Study the Effect of the Topographic Features on the Communication Towers by Using Remote Sensing and GIS Techniques

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Abstract

In the present study, practical field measurements of a selected real site locations of a selected asiacell towers have been done by using Germain GPS receiver, then the obtained GPS dataset were delivered to GIS desktop (Global Mapper9.2) for creating a new layer to be combined with DEMs file (resolution of 90 m) and satellite image of Mosul city, for the purpose of creating 3D visualization of the towers locations. This leads to easily manage the towers locations data and to study the effect of the topographic variation on the coverage range of each tower.

According to the topographic features of the study area, the results showed that the increase in the high transmission antennas leads to an increased coverage area of the cell. Also, radius of the coverage of the transmitter of (2 kilometers) gives a very good coverage for the case of 25m transmitting antenna height and 1.5m receiving antenna high as compared with other radius values

Finally, the 3D visualization in the GIS will support spatial analysis in the practical fields of Communications.

Key word: GIS, DEM, GPS, Terrain, Antenna

Introduction

The earth's characteristics can be analyzed in a Geographical Information System (GIS) using computerized maps, aerial photographs, Digital Elevation Models (DEMs) files, satellite images, graphs, and Global Positioning System (GPS) dataset[9]. GIS-to-GPS link is now greatly benefit such that many GPS receivers and their data loggers can write data directly into GIS format or even overlap satellites images and air photo in the field [8].

However, the cellular network based on the division of the geographical area to small areas identified by the expected radius of the coverage of the transmitter, each area has its own base station or custom tower[1]. Many types of remote sensing dataset are become the main database in the communication techniques in the world, these types of data are very important in the arrangement process of the transmitting and receiving antenna with respect to the topographic variation of the selected study area.

Remote sensing is the science of acquiring, processing and interpreting images that record the interaction between electromagnetic energy and matter[2]. Remote sensing plays an increasingly important role as a tool for inventory, monitoring and managing the natural aspect and resources. DEMs is one of the remote sensing data required in many applications as input for GIS to satisfy a high performance and flexible terrain models for the purpose of spatial and graphic topographic analysis. GIS is essentially a digital database of spatial information that can hold a wide spectrum of topographic, geologic, hydrologic, infrastructural, demoscopic, administrative and other data. It is organized in a way that facilitates access, retrieval, and display of the data through the specification of geographic locations [3]. It is a fully digital tool for the DEMs data analysis by producing a terrain height information layers in a digital geolocated 3D data.

GM (Global Mapper) is one of this professional GIS desktop program, it has built in functionality for distance and area calculations, raster blending and contrast adjustment, elevation querying and line of sight calculations as well as advanced capabilities like image rectification, contour generation from surface data, view shed analysis from surface data, and triangulation and gridding of 3D point data [4].

The basic purpose of this study is to utilize SRTM (Shuttle Radar Topography Mission)dataset and GM program to produce 3D visualization for the topographic variation of the study area, identify the georeferenced real site locations of the selected Asiacell transmitting towers, and then study the appearance affectivity of the terrain elevation on the coverage range of the towers through the view shed property in the GM9.2 desktop software. The view shed setup windows enable the user to perform a view shed analysis using loaded elevation grid data of the specified transmitter location, height, and transmitting radius of curvature (Appendix A).

GPS and coordinate system

The Global Positioning System (GPS) has become on of the most popular methods of navigation for user worldwide. A significant problem when using the GPS system is that there are many different coordinate systems worldwide. As a result, the position measured and calculated by the GPS system does not always coincides with one's support position. Therefore, in the surveying and mapping applications, it is necessary to set the GPS coordinate system to the locally adopted map reference system (datum). If an incorrect choice is made, a position can be out by several hundreds meter [5].

Almost all maps indicates their location using latitude and longitude as one of the unit measurement. Universal Transverse Mercator (UTM) is the second unit measurement which is properly the most commonly used map projection [6,7]. All the field measurements done by the present study is according to the UTM coordinate system.

Due to the current security situations in Mosul city, GPS measurements were performed for only some selected sites of the Asiacell Towers (10 towers). The GPS measurements were done only for the horizontal geographical position (latitude and longitude), i.e.; without the ground elevation of the tower sites. Through the study stages, the geographical coordinates of the towers were converted to the UTM coordinate system with specification of north hemisphere at the zone (38) and the World Geodetic System 84 (WGS84) reference ellipsoid, i.e., WGS84_UTM_Zone 38N. Table (1) lists the GPS readout field measurements of a selected Asiacell Tower inside Mosul city (in both geographical and UTM coordinate system).

Table (1): GPS field measurements of a selected Asiacell Tower inside Mosul city.

Tower no.	Latitude (Decimal)	Longitude (Decimal)	Easting (m)	Northing (m)
1	36.33037	43.12719	331906	4022220
2	36.35206	43.16539	335381	4024561
3	36.37173	43.13149	332380	4026801
4	36.37192	43.20470	338949	4026698
5	36.34586	43.12598	331831	4023941
6	36.32455	43.09456	328964	4021632
7	36.38839	43.15526	334548	4028608
8	36.3492	43.10067	329566	4024356
9	36.37565	43.19253	337865	4027133
10	36.30005	43.19311	337760	4018744

GIS and georeferencing process

GIS has a better database software allows the management of vast amounts of information that is referenced to digital maps. Global Mapper9.2 (GM9.2) is a package software that depending on the GIS dataset. It is adopted in the present study to perform the georeferencing and all required analysis processes of the adopted remote sensing data for the study area.

Georeferencing process is the process of aligning a non-georeferencing data set to known map coordinates and assigning a coordinate system. Georeferencing creates additional information within the file itself and/or in supplementary files that accompany the image file that tells GIS software how to properly place and draw it [7].

In the present study, the georeferencing process was applied this study for the purpose of alignment the GPS measured towers locations with the adopted remote sensing dataset (i.e. DEM and satellite image). The georeferencing process is very important to obtain a high level accuracy in the final results, especially in the determination of the coverage area related to the transmitting antenna, the distance measurement between any two transmitting towers as well as to ensure the excellent record of the location.

Digital Elevation Model

A digital elevation model (DEM) is a Shuttle Radar Topography Mission (SRTM) data sets of the near-global representation of the topographic elevation of the earth. The SRTM hardware included the Spaceborne Imaging Radar-C (SIR-C) and X-band Synthetic Aperture Radar (X-SAR). The SRTM data were collected specifically with a technique known as interferometry that allow image data from dual radar antennas to be processed for the extraction of ground elevation [8]. DEM is a digital file in raster format consisting of terrain elevations for ground positions at regularly spaced intervals. It is used often in geographic information systems, and is the most common basis for digitally-produced relief maps. The DEM files may be used in terrain analysis, with the generation of graphics displaying slope, direction of slope (aspect), and terrain profiles between designated points, as well as the extracting of the elevation parameters of the terrain [9]. The DEMs file are formatted in (.HGT) extension, and arrange into tiles, each covering one degree of latitude and one degree of longitude, named according to their south western corner. It is available in a 1-arc-second (approximately 30-meter) resolution data over the U.S.A and 3-arc-second (approximately 90-meter) data over non-U.S.A countries [10].

There are various utility programs and software for working with DEM, one of them is GM9.2 which adopted in the present study to perform all the analysis related to the site locations of the Asiacell tower. In general, GM9.2 is a package software that depending on the remote sensing dataset and supported by GIS information.

The name of the DEM file adopted in the present study is N36E43.HGT, which is stretch from 36.00N, 43.00E to 37.00N, 44.00E. The geographic dimension of this file is totally covered the required studied area. The elevations of the towers according to this DEM file are extracted by using GM9.2 desktop. The extracted elevation value of each tower from the DEM file according to their location are listed in table (2), Figure (1) shows the DEM file and the locations of the Asiacell towers (as numbered in table (1)) with respect to the topographic variation of the study area.

Table (2): ground elevation of the towers sites

Tower no.	Site ground elevation(m)
1	226.62
2	226.45
3	218.72
4	266.83
5	238.38
6	269.89
7	252.59
8	250.82
9	257.76
10	221.24

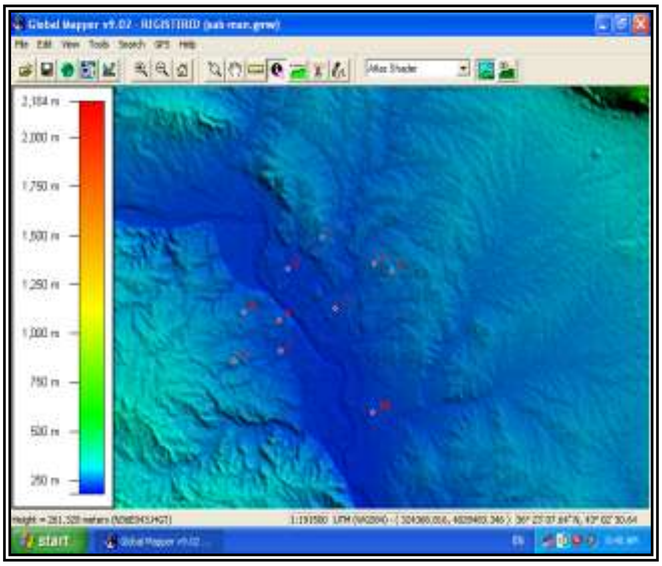


Figure (1): The locations of the Towers according to the DEM file

Figure (2): DEM, satellite image and towers location as shown by GM9.2 desktop window

Results and Discussion

There are two types of antennas may be used in the base station, the first one is an omni directional antenna-type covering an area of the cell in the form of full circle (360 degree), while the second type depends on dividing the cell into three sections-lapse sectors 120 degrees to reduce interference from co-channel cells, each sector contains a transmission antenna covers 120 degrees of the cell. The use of any of the above antennas will not affect the objective of the current study which is focused only on showing the effect of terrain on the coverage of the transmitted antenna, not on the other parameters which are considered as an important items in the techniques of communication system to increase the number of subscribers. Omni- directional antenna was adopted to be the transmitting antenna of the selected towers in this study

Figure (2) shows the real geographical sites of the transmitting antenna towers on both DEM and digital satellite image of the study area (Mosul city), in this figure, the GPS readout of the towers location were added to the digital satellite image and DEM data to create a clear picture features that can help us to know the terrain elevation of sites of the towers directly from the satellite image (by point out the required tower by the mouse). Figure (3) shows the 3D view of the topographic features around the study area.

Because of the security situation of study area, one of the effective transmission antenna towers has been selected (tower No.3) to study the effect of the terrain surrounding the tower on the coverage range of the antenna transmissions by identifying radius of coverage which will be changed through the (view shed tool) option in the GM9.2 desktop window with the survival of a fixed receiving antenna high (1.5meters), which represents the human's length average. Figure (4) illustrates the boundaries of the transmission antenna coverage when selecting a radius of coverage (5 kilometers) with transmission antenna high of 25 meters.

From figure (4), it can be observed the impact of the terrain elevation surrounding the transmitting antenna on the process of the full coverage, it must be noted here that the high of the receiving antenna (1.5 meters) plays an important role in the process of this coverage when compared its high with the height of the surrounding terrain of the specified receiving area. That’s mean, if there is only one transmitting antenna in the study area, the receiving antenna (1.5m) may be suffer from jamming in the receiving process if the adopted height is lower than the surrounding terrain height.

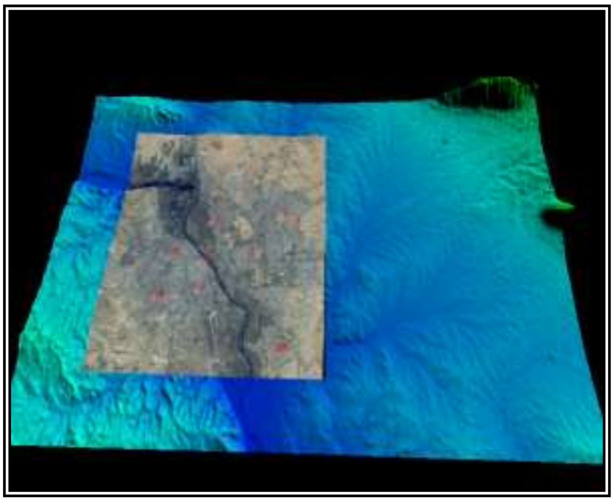


Figure (3): 3D view of the topographic elevation around the study area

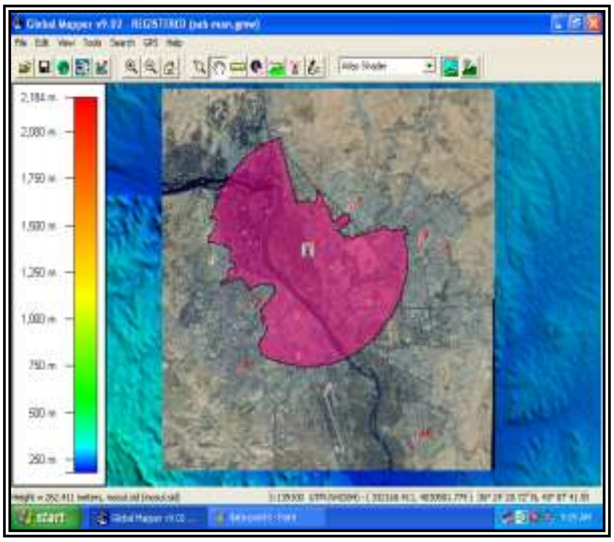


Figure (4): The coverage area of the tower (3) at the radius of coverage (5km)

The feature information of the coverage process of the transmitting antenna related to the tower (3) can be calculated directly from the view shed tool through the GM9.2 package. Figure (5) shows both the feature information and the coverage (visibility) area of the tower (3). Through figure (5), it can be determined the transmitting coverage area, which is amounted to (54.4 square kilometers) in this case, as well as percentage _visibility (percentage of coverage range) which was calculated to be (69.1%). From the figure (5), it can be estimated the elevation values of the study area through the elevation scale bar apparent in the left side of figure.

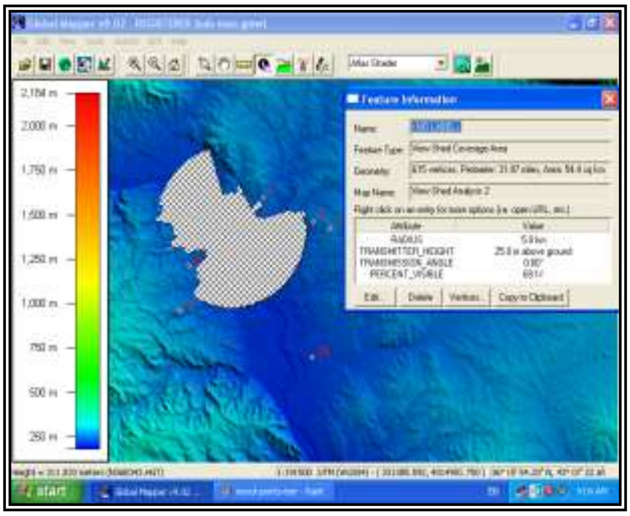


Figure (5): The feature information of the tower (3) at the radius of coverage (5km)

In order to minimize the impact of the terrain nature on the coverage area of the tower (3), the radius of coverage of the transmitting antenna was change to be (2 km) instead of the previous value (5 km) with the same antenna high (25m). Figure (6) illustrates the improvement in the coverage range as compared to the previous value of transmitting coverage radius, and this certainly will affect on the strength of received signals and then contribution on the service improvement of the company.

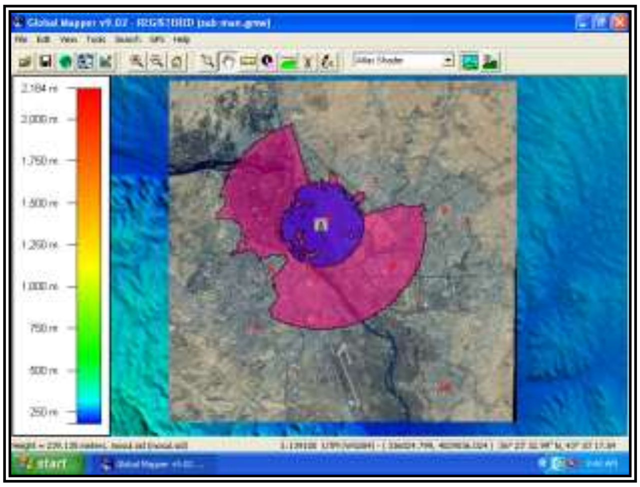


Figure (6): The transmitting overage area at the radius of (2km) and 5km)

According to new feature information related the transmitting coverage radius of (2km) shown in the figure (7) below, the area coverage boundaries has become (10.99 square kilometers) and the percentage _visibility was improved to be 89.0 %. It is clear that the transmitting coverage of the (2km) radius is better than the radius of (5km), this result is coincide with the technical result reported in the ref. [1] related to the coverage features in the urban areas.

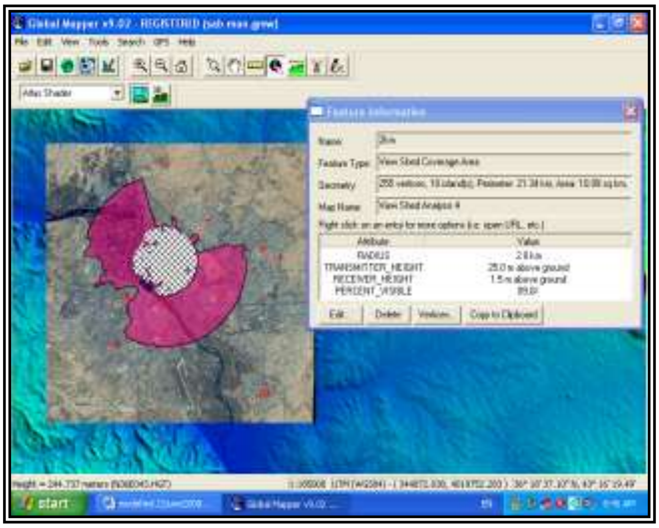


Figure (7): The feature information of the tower (3) at the radius of coverage (2km)

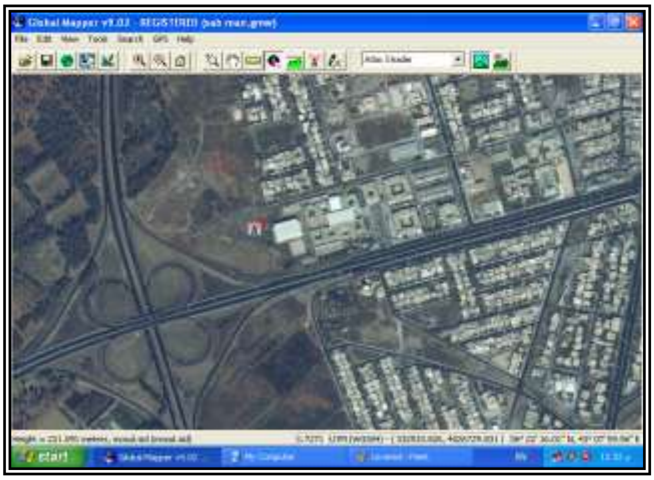


Figure (8): The location of the tower (3) as assumed in this study

From the figures (5) and (7), it is clear to us that it is necessary to study the nature of the terrain where no any obstacle may be found within the area that has been selected to install any communications tower. Also the receiving antenna (especially in the areas with high elevations and limited number of transmitting antennas) must be considered in this study. Therefore, it necessary to install many transmitting antennas distributed in a systematic form to ensure an optimum coverage of the transmitted signals, this processes can be solved by the communication specialist engineers.

Finally, the assumed location as considered in the present study was shown in figure (8).

Conclusions

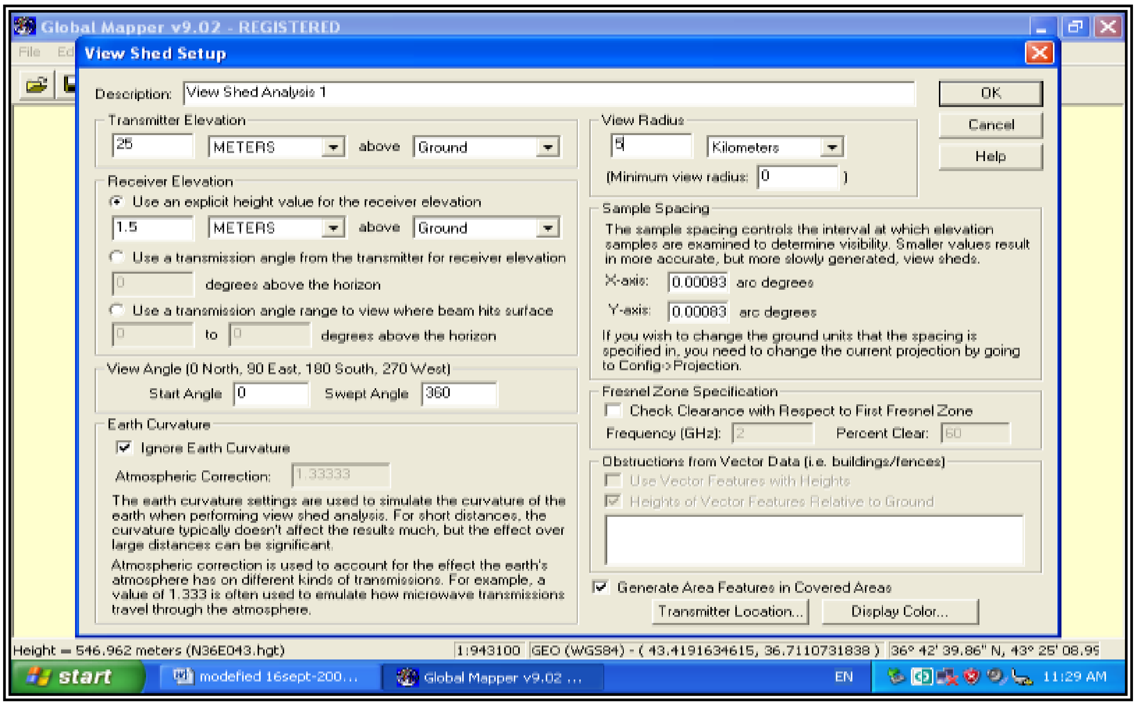
From the final results of the study, it can be conclude the following points**:**

1- The integration between remote sensing dataset, GIS software and GPS measurements may give more effective results in the selection of proper locations to install the tower.

2- The topographic features of the selected area to install the transmitting tower play an important role in the selection of the radius of coverage related to the transmitting antenna.

3- In the study area (Mosul city) adopted in the current study, it is preferred to applied (2km) radius of transmitting coverage.

Appendix (A): View shed set-up window in the GM9.2



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دراسة تأثير التضاريس الأرضية على أبراج الاتصالات باستخدام تقنيات التحسس النائي ونظم المعلومات الجغرافية

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(تاريخ الاستلام: ٢٨ / ٥ / ٢٠٠٩ ، تاريخ القبول: ١٨ / ١ / ٢٠١٠)

الملخص

في الدراسة الحالية، تم إجراء القياسات الحقلية لمواقع حقيقية لأبراج إرسال لشركة آسيا سل باستخدام منظومة تحديد الموقع العالمي نوع (Germain)، بعد ذلك تم تصدير هذه القراءات إلى نافذة نظم المعلومات الجغرافية لاستحداث طبقة بيانات خاصة وربطها مع ملفات أنموذج الارتفاع الرقمي(ذات دقة ٩٠ متر) والبيان الفضائي لمدينة الموصل (منطقة الدراسة) لغرض إنشاء رؤية ثلاثية الأبعاد لمواقع الأبراج في منطقة الدراسة باستخدام أحد برامجيات نظم المعلومات الجغرافية (Global Mapper9.2) إن استخدام هذا الأسلوب سيؤدي إلى سهولة تنظيم وتوزيع مواقع أبراج الإرسال بالنسبة إلى التغيرات الطوبوغرافيه لمنطقة الدراسة وتأثيرها على التغطية لكل خلية.

أظهرت نتائج البحث، انه نتيجة للطبيعة الطوبوغرافيه لمدينة الموصل فإن زيادة ارتفاع هوائي الإرسال سيؤدي إلى زيادة نسبة التغطية لكل خلية . وأظهرت النتائج أيضا، ، إن نصف قطر التغطية بمقدار (٢كم) لهوائي الإرسال يعطي تغطية جيدة في حالة كون ارتفاع هوائي الإرسال (٢٥)م وارتفاع هوائي الاستلام (١,٥) م مقارنة مع قيم أنصاف الأقطار الأخرى.

أخيرا، إن الرؤية ثلاثية الأبعاد في نظم المعلومات الجغرافية لها أهمية كبيرة في دعم التحليل المكاني في المجالات التطبيقية للاتصالات.

كلمات مفتاحيه: نظم معلومات جغرافية، منظومة تحديد المواقع العالمي، أنموذج الارتفاع الرقمي : تضاريس، هوائيات