Vol. 2 No. 5 (2024)

Spectrum of Engineering Sciences

SPECTRUM OF ENGINEERING SCIENCES

Online ISSN 3007-3138

Print ISSN 3007-312X

A Case Study on the Designing and Planning of LTE Radio Access Network using Atoll

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Abstract

To cater large number of mobile users along with new applications and gadgets, higher speed and capacity is required in the networks. To overcome this hunger 3GPP (a collaborative group of Telecommunication Standards bodies) has introduced a new high speed and lower latency radio access technology called as Long Term Evolution (LTE). This is the fourth generation technology as specified by 3GPP standards which can support from 1.4MHz channel bandwidth to 20MHz channel bandwidth along with peak DL Throughput of 100Mbps and 50Mbps in Uplink. The motive of this project work is to design, simulate and analyze the LTE radio system. Previously the networks designed by telecommunication researchers like 1G/2G/3G didn't make pace with the growing trends and demands so the need of LTE (4G) was fulfilled. Now regarding the radio network planning point of view, lots of software and tools are developed such as Atoll, Asset, Mentum Planet etc. but in this thesis we have used Atoll. Basically Radio access network planning can be defined as the phenomenon of proposing and suggesting new network nodes to be deployed in various areas along with the certain configuration setting for establishing a network. In this study we have selected some part of Khatai district of Baku City of Azerbaijan to plan and design a LTE

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3007-3138
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network by providing simulations of coverage by signal level, coverage by signal-to-noise-ratio and coverage by DL Throughput.

Keywords: LTE, Long Term Evolution, Radio Network Planning, Planning Tool, Coverage Prediction, Cost 231-Hata Propagation Model, evolved-NodBs (eNBs)

Introduction

Due to rapid increase in technology trends day by day this world has become a global village. After every ten years, new technology is emerging to ease the needs and demands of people. This faster growing trend has urged the researchers to develop 4G technology which is a converged network compatible with future generation networks [3]. It is anchored on maximum throughputs of up to 100Mbps in Downlink and up to 50 Mbps in Uplink depending upon various channel conditions. The channel bandwidths for LTE range from 1.4MHz to 20MHz. The main thing about this technology is that the frequency usage is used in an optimized manner along with the spectral efficiency [2].

Baku is the capital and largest city of Azerbaijan, as well as the largest city on the Caspian Sea and of the Caucasus region. It lies 28 m below sea level and is also named as "The city of Winds". It has very rich historical background, politics, tourism and diplomacy of Azerbaijan [6]. In this study we have designed LTE network with technical configurations such as using Frequency Band 9 (Downlink frequency: 1844.9MHz ~ 1879.9MHz), Channel Bandwidth is 20MHz.

The wireless technologies such as 2G/3G/4G are meant to focus on the Quality of Service (QoS) and user satisfaction. These QoS are set to achieve the best target coverage, signal quality and maximum throughput but there are always certain challenges

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Online ISSN
3007-3138
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which arise such as environment, fading, reflections, refractions, diffractions, shadowing, noise etc. due to this many of the QoS KPIs are compromised [4].

Basic Concepts of LTE and its Architecture

In the mid-2000s, the 3G (UMTS) networks overwhelmed by LTE to emerge as 4G networks which is fully IP based and focused on delivering multimedia content with improvement of QoS (Quality of service). Many important techniques such as OFDMA (Orthogonal Frequency Division Multiple Access), MIMO (Multiple Input Multiple Output) and AMC (Adaptive Modulation and Coding) are allowing LTE to provide low latency and high throughput rates [2].

LTE has numerous advantages such as supporting both duplex modes such as FDD and TDD. It is also backward compatible with previous technologies such as 2G and 3G networks. It has very simple architecture making it very cost optimal solution for operators [1].

LTE network architecture comprises of two main portions Evolved Packet Core (EPC) and Evolved UMTS Terrestrial Radio Access Networks (E-UTRAN). E-UTRAN contains Evolved Universal Terrestrial Radio access Network Base Stations (eNodeB) and the User Equipment (UE), where the UE communicates with eNB and eNBs can communicate with each other using X2 interface. EPC contains a Mobile Management Entity (MME) and a System Architecture Evolution Gateway (SGW) together with a Packet Data Network Gateway (PDN GW). The overall structure of LTE is shown in figure 1 [3].

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Online ISSN
3007-3138
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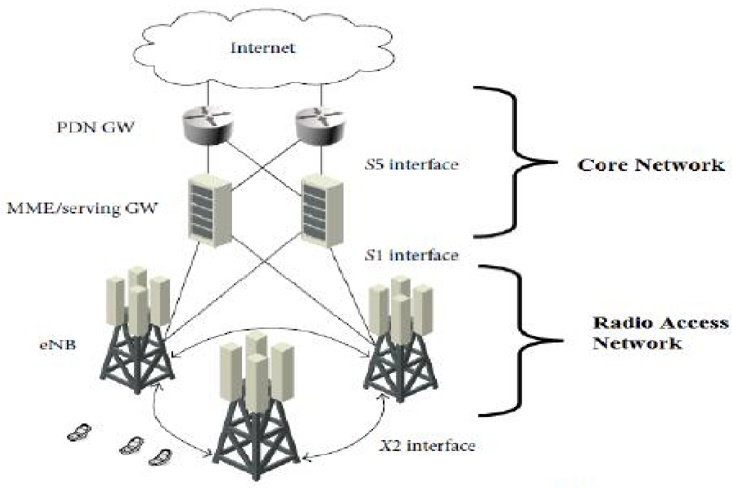

Figure 1: Simple LTE Network Architecture [3]

Radio Network Planning Mechanism

Planning a radio network is not an easy task but involves various steps. After the completion of these steps results a cellular network that could be an extension of existing LTE network or a fresh deployed network depending on the choice of telco operators [5]. Following are some steps involved for radio network planning which can be used in the software ATOLL as well:

- Define system parameters and network parameters.
- Know the topography, terrain and area of Baku city parts where network is planned.
- Indicate the number of e-nodeBs to be installed.
- Arrange a digital map of the city.
- Determine the range for communication between the UE and the BS.
- Know the type of zone: urban, suburban, rural or open country.
- Determine which propagation model is best suited in this case.
- Optimize the coverage using antennas.

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- Simulate the model using Atoll planning software tool.
- Evaluate the performance of the planned, simulated network.

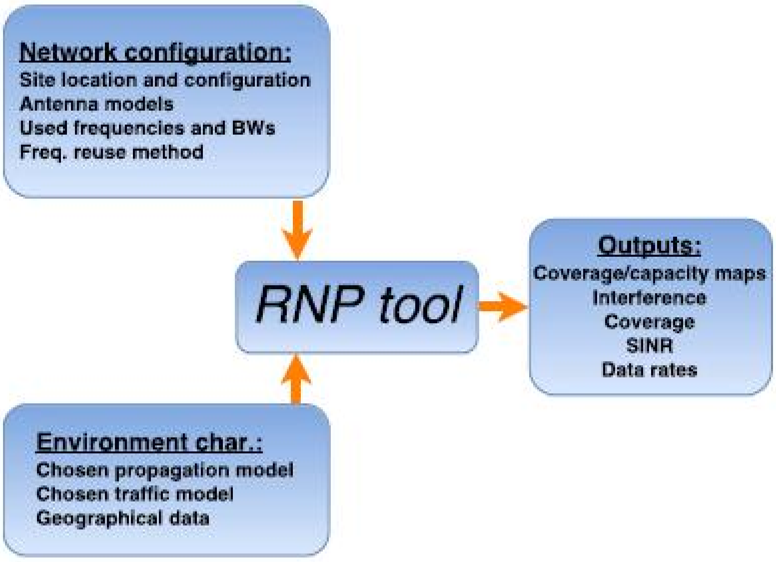

Figure 2: Planning portfolio [2]

Simulation steps using ATOLL

Below are now the steps using Atoll and with some use of Google Earth.

Google Earth is a computer program, formerly known as satellite imagery. The program maps the Earth by superimposing satellite images, aerial photography, and GIS data onto a 3D globe, allowing users to see cities and landscapes from various angles. So first we see the Baku city on google earth and can mark sites to be planned as seen in below figures.

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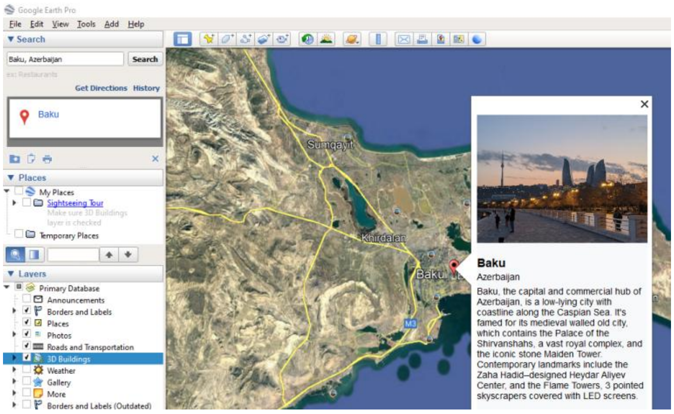

Figure 3: Google earth view of Baku city

Figure 4: Drawing a polygon and marking sites on it

Now open the Atoll and create a new project of "LTE" and set the coordinates for the city as shown in below figures.

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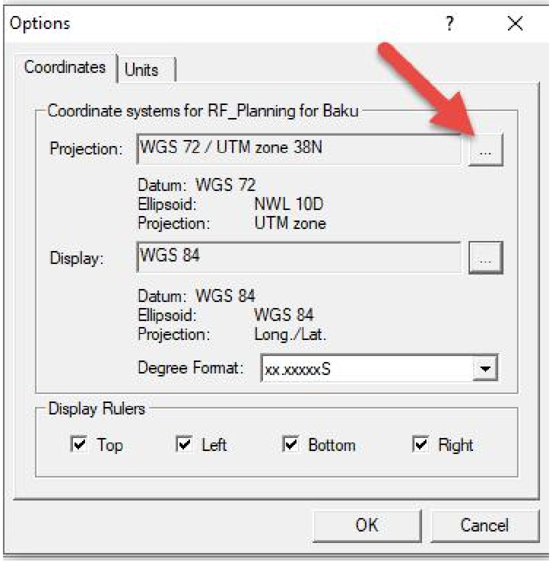

Figure 5: Setting Coordinate system for Baku city in Atoll

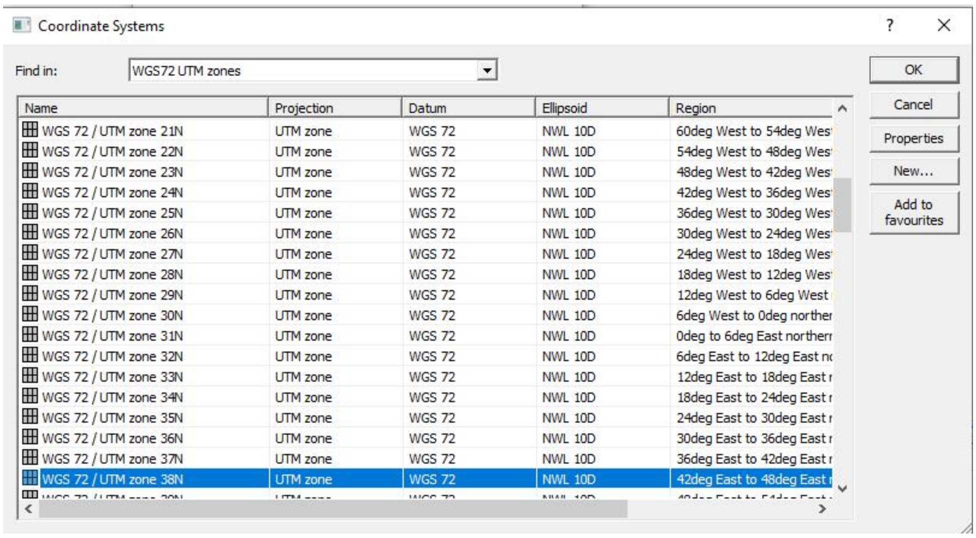

Figure 6 a: Selecting UTM zone for Baku city in atoll

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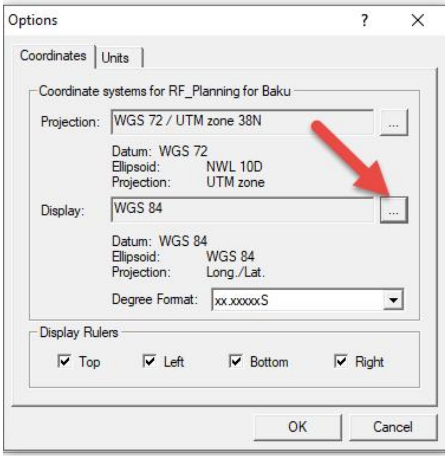

Figure 6b

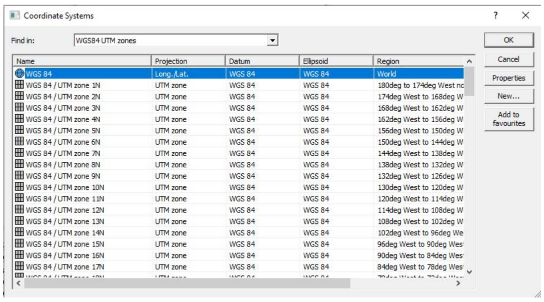

Figure 6c

Now import the Clutter data files in Atoll, as shown in below figures.

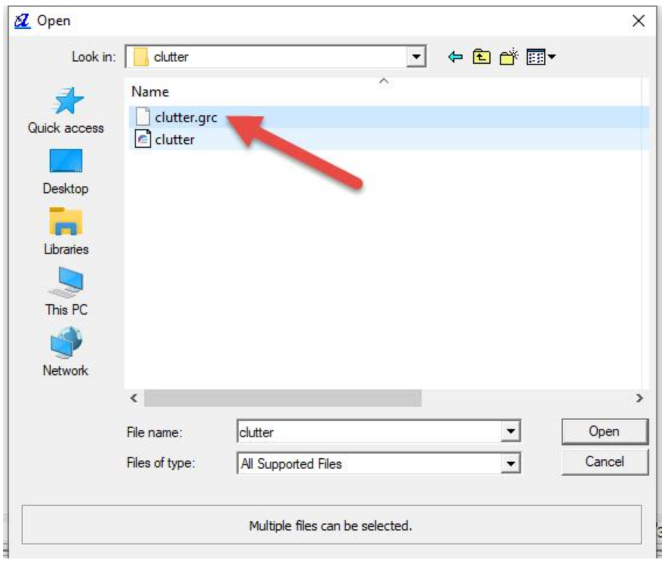

Figure 7a

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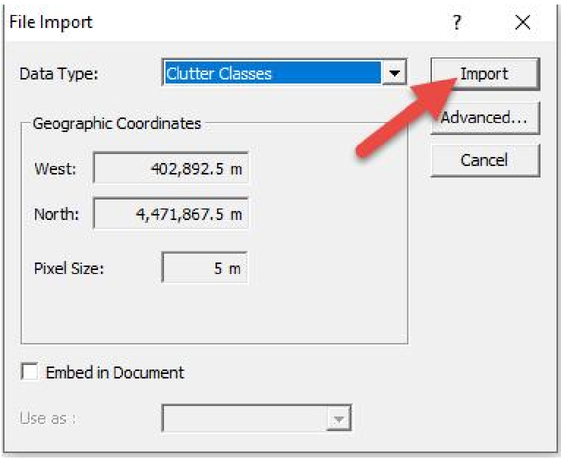

Figure 7b

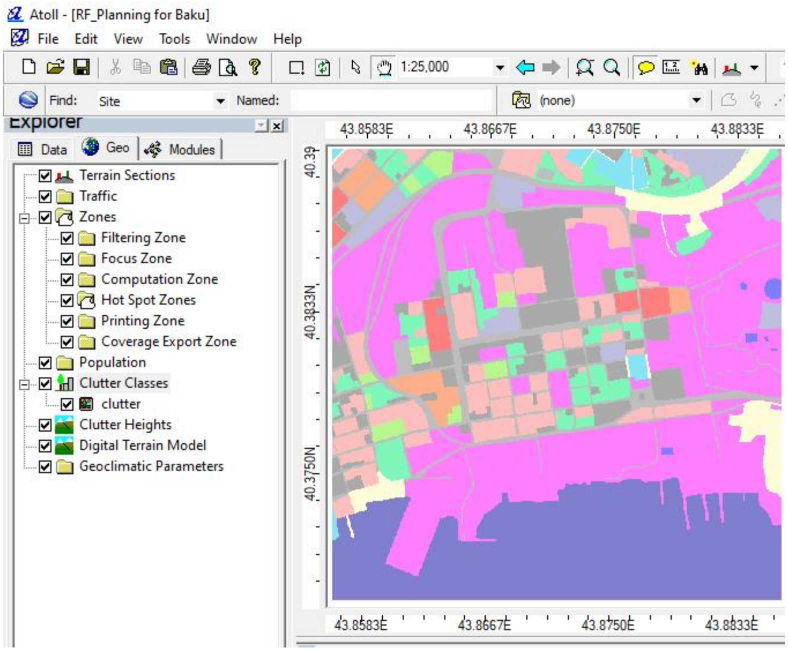

Figure 8: Clutter classes imported in Atoll

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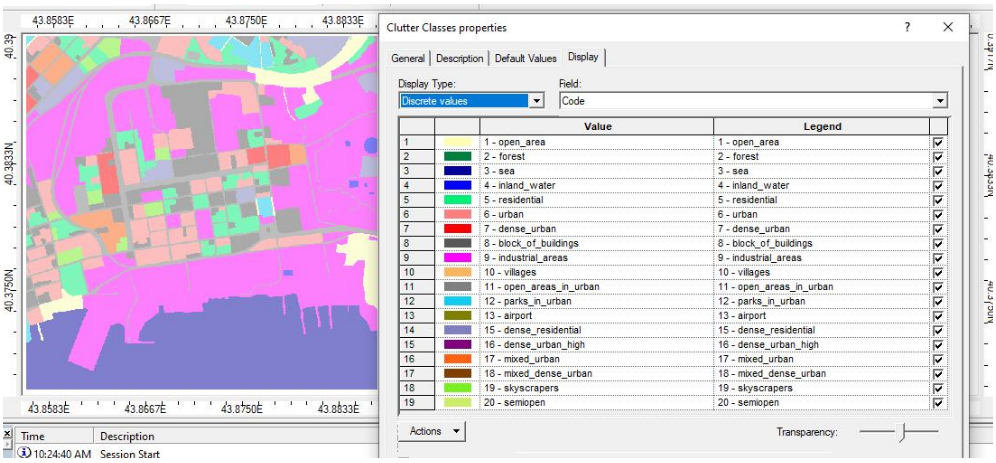

Figure 9: Various display types in clutter classes

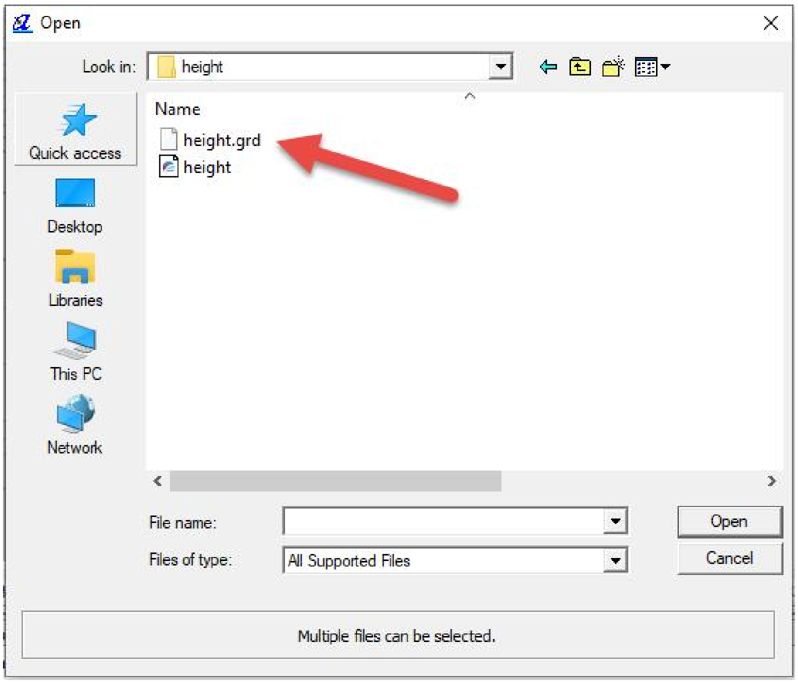

Figure 10: Importing “Height” files in Atoll

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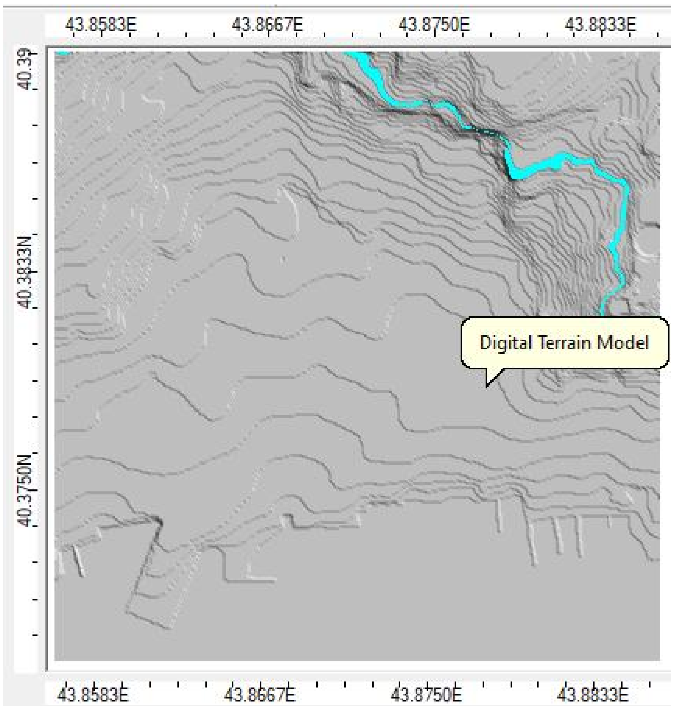

Figure 11: Imported height file in Atoll

Now similarly we can simultaneously import other files such as “Buildings”, “Coastline”, “Inland Water”, “Railways” & “Streets”.

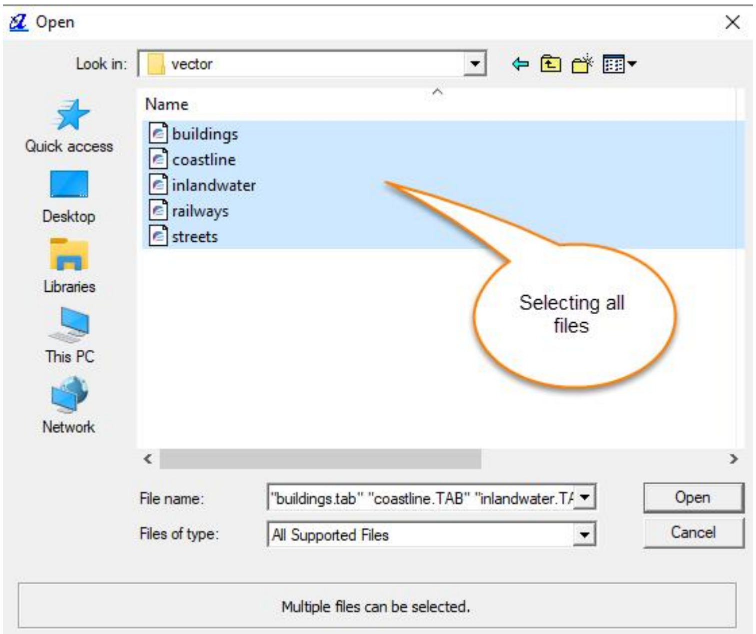

Figure 12: Selecting multiple files to import in Atoll

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After selecting all files, combined view can be seen below in figure.

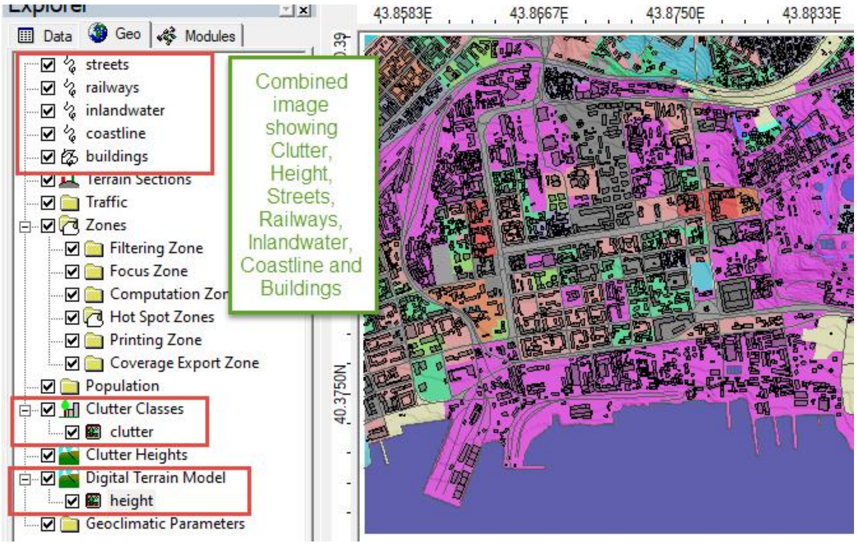

Figure 13: Combined view Clutter, Terrain and other zones.

After this, we import the sites in Atoll to run the coverage prediction for viewing the radio simulation.

Some of the configuration parameters are mentioned below:

. Frequency Band is 9 (TDD)

. Propagation Model: Okumura-Hata

. Antenna specs: 65deg beamwidth, 18dBi antenna gain, 2deg Electrical Downtilt

. Antenna Height: 20 m

. Mechanical Downtilt: 3 deg

. Antenna Azimuths: 0/120/240 degrees

. Number of Transmission/Reception Ports: 2T2R

. Channel Bandwidth: 10 MHz

In figure 14, the coverage simulation can be seen with various signal strengths represented in different colors.

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Figure 14: Coverage by Signal Level (RSRP levels)

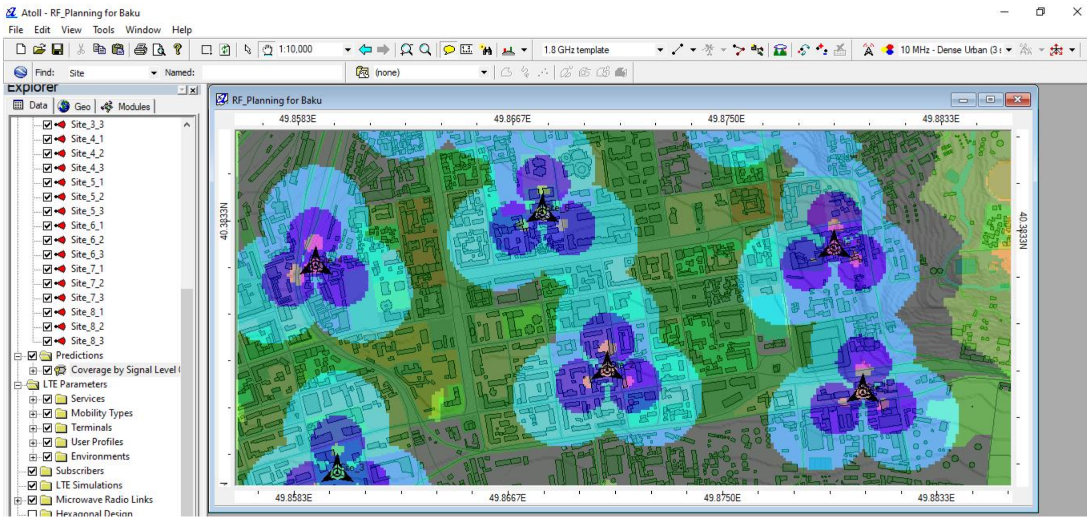

Figure 15: Full view of sites along with the simulation of Coverage

After getting this simulation, we can export this to Google Earth also as shown in figure 16.

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Figure 16: Coverage simulation view on Google Earth

Conclusion & Future work

The success of LTE network depends on its three factors: Coverage, Capacity & Quality. Coverage can be optimized by addition of sites or sectors in particular desired areas where Operator wants while Capacity can be optimized depending on network congestion and various call drops ratio so from Radio planning scenario we can add additional channels such as dual carrier or multi carrier other than that we can also add carrier aggregation techniques. In future also the networks can be planned through Atoll by using the same basic concept as discussed in this paper.

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SPECTRUM OF ENGINEERING SCIENCES
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