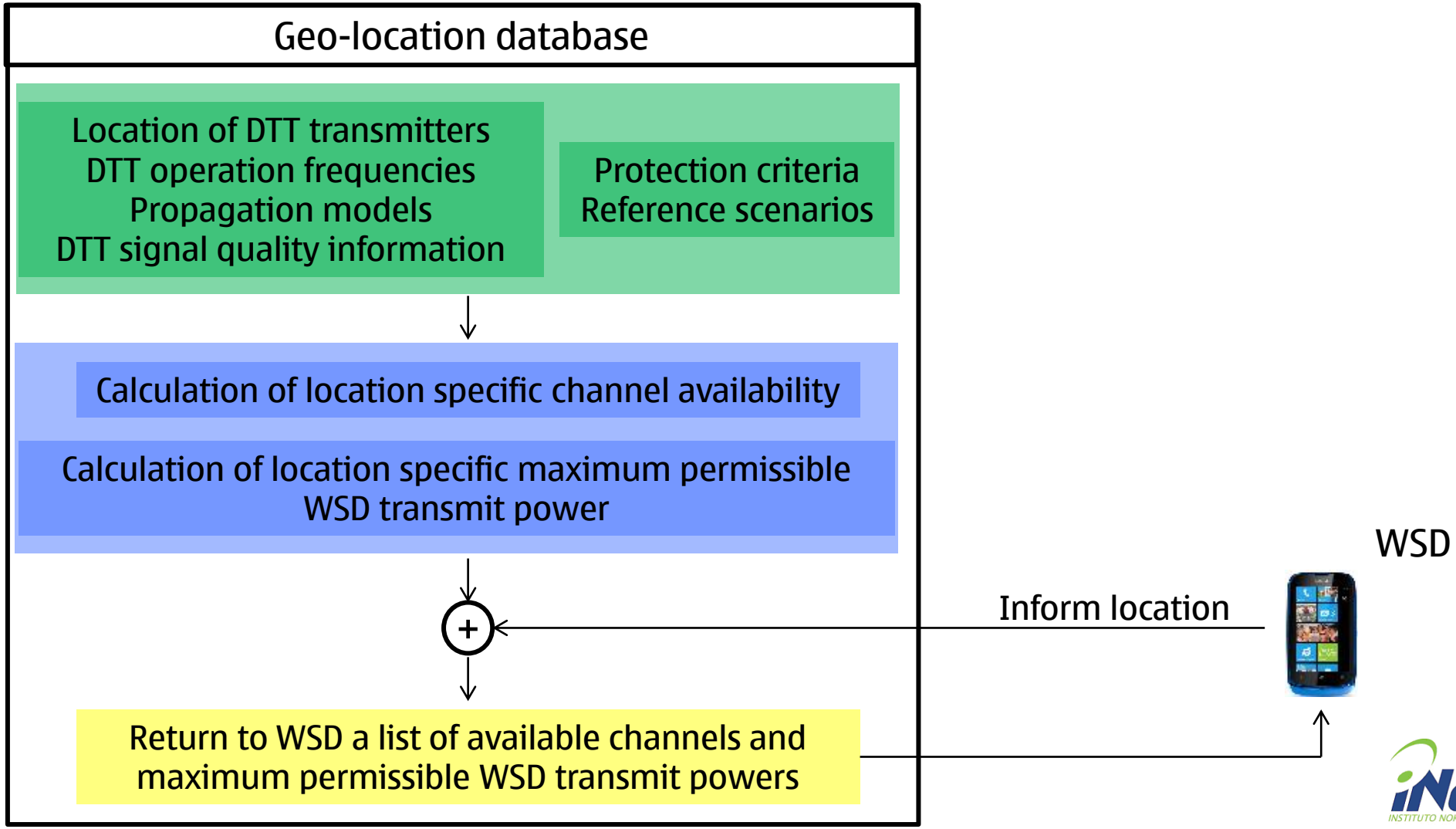
Introduction (2)

- Geo-location database assisted operation for TV white space systems



Scope

- Regulatory aspects are under discussion in Europe
  - Level of protection for the primary systems
  - WSD emission limits

- ECC Report 159
  - General methodology for the calculation of maximum permitted WSD power
  - Maximum WSD transmit power varies with the DTT signal quality

- This work proposes strategies to be considered at the geo-location database for the calculation of maximum WSD transmit power
  - In accordance with ECC methodology
  - Based on protection criteria and interference limits for primary systems

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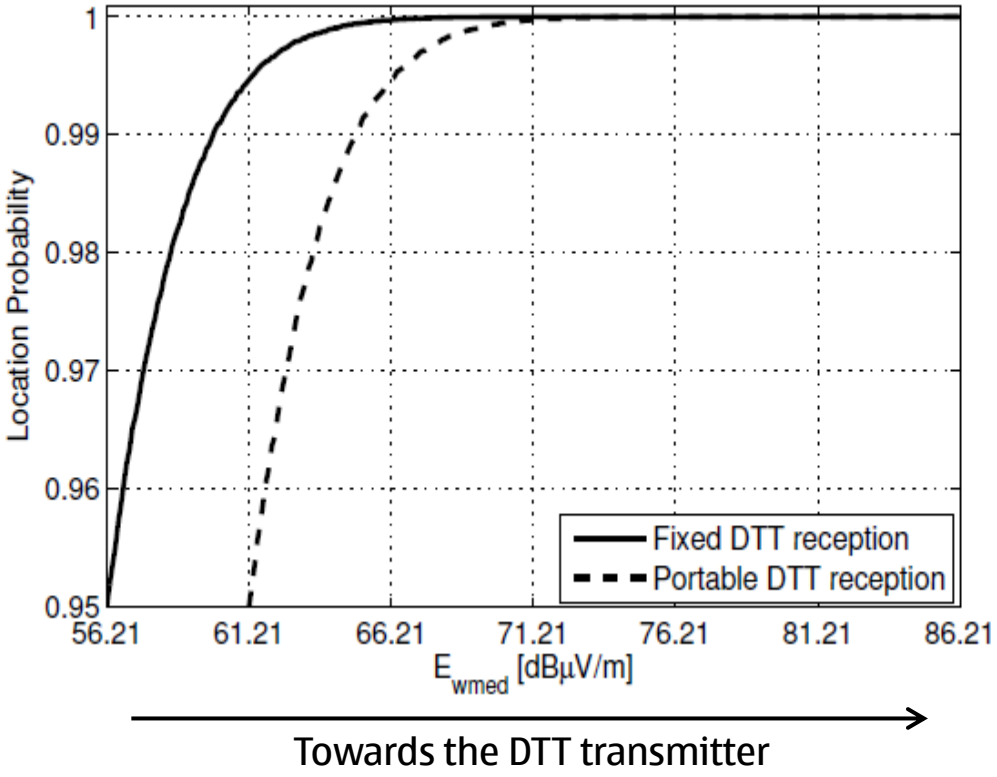
Protection criterion

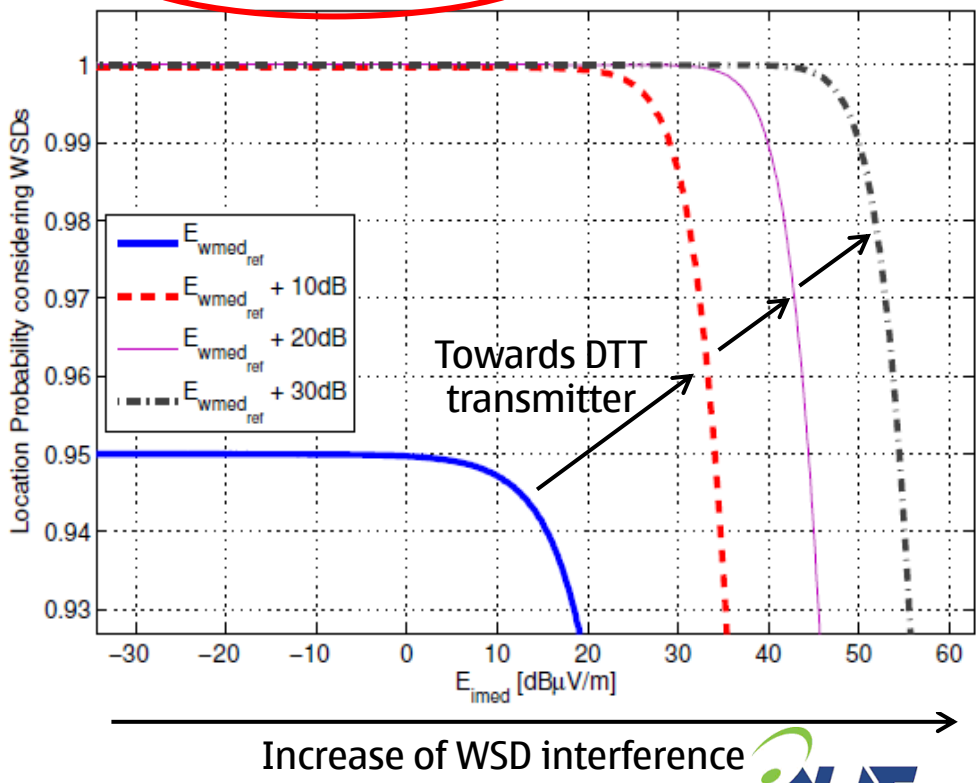
- Location probability (LP)
  - Probability with which a given area is satisfactorily served
  - Requirement for DTT: $LP \geq 95\%$



- Location probability degradation (ΔLP)

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

- Protection criterion
  - Agreed level of ΔLP (0.1%, 0.5%, 1%)



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Protection parameters for DTT receivers

- Protection ratio (PR)
  - Minimum signal-to-interference ratio (SIR) at the DTT receiver antenna

- Overloading threshold (O_{th})
  - Interference level above which the DTT receiver looses the ability to discriminate against interference signals at adjacent frequencies

- **Upper limits for ΔLP**
  - Model DTT signal and WSD interference as random variables
  - Calculate upper limits for interference for a given percentage of locations in a certain area
    - SIR at the DTT receiver must be higher than or equal to the PR
    - Mean interference field strength at the DTT receiver must be lower than or equal to the O_{th}

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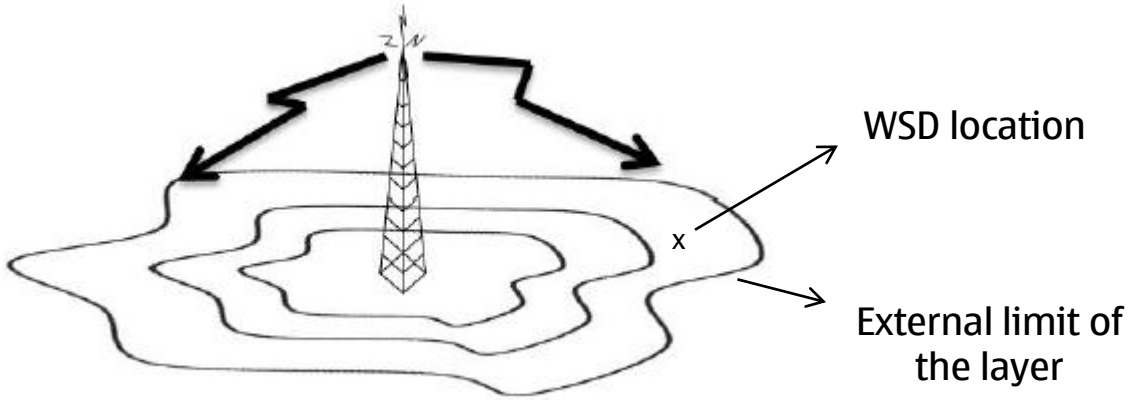
Strategies for the calculation of max. WSD EIRP

- Strategy 1
  - Division of the DTT coverage area in layers
  - Layers are limited by min. (external) and max. (internal) values of E_{wmed}
  - Fixed value of ΔLP in all layers



- E_{wmed} used in calculations is the external E_{wmed} of the layer
  - Computational effort proportional to the number of layers
  - High protection of DTT receivers against uncertainties or errors

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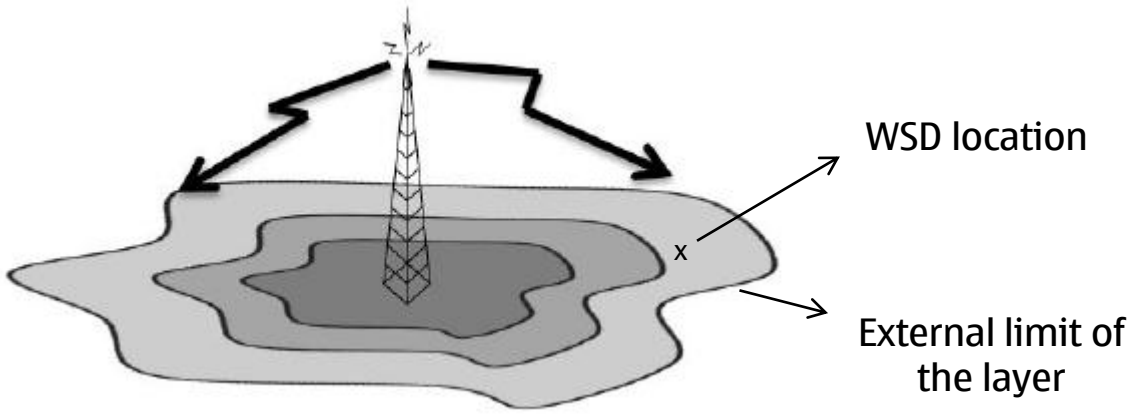
Strategies for the calculation of max. WSD EIRP

- Strategy 2
  - Division of the DTT coverage area in layers
  - Layers are limited by min. (external) and max. (internal) values of E_{wmed}
  - Distinct values of ΔLP in all layers, respecting calculated upper limits



- E_{wmed} used in calculations is the external E_{wmed} of the layer
  - Computational effort proportional to the number of layers
  - High protection of DTT receivers against uncertainties or errors
  - More flexible approach

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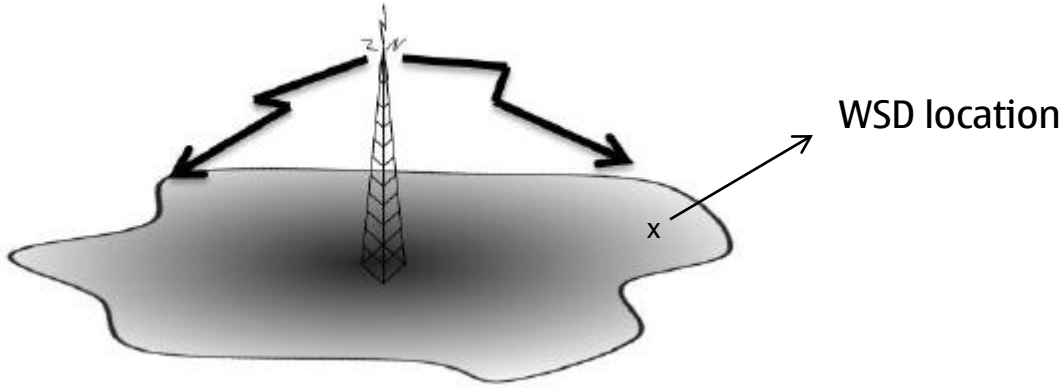
Strategies for the calculation of max. WSD EIRP

- Strategy 3
  - No layers
  - Calculations use
    - Exact value of planned E_{wmed} for the location provided by the WSD
    - Upper limits of ΔLP as a function of E_{wmed}



  - Higher computational effort
  - More subject to DTT protection fail due to uncertainties or errors
  - The most flexible approach

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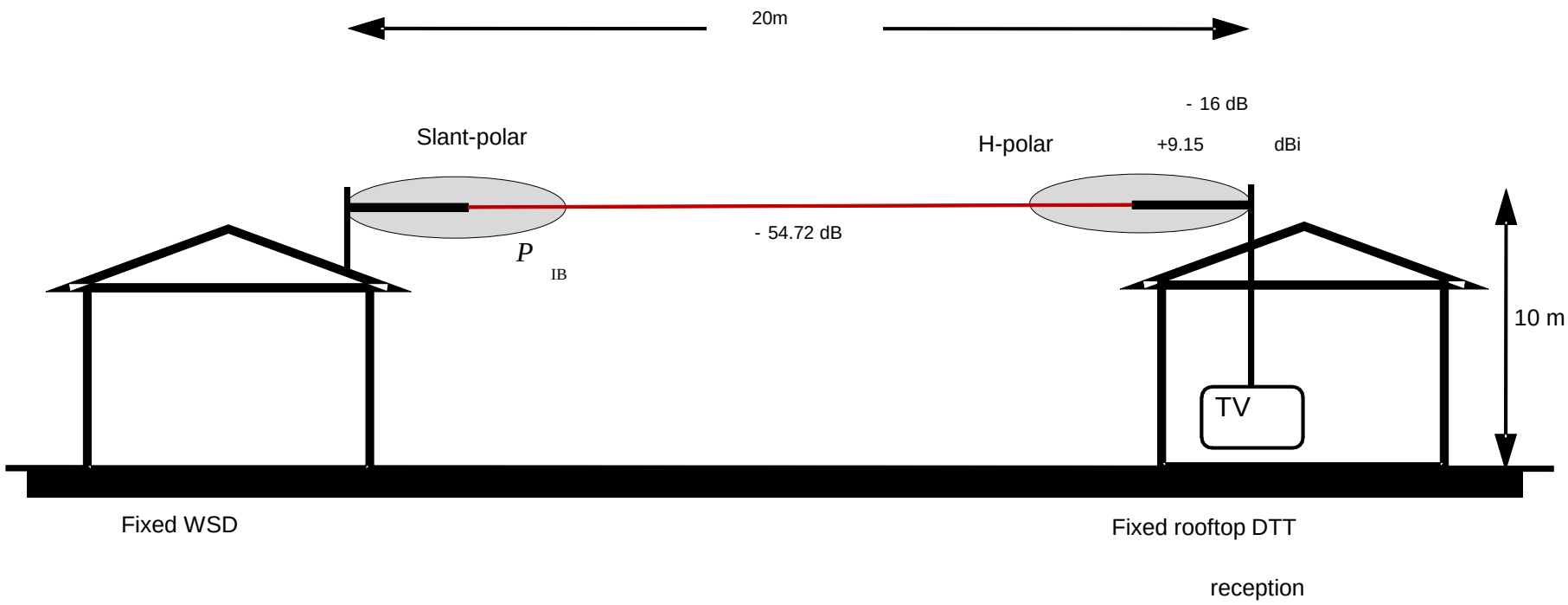
Simulations

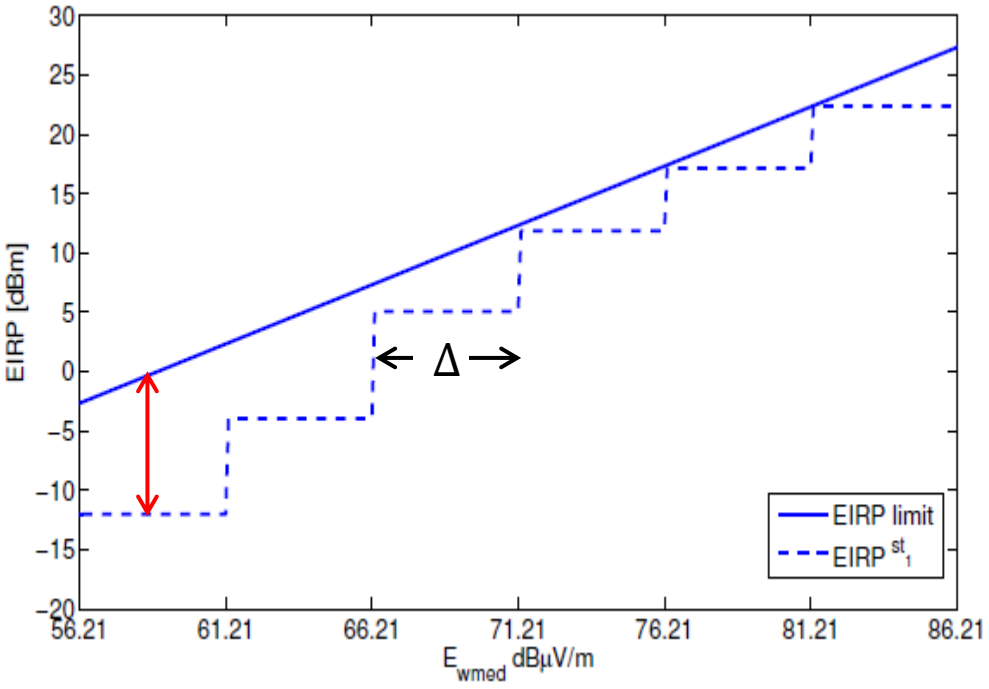
- Reference scenario
  - Fixed WSD transmitter – Fixed outdoor DTT receiver



Simulations

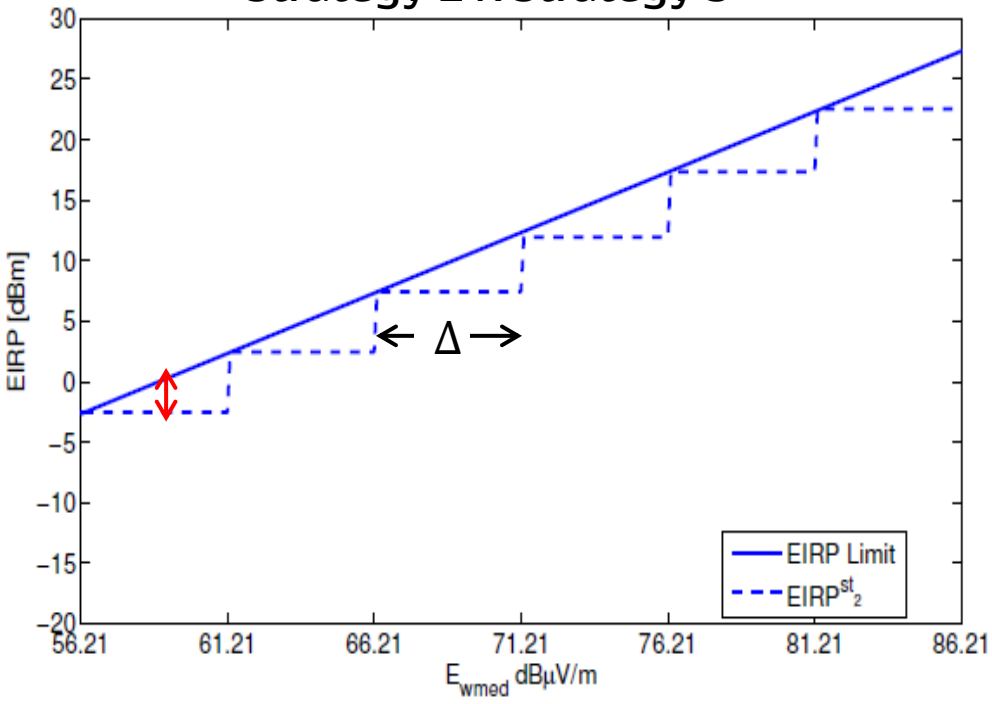
- Results
  - Layers with $\Delta = 5$ dB width

Strategy 1 x Strategy 3



Towards the DTT transmitter

Strategy 2 x Strategy 3



Towards the DTT transmitter

Conclusions

- WSD emission limits
  - Trade-off between WSD EIRP and protection of DTT receivers

- Viable strategies were proposed to the calculation of WSD emission limits at the geo-location database with different
  - Computational complexity
  - Level of protection against uncertainties and errors
  - Flexibility

Thanks!

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