CHAPTER I

1. INTRODUCTION

1.1 Background
In recent years, deregulation has opened up the telecommunications market to new companies, putting pressure on existing organizations to become more efficient. New technologies, such as fibre optics cables, more efficient terrestrial broadcasting, and satellites are offering greatly increased bandwidth. The mobile phone has become an integral part of people's lives. With this, the expectations for lower cost, improved line quality and better area coverage have forced leading service providers to improve the quality of their service through better network planning.

Telecommunications companies have begun to recognize that many of their work practices have spatial elements and data can be used more efficiently. The quality of the service relies on the signal strength available at the user's location. The signal originates from a network of antennas sited at strategic locations across the landscape. However, trying to work out the best network of antennas over a large area is difficult and is dependent on numerous factors; which include land cover, terrain undulations, building heights, composition and morphology. Generally, the operators recorded information on the locations, compositions, capacities and conditions of network equipment on a variety of maps, diagrams, and reports in the past. This is a very cumbersome process if one has to see the earlier history or records. The details are also not so accurate and often tends to re do the whole exercises which calls for field inspections. For many areas of the world, this information, together with good base mapping is not readily available and would be very expensive to measure using standard ground-based techniques. (Fry.C, 1999).

1.2 The Appeal and Potential of Remote Sensing
Rapid advances in satellite technology, an increase in the number of available
need for global environmental observation have progressively introduced space technology to the environment and planners community. This is not without reason. Information derived from space has a number of distinct advantages over conventional, ground-based measurements:

- Satellite-derived information is comparable. The same instrument takes measurements of the whole globe, allowing data to be compared between different geographic areas and times of acquisition.

- Satellite measurements are taken remotely. Satellite operators do not need the consent of a country or a party to a treaty to monitor a particular area.

- Satellite measurements are verifiable. Raw satellite data can be reprocessed by independent parties from commonly accessible data archives.

- Satellite measurements are continuous. Their global nature and long-term operation help close measurement gaps in space and time, providing a more integrated picture of the state of the earth's environment.

These characteristics make satellite measurements an indispensable information source in many cases. However, to exploit their potential they are usually integrated with in-situ measurements, climate models, socio-economic data and other relevant information. Geographic information systems and communication, navigation and other information technology are commonly used to add value to earth observation data and convert it into information of relevance to decision makers and planners.

Remote sensing techniques have gained increased acceptance among physical planners in urban and regional surveys due to the several inherent advantages. Acquiring information on the status of urban sprawl, the rate and direction of urban growth, water bodies, and forest cover, besides the information on the
existing land use / land cover pattern and available natural resources are very important and essential in any physical planning exercise. Although such information has been and is still being collected by ground surveys, satellite remote sensing with its synoptic view, repetitive coverage and ability to provide multi-spectral and multi-temporal data in a cost and time effective basis, has proved immensely beneficial to the planners.

Satellite data have been used for many applications such as urban planning, disaster management, agricultural monitoring and mapping of natural resources. With the availability of high-resolution imageries and stereo capabilities sensors, applications that are using 3-D visualization have become more and more effective and easy. At present space borne satellites are providing approximately 2 to 30 m height information DEM data. There are few applications like telecommunication needs the terrain undulations, height of the building, clutter and road network to be mapped for their tower siting issues.

1.3 Organisation of the Thesis
The thesis contains eight chapters, which are organised as under:

Chapter 1: This chapter provides introduction and background for the current research and brief description of DEM / DTM, its application areas and Mobile mapping, Earth Observation contribution to macro/micro cell planning.

Chapter 2: This chapter presents a comprehensive survey of earlier work that is relevant to the current study.

Chapter 3: This chapter describes the formulation of research problem, main objectives, tasks to be performed, data flow diagram, study area and data used.

Chapter 4: This chapter describes in detail one of the objective i.e. deriving height information from satellite image basics, elevation models from satellite
imagery, types of stereo imagery acquisition, concepts of generation of DEM from satellite data, uncertainties in surface models and evaluation and testing of the model.

Chapter 5: This chapter describes in detail the second objective i.e. land use / land cover information from IRS-1C LISS-3 data, types of multispectral classification techniques, concepts, algorithms and assessment of classification accuracies.

Chapter 6: This chapter presents third task i.e. extraction of road network, its methodology and complexities involved.

Chapter 7: This chapter describes in detail the last objective i.e. Spatial data integration for optimum site selection in GIS, modelling concepts, types of modelling, methodology adopted in this research work, uncertainty in spatial modelling and validation of the outcome of the modelling.

Chapter 8: A summary of work done along with conclusions are given in this chapter.

1.4 DEM / DTM
A Digital Elevation Models (DEM) provides a digital representation of a portion of the earth's terrain over two-dimensional surface. A DEM is normally generated by sampling a regular array of elevation values derived from topographic maps, aerial photographs or satellite images.

Opinion differs over whether "terrain" should be used in place of "elevation" in a DEM. Elevation is preferred when only relief is represented whereas terrain is used to imply attributes of a landscape other than the attitude of that landscape.
1.5 Applications areas

DEM are used in a number of applications in the earth, environmental and engineering sciences. Their earliest use dates back to the 1950s since which time, they have proved to be an important method for modelling and analysis of spatial-topographic information. Broadly, there are five main application domains where DEMs are utilized: civil engineering, earth sciences, planning and resource management, surveying and photogrammetry, and military applications.

1.5.1 Civil engineering

Civil engineers are mainly interested in using DEMs for cut-and-fill problems involved with road design, in site planning, and volumetric calculations in building dams, reservoirs and the like. It may be pertinent to point out that owing to such overt concerns with volume and design, calling a DEM a "terrain model" has more relevance to a civil engineer than other DEM users.

1.5.2 Earth sciences

The earth or geo-scientific applications mainly centre on specific functions for modelling, analysis and interpretation of the unique terrain morphology. These may include drainage basin network development and delineation, hydrological run-off modelling, geomorphological simulation and classification, and geological mapping. Generating slope and aspect maps, and slope profiles for creating shaded relief maps is a popular usage that employs DEMs.

1.5.3 Planning and resource management

This is a major grouping of diverse fields including remote sensing, agriculture, soil science, meteorology, climatology, environmental and urban planning, and forestry, whose central focus is the management of natural resources. Applications best characterizing this domain include site location, support of image classification in remote sensing by DTM derivatives, the geometric and radiometric correction of remote sensing images, soil erosion potential models, crop suitability studies, wind flow and pollution dispersion models. As is evident,
this group covers a wide range of concerns, and concomitantly requires a matching range of functionality to address such concerns. They include procedures for data capture, editing and verification, established data models and structures in both raster and TIN (Triangulated Irregular Networks) domains, and robust analytical, modelling, and visualization tools.

1.5.4 Surveying and Photogrammetry
On of the main objectives of employing surveying and photogrammetry is in building reliable DEMs, evaluating their accuracy towards finally producing high quality contours. This may be done in a number of production-related applications: surveyor photogrammetric data capture and subsequent editing, orthophoto production, data quality assessment, and topographic mapping.

1.5.5 Military Applications
The military domain is not only a leading consumer of DEMs; they are also a significant producer. Almost every aspect of the military environment depends on a reliable and accurate understanding of the terrain, elevation and slope of the land surface. The military usage of DEMs combines facets and methods of all the previous application domains, and their end objectives are very specialised and demanding. Examples of such usage would include intervisibility analysis for battlefield management, 3-dimensional display for weapons guidance systems and flight simulation, and radar line-of-sight analyses.

1.6 Mobile Mapping
1.6.1 Introduction
There is already a niche Earth Observation (EO) market in producing Digital elevation Models (DEMs) which are used to define transmission maps for cellular networks. Accurate DEMs are unavailable in many regions of the world and deriving them from satellite data may be the only realistic option. Information from satellite images can also provide both a suitable classification system and sufficiently recent data for the clutter information about land use in the area.
The DEM and the clutter layers are used within a GIS by telecommunications companies to model distributions of signal strength given the location of a proposed transmitter site and parameters such as antenna position and height (Jonathan 2001). The use of a model removes the need to actually visit each prospective site. This can then be used to optimise the coverage of cost, and the use of digital maps of urban areas and roads can ensure that populated regions are sufficiently well covered.

Already service providers are scrambling around the world to provide location-based services, amongst other services, to the mobile user. Location is a key piece, because the mobile device moves with the user. So a service is only relevant if it's within your location, and that's effectively where mobile mapping comes to the fore. The opportunity has always existed to market to the individual, but the cost of doing so made it a totally impractical concept for most businesses. Technology has changed and businesses can now seriously contemplate adopting far more accurate marketing techniques in a very cost-effective manner.

India may not be the most advanced, or the wealthiest, country in the world, but the market need can be no different to that in any other country. And with free Internet access for all predicted to be not far away because of the anticipated growth in Internet advertising revenue, cost to the end-user will not be an inhibitor to market growth. On the contrary, the technological developments in wireless communication and the business opportunities that flow from it could become a driving force for the Indian economy in the coming years.

### 1.6.1 Background

Majority of the mobile communication all over the world follows a general format called Global System for Mobile Communication (GSM) or Code Division Multiple Access (CDMA) network for their network services. There are three important stations for the operationalisation of Mobile Communication network Viz. 1. Mobile Services Switching Centre (MSC) 2. Base Station Controller (BSC) and 3. Base Transceiver Station (BTS) and shown in Fig. 1.
Both MSC and BSC is intelligent unit and communicate each other through microwave frequency. These two stations can be stationed anywhere inside the rooms or buildings, whereas the BTS have to be kept in high elevated place like high rise building top or mountain top or tower of height over 40 meters. The installation of BTS is a critical component in the operationalisation of Mobile communications. The function of the BTS is to receive and transmit the signal from the Cell/Hand phone to BSC and MSC. These signals were processed by BSC and MSC and in turn identify the position of the caller/receiver. In case the caller goes outside the limit of the one BTS, BSC/MSC would identify the nearby BTS and connects to the caller/receiver. The placement of BTS tower, which receives and transmit the signal from the hand set (cell) is depends on the parameters such as signal strength, terrain height, signal attenuation / obstructions from the surroundings, land use/cover classifications and road network.

1.6.2 Network Planning Process-I
The basic planning of network depends on the following parameters i.e. Service Area, Estimation of Traffic demand and available frequency resources. The most important aspect is the evolving an optimum coverage scheme of placing the cells over the entire service area so as to provide complete mobility to the subscribers.

1.6.3 Network Planning Process-II
Here the estimation of Cell radius is planned. It depends on service area, terrain conditions, density of foliage and man made structures. It also takes care of signal level at a unit distance from base station and signal strength decay per unit distance.

To map the above criteria, the surveys have to include clutter heights, vegetation levels, and obstructions from building or any other structures. The propagation
Figure 1  Mobile communication network
loss due to the above survey has to be calculated and the final coverage map to be prepared.

The propagation loss of the signal is given by the following equation;

\[ L_{FS} = 10 \log [(4\pi nd/\lambda)^2] \]

\[ L_{FS} = 32.44 + 20 \log (f) + 20 \log (d) \]

\[ L_{FS} = L_0 + 10 \gamma \log (d) \]

Where \( f \) = frequency in MHz  
\( d \) = distance in Kms.  
\( \gamma \) = SLOPE of the attenuation characteristics.

Commercially many software are available for the planning of Cell site such as TORNADO from Siemens, LG s/w for cell site, Motorola, Agilent Technologies and PLANET from NOKIA. It takes the above inputs from various sources and identifies the site. But the drawbacks in these software are extensive ground survey is required for each input.

1.6.4 Earth Observation (EO) Data for cell tower planning

The propagation of microwave signals for communication is greatly affected by the absorption, scattering and reflection of the signal from vegetation and urban structures in addition to topography. Using such data the signal strength from a transmitter network can be modelled before it is actually established. When planning cellular networks two categories of cells are considered:

- Macro-cell networks covering whole regions or counties.
- Micro-cell networks mainly confined to city centres.

Table 1 shows some of the areas where EO data can contribute to macro-cell planning, together with alternative sources of the information. For micro-cell planning (Table 2) much finer resolution is needed. Until the advent of VHR
imagery (Fig. 2) this was an area beyond the grasp of EO, but it is now at very large potential application particularly with the demands being made by the development of the forthcoming third generation of mobile telecoms.

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<tr>
<th>Task</th>
<th>Earth observation contribution</th>
<th>Alternative source</th>
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<tbody>
<tr>
<td>Extraction of land cover data</td>
<td>Land cover classification from 20-30 metre multi-spectral Images</td>
<td>Topographic maps, land cover maps/databases</td>
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<tr>
<td>Digital elevation elevation</td>
<td>Stereo satellite data 1-10 metre resolution</td>
<td>Digitised topographic maps national or commercial height databases, airborne interferometric radar</td>
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<tr>
<td>Infrastructure Information</td>
<td>Satellite orthoimages</td>
<td>Existing maps and road databases</td>
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<td>3D city models</td>
<td>Extraction of 3D city models from stereo 1-metre Earth Observation data</td>
<td>City databases, airborne laser, stereo aerial photos, ad-hoc planning</td>
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<tr>
<td>Extraction of lands cover data</td>
<td>Land-cover classification from 4-30 metre multispectral images</td>
<td>Topographic maps, city maps, colour aerial orthoimages</td>
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Figure 2 Temporal and spatial resolutions of optical satellite systems