

# ALCOMA

## Radio (Lines) basics

educational part

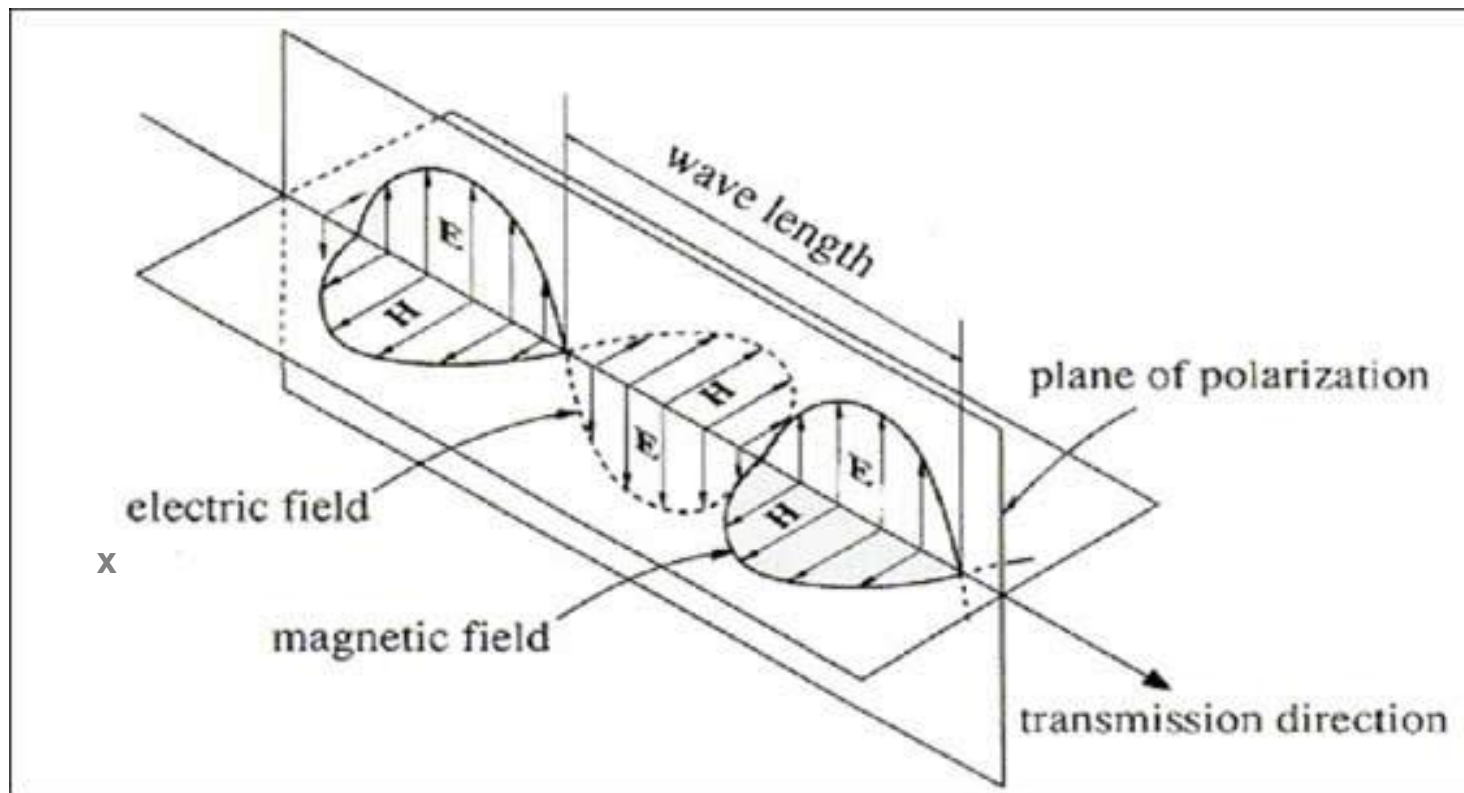
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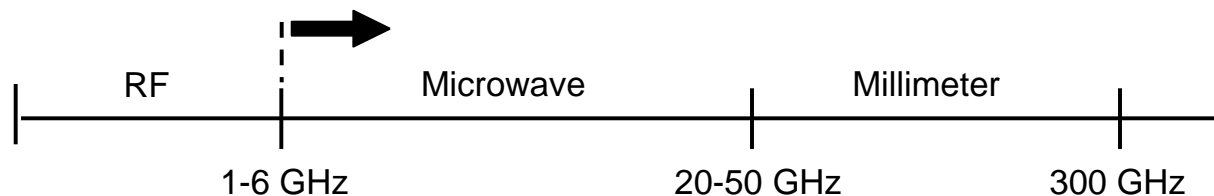
# Radio means electromagnetic wave

- What is planar wave
- Poynting vector  $\mathbf{S} = \mathbf{E} \times \mathbf{H}^*$  direction of energy travel



# Propagation types

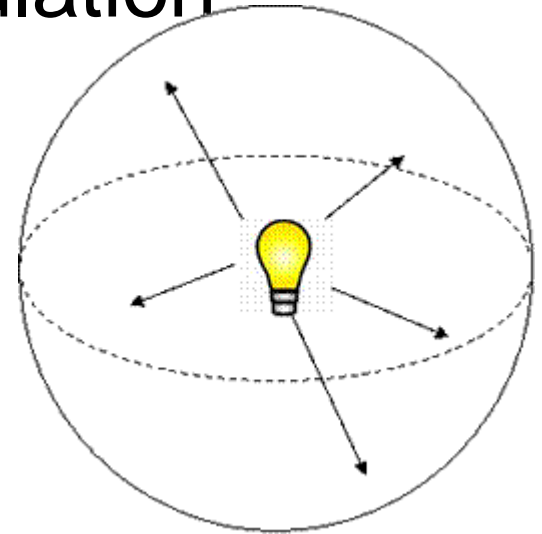
- **Ground-wave** propagation (AM LW radio)
- **Sky-wave** propagation (SW radio) ionosphere
- **Line-of-sight** propagation (VHF, microwave)
- Types could be combined



# Propagation basics

- main equation for FSL calculation

$$\text{Free Space Loss} = \left( \frac{\lambda}{4\pi r} \right)^2$$

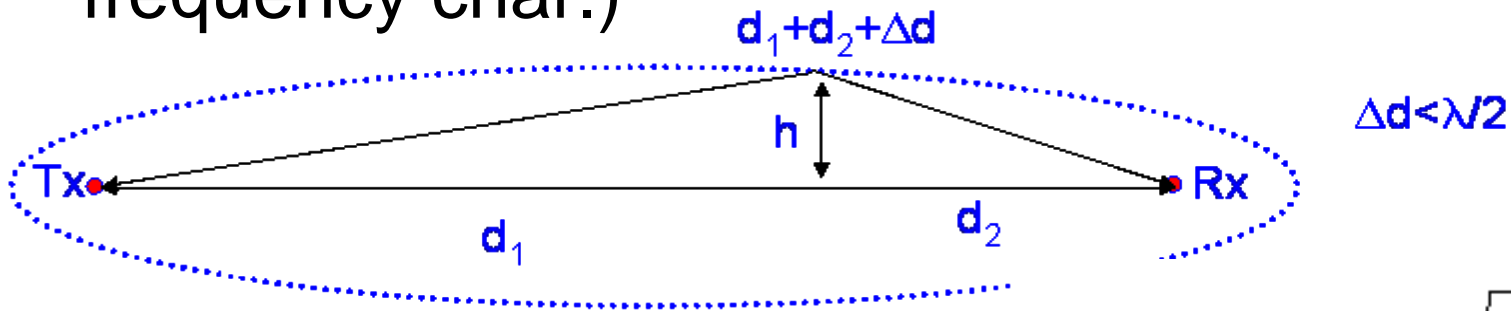


- „dB“ form (units GHz, km)

$$\text{FSL} = 92.4 + 20 \log(f) + 20 \log(d)$$

# Fresnel zone

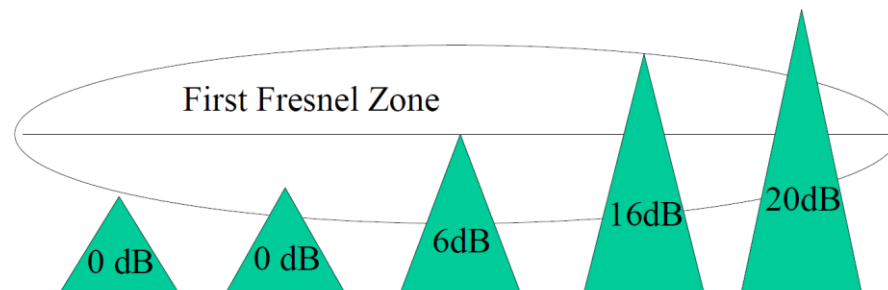
**Fresnel zone** – areas of constructive and destructive interference („bumps“ in phase and frequency char.)



$$\text{Fresnel radius: } r_1 = \sqrt{\lambda \frac{d_1 \times d_2}{d_1 + d_2}}$$

Radius of F1 (m, km, GHz)

$$r = 8.657 \sqrt{\frac{D}{f}}$$

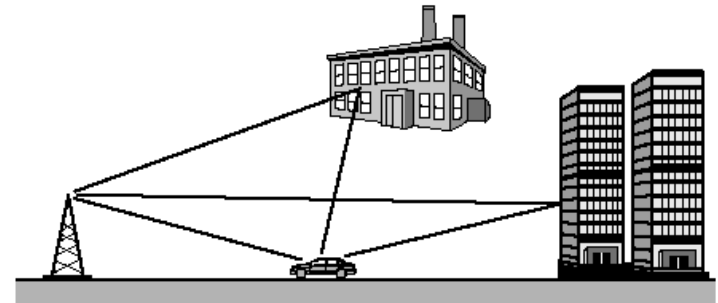


# Other Propagation Impairments

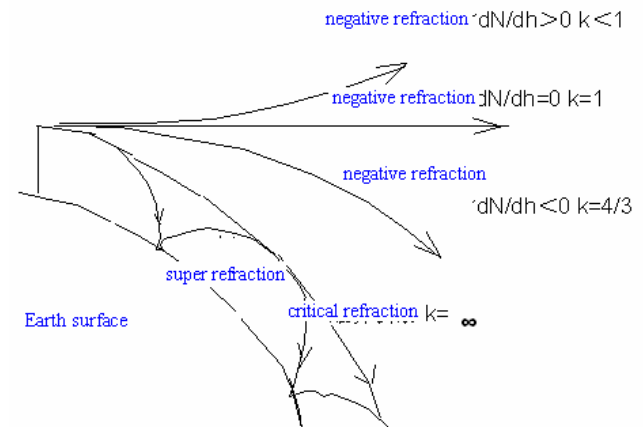
- **Atmospheric absorption** – water vapor and oxygen contribute to attenuation
- **Multipath** – obstacles reflect signals so that multiple copies with varying delays are received
- **Refraction** – bending of radio waves as they propagate through the atmosphere



(a) Microwave line of sight



(b) Mobile radio

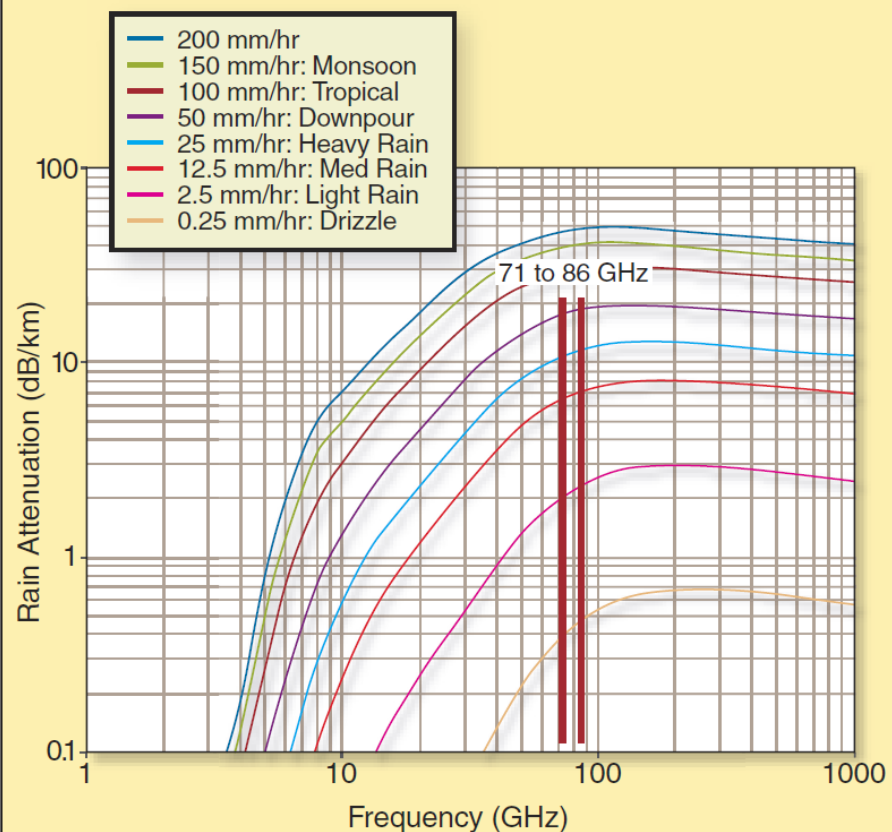
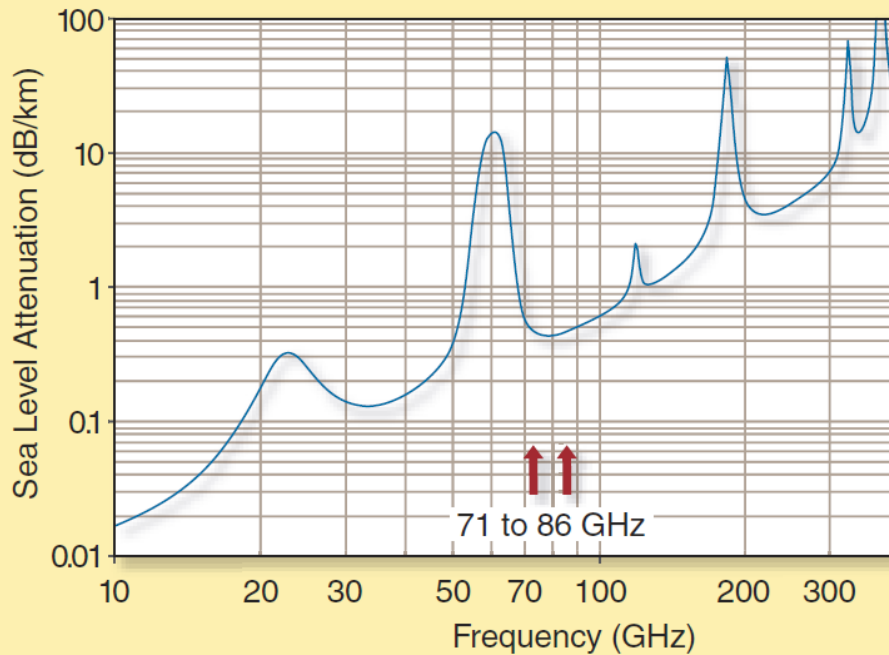


# Propagation „bible“ for professionals

- ITU-Recommendation P.530-13
- Propagation data for line of sight systems covers all aspects (statistics)
  
- ITU Recommendation P.837-5
- Rain- precipitation modeling
  
- Correct fade margin selection

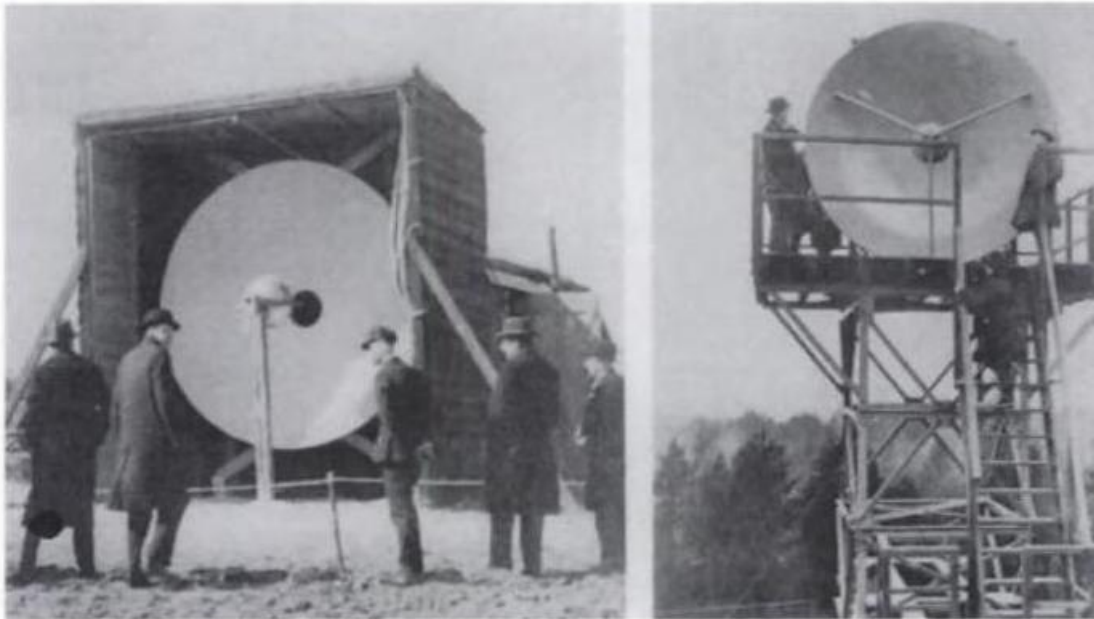
# Calculation of expected RSL

- $RSL = P_{out}[dBm] + G_{tx}[dB] + G_{rx}[dB] - A_o[dB] - E[dB]$
- $A_o = FSL$
- E – Extra absorption (Gas, Rain)
- $RSL > RX \text{ sensitivity} = \text{fade margin}$



# The first point to point link

- 1931 between Calais and Dover, 1.7GHz , 30km, 1.7GHz, 1W pwr.
- Carried single two way telephone channel
- Side effect – due to the Fresnel zone coverage the system was able to detect passing ships –first idea of using microwaves in RADAR



# Frequency bands

- **Licensed (professional)**
- Frequency coordination, planning, user protection
- High EIRP power
- ETSI Bands  
8,11,13,15,18,23,26,38 GHz
- Main target -reliability of connection
- Proprietary systems
- Backhaul connectivity
- P2P (P2MP 3.5GHz)
- Licence and equipment price
- **Unlicensed „freeband“**
- Strong regulation (mostly EIRP limitation),
- small distance range
- Shared service, no protection
- Standards 802.xx
- ISM 2.4GHz, 5.6GHz
- Mostly halfduplex P2MP
- „Consumer electronics“
- 17GHz, 24GHz P2P
- Light licensed or free
- 60GHz, 80GHz

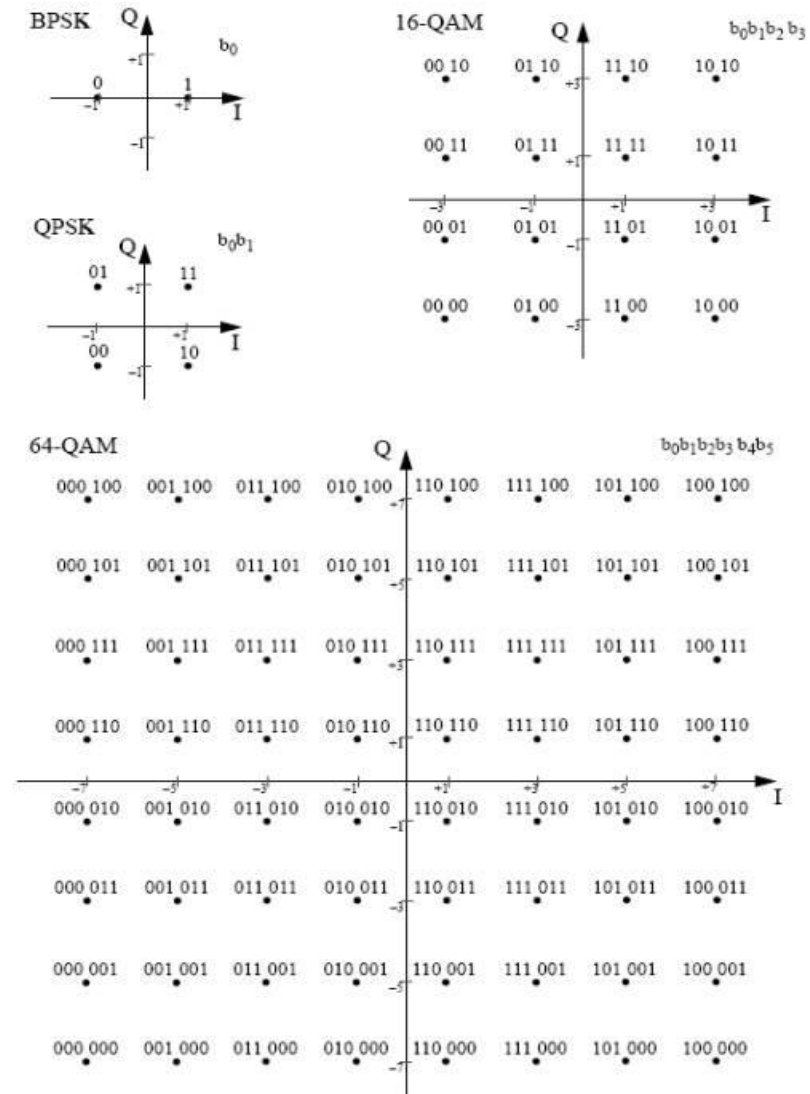
# Main differences between P2P link to WiFi based equipment

- Point to point link
- **Designed to make a transparent cable replacement**
- Independent full duplex channels (RX/TX)
- Used to transfer analog (TV) or digital data,
  - synchronous data (for switching networks), or network data (Ethernet)
- Highest data rate for given freq. Channel (256QAM)
- Backbone links
- 802.xx (Wifi, Wimax..)
- Used for P2P or P2 multipoint for multiple user access
- Time multiplex TX and RX uses one channel, OFDM for multipath propagation
- Non transparent processing, only for Ethernet, overhead data (beacon...)
- Used for last mile users
- Low EIRP

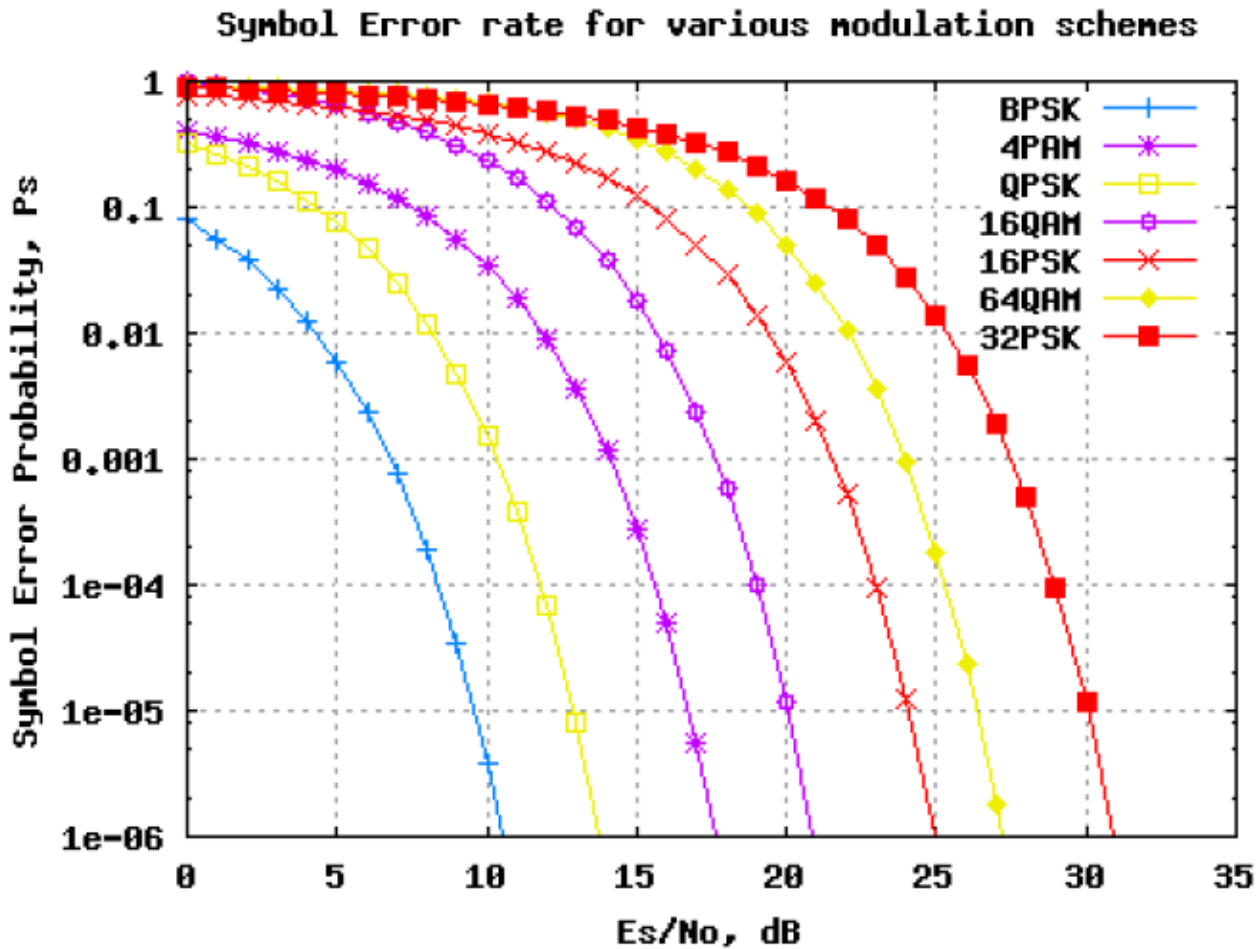
# Modulation secrets

- **Phase modulation**  
(BPSK, QPSK, m-PSK) –robust, low S/N
- **QAM modulation**  
(16,32,64,128,256QAM)  
P2P links – high efficiency and capacity, high S/N needed.

\***complex modulation**  
OFDM – designed for multipath encapsulated many QAM modulated carriers, used in Wifi, DVB-T  
Complicated demodulation, phase noise problem

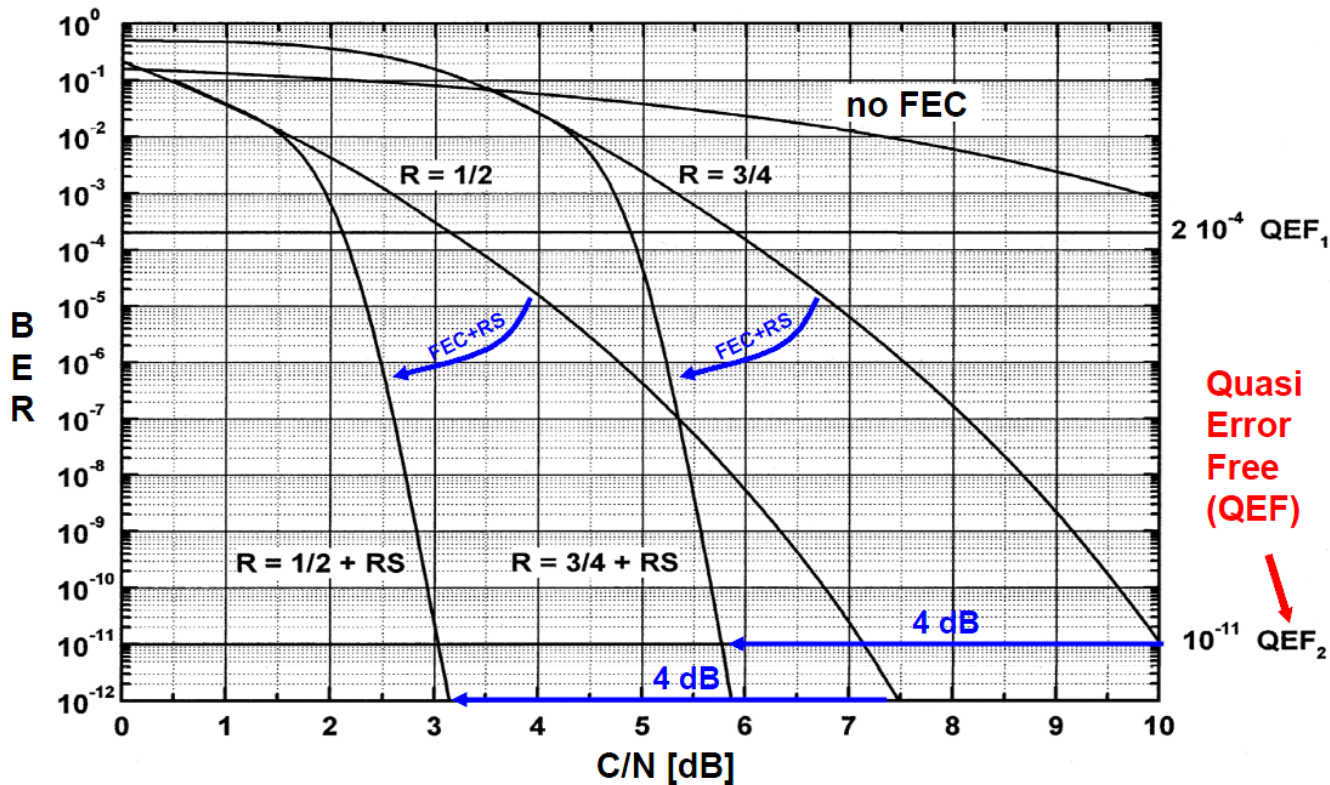


# Modulations –Es/N ratio comparison



# FEC secrets

- Adds redundant information to the data stream – used to identify and correct bit errors
- Trade-off of data size vs error correction



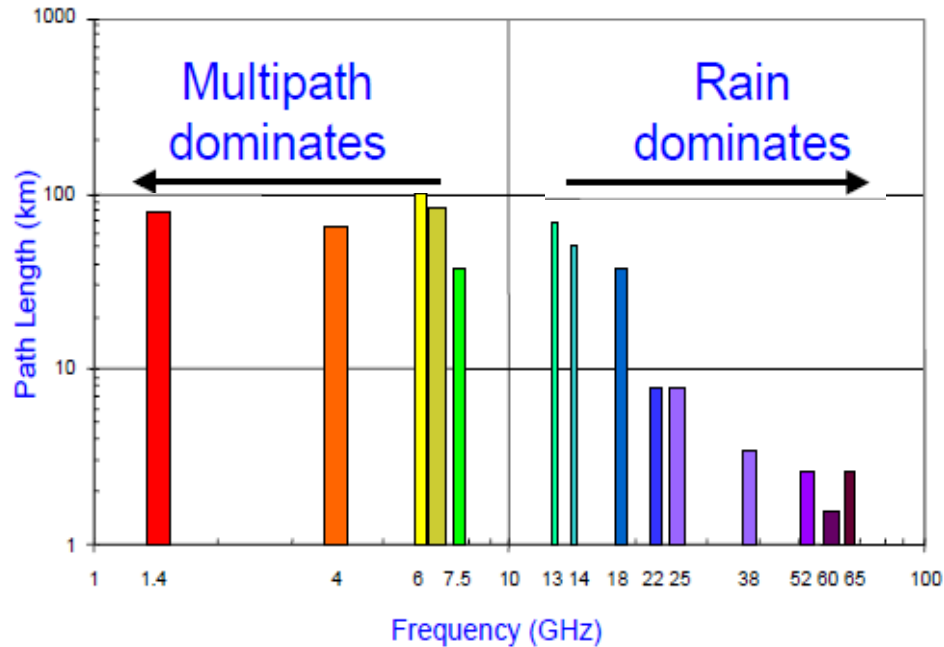
# Point to point links –maximum distances

Atmosphere attenuation problems –fading reserve  
 Ground curvature- LOS  
 Compare to satellite or space communication!!!

This plot shows typical path lengths per band

Note they decrease with increasing frequency

60GHz is particularly short - why?

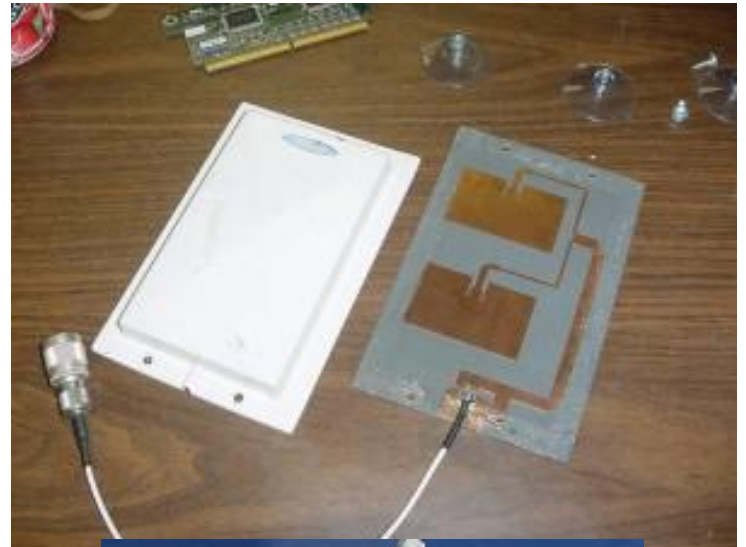


# Link Channel Capacity

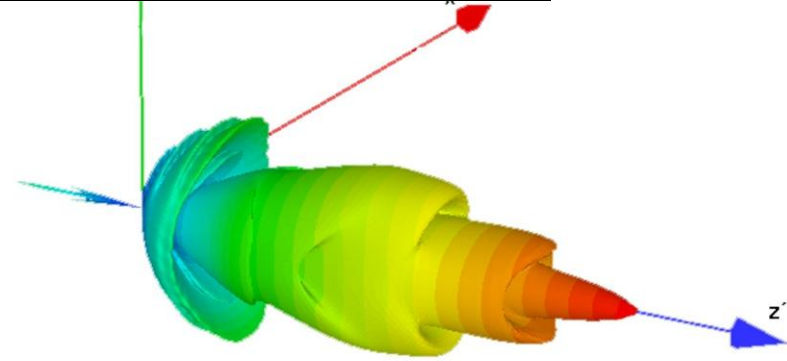
- **Data rate** - rate at which data can be communicated (bps) (Symbol rate x User rate) FEC...(Mbit-Gbit)
- **Bandwidth** - the bandwidth of the transmitted signal limited by channel size (7/14/28/56MHz up to GHz)
- **Noise** - average level of noise over the communications path ( $P=kTB$ ), S/N,  $E_b/N$  ratio
- **Bit Error rate (BER)** - rate at which errors occur
  - Error = transmit 1 and receive 0; transmit 0 and receive 1

# Antennas for microwaves

- Wire (Yagi, loops)
- Planar (patch, microstrip)
- Horn type
- Waveguide (slot)
- Parabolic dish+appropriate feed
- **Crucial parameters!!**
- (SWR, radiation pattern, construction)



# Parabolic Dish properties

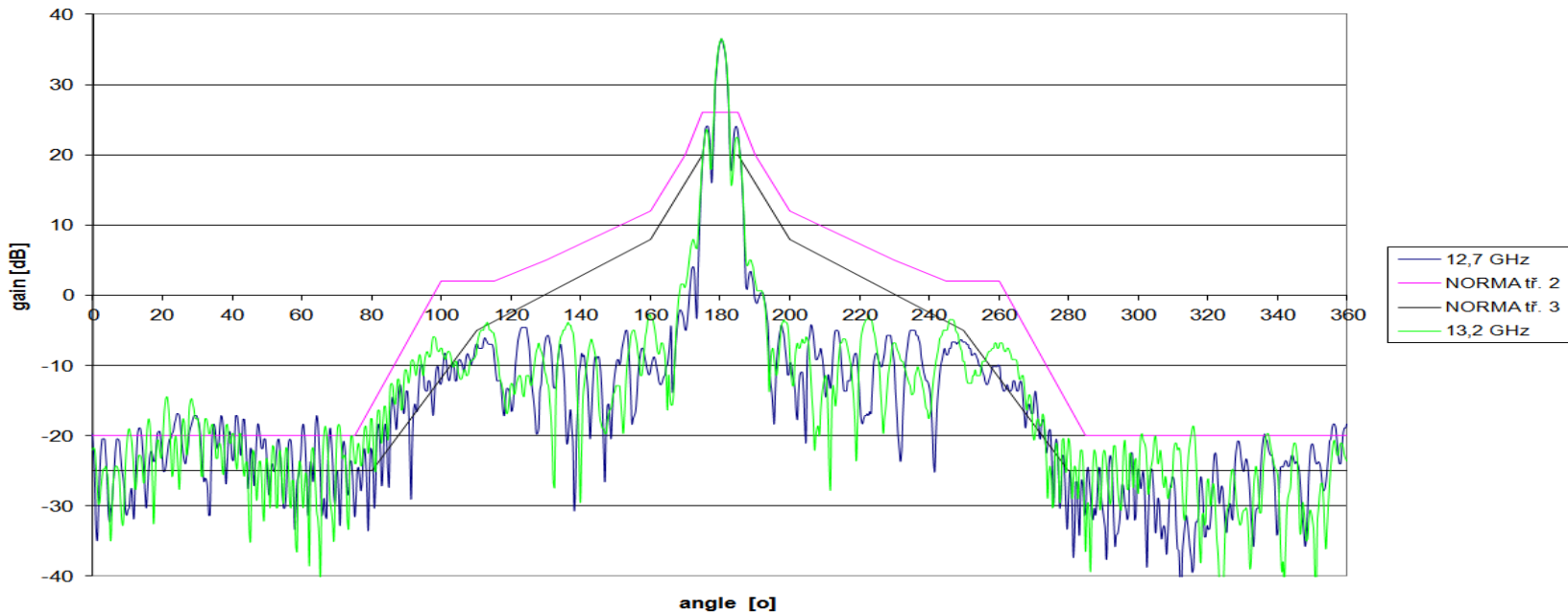


- Radiation pattern is 3D!!
- Gain  $G = \frac{4\pi A}{\lambda^2} \epsilon_A = \frac{\pi^2 d^2}{\lambda^2} \epsilon_A$
- Beamwidth (k=70, result °)  $\theta = k\lambda/d$
- Aperture efficiency –feedhorn,
- Antenna quality – sidelobes, polarization
- ETSI norm – for professional links – Class 2 or 3

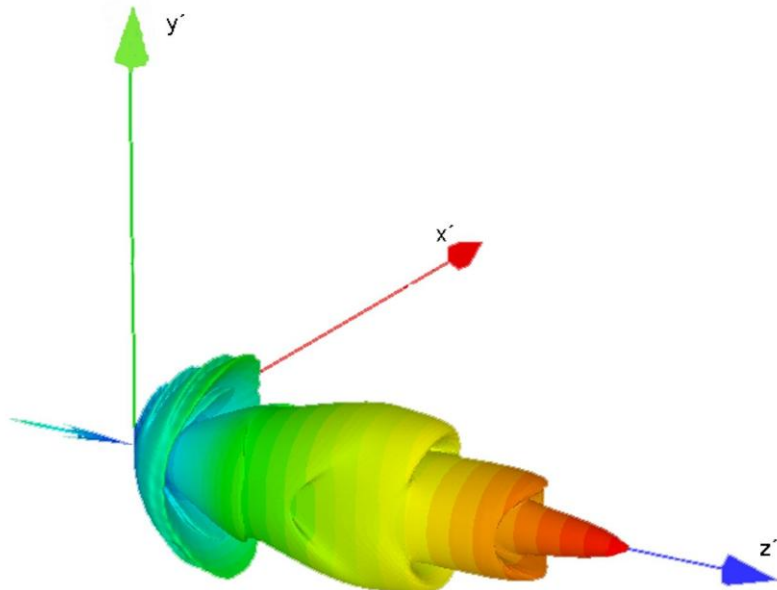
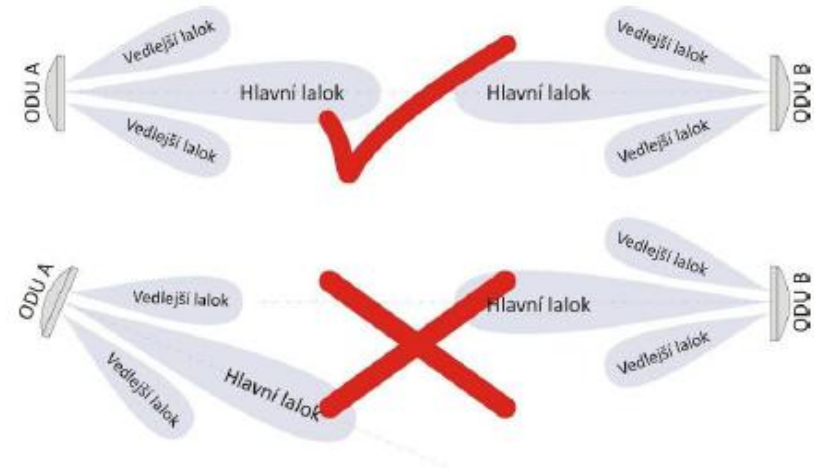
# Example of 0.6m antenna parameters

Freq.[GHz]	Gain[dB]	3dB angle [°]
5	28	6.93
18	39	1.92
80	52	0.43

Radiation pattern H, short collar parabolic dish

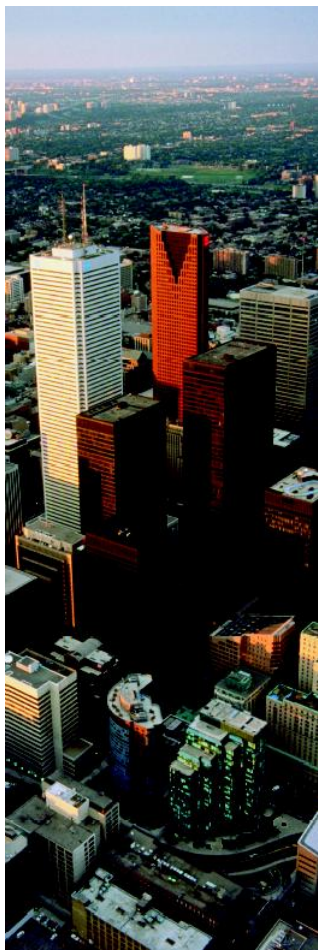


# Antenna pointing –sidelobe problems



1st sidelobes typically 15-20dB below the main lobe only

## Portfolio of products: ODU-IDU solution



- **Frequency bands**  
5-8,11,13, 15, 18, 23, 26, 38 GHz
- **User Interfaces**  
2FEth + 16E1, 4GEth + SFP + 2E1
- **Transmission speed**  
8 – 360 Mbps for configuration 1+0, up to 600 Mbps for 2+0
- **Output power**  
Up to 28 dBm depends on band, ATPC
- **Channel bandwidth and modulation**  
7, 14, 28, 56 MHz / QPSK, 16QAM, 32QAM, 64QAM, 128QAM, 256QAM, support of adaptive modulation
- **Management system**  
ALCOMA ASD, WEB, SNMP
- **Antennas**  
35, 65, 90 and 120 cm
- **Power Supply and consumption**  
48 V / up to 50 W for 1+0



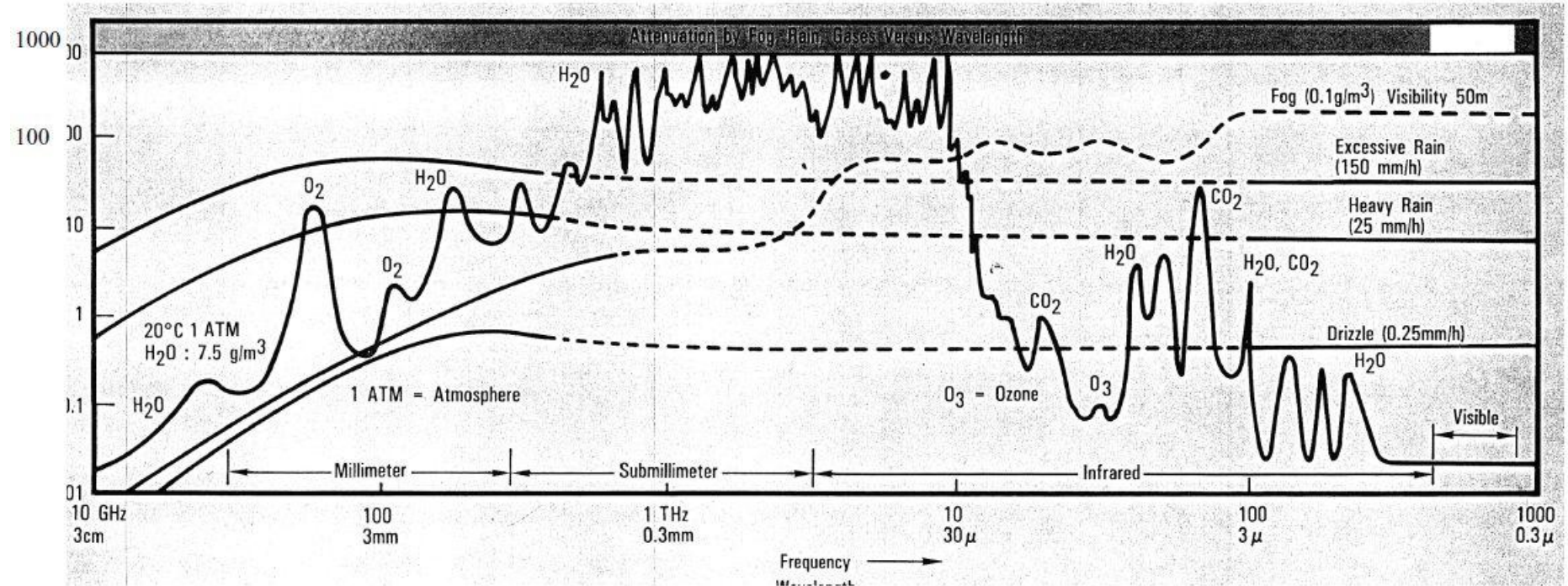
## Microwave links All ODU solution



- **Frequency bands**  
5-8, 11, 13, 17, 24, 80 GHz
- **User Interfaces**  
2FEth, 2GEth metallic/optical
- **Transmission speed**  
8 – 384 Mbps
- **Output power**  
Up to 28 dBm TX depends on band, ATPC
- **Channel bandwidth and modulation**  
7, 14, 28, 56 / QPSK, 16QAM, 32QAM, 64QAM, 128QAM, 256QAM, support of adaptive modulation
- **Management system**  
ALCOMA ASD, SNMP
- **Antennas**  
35, 65, 90 and 120 cm
- **Power Supply and consumption**  
48 V / from 25 W to 50W depends on TX power



# Future development ?



Source: TRW, Electromagnetic Spectrum Chart

- Atmosphere attenuation – wireless enemy

**THANK YOU!**

