# Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

**Submission Title:** Why/when is AWGN a suitable channel model for wireless front-/backhaul?
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**Abstract:** This presentation gives reason that an Additive White Gaussian Noise Chanel is a suitable model for wireless front- and backhaul. In addition some clues on the necessary future coordination for such links is given..

**Purpose:** Input to provide a channel model for wireless front-/backhaul to TG3 d.

# Why/when is AWGN a suitable channel model for wireless front-/backhaul?

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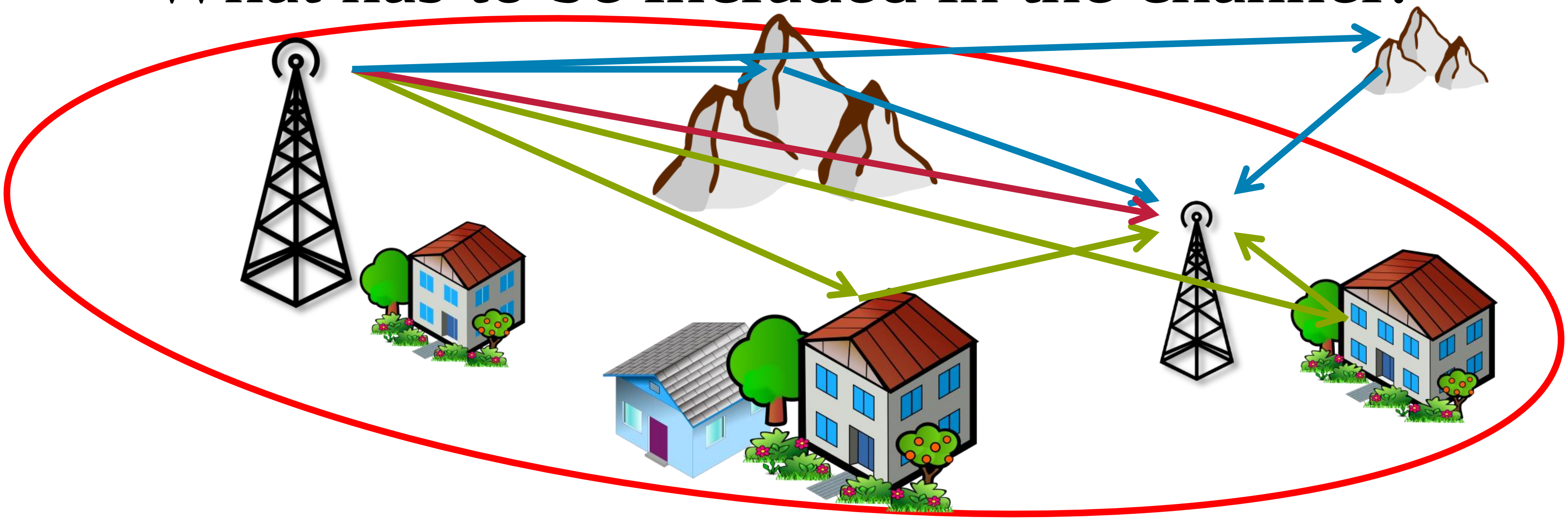
# Outline

1. What has to be included in the channel model?
2. Simple Link Budget
3. Directive Antennas
    - Impact of Directive Antennas on the Channel
    - Real World Antennas
4. Conclusion

# What has to be included in the channel?



- At first glance: every reflection/refraction/diffraction and scattering
- At second glance: everything less than 30 dB weaker than the direct path
- Typical distances

  Backhaul few 100m to several km (TRD, ARD); Fronthaul few 100m (TRD)
- Additional 30 dB of free space pathloss (FSL) correspond to a factor of ~31.5 in distance. For a direct path with a length of 100 m (1 km) a reflected path must at least have a length of 3.15 km (31.5 km) to be irrelevant

# (Simple) Link budget for the direct path

| | | | |
|---|---|---|---|
| SNR = | 0 | dBm | transmitter power (baseband) |
| | + $G_{tx}$ | dBi | antenna gain (transmitter) |
| | - $L_{FSL}$ | dB | free space loss |
| | + $G_{rx}$ | dBi | antenna gain (receiver) |
| | - 7.6 | dB | noise figure |
| | - $P_n$ | dBm | thermal noise |

Required Antenna gain:
- 2x 26 dBi @ 100m
- 2x 36 dBi @ 1km

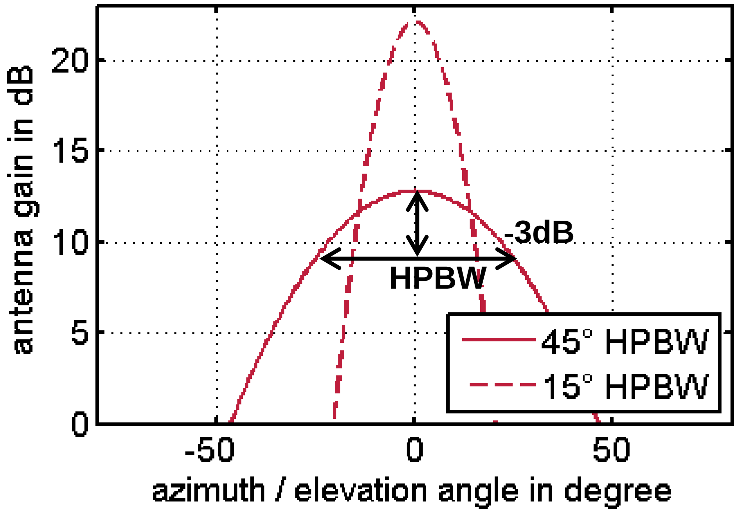
for SNR = ~10 dB

- free space path loss at 300 GHz: 122 dB @100m 142 dB @1km

- required BER of 10^-12 after FEC (TRD, ARD)
- reasonable SNR = ~10 dB for a QPSK (see Doc. IEEE 802.15-15-13-0406-00-0thz)

- carrier frequency: 300 GHz bandwidth: 50 GHz

# What kind of antenna?

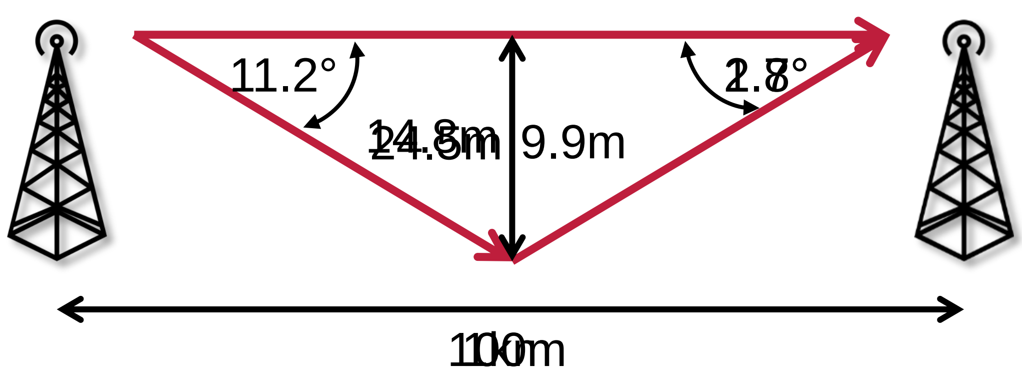



- Suitable antennas are e.g.:
  - dish antennas
  - cassegrain antennas
  - may include lenses
- Common properties:
  - High antenna gain
  - No grating lobes, usually no side lobes
  - dimensions scale with gain and wave length
- Assuming a Gaussian antenna pattern in elevation and azimuth:

| HPBW | gain | gain-30 dB reached at (one antenna!) |
|---|---|---|
| 1.5° | 42.1 dBi | 2.4° |
| 2.5° | 37.7 dBi | 4.0° |
| 5.0° | 31.6 dBi | 7.9° |
| 10° | 25.6 dBi | 15.8° |
| 15° | 22.1 dBi | 23.7° |

# A simple worst case evaluation

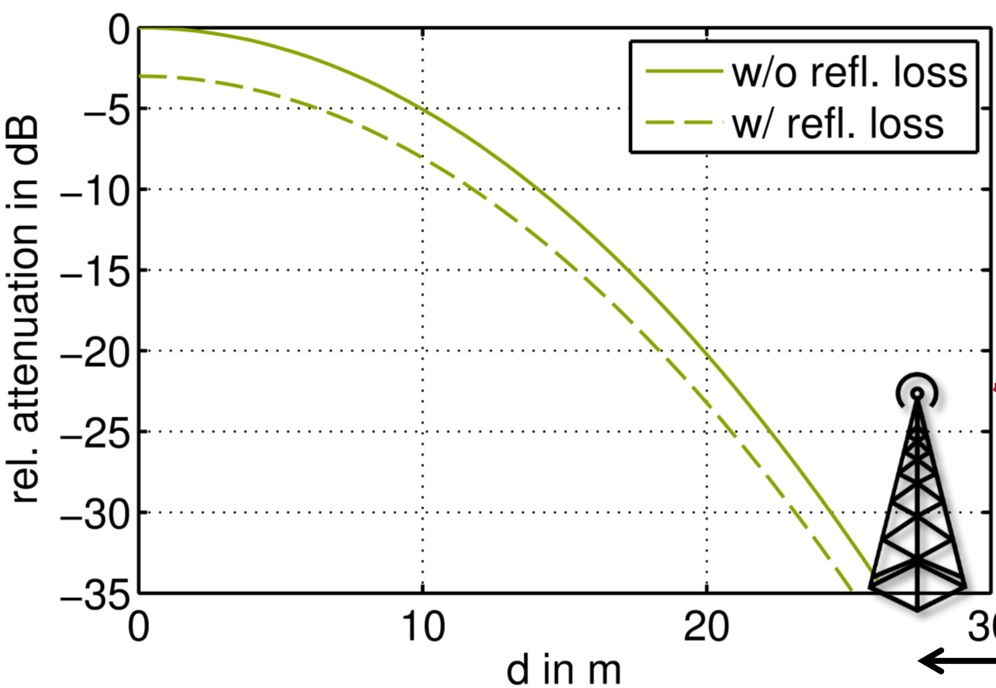
| HPBW | gain | gain-30 dB | 2x gain-30 dB |
|---|---|---|---|
| 1.5° | 42.1 dBi | 2.4° | 1.7° |
| 2.5° | 37.7 dBi | 4.0° | 2.8° |
| 5.0° | 31.6 dBi | 7.9° | 5.6° |
| 10° | 25.6 dBi | 15.8° | 11.2° |
| 15° | 22.1 dBi° | 23.7° | 16.8° |



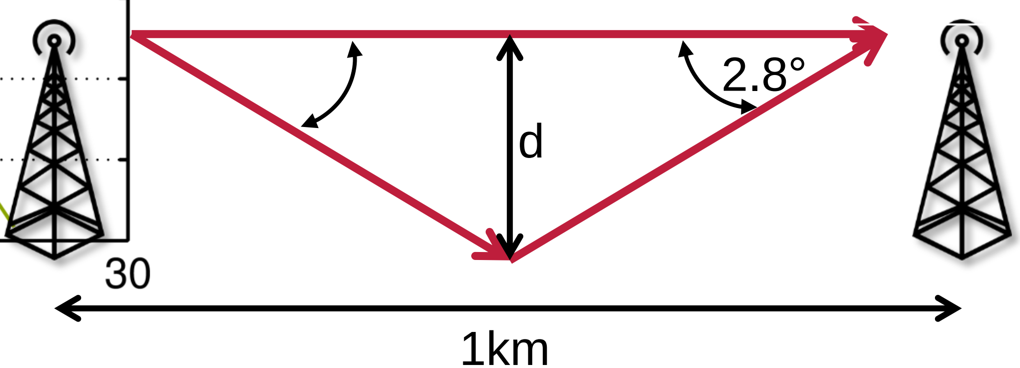

d=9.9 m @100 m distance for 10° HPBW
d=24.5 m @1 km distance for 2.5° HPBW
d=14.8 m @1 km distance for 1.5° HPBW

# A slightly more sophisticated evaluation

| HPBW | gain | gain-30 dB | 2x gain-30 dB |
|---|---|---|---|
| 2.5° | 37.7 dBi | 4.0° | 2.8° |




- Only attenuations from the antenna pattern, FSL is negligable
- With equal antennas at the receiver and the transmitter a distance of ~25 m is required
- Additional reflection losses decrease the distance slightly (e.g. 3 dB)



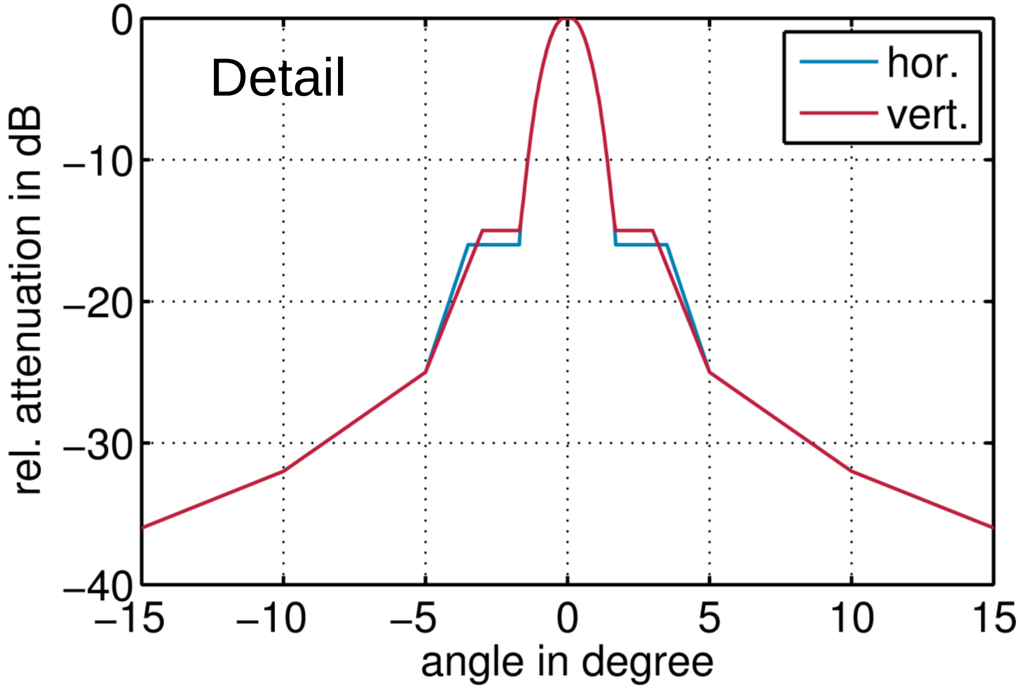
# And in the real world? (1)

- No dish antennas available at 300 GHz, yet

- Dish antennas for 71-86 GHz are available, e.g. Commscope VHLP200-80

  Gain 41 dBi

  HPBW 1.5°



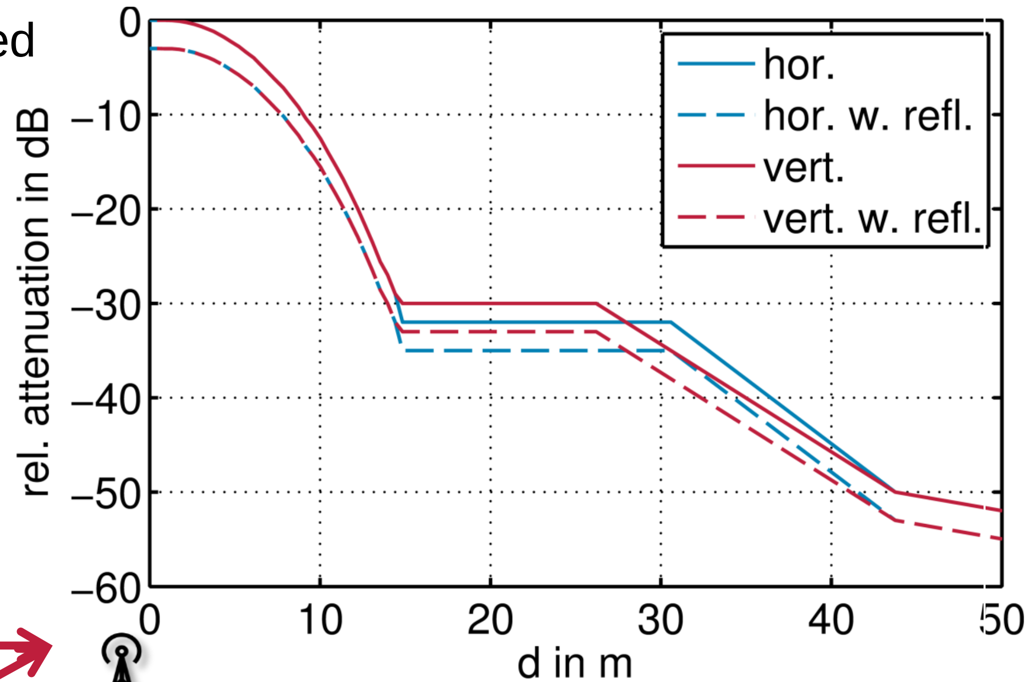

- Also Antennas with only 0.5° HPBW are available at 80 GHz

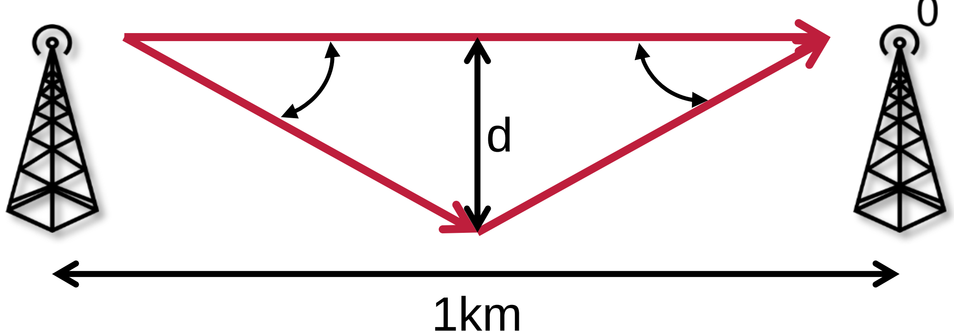
# And in the real world? (2)

- At less than 15m -30dB is reached for one of these antennas at Tx and Rx:

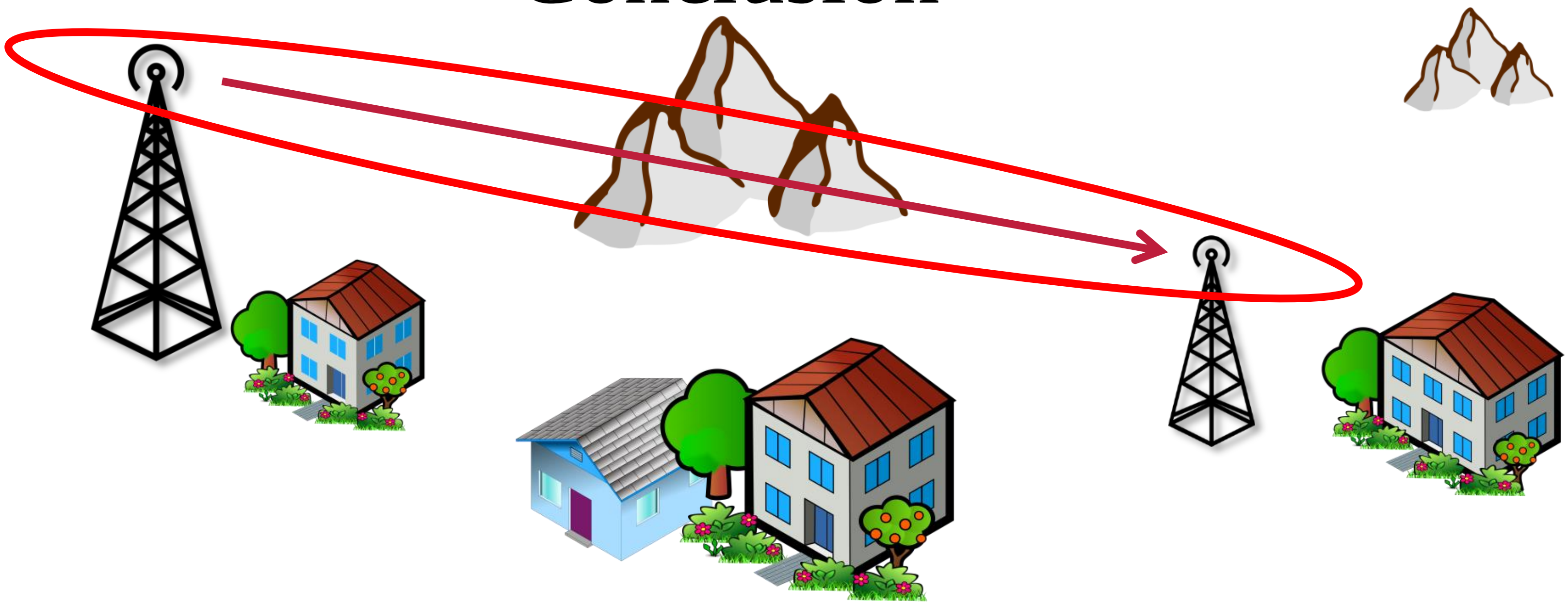
  Gain 41 dBi

  HPBW 1,5°
- With the Gaussian Antenna example 25m are required with a HPBW of 2.5° and also 15 m with ~1.5°
- (SNR increased by 2x 5 dB)



# Conclusion



- Multipath propagation is irrelevant (regarding the necessary planning process and the necessity to coordinate backhaul and fronthaul links with national regulators)
- AWGN sufficient for propagation aspects
- BUT still super wide band channels (more than ultra wide band)

# ***Danke für Ihre Aufmerksamkeit!***

*(Thank you for paying attention!)*

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