

RADIO NETWORK DESIGN – PROJECT GROUP # E12

Students:

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Specifications of the radio network.

You are requested to design a Private Mobile Radio (PMR) Network¹ according to the following specifications:

Covered region:	a 100 km x 100 km square area centered around the city of Mashhad (مشهد, Iran) (the <u>center</u> of the area of interest is shown in the attached map below)
Frequency of operation:	158 MHz
Modulation type:	ETSI Digital Mobile Radio (DMR)
Repeater stations (DMR):	Motorola SLR5500 (see attached data sheet)
Vehicular terminals (DMR):	Motorola DM4000e (see attached data sheet)
Repeaters' interconnection:	Point-to-point microwave links (see design guidelines in Appendix B);

Instructions:

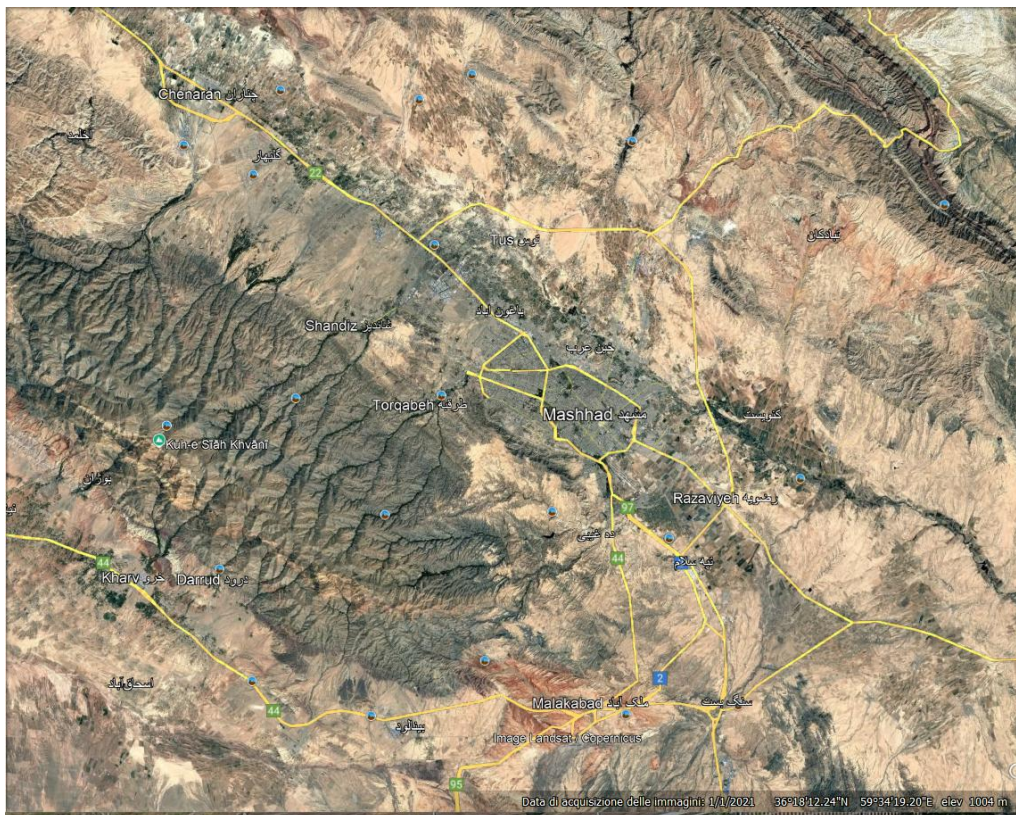
- The software to be used is RADIOMOBILE; you can get it from: www.ve2dbe.com/english1.html
- In WEBEEP-> WMP -> MATERIALS -> RADIOMOBILE folder, you will find:
 - extended user manuals in English and Spanish (please read the manual accurately because it includes a very detailed tutorial);
 - a FAQ list with updated hints/instructions.
- You can find some tutorials also on YouTube
- Repeaters can be located on mountain-tops for an extended coverage (see Appendix A).
- The network must be designed minimizing the number of repeaters (base stations) used.
- The repeaters (base stations) must be inter-connected using point-to-point microwave links, so they must “see” each other (see Appendix A) – of course, there is no need for all the repeaters to see all the others: a minimum of two other repeaters must be visible to guarantee reliable routing.
- For the microwave interconnection network, please search the Internet to find the data-sheets for antennas and radio nodes, and include those in your report.
- For the hand-held and vehicular antennas assume a gain equal to 0 dBi.
- Of course, radio coverage over sea (if present) is not requested.

¹ For more details on the PMR network topology, please refer to Appendix A.

Steps requested

- You will have to prepare a report (in English) according to the following scheme:
 - Introduction
 - Description of the problem (location, characteristics of the network, etc.)
 - Detailed description of the structure of the PMR network, including: number and location of the repeaters (base stations), transmit power, type of antennas used at the base stations, coaxial cables employed, etc.
 - Detailed description of the structure of the microwave network, including: number and location of the microwave radios, frequencies of operation of each link, transmit power, type of antennas used, etc.
 - Radio coverage maps for vehicular terminals, Fresnel ellipsoids for microwave links among base stations, etc.
 - Conclusions
- The total length of the report must be between a minimum of 10 and a maximum of 15 pages.
- Once you have prepared your report, you have to send it to me via e-mail for inspection.
- After your report has been approved (by me), you will have to present your project in an oral discussion with me.

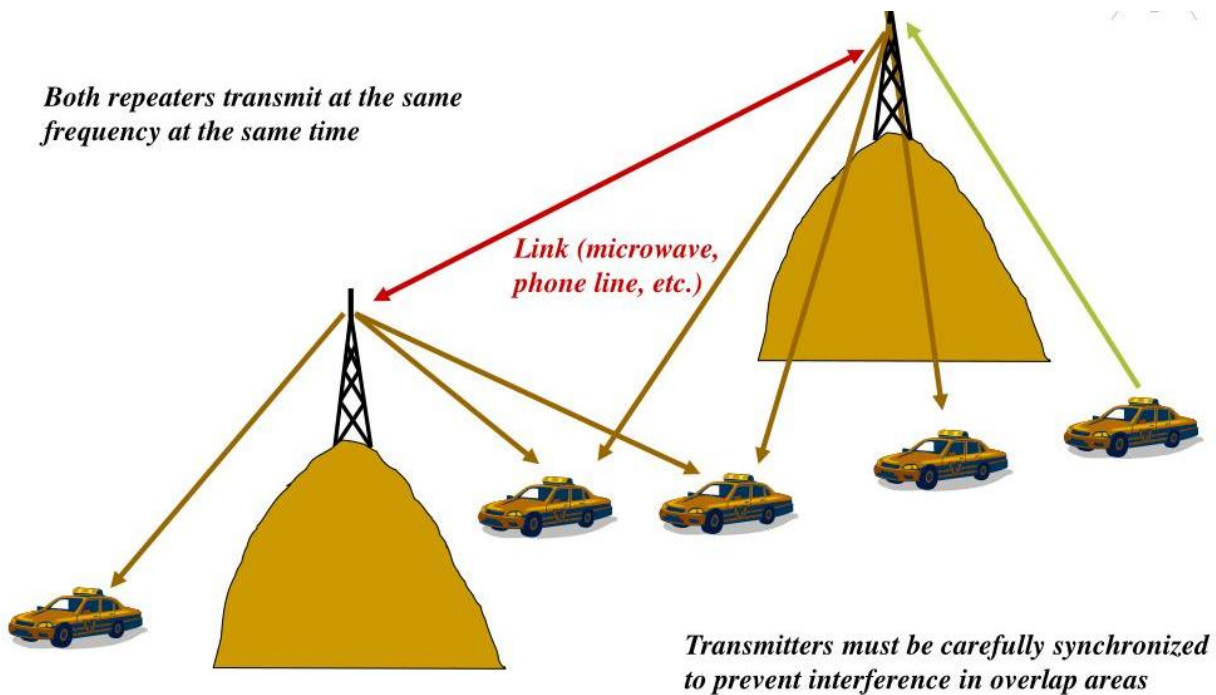
CENTER OF THE AREA OF INTEREST



APPENDIX A – THE PRIVATE MOBILE RADIO NETWORK

A Private Mobile Radio Network (PMR) is quite different from the well-known Cellular Radio Network, in several aspects:

- The PMR supports a limited number of professional users (e.g. police, firefighters, ambulances, security services, etc.); it's not a public network like the cellular network;
- There are few “base stations” (called “repeaters”) that cover the area; in our case (100 x 100 km²), anything between 5 and 15 repeaters is usually enough (depending on the orography);
- Repeaters operate in the VHF (154 – 174 MHz) or UHF (430 – 470 MHz) bands;
- Repeaters are located on top of mountains/high rise buildings, to maximize their coverage; it is not infrequent for a repeater to have a radius of coverage of tens of kilometers;
- Repeaters are linked together via microwave links, using point-to-point interconnections (red line in the picture below), so that all the users in the area receive the same signal;
- A user accesses the closest repeater using a VHF or UHF frequency, and his/her signal is distributed to all the repeaters via the microwave links, so that all the other users (and the Operations Center) can listen to the communication.



Conceptual topology of a SIMULCAST PMR network

APPENDIX B –MICROWAVE NETWORK DESIGN

The repeaters are interconnected through microwave links; the operational frequency of each link must be chosen according to the length of the link itself, according to the following criteria:

- Urban (< 5 km): 32 or 38 GHz, parabolic antennas (diameter 0.3 to 0.6 m)
- Short haul (0 – 10 km): 18 or 23 GHz, parabolic antennas (diameter 0.6 to 1.2 m)
- Mid haul (10- 25 km): 13 or 15 GHz, parabolic antennas (diameter 0.9 to 1.2 m)
- Long haul (25-70 km): 7 or 10 GHz, parabolic antennas (diameter 1.8 m and above)

Whatever the frequency, the link margin must be at least 10 dB above the modulation threshold. A higher margin is usually desired for frequencies above 10 GHz to counteract rain attenuation.