# EMSMN Lab. 1 – report

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## Coverage Analysis

Complex permittivity of **wood** is: (2.5 - 0.03i)*Eps_r
0.03/2.5 = 0.012, so the material has poor reflection properties, but good penetration properties.

Comments on isotropic antenna's radiation pattern:
Magnitude is the same in every direction, because the antenna is isotropic.

Comments on rays arriving to Rx in **LOS** conditions:
Rays with highest magnitude (around -40 dB) go directly from Transmiter, furthermore there are more rays recieved that are reflectionsm however their power is smaller(less than -70 dB) than the direct ones.

Comments on rays arriving to Rx in NLOS conditions:
When direct ray in NLOS conditions is compared to direct ray in LOS conditions we can note that direct NLOS ray is smaller by 20dBm, it is caused by longer path between the transmiter and reciever.
Furthermore the delay on the reciever at the end of corridor is higher than those in the middle of the room, however, after examining impulse response we can observe that rays for NLOS conditions arrive at the reciever roughly at the same time.
It is worth noting that rays when reflected by wood lose most of their power, beause of wood's material properties.

Complex permittivity of **concrete** is: (7 - 0.8i)*Eps_r
0.8/7 = 0.11.
Compared to wood, this material has better reflection properties, but worse penetration.

Comments on rays arriving to Rx in **LOS** conditions (compare with the previous observations):
There are more reflected rays than in the 'wood' case. Overall, the average power received is slightly higher.

Comments on rays arriving to Rx in N**LOS** conditions (compare with the previous observations):
Because concrete has bad penetration properties, the receivers in NLOS conditions have lower received power for concrete than for wood (15 dBm lower).
The main difference is that for concrete, the waves that reflect from walls have the highest power and waves that penetratre have very low power.
For wood it is the the reverse - waves with highest power penetrated the material, where the reflected waves had very low negligible power.

Comments on horn's radiation pattern:
Horn's radiation patern has two components, vertical and horizontal. Furthermore we note that antenna radiates in only one direction. In result more rays arrive at the recivers but they have smaller power

because transmiter, transmits in horizontal and vertical directions.

### Comments on the coverage plot:

We can clearly see the radiation pattern of the antenna. Because it is concentrated towards the middle of the room, the receivers there receive very high power. Furthermore - the receivers in the corridor receive more power because of that (apart from receivers in the end of the corridor).
All other receivers get good power (about -60 dBm), apart from receivers in the bottom right of the room (about -75 dBm)

### Comparison of the three coverage plots obtained for various scenarios:

Isotropic antenna radiates in a uniform pattern around the whole room at the expense of low signal power for the receivers in the corridor.
Horn pattern antenna is concentrated more towards the middle of the room. Receivers in the corridor receive more power than in the isotropic case, but some receivers in the bottom right of the main room get less power.

## Impact of Antennas' Polarisations

### Comments on the coverage plot obtained for cross-polarized antennas:

As expected, receivers get no power in any of the places, apart from the receivers present very close to the transmitter (they get -65 dBm)

### Comments on the coverage plot obtained for the circularly polarized Rx antenna:

The results are way better than for the cross-polarized case. The coverage plot is very similar to matching linear polarisation case. The only difference is that the received power is smaller by about -5 dBm overall.

### Pros and cons of using circularly polarised antennas in the radio networks:

In case of polarisation mismatch like we simulated, we can still receive signals if we set the receivers to circular polarisation. The downside is that the power is smaller than if we were to match the polarisations.

## Delay Spread

### Differences between the delay spread plots obtained for isotropic and horn Tx antennas:

For isotropic the delay spread is rather uniform (ranging from 15 ns to 35 ns) in the room. At the beginning of the corridor it gets worse (even up to 60 ns), because of various reflections. At the end of corridor the delay is very low (2 ns), but the signal is very weak.
For horn antenna, the delay spread is very small in the main direction of the signal propagation. However the delay spread is terrible in recivers that are not on the main beam path. It is caused by large amount of non-negligible reflected rays.

### Differences between the delay spread plots obtained for various directions of the horn:

For phi = 30 deg, overall delay spread decreased. The bottom right corner of the room has smaller delay spread than in the previous case. Furthermore, the delay spread decreased significantly in the corridor. All of it at the expense of the top left side of the room, however it is as bad as the bottom right of the room for phi = 45 deg.

For phi = 60 deg
This case is the best out of all three we examined. The delay spread increased in the corridor, but the overall delay spread is decently low in the room, with the exception of small area directly above the transmitter.
All of those differences are caused by different reflection angles.

Comments on the relationship between the delay spread value and multipath richness:
The more multipath waves are present, the bigger the delay spread. Also - the multipath variety matters and the power they carry.

What is the meaning of the delay spread parameter for single-frequency and multi-frequency radio systems?
In single-frequency systems the delay spread has higher significance because if multiple signals of the same frequency meet in one place (at the reciever) with different times of arrival, they might either interfere each other or amplified. This results in possible data loss.
In multi-frequency systems the delay spread has smaller significance, becuase the reciever can differeniate between signals of different frequencies.