Reflection Effects of The Sea in The GSM Telecommunication Systems;Measurements, Tests and Suggestions

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Abstract: **-** In this study, reflection effects of the sea in the GSM networks are described. In the GSM networks, especially some BTSs (Base Station Transceiver) have to be designed near the sea so some radio waves propogates uncontrolly from BTS and these waves propogates far away via the sea. This situation is not prefereed for GSM cell planner. In this study, two BTSs which are located Black Sea in Turkey are researched (about 97 km from eachother). Normally, although these two BTSs are not neighbour eachother but drive test shows that BTS1's signal influences BTS2's signals. This abnormal situaiton was determined with drive tests and finally, some suggesitons were offered.

Key words: -Enterference, sea effect, propogation,reflection

1. INTRODUCTION

RF waves which are a kind of electromagnetic waves propagate near to the world surface being sphere in some degree and also these waves are influenced from this geometry. Reflection, fraction, scattering fading effects are occured because of pressure, moisture, different temperatures, changing density. In addition, surface forms and structures also influences communications. For example, sea is a good conductor but dry grouns is a bad conductor [1].

There are many different types of electromagnetic and radio waves described above. They are typically generated as disturbances sent out by oscillating charges on a transmitting antenna. An electromagnetic wave is composed of electric and magnetic fields. The electric and magnetic fields are perpendicular to eachother and direction of propogation. They are in sinusoidal form and characterized by their wavelengths and frequency.

$$C = \lambda . f \qquad (1)$$

where;

λ is wavelength in meters per cycle,
f is frequency and c is speed of light (3.10^8 m/s)

Radio waves fall in the frequency spectrum between 3 Hz and 3000 GHz. Mobile communication for GSM is 900 MHz, 1800 MHz or 1900 MHz so it is in this frequency band.

In this study, BTSs (Base Transceiver Stations) locating Blacksea Cost of Turkey are examined. Because we know that radio waves propagate unattenuationly so radio waves sometimes propagate from sea to land uncontrolly. This signal causes sometimes drops, sometimes handover fails or interferences and effects all networks' performance and quality. For this reason, GSM cell planning is important issue and each cell planner must take into consideration sea effect.

2. RADIO WAVE PROPAGATION

In this section, we are primarily interested in the transmission loss between two antennas: the transmitter and the receiver. Many factors including absorption, refraction, reflection, diffraction and scattering affect the wave propagation. However, in free space an electromagnetic wave travels indefinetly if unimpeded

Since an isotropic antenna distributes the emitted power P_t, equally in all directions, the power density S_r (power per area unit) decreases as the irradiated area $4\pi d^2$, at distance d increases, that is :

$$S_r = \frac{P_t}{4\pi d^2} \quad (2)$$

If the transmitting antenna has a gain G_t, it means that is concentrating the radiation towards the receiver. The power density at the receiving antenna increases a factor proportional to G_t, that is :

$$S_r = \frac{P_t G_t}{4\pi d^2} \quad (3)$$

The power received by the receiving antenna P_r is proportional to the effective area A_r, of that antenna, that is :

$$P_r = S_r . A_r \quad (4)$$

It can be shown that the effective area of an antenna is proportional to the antenna gain G_r, and the square of the wavelength λ, of the radio wave involved, that is :

$$A_r = \frac{G_r \lambda^2}{4\pi} \quad (5)$$

and hence, the received power becomes

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi d)^2} \quad (6)$$

The transmission loss can be calculated as the ratio between the transmitted power and received power, that is :

$$loss = \frac{P_t}{P_r} = \frac{(4\pi d)^2}{G_t G_r \lambda^2} \quad (7)$$

Radio engineers work with the logarithmic unit dB so the transmission loss L, then becomes :

$$L = 10\log(loss) = 10\log(\frac{(4\pi d)^2}{G_t G_r \lambda^2})$$

(8)

$$= 20\log\left(\frac{4\pi d}{\lambda}\right) - 10\log(G_r) - 10\log(G_t)$$

Radio engineers treat the antenna gains $10\log G_r$ and $10\log G_t$,seperately so what is given in the literature as the path loss L_p, is only the term $20\log(4\pi d/\lambda)$. To make it clearer, the path loss in free space is :

$$L_p = 20\log\left(\frac{4\pi d}{\lambda}\right) \quad (9)$$

Note that the wavelength dependency of the path loss does not correspond to losses in free space as such. It is a consequence of the finite effective receiver area.

After the Electromagnetic waves leaves from the transmitter, they move with the effecting of propagation environment's geometry and the electrical parametries of. Electromagnetic wave sending from an antenna can be reached to the receiving antenna with different ways. Knowing these different ways is important for the increasing productivity of communications [2].

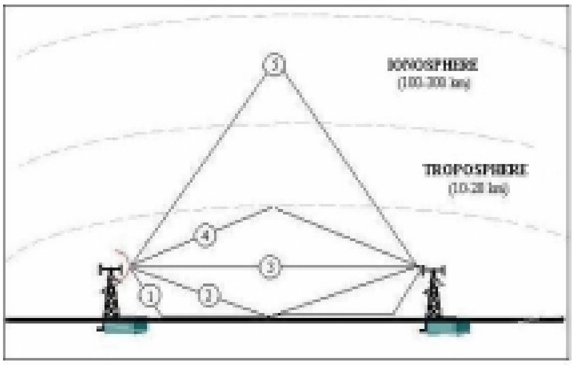

Fig.1. Different communication waves between transmitter and receiver;
1) Surface waves 2-3) Space waves 4) Troposphere waves 5) Sky waves

All of 1,2 and 3 is called ground waves. Communication quality between transmitter and receiver depend on these communication ways.

In addition, ground constants effects negatively or positively to the communication. Because these gorund constants have different conductivity and dependent constants.

Amplitude and phase of reflection waves from ground depend on reflection constant at the reflection point and they change with vertical and horizantal polarization. World is neither an excelent conductor nor an excelent insulator so reflection constant depends on ground constant, dielectric constant and (ε) conductivity.

SURFACE	CONDUCTIVITY (σ)	DEPENDENT CONSTANT (ε_r)
Poor ground (dry)	10^{-3}	4 -7
Average ground	$5*10^{-3}$	15
Good ground	$2*10^{-2}$	25-30
Sea water	5	81
Fresh water	10^{-2}	81

For the cell planning, it is very important to be able to estimate the signal strengths in all part to predict to path loss. The model can be used as a first approximation. However , more complicated model exist. Improvements can be made by accounting for:

- The fact that radio waves are reflected towards to earth's surface (the conductivity of the earth is an important parameter)
- Accounting for transmission losses, due to obstructions in the line of sight.
- The finite radius of the curvature of the earth
- The topographical variations in a real case, as well as the different attenuation properties of different terrain types, such as forests, urban areas, etc [3,4].

3. REFLECTION EFFECTS OF THE SEA NEAR THE COASTS IN THE GSM NETWORKS

In the real GSM network in Turkey, there are two BTSs which are located Black Sea in Turkey are researched (about 70km from eachother). Normally, these two BTSs aren't neighbour eachother. But drive test shows that BTS1's signal influences BTS2's signals. In conclusion of this test, BTS2's signal interferes BTS1's signal so BTS1 have to be neighbour of BTS2.

Tirebolu (TBOLU) is a town the east of the Giresun city in Turkey. There is a BTS in Tirebolu near the coast. Its tower is 75 meter and it is installed for Blacksea mainroad coverage and Tirebolu suburban coverage Caytepe (CAYTP) is a village of the west of the Ordu city. Its tower 75 meter and it is installed for Ordu – Fatsa road coverage.

Fig.2. Geographic map of TBOLU-CAYTP (1/1.900.000)

Fig.3 Site location map of TBOLU and CAYTP in PLAnet

Normally, these two BTSs mustn't be neighbour because Fig.-4 shows that TBOLU is 97 km far away from CAYTP so timing advance (TA) parameter doesn't permission this neighbourhood. Because these two BTSs are too much far away from eachother

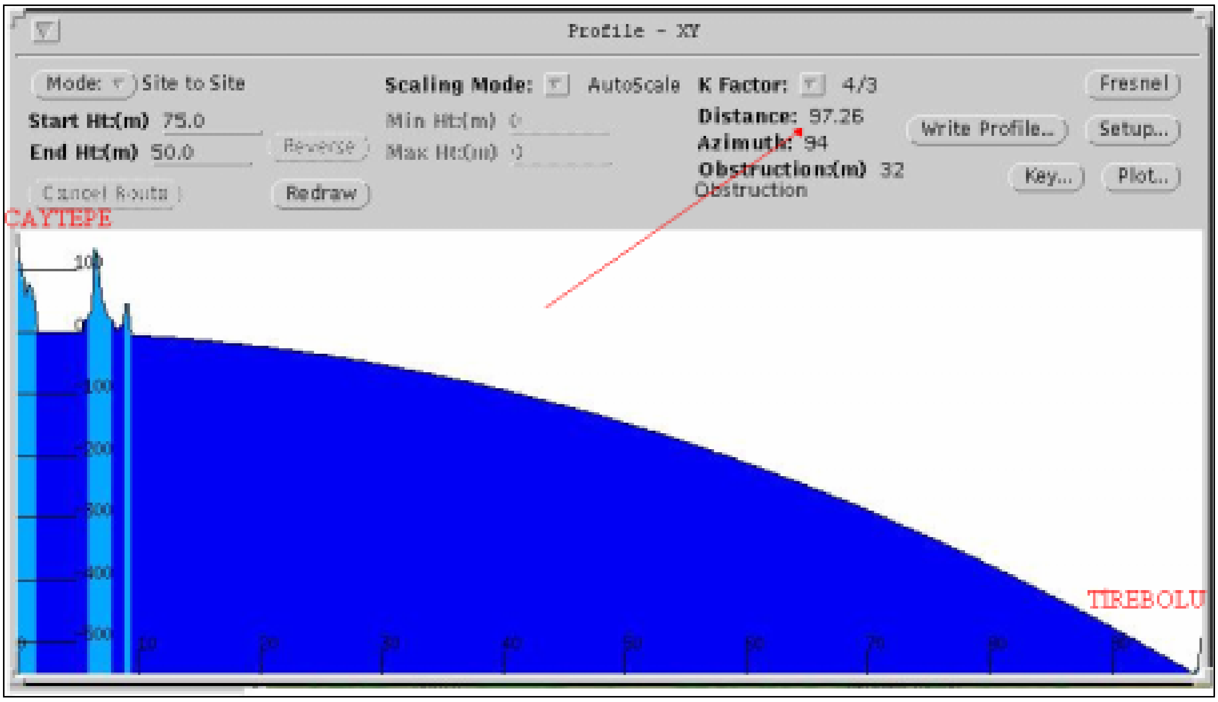

Fig.4. Tirebolu – Caytepe Profile output from PLAnet

4. MEASUREMENTS AND TEST REPORTS

In this section, radio network measurement has been prepared from CAYTP to TBOLU and analyses the drive test results. The drive test measurement was performed by "Ericsson TEMS Set" test & measurement tool. Mobile originated automatic calls placed with 5 minutes call duration and 15 seconds idle time duration between two sequential calls. Immediate call future was activated during the whole drive test to be able to start the next call right after an unexpected dropped call.

The drive test data has been collected for both forward (from CAYTP to TBOLU) and reverse (from TBOLU to CAYTP) directions using same configuration. TEMS test's results show in Fig. 5

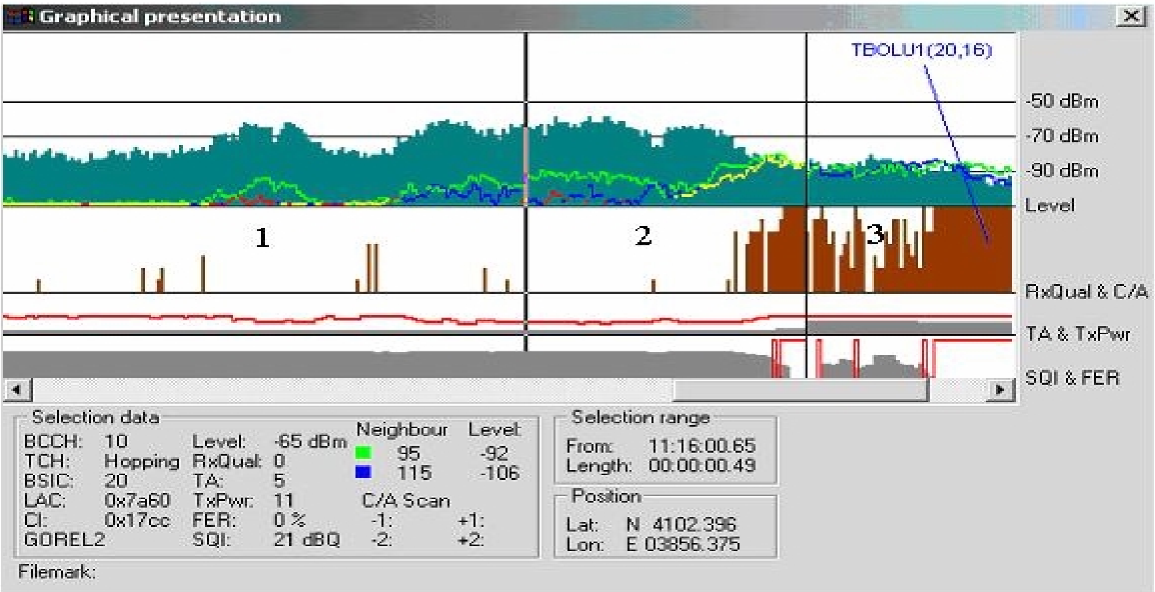

Fig.5 TEMS test TBOLU site's

Figure-5 shows the drive test results. According to this, TBOLU site's BCCH (Broadcast Control Channel) frequency is 16 and BSIC(Base station Identity Code) is 20. Figure-3 shows that there is a BCCH or BSIC interference in TBOLU site. When TBOLU site and its neighbours are observed, there isn't another site having same BCCH or same BSIC with TBOLU. When other sites are observed in this research area, some interesting results are obtained. CAYTP site's signal propagates on the sea (unattenuationly) and CAYTP is the best or second best neighbour of TBOLU. This is great surprise for a cell planner. But it is completely true. It's a game of the nature. But it is an unexpectable situation. Because frequency planning will be more difficult henceforth. In addition, this situation becomes more handover drop or handover fail in the network so network quality may probably breakdown.

5. CONCLUSION

Test results shows that sea effect is an unaviodable reality in the GSM network and effects network quality so cell planner or network planner must take into consideration sea effect. When a cell planner makes a survey or frequency plan near the sea site ;

- If not necessary, site shouldn't be installed with tower.
- Antenna types' choice is important issue. Horizantal and vertical beamwidth should be small (for example 20^o)
- Faraday cage has to use behind antennas because of hindering reflection
- To make frequency planning, terrain structure must be known exactly.

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