HOW MUCH TV WHITE SPACE IS THERE IN GERMANY?

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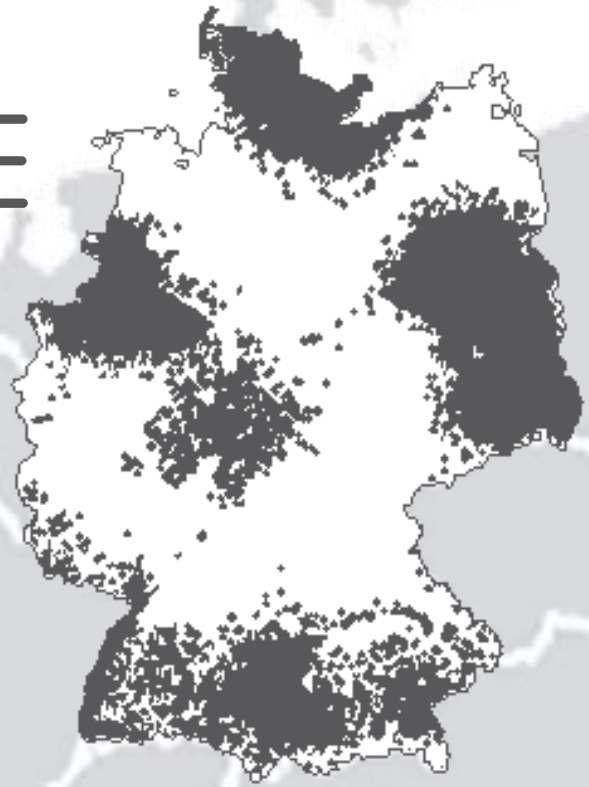

17. ITG Fachtagung Mobilkommunikation
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OVERVIEW

1. Introduction

2. TV White Space assessment
   1. DVB-T terrain-based propagation modeling
   2. Prediction of TV coverage areas

3. Calculation of maximum permitted White Space Device power

4. TV White Space availability in Germany

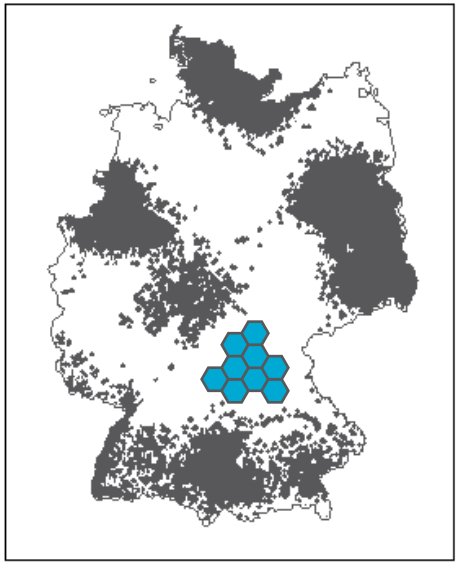
5. Conclusion

MOTIVATION

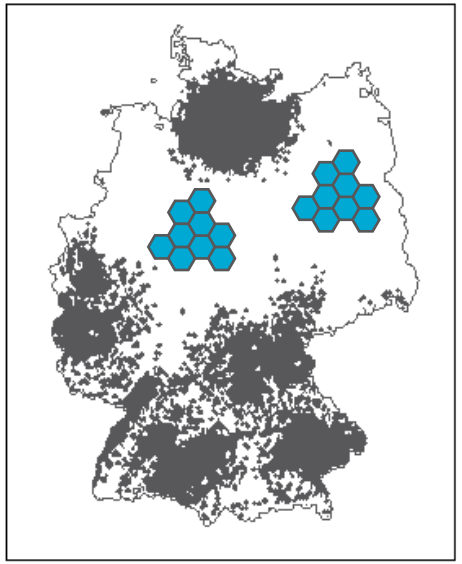
- Increasing mobile broadband traffic triggers search for new ways of spectrum utilization
- Dynamic opportunistic spectrum access on a secondary basis one considered approach
- TV band is locally underutilized
  - In Europe DVB-T operates in 40 channels between 470 and 790 MHz
- Secondary access to TV band envisaged under non-interfering, non-protected paradigm and subject to certain regulatory limitations
  - Considerably different spectrum environment compared to dedicated spectrum
- Scope: quantify amount and utility of this spectrum environment for secondary users

TV WHITE SPACE (TVWS) DEFINITION

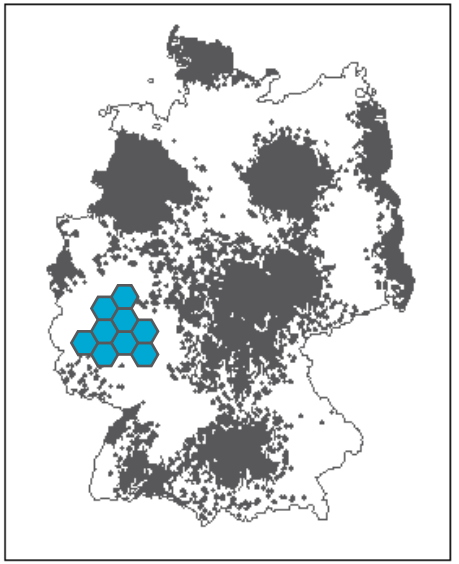
UHF Channel 39



UHF Channel 40



UHF Channel 41



TVWS TV Coverage areas

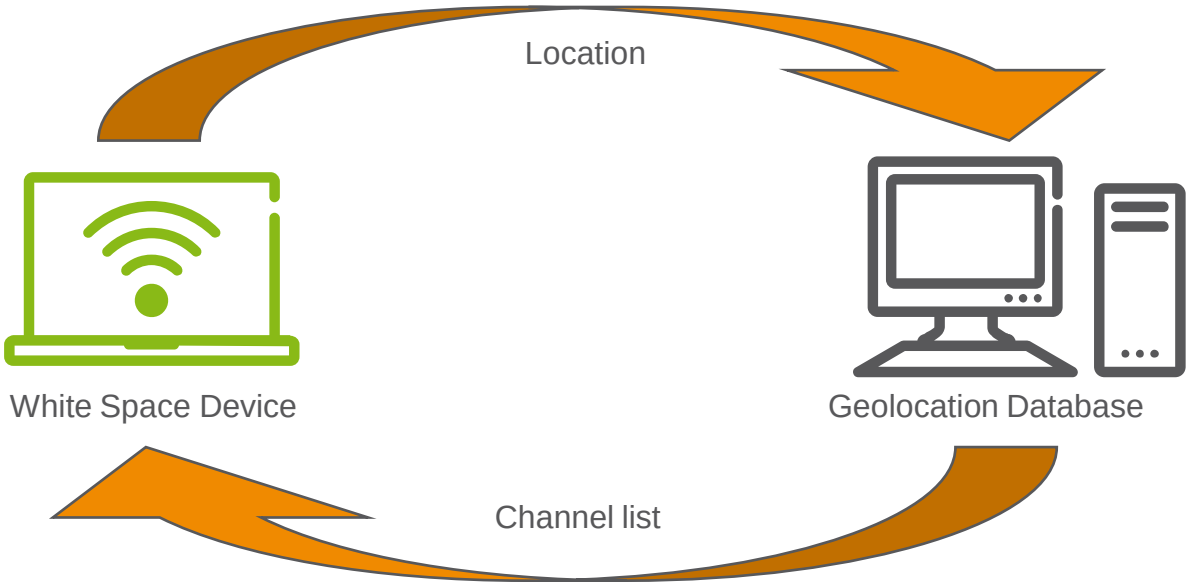
› TVWS exist in locations where successful TV reception is no longer possible* and thus secondary usage by White Space Devices (WSDs) can be permitted

*according to a certain threshold definition (TV coverage in practice is not a binary phenomenon)

GEO-LOCATION DATABASE APPROACH

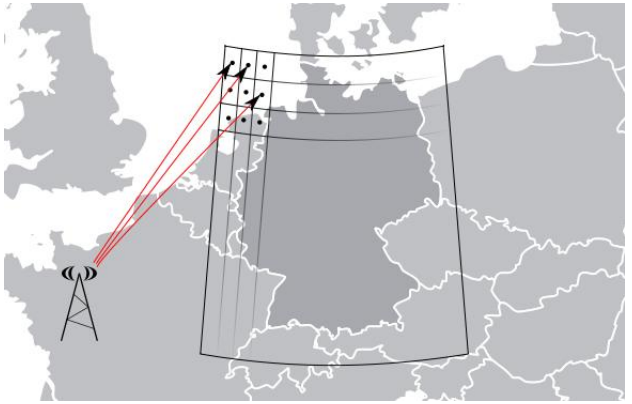
- How to find White Space
  - Appropriate Spectrum Opportunity Detection Method needed
  - Part of spectrum regulatory rules for secondary users

- Geo-location database principle
  - White Space Devices (WSD) provide their location in database query
  - Database tells them which channels they may use at given location

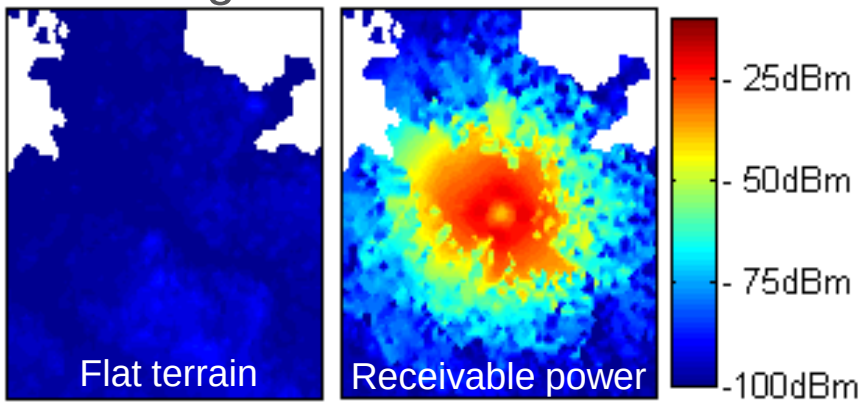


DVB-T FIELD STRENGTH PREDICTION

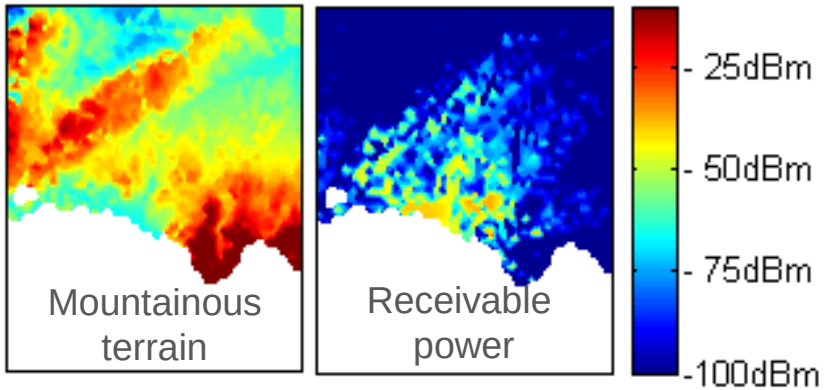
- Longley-Rice's Irregular Terrain Model (ITM) (SPLAT!)
- BNetzA database containing all TV transmitters in Germany and surrounding countries
- SRTM terrain data, 90m x 90m resolution
- Estimation per transmitter per channel and for grid with pixel resolution of 2.5km x 5km (60.000 pixels)



Hamburg UHF Channel 40



Bodensee UHF Channel 21



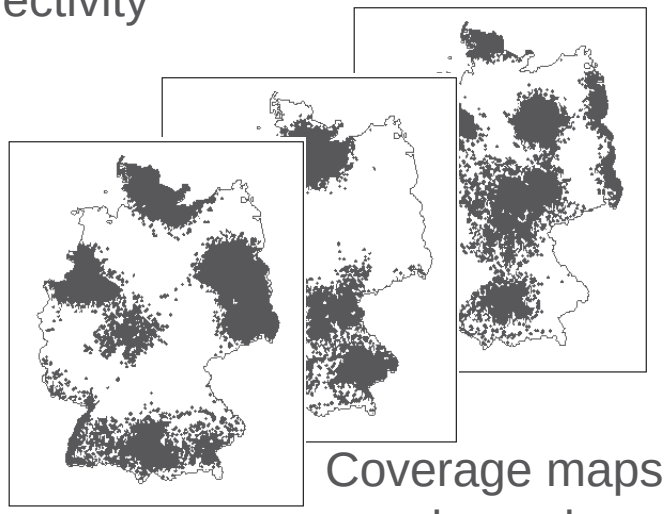
DVB-T COVERAGE AREA PREDICTION

› TV transmitter coverage areas
→ decide if pixel has sufficient
location probability

$$q_1 = \Pr\left\{ P_{\mathrm{S}} \geq P_{\mathrm{S,min}} + \sum_{i=1}^{K} r_{\mathrm{U},k} P_{\mathrm{U},k} \right\}$$

depending on
- Received power from serving TV transmitter(s) (incl. SFN gains)
- Interference from other TV transmitters (co- and adjacent channels)
- Antenna polarizations, TV receiver antenna directivity

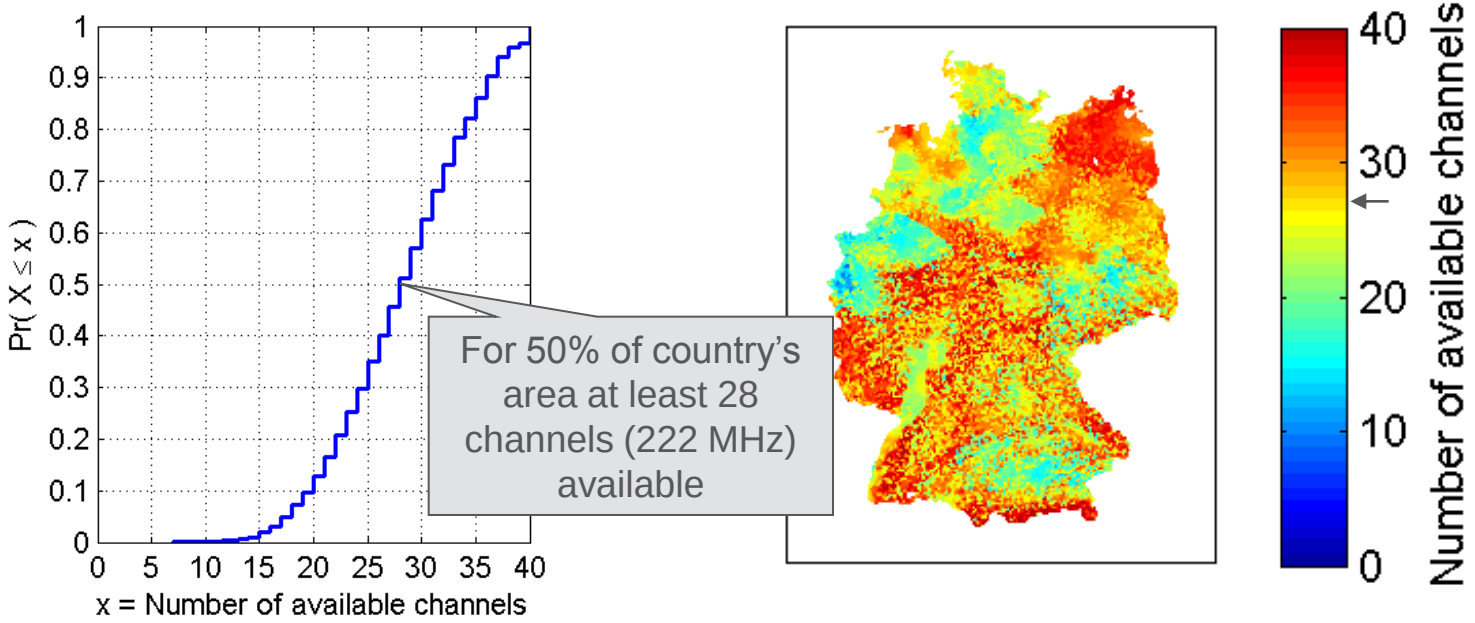
› For receivable power maps calculate corresponding binary coverage maps



Coverage maps per channel

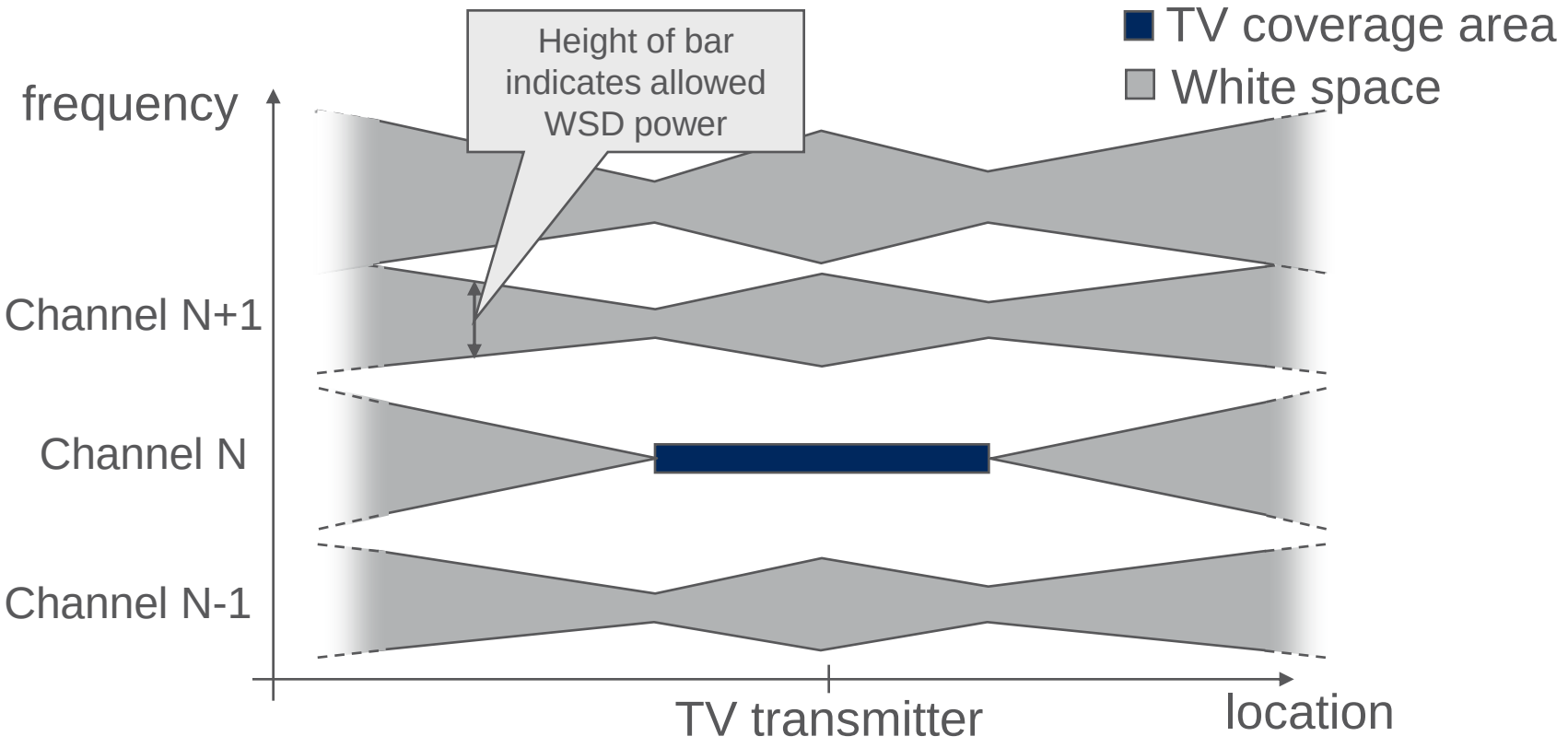
NUMBER OF UNUSED TV CHANNELS PER LOCATION

- Sum up number of channels for which pixel is not part of coverage area
- Interpret set of channel counts per pixel as random sample, draw CDF



- 10% of locations: more than 36 channels (288 MHz)
- 90% of locations: more than 20 channels (160 MHz)

MAXIMUM PERMITTED WSD TRANSMIT POWER



- Location-dependent WSD power
  - Increases outside of co-channel coverage area
  - Transmission also permitted in adjacent channel coverage

EUROPEAN CEPT ECC SE43 METHODOLOGY

› Criterion: permitted degradation of TV Location Probability

$$q_1 = \Pr\left\{ P_S \geq P_{S,\min} + \sum_{i=1}^{K} r_{U,k} P_{U,k} \right\}$$

› Degraded (1%) Location Probability with WSD interference

$$q_2 = \Pr\left\{ P_S \geq P_{S,\min} + \sum_{i=1}^{K} r_{U,k} P_{U,k} + r(\Delta f)\, G\, P_{WSD} \right\}$$

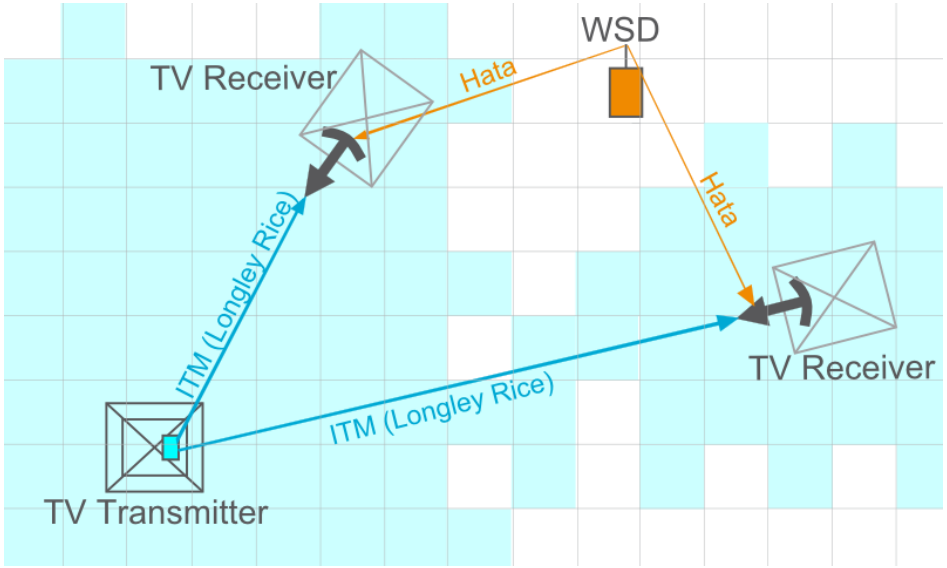
→ Solve for P_{WSD}

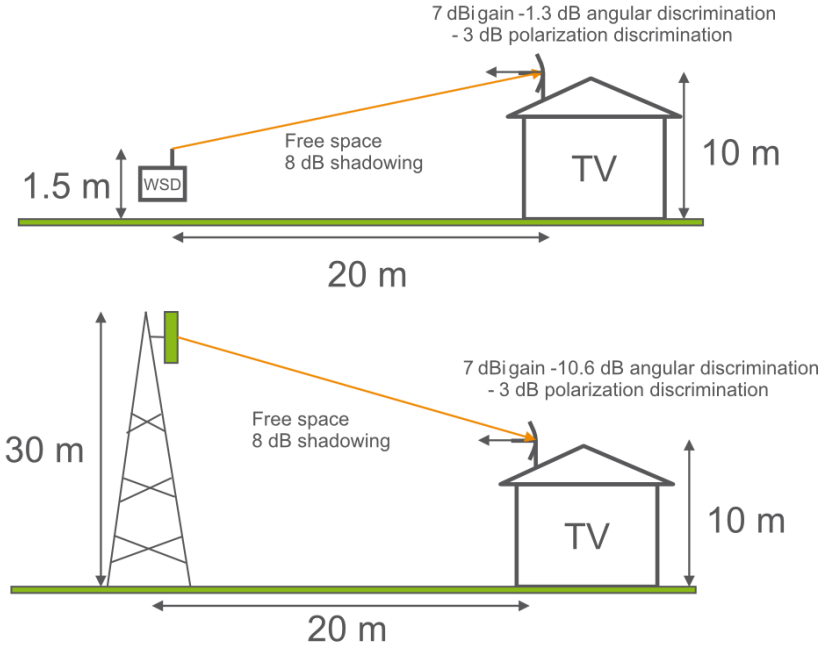
Protection ratio Coupling gain Maximum WSD transmit power

› Requires knowledge about critical point
  - location of TV receiver most sensitive to WSD interference
  - in case several TV coverage areas

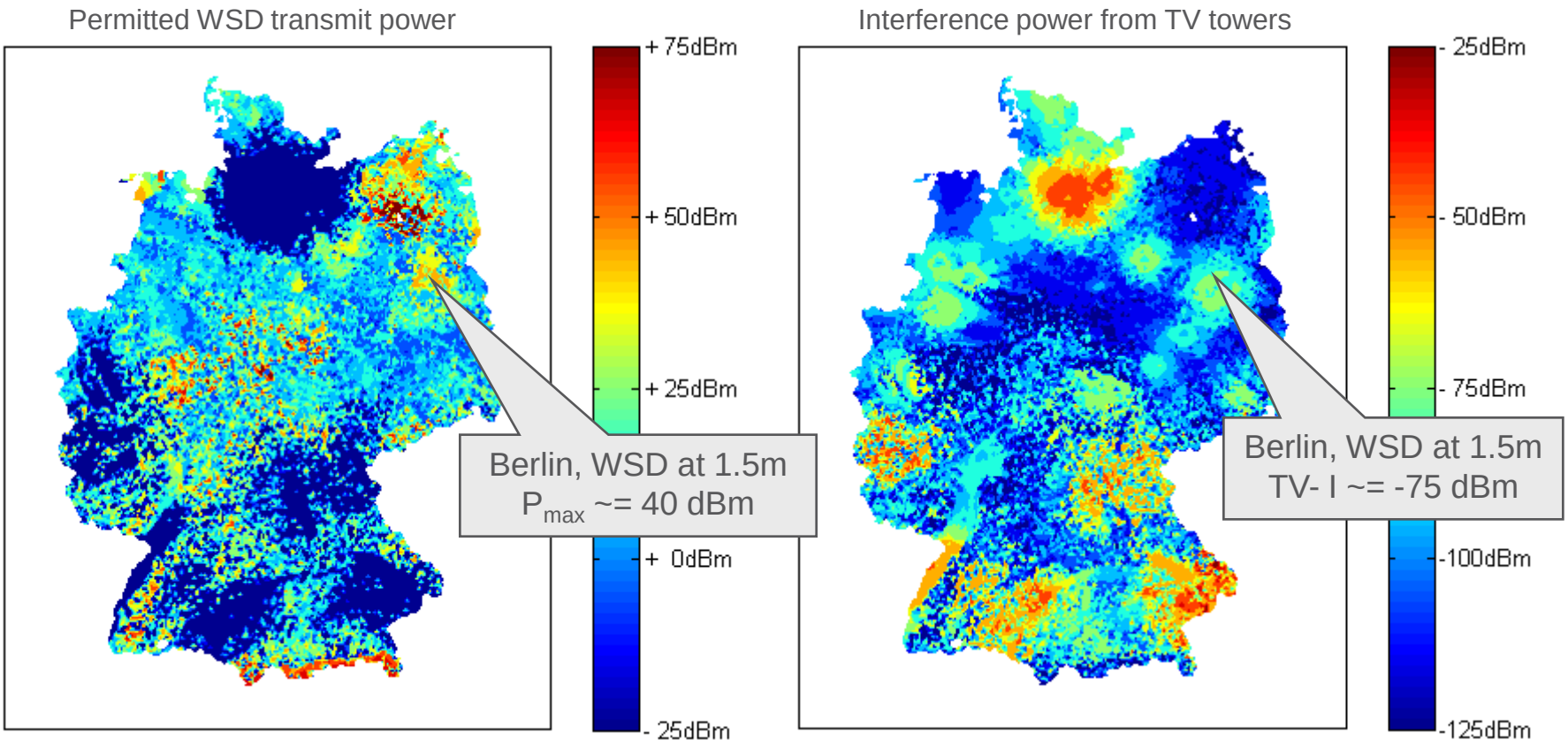
GEOMETRIES TO FIND CRITICAL POINT

- Determine critical point as TV receiver location which is the most limiting for WSD transmit power
  - Spatially separated on co- or adjacent channel
  - Within same location pixel as WSD on co-channel





WSD POWER & TV INTERFERENCE
FOR UHF CHANNEL 40 (622-630 MHZ)

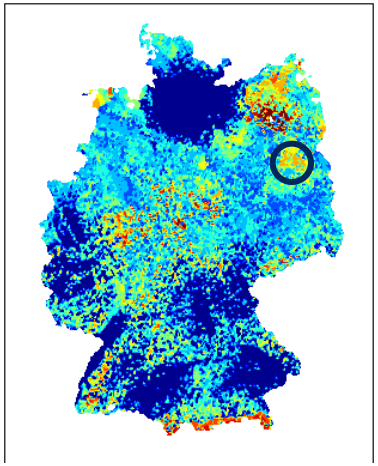


› High spatial variability of permitted transmit power and perceived interference

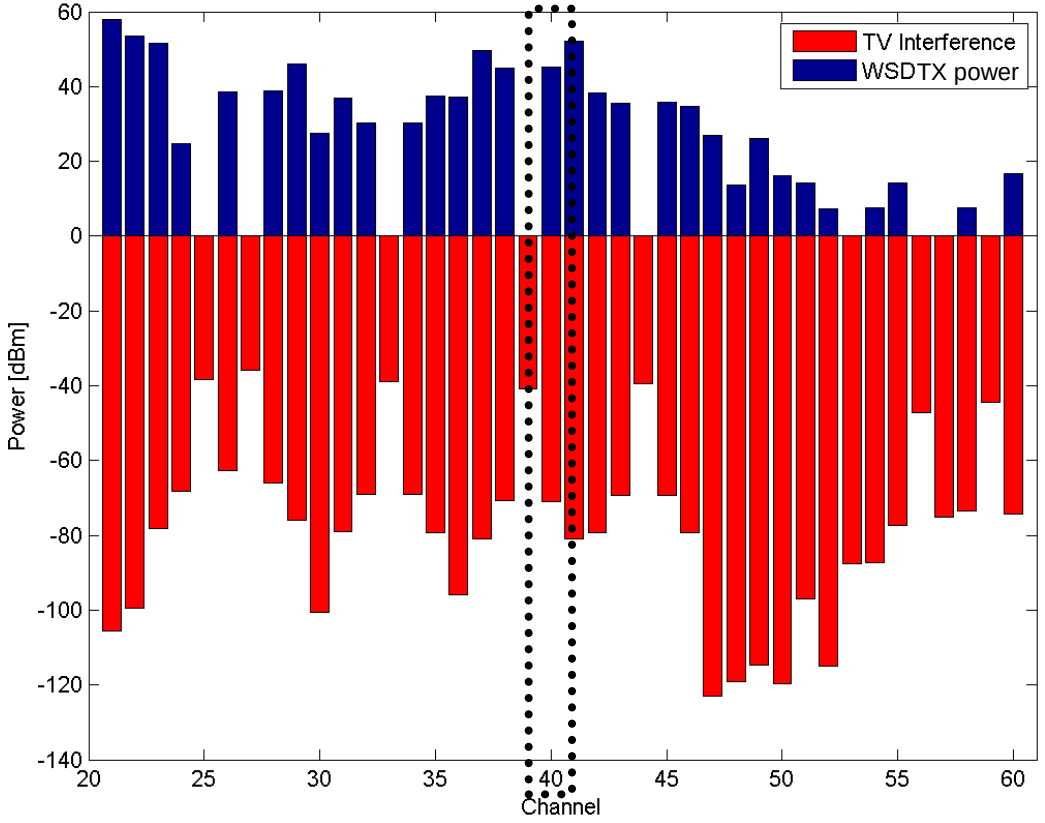
WSD at 1.5m height

WSD POWER & TV INTERFERENCE
FOR UHF CHANNELS 21-60 IN BERLIN

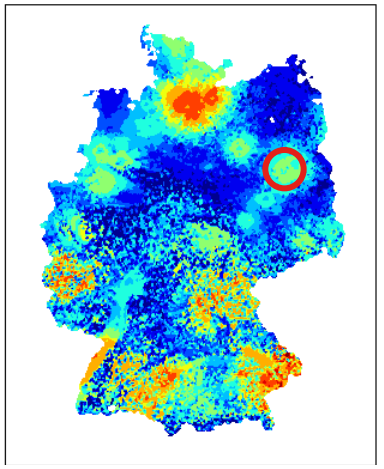
Permitted WSD power



Map for CH 40



Map for CH 40



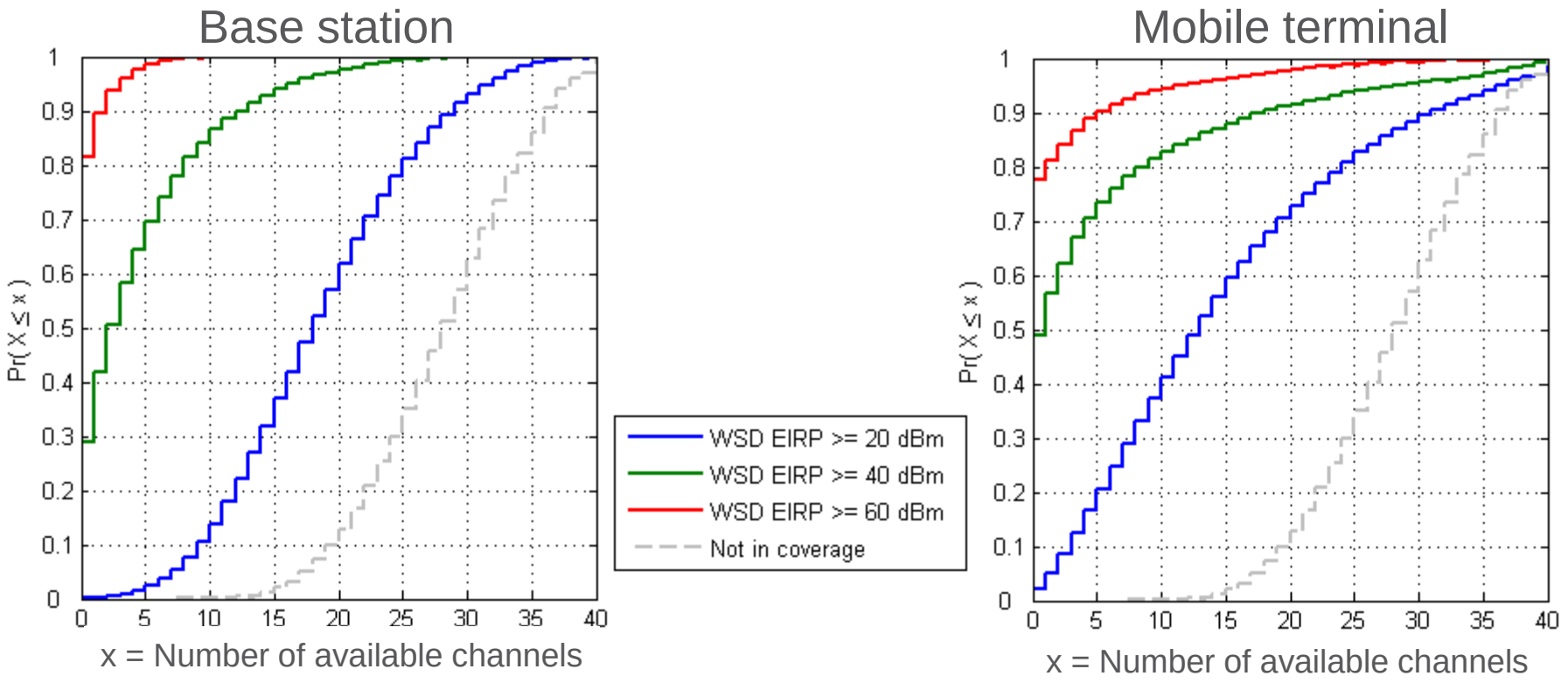
Interference from TV towers

› High variability of permitted transmit power and perceived interference among channels

WSD at 1.5m height

AVAILABLE TVWS CHANNELS
FOR GIVEN WANTED TRANSMIT POWER

- Count channels per location allowing a given WSD transmit power
- Draw CDF for this metric using all locations as sample set



CONCLUSION & OUTLOOK

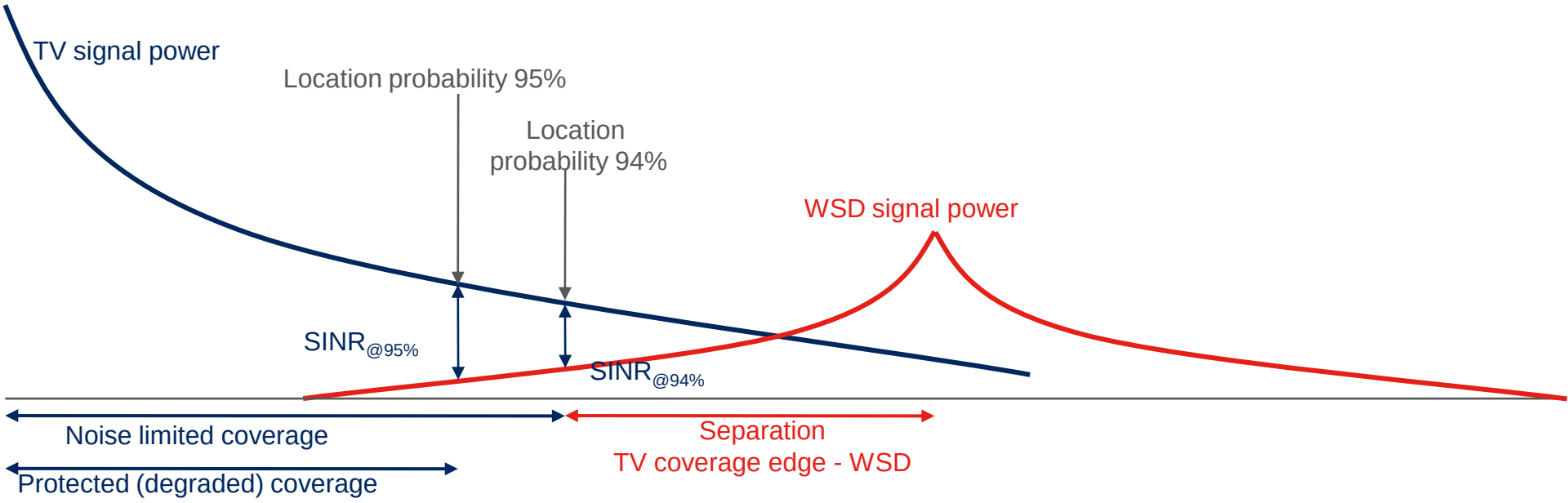
- Quite significant amount of spectrum unused by TV system
  - Strongly location-dependent availability
- Tradeoff between WSD wanted transmit power and number of available channels → favors short range / low power applications
- Considerable TV interference – white space is not really white
- Some remaining open questions…
  - How valuable is TVWS (compared to clean dedicated spectrum)?
    - This depends on what TVWS shall be used for → use case specific analysis needed
  - How well does supply match demand?

ERICSSON

PERMITTED WSD TX POWER CEPT ECC SE43 METHODOLOGY

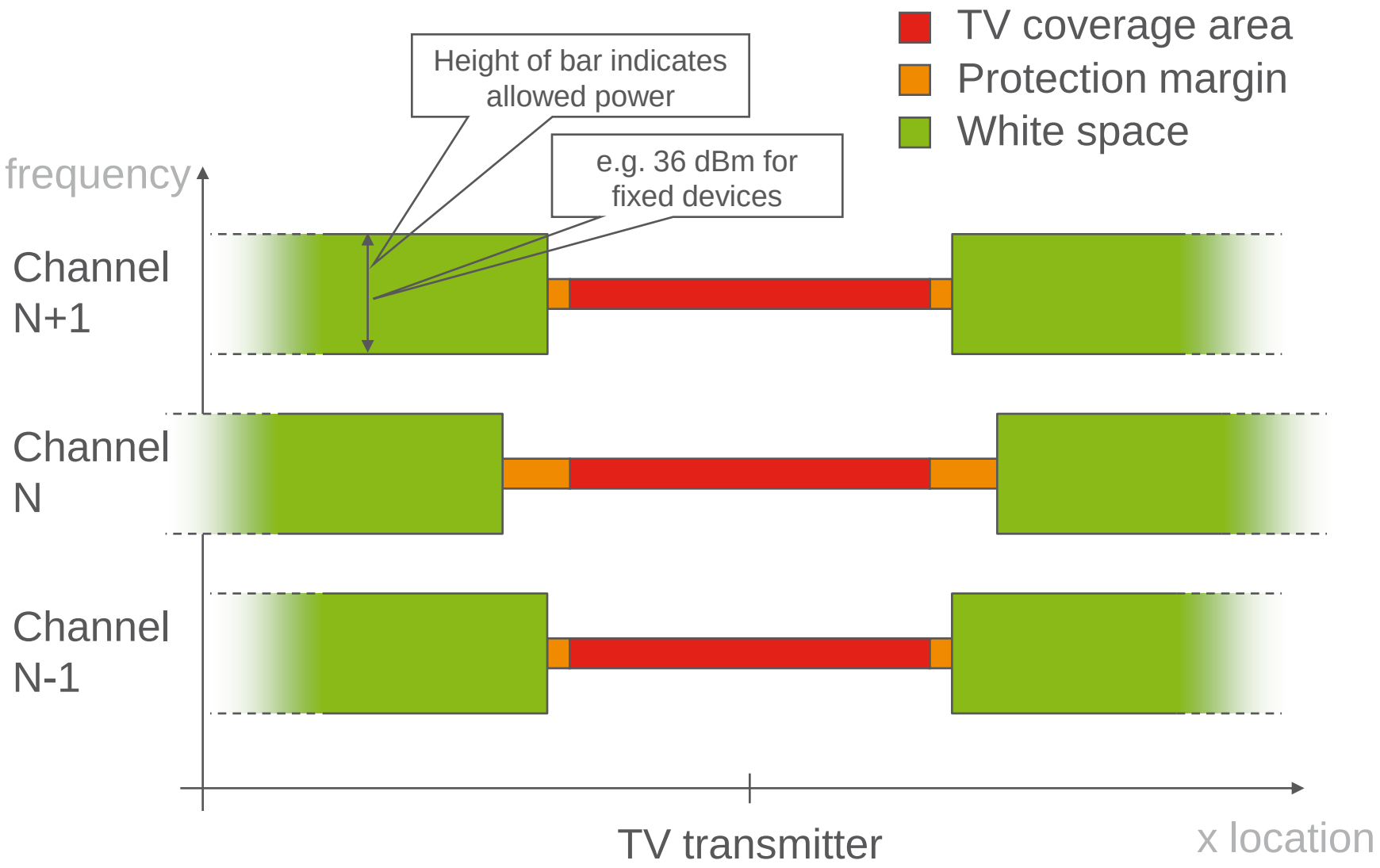
› Degraded (1%) Location Probability with WSD interference

$$q_2 = \Pr\left\{ P_S \geq P_{S,\min} + \sum_{i=1}^{K} r_{U,k} P_{U,k} + r(\Delta f)\, G\, P_{IB}^{CR} \right\}$$ → Solve for P_{IB}^{CR}

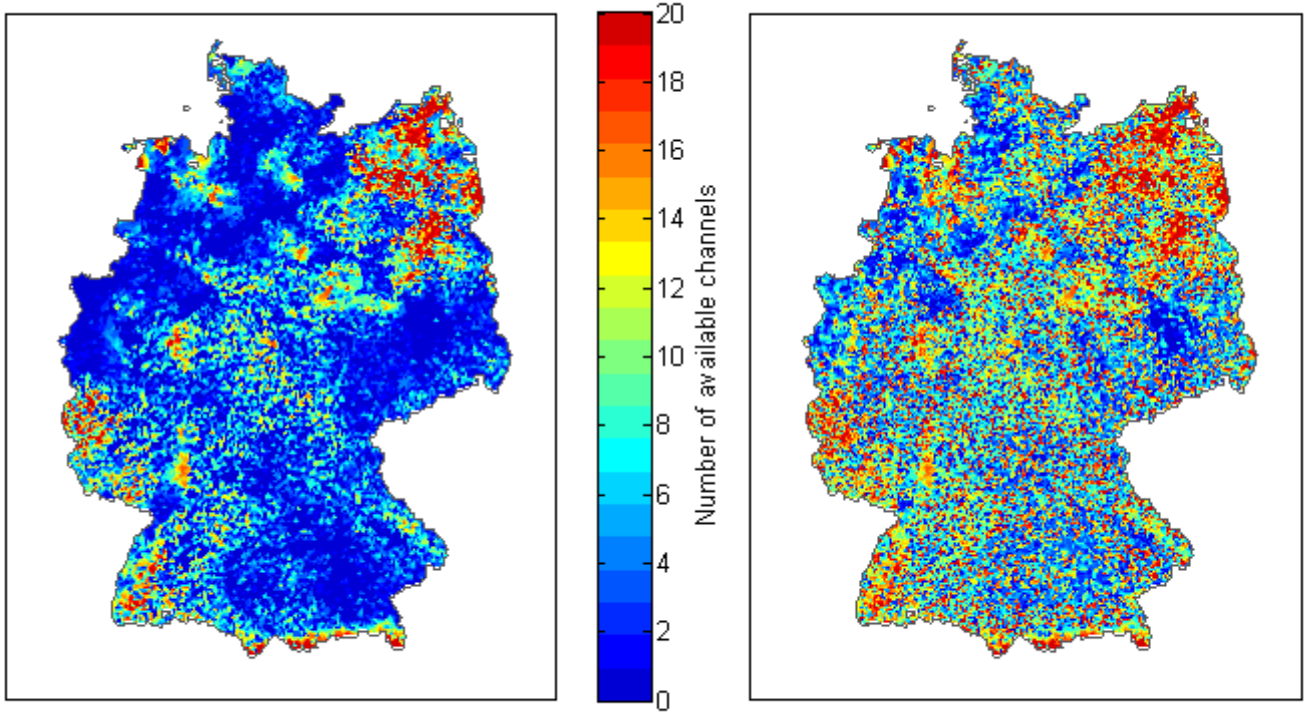


THE FCC APPROACH

FIXED MAX. OUTPUT POWER DEPENDING ON DEVICE TYPE



NUMBER OF AVAILABLE CHANNELS FOR GIVEN WANTED TRANSMIT POWER



- Base station
- Permitted to operate on given number of channels with 40 dBm

- Mobile terminal
- Permitted to operate on given number of channels with 20 dBm

POTENTIAL TO DEPLOY SECONDARY SYSTEM WITH TYPICAL TRANSMIT POWERS IN TVWS

DVB-T COVERAGE - RESULTS

- Moving along path at Lon. 10°W (y-index 121)
- Available channels and total number of available channels.