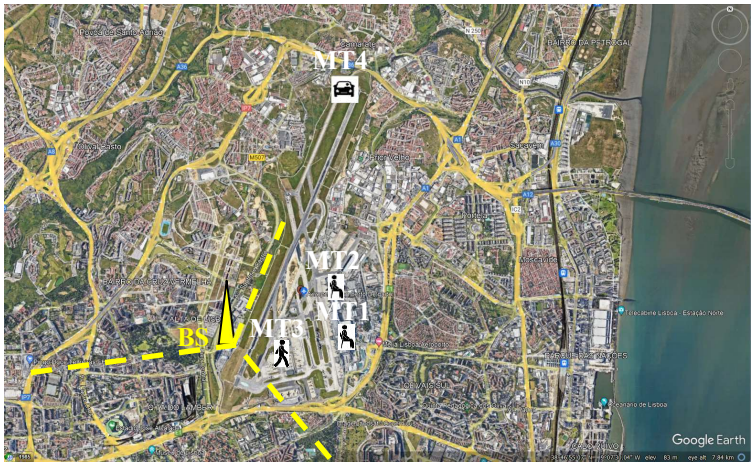
TÉCNICO LISBOA

Mobile Communications Systems
Master in Electrical and Computer Engineering
Prof. Luis M. Correia
26th May 2023
Supplementary date Exam
2h00 duration

An operator has a Base Station (BS) on the rooftop of the logistics building at Lisbon Airport, with co-localised GSM/EDGE/900 (4 radio channels/sector), UMTS/HSPA+/900 (1 radio channel/sector), LTE/Class4/2600 (100 Resource Blocks) and NR/3600 (500 Resource Blocks μ=0) systems, sharing tri-sectorised dual-band dual-polarised diversity dipole antennas with 15 dBi gain (13º vertical half power beamwidth) down-tilted by 6º for the first three systems, and an active 8×8 antenna with 25 dBi for the last one, all fed by 47 dBm (the radio channels are always in the middle of each band, with GMS and UMTS adjacent to each other). Mobile Terminals (MTs) are considered to be multisystem smartphones, with a 0 dBi antenna, fed by 24 dBm, for any system. In all systems, the noise figure is considered to be 5 dB for the BS and 8 dB for the MT. The local cellular planning can be considered to be approximately uniform. This BS is intended to have a sector covering the non-built areas of the airport.



BS: antennas at a height of 8 m above ground level (80 m above sea level), the surroundings being considered flat.
MT1: person seating outdoors at the balcony of terminal building, 10 m above ground level, 1.2 km from the BS in LoS.
MT2: person seating indoors by the window at terminal building, 10 m above ground level, 1.2 km from the BS in LoS.
MT3: person walking (4 km/h), 0.5 km from the BS in LoS.
MT4: person driving (30 km/h), 3.3 km from the BS in LoS.

1. Take user MT4, connected to the UMTS BS, performing a voice connection.

a) Calculate the average power received at the MT. Comment on the result. **[2.0]**

b) Would the variation of the signal with time around its average be the same for all MTs? Would there be good and bad cases? **[1.5]**

c) Assuming that BS antennas are optimised, do you expect them to be of the same size and shape? **[1.5]**

d) Calculate the coverage probability of the MT? Comment on the result. **[2.0]**

2. Take users MT4, connected to the GMS BS, performing a data connection.

a) Calculate the outage probability due to fast fading, when the MT is not in line-of-sight with the BS, assuming the same average received power as in 1.a). Comment on the result. **[2.0]**

N.B.: All your answers must be justified.

b) Would you use another model for 2.a) in case the MT would be in line-of-sight with the BS? **[1.5]**

c) Calculate the average fade duration. Comment on the result. **[1.5]**

d) Would you expect the signal at the output of the combiner at the BS to be the same if PSC or MRC would be used? **[1.5]**

3. Assume that the airport has 500 staff, using 2 GSM specific radio channels of the sector for their voice communications, with 30 s per call.

a) Calculate the average traffic per user that ensures a blocking probability of 1%. Comment on the result. **[2.0]**

b) What would be the behaviour of the carrier-to-interference ratio for MT4 when it approaches the BS? **[1.5]**

c) Calculate the handover probability for MT4, assuming that it is on the cell border. Comment on the result. **[1.5]**

d) Would you consider adequate that the NR network would be used for exchanging messages? **[1.5]**

Solutions

1.

a) -82.8 dBm (via the Flat Earth Model). The value is rather high, posing no coverage problems.

b) No. Multipath around MTs is different, ranging from those on the runway to those indoors. Multipath is expected to be higher indoors compared to the runway, since in the latter there are no nearby reflecting surfaces.

c) Yes. Active antennas have many lobes, compared to a single main lobe in passive ones, each lobe with a higher gain.

d) ~100%. Given that the received power is very high, coverage is very good.

2.

a) 0.02% (via the Rayleigh Distribution). This value is very good, meaning that outage is very small.

b) Yes. The Rice Distribution, given that there's LoS.

c) 1.95 ms. It's a small value, in the order of the frame, hence, not presenting many problems.

d) No. For an increasing number of antennas, the signal will be higher and vary less.

3.

a) 14.7 mErl. It doesn't present many capacity problems, but it should be higher for this usage.

b) C/I will decrease, since C will decrease and I will increase.

c) 5.3%. It's an acceptable value.

d) No. GSM has a very low data rate, hence, not being suitable for video transmission.