Design of Geoinformation Utility System for Survey of India Using High Resolution Satellite Data

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Design of Geoinformation System for Survey of India Using High Resolution Satellite Data

by

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Abstract

In India, there are tremendous pressures towards improving the accessibility and use of geo information. The Survey of India (SOI) and other related organizations are striving for sharing the datasets so that costs for data collection and management are reduced.

In the changing scenario in Indian perspective, initiatives in the form of Indian NSDI are necessitating a change in the basic approach of provision/access to geoinformation. In this regard Survey of India has taken a number of initiatives like using satellite data for creation and updation of core datasets and in near future is likely to acquire modern enabling technologies like, air borne laser terrain mapping, digital camera with GPS on board to augment the existing process core data generation. In this regard SOI recently e redefined its vision to achieve this dream. The importance of geoinformation at high resolution for micro level planning and decision-making processes in view of diminishing resources is increasing.

The objective of this research is to design a geoinformation utility system (GUS) using high-resolution satellite data like Ikonos. The GUS is conceptualised as an infrastructure set up for the efficient distribution of data/information to enhance its availability, accessibility and use at an affordable cost. The integrating nature of technology and requirement of having behaviour logic, which enables the system to adapt to the highly dynamic environment, are the main driving elements to design such a system. The behaviour logic as I understand provides a means to understand the environment and provides the requisite flexibility to the system to maintain a meaningful relationship with the external environment and may not require redesigning of system every time there is a change. Having conceptualised such a system, the research focuses on networking environment where such GUS's are established as information nodes and can provide a pyramid of building blocks for strengthening the Indian NSDI infrastructure. The product diversity can be achieved in a way where right proportions of data and processes are mixed or combined to give different *flavours.* The selection of right data and innovating use of existing or new processes may assist SOI in providing the geoinformation as a utility.

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My deep appreciation goes to my wife Sureeta Munshi and my daughter Ameya Munshi who did not spare any effort to encourage me.

Finally, I would like to dedicate this work to my mother late Mrs.Kamla Munshi. May God give her rest and peace there.

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1. Scenarion for change

Theory without experience is fantasy.
Experience without theory is blind

(Adopted from Bermeyres, 1994)

1.1. Motivation

The continuous developments in information and communication technology (ICT) has revolutionised the acquisition, analysis and dissemination of spatial data and created new processing options and opening of new application areas. The various challenges and opportunities afforded by ICT has made the environment in which geoinformation providers are operating very dynamic and this necessitates a change in the conventional way of doing their mandate tasks. This chapter addresses the present day situation which are driving the mapping organisations to do their tasks in new ways and that too as a business challenge.

1.1.1. Business challenges

As technology evolves many approaches, which were considered unavailable in the recent past, have become possible. With continuous development of Information and communication technology (ICT) we are able to communicate, share data, for example through the Internet to any part of the world. With the hardware development, it has become easy to store, manage and analyse large sets of geographical data. The development of modern technologies like Global positioning system (GPS), digital Photogrammetry, satellite remote sensing techniques, has given a boost to geo data acquisition in totally new and innovative ways. These innovations through the technology are motivating the National mapping agencies (NMA) to a new business that too in a competitive environment. Consequently NMA's are facing both internal and external challenges. It is an accepted fact that the core business of NMA's was to produce national topographic coverage in paper format and presently most of the NMA's are using modern technology to speed up this process as per their the mandate.

As a producer of foundation data for a number of potential users, apart from the traditional topographical maps (hard copy/digital form) NMA's are being asked to provide the unpublished data like geodetic control, ortho-image, digital elevation model (DEM), elevation data etc. In order to provide access to the users, it is pertinent that such type of data being generated in these organisation is required to be maintained in a well organised manner, in a suitable format and provided to the user in an acceptable time frame and above all in the most current form. To have a competitive edge and the innovations offered by the modern technologies, these organisations are in a transition mode from the conventional way of doing the business (data generators) towards the modern management concepts of identifying customer needs and subsequently the necessity of having the utmost customer satisfaction with respect to the products and services being offered (a proactive data provider). In doing so, the reengineering processes have been initiated in most of the organisations to grab the opportunities offered by the technology, increasing application domains and secondly to remain a competitive contender in the geo-information environment.

The increasing capabilities, decreasing costs and enhanced user friendliness have all contributed to the recent gains in the rate of adoption and wide spread use of Geographical Information Systems (GIS) technology and has resulted in fast development of GIS market, increase in the application domains and the emergence of new generation of GIS users who are better aware of product quality requirements. The expansion of customer base as a result of growth in the application domains has created a need for diverse geo-information products and substitutes for conventional maps.

1.1.2. Advanced Data Acquisition technologies

The significant advancements in spatial data acquisition technologies is necessitating changes in the way of acquisition, followed by the requisite processing to get an meaningful output. The Global positioning system (GPS) has revolutionised the perception of data acquisition among the Survey community and are now able to study the Globe very with greater ease and efficiency. It has become possible to have very precise measurements with respect to the Earth dynamics and consequently we are moving towards an International Terrestrial Reference frame (ITRF) for giving the user community a more realistic and precise environment. Similarly other enabling technologies like Laser altimetry, Synthetic Aperture radar (SAR), digital Photogrammetry, remote sensing etc are readily available for effective utilisation. The advancement in remote sensing technology (aerial photography and satellite imageries) coupled with Inertial navigation systems (INS)/GPS are becoming the most enabling technology being adopted by the NMA's to meet the complex business challenges.

- **Aerial Photography**

  Aerial photography has been used since early 20th century to provide spatial data for a wide range of applications. It is the oldest yet most commonly and time tested remote sensing technology used by the NMA's. In the recent past there have been most significant advancements/improvement to standard aerial photography (ITC educational textbook series 2nd edition, 2001). They are highlighted as under:

  - The advances in airborne remote sensing technology were Global navigation satellite systems (GPS, Galileo) provide a means of accurate navigation. They offer precise positioning of the aircraft along the survey run ensuring that the photographs are taken at the correct points. This method of navigation is especially important in areas where topographical maps do not exist, are old, are of small scale or of poor quality. The major aerial camera manufacturers offer complete software packages that enable a flight crew to plan, execute and evaluate an entire aerial survey mission. Before the survey the boundaries of the survey area to be photographed are first entered in the software along with the basic mission parameters such as the required scale, lens focal length, overlap requirements, terrain elevation etc. the programme then calculates the optimum positions of the required flight lines as well as the positions of the individual photo centres. During the flight the software instructs the camera precisely where to take the photographs. After the mission the coordinates of the photographs taken are downloaded and an instant index of the photography is produced.

- The aerial cameras are now having gyroscopically stabilised camera mounting, which enables it to remain vertically downwards, and minimises tilt distortions.
- Airborne digital sensors (ADS) of LH systems and the digital modular camera (DMC) of Z/I imaging are the latest entry in the field of aerial cameras with charge couple devices (CCD) instead of conventional film cameras and output generated are in digital form. The design of camera is such that it enables multispectral data acquisition and overlapping images are taken along the track enabling direct generation of digital elevation model (DEM). Compared to film, CCD recording allows a larger spectral domain. The sensitivity of CCD is higher and more flexible than the conventional photographic film. Further the resultant image is already in digital format, which avoids the need of scanning the film, and as a consequence the error due to scanning gets eliminated.

- **Satellite remote sensing**

The thrill one gets on viewing an aerial photograph often compels one to ponder if the entire earth could be viewed aerially. This thought has become the focal point in the development of Remote Sensing science. In the early ’70s, when Landsat satellites with a resolution of 80 metres in 4 spectral bands were launched, the ability to view the entire earth in 80-metre resolution was revolutionary. But soon this marriage of convenience was to end as expectations of many were washed off due to poor resolution and the 80-metre resolution, though sounding great, proved to be merely a revolutionary thought. Moreover, most of these satellites were experimental with emphasis placed on developing technology rather than using the data. But things were not to remain the same as the next generation of remote sensor Thematic Mapper (TM) aboard Landsats 4 and 5 followed by SPOT 1, 2 and 3’s High Resolution Vertical (HRV) sensors proved remote sensing a boon to the scientific community. With resolutions of 30 metres and 20 metres respectively, the data provided by these sensors were quite useful for a variety of applications. India was to soon become a major contributor to the science and with its latest IRS series of satellites providing images with a resolution of 5.8 metres. It has become a pioneer. However, with the recent launch of the IKONOS satellite having a resolution of one metre, satellite history will never be the same again. Continued technological innovation in tools associated with the use of remote sensing data is poised to make space remote sensing the next major commercial success in space, following telecommunication satellites.

The magic word in today’s world is ‘globalisation’. Globalisation of the market place is a current trend. Nations are moving from independent states dependent on trade within a small group of nations to interdependent states buying and selling in a global trading system. Space-based remote sensing has become a part of this globalisation trend. Nations that cannot afford their own high resolution satellites and related support infrastructures no longer feel left behind in the race as they can very easily enter into licensing agreements with giants or even build their own ground stations and pay fees to satellite owners for down linking data, thereby allowing the smaller nations to be a part of the remote sensing market without extensive or expensive investments (Pal T, Nov2003). The applications of remote sensing data have acquired new dimensions with the successful launch of many high-resolution satellites. High-resolution satellites are now providing imagery that yields much finer details of the earth's surface. These satellites essentially produce images that approach air photo quality in terms of discernable detail. The data is extensively used for large-scale mapping, town planning and strategic applications.

The imaging of high-resolution data should ensure the effective transformation of the finest details contained in a digital image on to the photographic media for better visual interpretation. For cartography, high-resolution data in Panchromatic and multi spectral imaging mode may be suited to generate map products in 1:5000 and 1:10,000 scale. Due to the large data size of the high-resolution data, large-scale photoproducts cannot be generated using conventional film recorders due to Spot size & writing size limitations. The successful launch of Ikonos imaging satellite with one metre spatial resolution has opened a host of new applications for satellite imageries (Even some platforms recently launched like Quick Bird have been reported to have sub-metre resolution).

- The same is true for GPS, digital Photogrammetry, airborne laser terrain mapping (ALTM) etc. Further the importance of GIS as a tool in the policy matters/decision making/planning processes is growing and with improvements in the capabilities and reduction in the price of Remote Sensing (RS) and GIS their importance is likely to grow continuously. It is therefore possible to visualise a scenario where the *diffusion* of GIS and RS technology is not a distant dream (similar to wireless communications e.g.; mobile telephony, internet, etc.). The diffusion means percolation of use of geoinformation to a community level development programmes.

1.1.3. Redefined Vision of Survey of India:

- To take the advantage of the present day technology and deliberate on various criticism appearing in various articles a workshop was held in Nov 2002 entitled "Survey of India: Towards a contemporary Renaissance" at Jim Corbett National Park, India where representatives of key organizations to include Indian space Research organization (ISRO), Ordinance Survey, ITC, The Netherlands where also present apart from the officials of department of Space and Technology and some private ones (Krishna/Hardley, Feb 2003).

- The following key issues were addressed at the workshop:
    - Survey of India's mission, vision and strategic objectives.
    - Commercialisation of Survey of India.
    - Likely future products and services
    - Issues related to the organizational structure and human resources

- It is at ***Jim Corbett National Park*** after deliberations on the key issues The Survey of India redefined its vision as follows:
    - ***The SOI will take a leadership role in providing customer focused, cost effective and timely geo-spatial data, information and intelligence for meeting the needs of sustainable National development and new information markets.***

1.1.4. NSDI initiative by Government of India

- The initiative taken by the government of India to develop national spatial infrastructure (NSDI), which was enforced by the National Spatial Data Infrastructure Act, 2002.It extends to the whole of India. The basic aim of government is to establish a national infrastructure for the availability of and access to organised spatial and associated non-spatial data and promote the use of the spatial data infrastructure at community, local, state, regional and national levels for sustained economic growth, NSDI Secretariat is being set up by Department of Science and Technology, Government of India with an objective to coordinate amongst various stakeholders of NSDI for India. The Users of the spatial information of the NSDI would be groups from government, private sector, academia, NGOs and even the public, at large. Access procedures and filters on the NSDI would enable the right access of information.

The main stakeholders of NSDI as per the official website of Indian NSDI (http://www.nsdiindia.org/) are as follows:

Ministry of Rural Development
Ministry of Urban Development
Ministry of Environment and Forests
Department of Information Technology
Survey of India
Geological Survey of India
Registrar General and Census Commissioner of India
National Natural Resource Management System
Natural Resource Database Management Systems
Forestry Survey of India
National Atlas and Thematic Mapping Organisation
National Remote Sensing Agency
Indian Metrology Department
National Informatics Centre

- The main efforts of NSDI are in the direction of supporting national requirements of governance, sustainable development and economic growth. At the same time, the NSDI efforts are in consonance with global efforts – in fact India has a lead position in the global arena of SDI activities. The NSDI is envisaged to create a structural framework for spatial information in support of sustainable development at all levels – individual, community, village/city, district, State and the Nation and to leverage economic growth.

- The NSDI would be a network of servers that would enable successful data sharing. The fundamental elements to support the data sharing envisaged by the NSDI task force are follows:-

  - NSDI Web-Server: - It would be the front-end interface to NSDI and will provide open access to NSDI information and secure entry to NSDI metadata and NSDI agency servers.

  - NSDI Metadata Server: - The server would maintain the NSDI metadata content. At higher level it would be linked to NSDI Web server and lower level through NSDI Server Catalogue to NSDI agency servers.

  - NSDI Agency Server: - The NSDI agency server (or servers) would hold the actual data of the particular agency.

  - The data exchange standards to solve heterogeneity issues among the users have been made and recently standards for metadata have been developed (a framework to document the spatial data and declare its contents for users). The Metadata helps users to find the data they need and determine how best to use it. The main purpose can be as follows:

    - Locating and searching for spatial data.
    - Browsing spatial data
    - Deciding whether the spatial data will meet the application need.
    - Finding how the spatial data can be accessed.
    - Finally obtaining the spatial data

(Adopted from "NSDI metadata standard", Publication of Government of India, Department of Space Indian Space research Organisation, October 2003).

1.1.5. Why high resolution data

With increase in population growth, decrease in natural resources, increase in disasters the Earth is Virtually shrinking (Fig 1.1). Any changes in the geographic phenomena whether manmade or natural will have significant effect on our environment especially the human activity. The spatial or the geometric attributes of the phenomena will have to be studied very minutely with respect to its changes having consequential effects on environment or during the rescue operations in any disaster occurring on this Earth. Secondly with rising land costs in Cities, the use of GIS for urban planning involves a study of manmade things mostly parcels, roads, sidewalks and its interaction involving natural things. All these phenomena are required to be studied and analysed at much larger scales/resolutions for arriving at an appropriate decision suitable for sustained economic growth and development.
In this era of uncontrolled population growth, any disaster occurring results in high magnitude of casualties. In order to carry out rescue operations in a swift and efficient manner, large resources have to be mobilised at short notice in an un obstructive manner. This requires an anticipated meticulous planning by the concerned agencies.

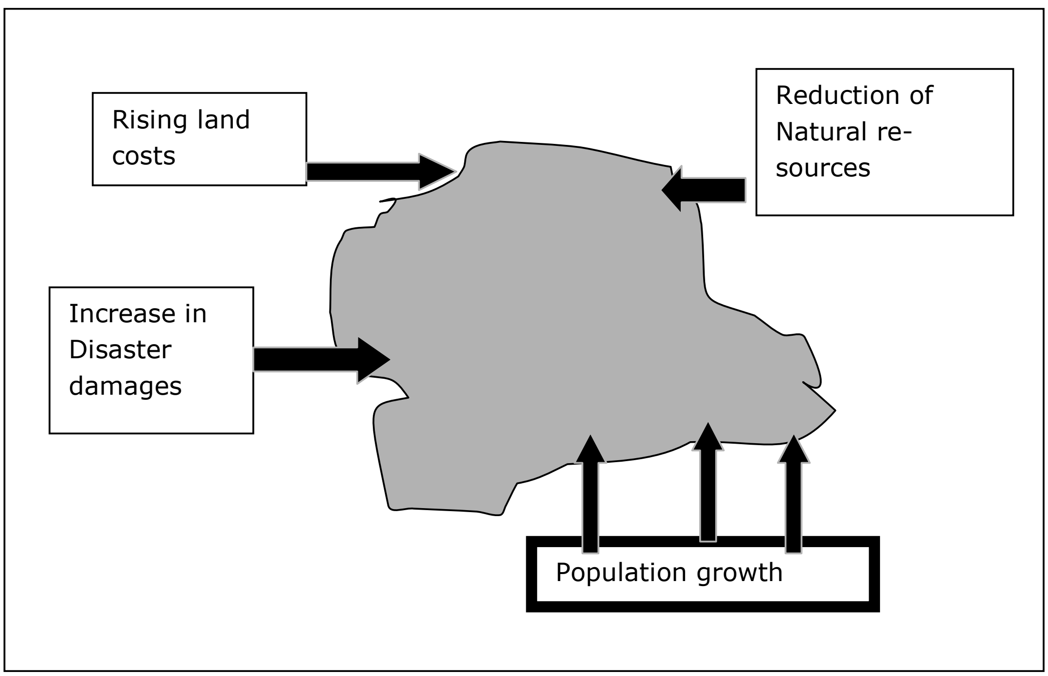

Figure 1.1: The present scenario

This planning requires t the relevant spatial data at large scales or high resolutions, provided the data /information is available at these scales/resolutions. In the figure 1.1 above with such forces acting along the spatial extent of our globe, monitoring of the geographical phenomena very minutely and precisely, using the modern enabling technologies and subsequently analysing the consequential impact on the ecology becomes an unavoidable duty of all people concerned with the planet and in turn for sustained development and economic growth.

This scenario for change can be accomplished provided spatial data or geoinformation is readily available at large scales/high resolutions.

With this background of present day environment this research of 'Design of Geoinformation Utility system for SOI using high resolution satellite data, focuses on the use of most commonly used and tested spatial data acquisition technology of high resolution satellite data by SOI the national mapping agency of India as an essential requirement and how best the data acquired from the imagery can be made available to its potential educated users as a utility to satisfy their needs at the desired place, time, in a suitable form at an affordable cost.

1.2. Research Problem

The SOI enjoys an excellent reputation for its invaluable databank, for its work culture and its brand equity. SOI assets include the national spatial reference frame and topographical maps, at scales of 1:25,000, 1:50,000 and 1:250,000. SOI has covered the nation with 385 topographical sheets at 1:250,000 scale and over 5,000 topographical sheets at 1:50,000 scale. SOI has mapped more than 35% of the country at 1:25,000 scale (Georgiadou Yola, Feb 2003). This is an impressive record for any country in the world. Digital maps, containing the full content of conventional topographic maps were too complicated, out of date and badly structured to be of immediate use to the users, both government and the private and NGO sectors. This often forced them to look for substitute products or to make their own digital versions of these maps. The result has been an innumerable but unmeasured duplication of work.

A map is a means by which we collect and represent geographic data. As we look at the map we do not see it as a meaningless mishmash of points, lines and polygons. In general for many people who matter in the planning processes/decision making, the acronym GIS is synonymous with maps. The expression "map" is not restricted to map sheets or other graphical representations, but it refers to a terrain description with a geometric component, independent whether it is an analogue graphical map or a database in some form. The base data generated by GIS is essentially scale less and contains all data required for even the largest scale map. And with this a geographical phenomena can be viewed as point and some other time as polygon. For each map scale a cartographic database is derived from this base database and hence the requirement of multi-scale cartographic database. Further with the capability of the GIS technology maps can be used to produce a number of different types of analysis including way finding and siting decisions. The result of such analysis of map is often a new map as output. This new map will have combined data available from the existing (or original map) in such a way as to produce new information or geo information. Thus from the same basic data set it is possible to produce information/data in many ways/forms, the only limitations being the data itself and the system of generating the data. The possible outputs generated can be delivered to the users in various types of media i.e. hard copy, digital form etc. with much ease as compared to the conventional reproduction processes where colour separates, scribing etc were required before the final output in hard copy form. The delivery of products in the present environment raises an issue of interoperability problems but this is being resolved through the initiatives taken by various countries and GIS communities by developing spatial data infrastructures (SDI), open GIS Consortium (OGS).

It is an accepted fact that the task of geographical data acquisition has been the most expensive and time-consuming affair in the mapping organisations. The Innovative integration of existing Information technology and modern mapping system as well as modern management skills / operation management techniques has motivated NMA's to speed up the process of firstly updation and initiated system thinking processes of creating/generating user defined maps (utility maps) for decision makers from local to the Federal government. The thrust has now shifted towards providing geo information required for micro level planning. With these technological developments the SOI has taken certain initiative with respect to its mandate and expectations from the user community. The systems thinking process has been started by the top-level management of SOI and are in the process of restructuring the organisation. Simultaneously at one of the recent workshops held in India SOI even redefined its *Vision to meet the requirements with respect to the prevailing dynamic environment (refer above).*

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In this context its strongly felt that before the new technology of large-scale mapping from high-resolution satellite data is fully implemented by Survey of India, lessons learnt from the past be appreciated and evolution of service oriented cum customer focus strategy be regarded as vital input. In other words traditional map production needs to be changed to, as a *geoinformation product where one data set* created *by SOI can be included in a variety of different geoinformation products/services.* The quality of product depends on user needs and if geoinformation providers produce products of higher quality than what the user expects, the product may serve the user but it causes unnecessary cost to producer (Kerk and Frank, 99). Furthermore the proper management and dissemination of the geoinformation production is need of the hour. And to accomplish this vision the following challenges require immediate attention: -

(a) System requirements to be seen from user's point of view.
(b) Organizations with conventional and manual technologies to adopt advance technologies.
(c) Responsiveness which is combination of efficiency and effectiveness to be as expected by the users (Radwan, 2001).
(d) There should be systematic way of recording user preferences and trade offs to improve the response.

The well-structured way of production/dissemination of geo data at large scale can give valuable contribution to strengthen the infrastructure of the NSDI (as a geoinformation utility). A definition of a Geoinformation Utility (GIU) is given as "an infrastructure set up for the efficient distribution of data/information to enhance its availability, accessibility and use at an affordable cost (Addai 1995). As such in the conventional Top-down approach for Indian NSDI defining the fundamental geo spatial data sets, building clearing houses, establishing meta data standards and access protocols and resolving the information policy are some of the factors where this Utility system can become a reality. From concept to reality the bottom up approach or the initiative taken at tactical/operational level within the framework of Top-down approach, to realize utility system can contribute towards a national framework for accessing, combining and using the data efficiently and effectively at an affordable cost (Georgiadou Y, Nov 2003 under print).

The research focuses on designing a geoinformation utility system for supply of core data using high resolution satellite data where emphasis is on how to improve the accessibility /delivery of this data to the potential users and have capability for producing diverse products/services.

1.3. Research Objective

Design of Geoinformation Utility System for Survey of India using High Resolution Satellite Data.

The main objective can be effectively be ensured through the following sub objectives: -

1. To analyze the existing system being utilized for geo information production and identify the performance problems, thereafter redesign the existing system within the framework of improving the geo data services as a Utility system.
2. To improve the information extraction using high-resolution data.
3. To develop the utility system to improve access to geo-information.

1.4. Research Questions

1. How to analyze and identify the performance problems?
2. What actions are required for fast access and update?
3. What can be the scenarios to deliver diverse products and services from high-resolution satellite data?
4. What can be the specifications of this system?

1.5. Methodology

Geo information product combines data sets acquired from one or several data sources and can be offered in various forms. The product produced may be on different format and poses problem of integrating the data (Kerk and Frank, 1999). This is being resolved by developing standard exchange formats as an initiative of NSDI, open GIS consortium and may be out of the scope of this study. The each step in creation processes for geo information product as per user needs/requirements can be identified so that it gives value for user at each step and then determines quality, accuracy, reliability and speed.

This can be achieved by answering the research questions as follows: -

Question 1: This can be answered by carrying out the SWOT analysis to identify the improvement goals/actions?

Question 2: This can be addressed by identifying the actions?

Question 3: This is best answered by using sample data generated using high-Resolution satellite data.

Question 4: This can be addressed by conceptual design of a utility system.

1.6. Thesis structure

Chapter one: Describes the motivation research problems, research questions & objectives and overall structure of the thesis.

Chapter Two: It describes the growing importance of geo data/information in planning/decision making process and how this information will diffuse into the society to become a utility similar to communication technological innovations like mobile communication, internet, net banking etc.

Chapter Three: This chapter describes the situation as existing in Indian context with emphasis on the Indian national mapping agency The Survey of India (SOI) with respect to availability, delivery, accessibility of spatial data and role of Indian National remote Sensing Agency (NRSA) and the implications of Indian NSDI in 2001. Thereafter a SWOT analysis is carried out to identify the actions for improvement for production of geo information using high resolution Ikonos satellite data. The list of possible actions has been derived based on SWOT. This chapter answers my research question no: 1 and 2.

Chapter Four: This chapter describes the conceptual architecture of geoinformation Utility system. The system has been designed where standard production processes required for mandate tasks and user specific processes are conceptualised to be functioning independently and flexibility is maintained to cater to the dynamic environment.

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Chapter Five: This chapter describes the necessary recommendations for implementations of such a system to include the following:

What technology is required to implement such a system?

What changes are proposed in SOI functioning for the implementation?

This chapter and chapter 4 answer the research question no: 4.

Chapter Six: The output as a geo information product in various scenarios has been explained by using the sample data of Dehardun City generated using Ikonos pan data. This chapter answers my research question no: 3

Chapter seven: Conclusions and recommendations

The final conclusion and recommendation as appreciated by me are given in this chapter.

2. Using Geoinformation as a Utility

2.1. Introduction

One of the distinguishing characteristics of human beings is the desire for improvement; we are capable of looking at the world in which we live, visualizing a different world where things are organized differently and better and then striving to change the world in order to have the desired improvements. These desired improvements could be achieved through some *process of inquiry* to recognize some problem or opportunity, which guides towards a desired end. (Lewis ,1994). The process of enquiry may be termed as *system thinking*. We therefore continuously think about the system mission, vision, gaols etc.

A system can be defined as a set of inter-related components organized together to form an entity for a *purpose* rather than an aggregation of components without any purpose. The environment will greatly determine the performance of system and it's very important to identify the nature of the relationships between the entities in the environment and the system. The system boundary represents a point of contact between system and the outside world and across it all transactions and exchanges take place. The location of the system boundary and therefore the definition of the system environment are entirely depended upon the system and its purpose. Whatever be the system, the environment of that system will change with passage of time. Change is endemic to the world and to all those things that we might wish to investigate through system thinking. Anything, which interacts with surroundings but cannot cope with unforeseen interactions, is unlikely to survive.

In the context of Geo-information provision systems like National mapping agencies (Survey of India) have to adapt themselves to the changing environment so as to have a meaningful relationship with the prevailing environment. Further an organization must understand its environment (both internal and external) if it is to be successful in accomplishing its mission. Because of the increasingly complex nature of the environment within which organizations operate, a variety of new and challenging demands face today's managers. Secondly the world outside the organization has become more complex and faster paced. The issues that once have been viewed from a narrow or parochial perspective are now addressed as a part of global view (Obermeyer, 1994)**.**

2.2. Defining Utility

To have value information must be linked to other information and only then it becomes a source of knowledge and a ***utility.*** A utility has been defined as the ability of a good or service to satisfy a human need. The utility is created when user can be provided goods/services with respect to time, place, of his/her choice.

Accordingly, to build customer relationship for effective marketing, the utility has been classified into four categories (William A., 21-10-2003), which are described as under: -

- Form utility: Converting production inputs into finished products creates form utility.
- Place Utility: Making a product available at a location where customers wish to purchase it creates Place utility.
- Time utility: Making a product available when customers wish to purchase it creates time utility.
- Possession utility: It is created by transferring title (or ownership) of a product to the buyer. Along with the title to its product, the seller transfers the right to use that product to satisfy a need

The fig 2.1 describes how by understanding the user needs and providing the right information at right time and place can create the utility and how the product/services can satisfy the user needs. In view of this the characteristics of building a Utility information system can be as follows: -

- Understandable
- Reliable
- Relevant
- Complete
- Concise
- Timely
- Cost effective

In the context of geoinformation, the geoinformation utility system (GUS) can be defined as an geographical information set up for distribution of data/information where utility is created by providing the quality data/information which is relevant/timely for intended use/reuse and cost effective.

Further a Geo-information system helps an organization to carry out functions effectively and efficiently. It is the management of information and this management aids in creating a service or product from the raw materials.

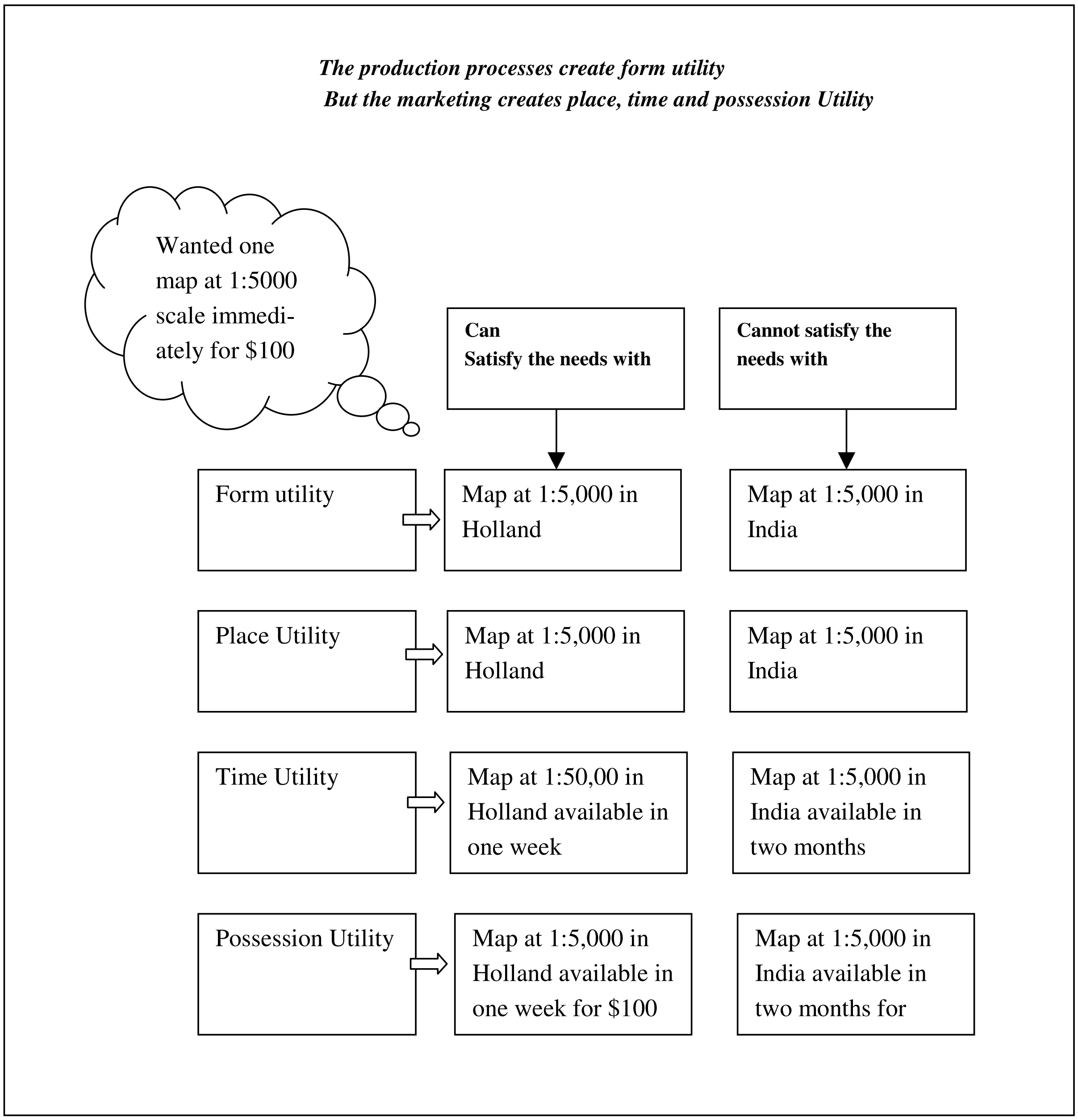

Figure 2.1: Type of Utility

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2.2.1. Innovation through the Technology

We live in an age of information where we use this information to tackle the ever-growing complex issues of today's society. Spatial Information in particular is one of the most critical elements underpinning the decision making for many disciplines.

There can exist an environment in which all stakeholders cooperate with each other and interact through the technology, to better achieve their objectives by avoiding the duplication associated with the generation and maintenance geo-data and subsequently helping in decision-making process to achieve sustainable economic growth. If we harness the capability of interacting and integrating of data through the technology, this will definitely lead us to development of innovative applications of geo-information and that too at an affordable cost.

A frame work that will facilitate the flow of information to relevant stakeholders to enable them to participate in and contribute to the decision making about how land resources are to be used and in this way information supports a good governance (Ian Wiliamson, 2003), and which is being realized through creation of National Spatial Data Infrastructure of India (Indian NSDI).

2.3. The requirement

Geographic information or Geo information is the information, which can be related to the specific location on the earth. It covers an enormous range, including distribution of natural resources, the incidence of pollutants, description of infrastructure such as buildings, utility and transport services, pattern of land use and health, wealth, employment, housing etc. The government at all the levels from the central to the local is now recognizing the need of high quality and reliable geoinformation. With unprecedented increase in population, the cities/towns/villages are experiencing unplanned/ haphazard growth and overburdening of the existing infrastructure. The foresight and planning process hence plays a vital role in today's environment and are benefited with timely availability of spatial information. For quick response to natural disasters, accidents and environmental crisis, much of the information needed to make sound decisions in such cases is based on Spatial Data and absence of data can lead to disastrous consequences. All decisions for sustainable development and economic growth are based on the analysis of spatial data from different sources although attribute data requirement cannot be ignored. Secondly the most human activity depends on geoinformation: on knowing where the things are and understanding how they relate to each other. Many aspects of decision making for management, planning and investment by the Government and the commercial world depend on it. (Chorley RJ, 1987).

The use of high-quality reliable geo spatial information, preferably at high resolutions is critical to virtually every sphere of socio-economic activity especially, agriculture, forestry, land management, water management, infrastructure development, urban planning, disaster management and business, land taxation, land use planning and development, and management of natural resources etc. As such this leads us to realize the importance of having reliable geo spatial data sets at *high resolutions* as a vital input for efficient and effective ***Governance***. Further it is evident that in present situation where the cost of lands/built-up areas are exorbitantly high and are increasing day by day the necessity of having the spatial data at high resolutions of commensurate accuracy and reliability cannot be overlooked. Secondly with the advent of diverse geo spatial data acquisition technologies for high resolutions, the task of creating a timely and reliable geo spatial data has definitely become simple, cost effective and fast as compared to the conventional methods. The above mentioned enabling characteristics of the present day technologies has *motivated* the geo spatial information providers to make an effort in this direction in a cost effective manner and has definitely enhanced the efficiency.

This has been followed by the swift proliferation of the affordable and easy-to-use GIS tools that has seen the emergence of a new generation of geo information users who are better aware of product quality requirements thus making unprecedented demands on Geo spatial information providers. Further the expansion of the customer base as a result of growth in the number of application domains has created an urgent need for diverse geo information products and services (Radwan, 2001). In the present scenario the possible areas where geo information matters can be as follows (Chorley RJ, 1987): -

- Monitoring Changes: in resources to include land building, equipment, infrastructure
- Monitoring changes in economic, social, demographic, environment conditions.
- Forecasting changes: in housing requirements, economy, and demand for land, leisure and community services.
- Service planning: through identifying and forecasting changes in the patterns of the need for services and investments as a basis for the delivery of services and deployment of resources.
- Resources management: building maintenance refuse collection, route scheduling of supplies vehicles etc.
- Transport network management: to include the provision and maintenance of highways, public transport schedules, and street cleaning.
- Public protection and security systems: police command and control systems, locations of fire hydrants, pattern of crime and incidents of fire.
- Property development and investment: preparation of development plans: assessing land potential and preparing property registers: promoting industrial development: rural resource management.

In view of the above-explained application areas, the users of geoinformation can be:

- Central/state govt for planning of national and regional development programs.
- Department of agriculture: -for land use planning, land use change and resource management.
- Forestry department: -for the inventory, exploitation and management of forest resources.
- Department of Utilities: - for the distribution and management of water, gas, electricity and the management of sewage.

- Department of defence- for defence and security purposes.
- Water resources department: - for the study of potential, quality and exploitation of water resources.
- Transport authorities: - for the provision and maintenance of transportation networks such as roads, railways and canals, rivers; for information on road traffic.
- The Engineering department: for site locations and conditions, for construction of roads, buildings dams etc.
- Mining department: -for information on geology, minerals, and other geophysical information.
- Town Planning department: - for urban planning
- Department of land: - for land and property registration, acquisition, delivery, valuation and taxation.
- Department of environment:- for environmental monitoring such as the effects of pollution, changes of atmospheric conditions, the incidence of diseases river water quality, thermal discharges from power stations/industries.

- Department of tourism: - for tourism, recreational services/sites, etc.

2.4. Conclusion

The users of geoinformation require the relevant data/information at appropriate time and cost that too at high resolution and in the most appropriate form to meet the requirements for planning /decision making for sustainable growth and economic development in the present environment of managing diminishing resources, population growth and disaster mitigation etc. To achieve this aim, the situation analysis with respect to SOI and list of possible actions for providing the geoinformation in diverse ways (using ICT) in a most appropriate time/cost has been done in chapter 3.

3. Situation analysis

3.1. Introduction

This chapter describes the current mandate, functions, data, products and services of the organisations namely Survey of India (SOI) the national mapping agency of India and National Remote Sensing Agency (NRSA), the Indian space agency. The purpose of this chapter is firstly to set a base for the analysis of the current situation with respect to data being produced by SOI using High resolution satellite data being provided by NRSA and thereafter carry out SWOT analysis within the framework of making the data provision as a geo information utility system (GUS).

3.2. Survey of India

The history of the Survey of India dates back to the 18th Century. Forerunners of army of the East India Company and Surveyors had an onerous task of exploring the unknown. Bit by bit the tapestry of Indian terrain was completed by the painstaking efforts of a distinguished line of Surveyors such as Mr. Lambton and Sir George Everest. It is a tribute to the foresight of such Surveyors that at the time of independence the country inherited a survey network built on scientific principles. The great Trigonometric series spanning the country from North to South East to West are some of the best geodetic control series available in the world. The scientific principles of surveying have since been augmented by the latest technology to meet the multidisciplinary requirement of data from planners and scientists. (Organized into only 5 Directorates in 1950, mainly to look after the mapping needs of Defense Forces in North West and North East, the Department has now grown into 18 Directorates spread in all parts of the country to provide the basic map coverage required for the development of the country. Its technology, latest in the world, has been oriented to meet the needs of defense forces, planners and scientists in the field of geo-sciences, land and resource management. Various Ministries are utilizing its expert advice and undertakings of Govt. of India in many sensitive areas including settlement of International borders, State boundaries and in assisting planned development of hitherto under developed areas. Faced with the requirement of digital topographical data, the department has created three Digital Centers during late eighties to generate Digital Topographical Data Base for the entire country for use in various planning processes and creation of geographic information system. Its specialized Directorates such as Geodetic and Research Branch, Research & Development Directorate and Survey Training Institute have been further strengthened to meet the growing requirement of user community. The department is also assisting in many scientific programs of the Nation related to the field of geo-physics, remote sensing and digital data transfers

3.2.1. Present Role

Preparation of up-to-date topographical coverage in map form is the primary role of the Survey of India. The dissemination of these maps, prior to 1047, was limited for official use only. However, realizing the importance of topographic database for development, planning and other scientific research, the map dissemination policies underwent reviews from time to time and as a result, open circulation of maps covering about 2/3rd land area of the country on large scales was permitted to the public.

The Survey of India (SOI) is the only Government (Govt) agency in India, fulfilling the Govt needs for spatial information, conventionally in the form of paper maps. SOI is 235 years old and is responsible for all topographical and development surveys and acts as advisor to the Government of India on survey matters to include geodesy, Photogrammetry, mapping and map reproduction (printing).

The country has been covered by topographical (topo) maps on 1:250.000, 1:50,000, 1,25,000 scale. India is covered by nearly 385 topo map on 1:250,000 scale and these are also referred to as degree sheet. Each degree sheet has 16 topo sheets of 1:50,000 scale and each 1:50,000 scale sheet contains four 1:25,000 sheets (Fig 3.1) .In the fig each degree sheet has a scale of 1:250,000 and is referenced from the index maps as say55D, each 1:50,000 map is referenced as say 55D/14 and finally each 1:25,000 map is referenced as 55D/14/NW.

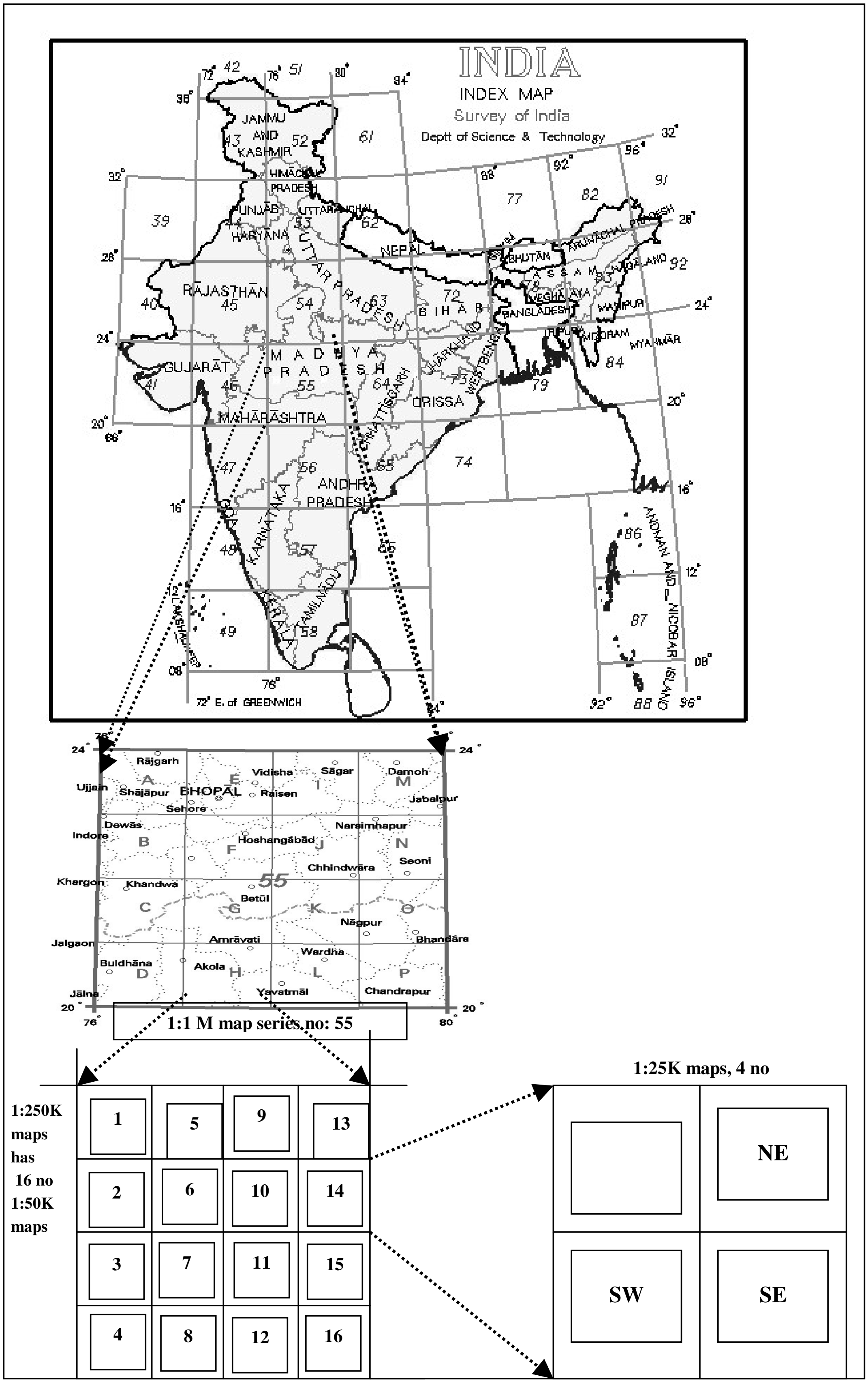

Figure 3.1:Map reference system SOI

The main duties and responsibilities of the Survey of India (Srivastava RN, Aug 2000) are enumerated below: -

- All Geodetic Control (Horizontal and Vertical) and Geodetic and geophysical Surveys.
- All Topographical control, Surveys and Mapping within India.
  Mapping and Production Of Geographical maps and Aeronautical Charts.
- Surveys for Developmental Projects.
- Large-scale Cities, Guide Maps & Cadastral Surveys etc.
- Survey and Mapping of special purpose maps.
- Spelling of Geographical names.
- Demarcation of the External Boundaries of the Republic of India, their depiction on maps published in the country and also advice on the demarcation of inter-state boundaries.
- Training of officers and staff of Survey of India, other Central and State Government department and trainees from Foreign Countries.
- Research and Development in Digital Cartography, Printing, Geodesy, Photogrammetry, Topographical Surveys and Indigenisation.
- Prediction of tides at 44 ports including 14 foreign ports and publication of Tide Table one year in advance to support navigational activities.
- Scrutiny and Certification of external boundaries & coastline on maps published by the other agencies including private publishers.

3.2.2. Current Organizational structure

Currently, SOI is organized on the basis of field survey parties, cartography, reproduction, specialised digital mapping, geodetic research and development etc, and is headed by The Surveyor General of India. Its headquarter is located at Dehradun, Uttranchal state. It has 18 directorates having area of responsibility based on topographical map coverage. In addition, SOI has Modern cartographic Centre (MCC) in Dehradun, Digital mapping centres (DMC) in Dehradun and Hyderabad. SOI has got its own Survey Training Institute (STI) located in Hyderabad for human resource development. In our context the main organisational structure of SOI is highlighted in fig: 3.2. It's to be highlighted that the operational works in the organization are task oriented and are carried out by independent survey detachments (or functional teams) based on this basic unit of survey parties under a Circle directorate.

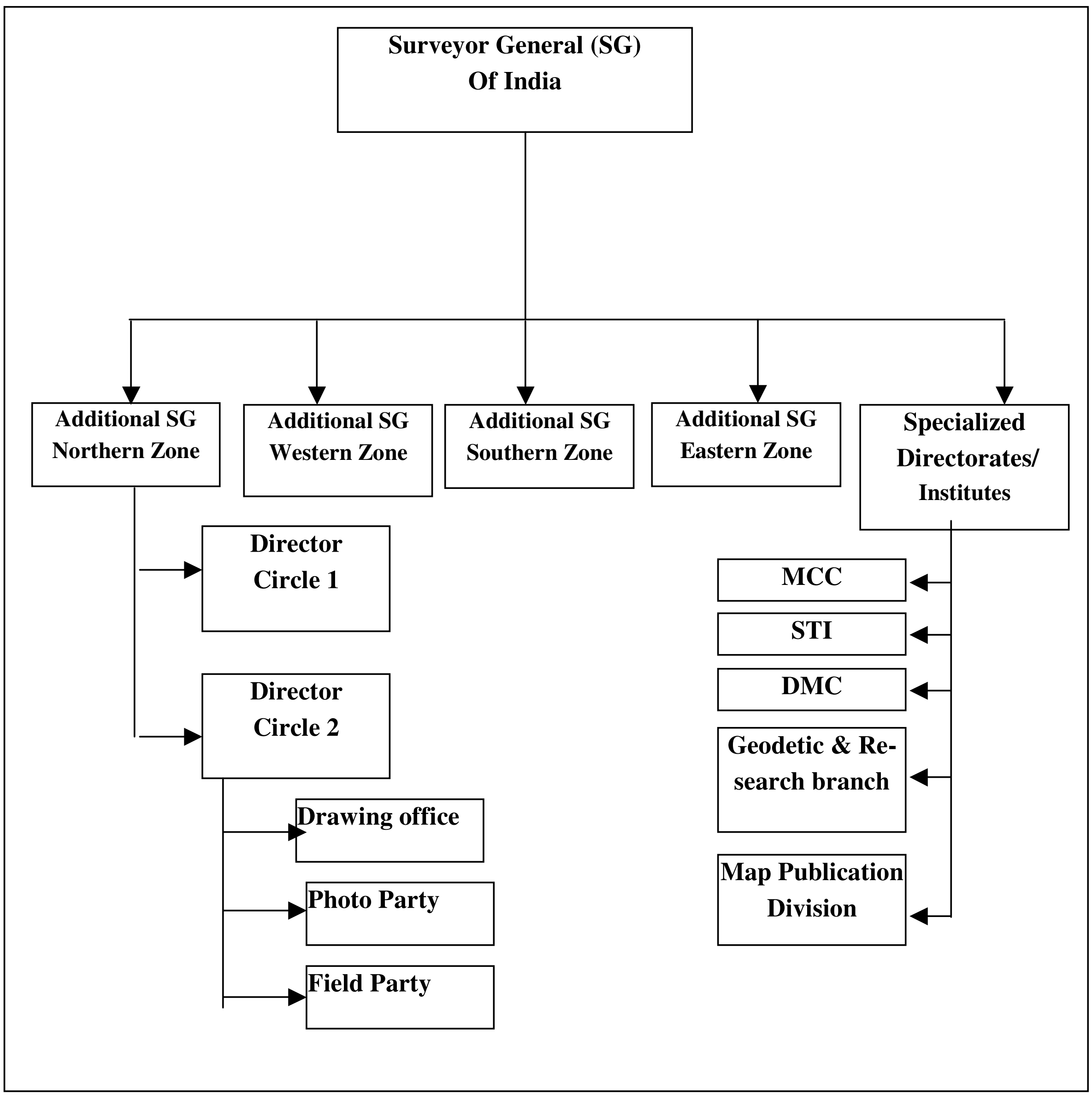

Figure 3.2: Current Organisational structure of SOI

3.2.3. Functions/services

SOI is a government department involved in production of standard digital topographical maps from the existing hard copy maps. It has over the years developed comprehensive feature code specifications for digitisation process and this code is unique and an asset to the country and if used by the users semantics problem with respect to data sharing can be resolved to some extent. SOI organises the training courses to its staff for upgrading the skills and improve quality of work. This subsequently helps to maintain same standards/specification with respect to surveying techniques in the department. SOI presently is involved in various activities and the various functions/services being undertaken by the organization are highlighted as under (Srivastava, 2000): -

(a) Topographical surveys
  (i) Establishment of geodetic control framework through precise planimetric, height, gravity, Geomagnetic and tidal observations and topographical Control network.
  (ii) Photogrammetry and ground surveys.
  (iii) Maps in soft copy forms on various scales to Expedite map revision process.

(b) Developmental surveys
  (i) Paid for surveys for development projects in hand and soft copy forms.
  (ii) Provision of data for precise alignments of tunnels, dams, power house complex, barrages and railways, etc.

(c) Public series mapping
Guide maps, town maps, road maps, tourist and trekking maps, etc. on various scales. Geographical maps on 1:1 million scale and smaller scales in hard and soft copy forms.

(d) Publication of charts and tables
  (i) World aeronautical charts.
  (ii) Indian tide table.
  (iii) Monthly mean sea-levels of Indian tidal stations.

(e) Mapping for defence forces
  (i) IAF charges and maps.
  (ii) Cantonment maps.
  (iii) Topographical maps with special information.
  (iv) Special maps/digital data.

(f) Assistance to scientific programmes
  (i) Irrigation and multipurpose hydro-electric schemes.

(ii) Glaciological studies.
(iii) Crystal movement/dam deformation studies.
(iv) Tidal studies.
(v) Gravity and geomagnetic observations.
(vi) Digital cartographic database. Elevation models, etc.

3.2.4. Data/Products

SOI is the main data producer of foundation data or core data sets. Core data sets are topographic coverage, geodetic network, road network address system, geographical nomenclature etc that describe physical, economic, human and historic geography in a consistent and coherent manner for policy development and execution, security, economic development protection of environment (Georgiadou Y, Nov 2003 under print), to which most users of geo-information relate hence become the base / vital for decision making process. In Indian context SOI is producing and maintaining the following types of data/products:

- Geodetic control points: They have been monumented and in the present circumstances GPS control stations have been made active to study the earth dynamics/plate movements.
- Digital orthophotos: Currently SOI maintains analogue aerial photographs which are being made digital by scanning process to create a digital database of aerial photos.
- Topographical Coverages: As mentioned earlier the topographical coverage consists of map scales of 1:100000, 1:250,000, 1:50,000 and 1:25,000. The maps as mentioned are very old and in most of the case even 20 years old although SOI has recently taken initiative to update its maps using satellite imageries and in the process of updating the same. On 1:25,000 scale only 30 to 35% of the country has been covered by the SOI and it has realized the need of core data at this resolution and are in the process of undertaking the initiative of adopting new technologies to include high resolution satellite data, airborne digital cameras, airborne laser altimetry etc. to speed up the process of updation and creation of core data sets at high resolutions.
- Digital elevation models (DEM): As a part of topography, SOI maintains contour lines and spot heights in analogue as well as digital form and provides digital terrain models (DTM) for specific needs due to the restriction policy on issue of spatial data in Indian context.
- Other type of guide maps, tourist maps, road maps, where height information, vital points (VP), vital areas (VA) are not shown.

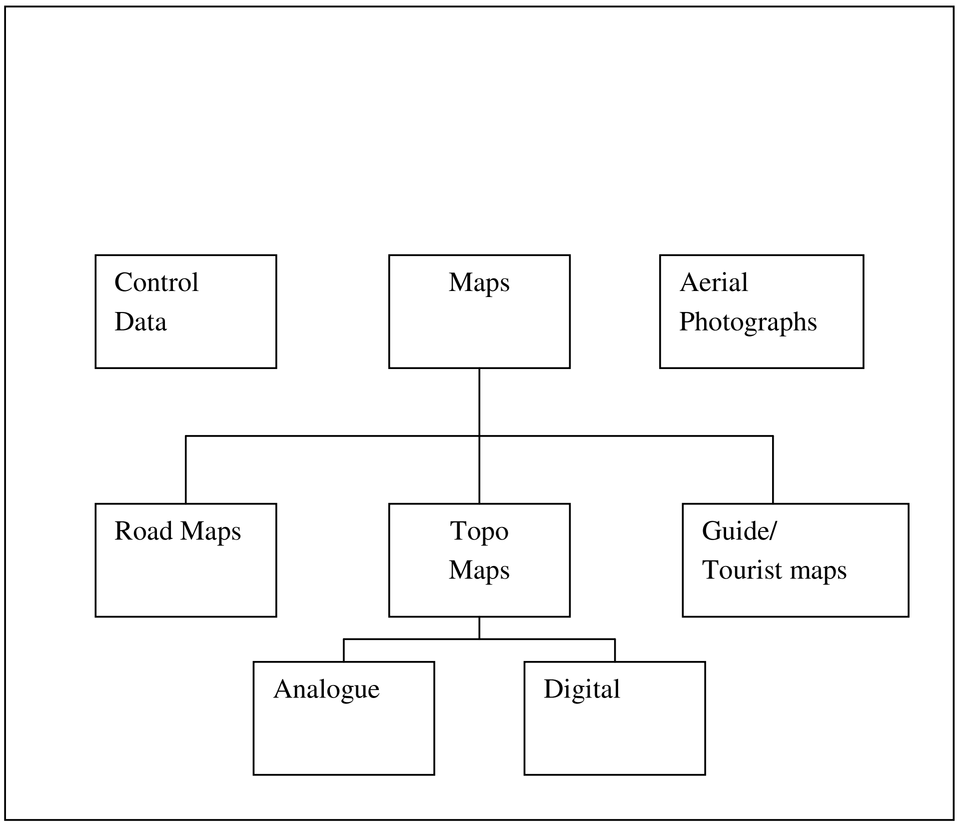

Figure 3.3:Products of SOI

3.2.5. Maps on WGS84 datum

- The topographical data falling within 50 kms of International border and along the costal line are restricted as per the Government order and can be issued to Government departments /non government organisations (NGO) after completing the necessary formalities as laid down by the ministry of defence. Moreover the topographical data in digital form is also restricted. To overcome the difficulties SOI has introduced dual series maps. Existing ones on Everest datum for Defence needs and second series of maps on WGS84 datum on UTM projection with fewer details for public use. Maps of two cities on 1:25,000 scale on WGS84 were released in Nov 2000. (http://www.directionsmag.com/press.releases)

3.2.6. How to obtain maps and data

The maps/data can be purchased by the users from the map sales offices, which are well dispersed all over the country (the official website of SOI).

- **Maps of The RESTRICTED Zone**
  Maps on scales larger than 1:1 million of certain areas, published by the Survey of India are classed as RESTRICTED. The limited of such areas has been shown by thick line on the index maps. Restricted maps are issued to Govt. Officials, Educational and Scientific Institutions and Semi-Govt. Organizations including public undertaking for bonafide purposes. Applications for such maps must, however, be made on Form 0.57(a) obtainable from any of the Survey of India, Maps Scale Offices. Issues of Maps are subjects to the conditions mentioned in the form and these are liable to be revised by the Ministry of Defense, Govt. of India. Every indent should clearly indicate the purpose for which the maps are required. Private individuals and organization/commercial firms can also obtain RESTRICTED maps subjects to there demand being approved by the Ministry of the Defense, Govt. of India, through the state Govt. to whom they should apply.
- **Geodetic, Geophysical, Trignometrical & Height Data**
  For Geodetic and geophysical data request should be made to the Director, Geodetic and Research branch, For Trigonometric and Height Data request be made to the Director, Geodetic and Research branch or the Director, Regional Circle of Survey of India. Data of certain accuracy is restricted and can be supplied only after getting clearance from the Ministry of Defense.

3.3. National Remote sensing agency(NRSA)

National Remote Sensing Agency (NRSA) is an autonomous organization under Department of Space, Govt. of India engaged in operational remote sensing activities. The chief activities are satellite data and aerial data reception, data processing, data dissemination, applications for providing value added services and training.

The National Remote Sensing Agency (NRSA) is the focal point for distribution of remote sensing satellite data products in India and its neighboring countries. NRSA has an earth station at Shadnagar, about 55Km from Hyderabad, to receive data from almost all contemporary remote sensing satellites such as IRS-P4, IRS-1D, IRS-1C, IRS-P3, IRS-1B, ERS-1/2, Landsat-5 and NOAA series of satellites. The data is recorded at Shadnagar on High Density Digital Tapes (HDTs) or Digital Linear Tapes (DLTs) or CD-ROMs or 8mm Digital Tapes (DATs) depending on the mission, and archived for providing data products to users as and when orders are received. As per the archival policy data will be archived for a period of 5 years before being selectively purged. .

NRSA has acquired the capability to design, develop, deploy and operationalize multi-sensor satellite based ground systems comprising of ground and application segments to meet domestic and international requirements. The acquired data is being processed in-house and transformed into variety of data products for distribution among the user community. Apart from data supply, it has the capability to undertake project-oriented studies in variety of disciplines.

NRSA has organized training activities to train professionals, scientists as well as decision makers on Remote Sensing and GIS. A dedicated training center, Indian Institute of Remote Sensing, located at Dehra Dun gives M.Tech (Remote sensing) course of 24-months to 4-days decision maker's courses. The NRSA Headquarters at Hyderabad has a Training Division, which organizes similar training courses as well as custom made courses. NRSA has collaboration with ITC, The Netherlands for training.

3.3.1. Product information

NRSA provides extensive information related to data products such as price lists, reference maps, data format documents, hand books and newsletter to apprise users about the changes/developments from time to time and are planning to introduce digital order forms so that users can place the orders through INTERNET. Data products are supplied on a wide variety of media and formats as follows: -

Photographic Products

- B&W and False Colour Composites (FCC)
- Positive transparencies (240 mm)
- Negative transparencies (240 mm)
- Paper prints (1x, 2x, 4x and 5x enlargements up to 1000 mm width)

- **Digital products**
  - CD-ROMS
  - 8mm Tapes (DATs)

3.3.2. Data Ordering

Users can place orders for data products by filling the order form specifying the sensors, type of product, period of interest, etc. along with 100% advance payment in the form of a DD payable to NRSA at Hyderabad. A running account will be opened at NDC and the funds will be deposited in the account. Upon receipt of an order, NDC will take up the same for processing and send a confirmation (in about 3 -4 days) to the user.

Products are generally dispatched within a week to ten days from the date of confirmation and are generally shipped by courier/speed post with the invoices. For the satellite data products of foreign companies, user have to place demand through NRSA and not directly and same procedure as for the products of NRSA is to be followed. NRSA claims that the turn around time for data supply for their products is less than a week depending upon the revisit time of the sensor, cloud cover etc(NRSA, Oct, 2003).

3.4. As-Is situation in SOI using high resolution satellite data

To produce maps at large scales SOI has adopted the methodology to use high resolution satellite data being easily available and fairly up-to-date and extract the planimetric details. The SOI receives satellite data from the National space agency in this case the National Remote Sensing Agency and control points in the form of ground control points (GCP) from its own geodetic survey branch. The data is processed in the photo party (Circle) to include the following (ref fig: 3.4): -

- Selection of GCP's from the hard copy of the image
- Image plot duly marked with GCP's are given to Geodetic and research branch (G&RB) for providing the coordinates of the identified GCP's in WGS84 frame.
- The GPS field observation is done using Geodetic GPS receivers.
- The post processing is done by Geodetic and Research branch using International GPS service (IGS) data available on the Internet and Burnese software.

- After the post processing the coordinates of the GCP's (Geodetic data) are sent to the respective circle office in hard copy form
- The Survey party under the Circle does the geo-referencing and feature extraction, based on the geodetic data, satellite imagery (only planimetric details are extracted).
- The same persons who are involved in the particular type of feature extraction do Field survey/verification.
- The colour separates are prepared by the party and given to Printing Office and thereafter the printing is completed.
- Map delivery through The sales wing of Publication division

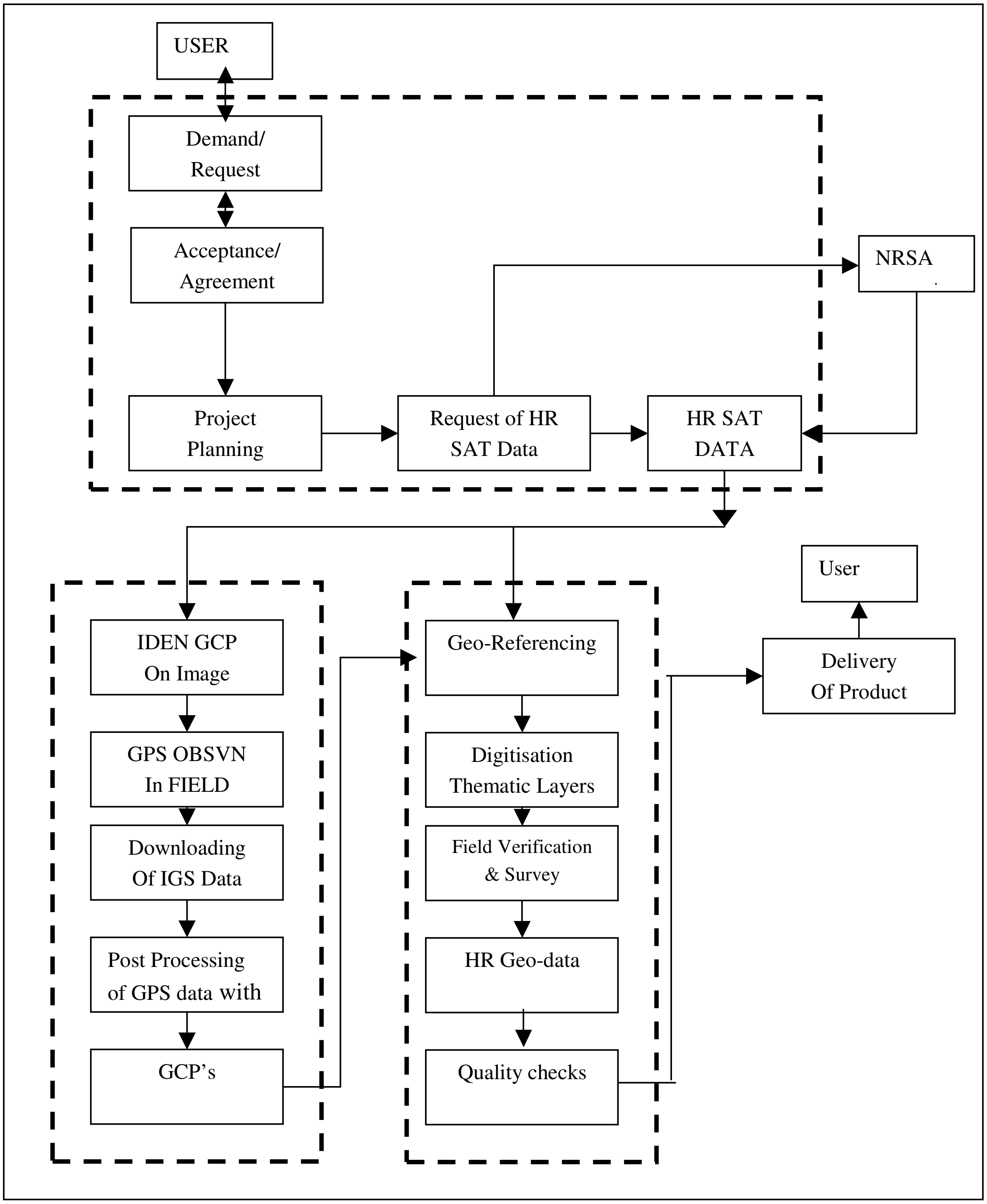

Figure 3.4: AS-IS process model

The SOI has recently adopted the technology of planimetric mapping using high-resolution satellite pan data of Ikonos (mono) rather than the stereo data due to its high cost and has successfully generated the map of Dehradun city, the state capital of Uttranchal state in India at RF scale of 1:5000 and same has been supplied to the state Government

3.5. SWOT analysis

SWOT analysis is a basic management tool that is used in strategic planning including policy development and problem solving. It provides a basis for assessment of the organisation and relationship with the external environment. SWOT stands for internal strengths (S) and weakness (W) and external opportunities (O) and threats (T). The SWOT analysis is based on matching the various S's and W's with the O's and T's and gives a possible breakdown of actions that enable an organisation to gain competitive advantage (fig 3.5). The only actions that reflect the competitive advantage are considered. Attack, exploit, explore and avoid are the key words in the analysis step (Radwan, 2001)(fig 3.6). By combining S and O, set of actions can be to exploit the combination of S and O. Similarly with W and T explore the O's to overcome W's and so on.

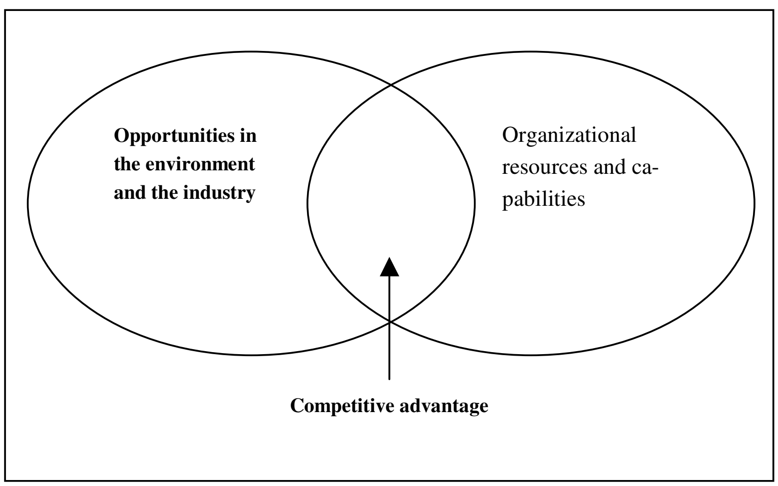

Figure 3.5:Competitive advantage

The SWOT analysis of organisations like SOI, is a complex process in which a specialised group consisting of experts from SOI and management groups is required to understand firstly the internal strengths and weakness and thereafter the analysis of external opportunities and threats. It's after that the actions required as shown in Fig 3.6 are identified.

	Opportunities **(O)**	**Threats (T)**	**O vs. T Actions**
Strengths (S)	Make use of 'S' to take advantage of 'O' Exploit	**Use 'S' to counter 'T'** ***Attack***	**S/O/T** Exploit & Attack
Weaknesses (W)	**Minimize 'W" with 'O'** *Explore*	**Remove 'W' in front of 'T'** *Avoid*	**W/O/T** *Explore what to avoid*
S vs. W Actions	**S/W/O** *Explore what to exploit*	**S/W/T** *Avoid areas Requiring attacks*	

Figure 3.6:SWOT Matrix

The term weakness may not sound pleasant for such organisations. I shall be using the word *improvement actions (**I**) in place of weakness.*

After doing literature review, discussions with my supervisors and various faculty members of ITC, the Netherlands who are well aware of the situation in Indian context and some personnel experiences in using the data from SOI, the Swot analysis is described in the succeeding paragraphs.

3.5.1. Strengths (S)

- Network of establishment all over the country: - Survey of India being the National Mapping agency has a network of establishments all over the country. This enables the department to carry out the tasks in a uniform manner and provides consistent standards for surveying and mapping.
- Trained manpower: The Organisation has its own training establishment for imparting training to officers and staff for adopting uniform techniques in surveying and mapping.
- Unique Core data provider: - The map data representing the core data is unique and is a primary requirement for spatial data referencing.
- Known for its standards and accuracy: - The Geodetic, Topographic and levelling data produced by the department is known for its accuracy, though may be lacking in currency of data.
- Complete coverage of topographical maps except 1:25,000 series.
- Good quality control on its products and services
- Experience in conventional mapping operations and hence has ability to exploit capabilities of GIS (chapter2)
- Has developed unique feature code manual for all topographical details and as a result, all digital products are produces in a uniform and consistent way.
- Support for change by the department of science and technology as SOI is in the process of acquiring ALTM and digital airborne camera technology in near future.
- Availability of modern hardware and software in the organisation
- Redefined vision of the present Surveyor general of India to exploit the present day technology and support from the government.
- Sincere and hardworking workers who always follow the standard operating procedures
- Well-developed and time-tested standard operating procedures.
- Availability of reliable spatial data

3.5.2. Improvement Actions (I)

- *Data is produced is a standard product as a map and not as per the per user's needs.*
- Data are partially availability at high resolutions, maps at 1:25,000 scale cover only 35% of the country
- The data maintained is not current.
- *Data produced using high-resolution satellite data is not stored in structured way.*
- The website is less interactive with respect to providing the information services.
- *Lack of having system to have diverse products and services.*
- *Lack of maintaining the record of user's preferences and trade offs.*
- The subordinate staffs are not highly trained in image processing techniques although the basic operations of geo referencing and feature extraction are the best in the country.
- *Circle directorate the main work force is divide based on topographical map index, and cover more than one state. This gives a lack of affiliation and no sense of belonging to the Circle directorate and may result in switching over of priorities from one state to another. This can lead to dissatisfaction among users.*
- The GCP data is maintained in a word file and there is no unique referencing system for making it accessible to all concerned for use in their specific domains.
- *No marketing strategy except the official website.*
- *Directorates are not connected through networking for easy data sharing/accessibility.*
- *The work environment is highly centralised and all users have to approach through SGO, office for data requests /access.*
- The topographical data contains many details, which may be too complex for many users.

3.5.3. Opportunities (O)

- *SOI can get satellite data even of foreign commercial high-resolution satellite data providers like Ikonos, quick bird through NRSA.*
- *The indigenous launch of Indian Cartosat series of satellite of resolution 2.5 meters offers a business opportunity to expand its operations of the production of high-resolution data.*
- *The satellite products can be procured very easily and SOI can produce processed data very quickly and with high quality, which can create a monopoly in the GIS market.*

- *The core data is critical to the buyer's success in their application domain and thus creating an opportunity to have continued supply of customers and chances of earning high profits by selling to the users who are always ready to accept the unique and reliable data of SOI.*
- Since having the core data provider the users are more inclined to have long-term relationship, which creates an environment of less competition.
- *There is urgent need of core data at high resolutions for micro level planning*.
- *The availability of data acquisition technologies and support of Government to acquire these technologies like high-resolution satellite data, airborne digital camera with GPS on board (chapter1), ALTM etc.*
- *New vision of SOI at Jim Corbett national park where emphasis was customer satisfaction*.
- Presently numbers of competitors are very few and can have competitive edge over others.

- *The department can better serve the people through the Indian NSDI gateway for enhanced accessibility etc*.

- The need of high quality and reliable data is being recognised by the government at all the levels from central to local level. Hence, the geo-information market is increasing.

- The percolation of concepts of spatial planning at community level

- The acceptability of the data because of the standards and accuracy.

- Availability of techniques for online updation of data using remote sensed data.

- Precise processing techniques for GPS data through IGS services available which is most suitable for geo referencing the image data.

- Reengineering of SOI initiated by the Government.

3.5.4. Threats (T)

- *Buyers can bypass SOI for products as they can also get the raw satellite data from NRSA and do the necessary field survey using GPS etc. and can create the type of products offered by SOI*

- *Low market growth for conventional products.*

- *Parallel large scale mapping initiatives of private competitors may take away the users*

- Copy rights violations in use of data by the users and may sell the original data to others without giving any royalty to SOI.

- Restriction policy on spatial data availability.

- Users are dissatisfied with the present state.

3.6. Set of actions

The set of actions have been classified as exploit, attack, avoid and explore and are given in succeeding paragraphs.

3.6.1. Exploit (S/O)

- With well trained persons, taking the opportunity of supplying the value added products
- With large network all over the country take advantages of opportunities of the requirement of core data at high resolutions for cities and towns and initiate project works with the users all over the country simultaneously and increase market share.
- Using the availability of modern hardware and software in the organisation and opportunity offered by the modern data acquisition technologies like high resolution satellite data, digital airborne Photogrammetry, ALTM etc, and support from government for the same, SOI to acquire the same and readily create a variable/flexible system to create diverse products as per the user needs.
- Using the support for change by the government, ability to produce high quality products and the NSDI initiative, create metadata services through the infrastructure of NSDI and provide sufficient information about the new products and services through the official website of SOI in an interactive way.

3.6.2. Attack (S/T)

- Make users aware of the data quality and standards of SOI through web services, newsletters and ability to provide consistent service due to network of establishment all over the country and consequently users can be motivated to use SOI services than producing data themselves.
- Availability of modern hardware and software coupled with well trained man power provide diverse products as per user needs to compensate for low market for conventional products.

3.6.3. Explore (I / O)

- Create databases to enable speed update, improved response time
- Produce diverse products as per user needs
- Produce data at high resolutions by making use of enabling technologies and the support from the government so as to meet the shortfall in having data at high resolutions .
- Make use of network of establishment to attract customers

- Additional Circle directorates are created to have at least one Directorate for each State and reorganised based on the requirement of diverse products and services. The organisation be based on modular concept where the independent modules or groups working under have the capability to be regrouped for specific tasks /technology without having to reengineer every time as the opportunity is given by the Government to reengineer.

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3.6.4. Avoid (I / T)

- Create awareness campaigns / seminars for overcoming the threat from the low level competitors
- Update technology to enable creation of new products and services and manage by processes rather than functions to speed up response time
- Develop products based on users requirements so that users are not dissatisfied.

3.7. List of possible actions

Base on the analysis as done in above paragraph the list of possible actions required for necessitating changes are as follows: -

- The circle directorate is identified as the main hub for all activities related to geoinformation production processes and requires being proactive.
- Using the government support for change, the ability to produce high quality data and well-trained personnel take advantage of opportunity to supply value added products.
- Using the modern data acquisition technologies for high resolutions data and need to have geoinformation at high resolutions, take initiative to produce the data at high resolutions.
- Using the availability of modern hardware and software, network of SOI establishment and the opportunity offered by the user community for having high resolution data for cities and towns, initiate process of production of data
- Update technology to enable creation of new/diverse products
- Create databases to enable provision of data to all users, speed up operations, and improve response and provide metadata services and possible linking with Indian NSDI infrastructure.
- Create metadata as per NSDI format.
- Create diverse products and services as per the user needs.
- Manage by processes rather than by functions to speed up response time. This requires reorganising the existing structure supporting the identified processes.
- Create additional Circle directorates so that each state has one circle directorate to provide spatial data /products as per the needs.

- Adopt/acquire new technologies for data requirements at high resolutions.
- Having different technologies at hand for data generation the new organisational structure of Circle recommended to be based on modular concept where the groups/cells working under them are capable of functioning independently so that they can be regrouped as per the project requirements/priority and managers can retain flexibility in redeployment of resources at hand.
- Managing by processes and not by functions and keeping in view users demand requires design of a system which can have flexibility in combining data from databases and the processes to get data /product as per user needs. The system should allow the development of new processes while incorporating new technology without changing the entire system. The system components can be independent entities but be able to communicate with each other.
- Create diversity of products rather than conventional products since the conventional products are sometimes complex for the users to understand.
- Initiate campaigns to introduce the organisation and the products and services to the users.

3.8. conclusion

The based on SWOT analysis and the new vision of SOI, designing a utility system at Circle directorate level is a mandatory requirement and, list of possible actions, provides guidelines for formulation of operational level strategies. The operational strategy and design of a new GUS is covered in next chapter.

4. Design of utility system

4.1. Introduction

The objective of this chapter is to design a new geoinformation utility system for SOI using high-resolution satellite data in a distributed environment to facilitate product diversity, provide most up to date topographic data as per the mandate and simultaneously respond to user needs in an acceptable time frame and that too at an affordable cost.
The term distributed system environment refers to a distributed collection of users, software, and hard ware, whose purpose is to meet some pre-defined objectives. A distributed system requires physical networking, system services and application software. The overall designed system is known as a distributed computing environment (DCE). In general, computer systems provide four types of interrelated services. The data storage services provide users with efficient storage media. The data access services provide functions for retrieving data from the storage media. The application services provide users with capabilities to execute specific tasks. Finally the presentation services provide display facilities and user interfaces to end-users. There are several design possibilities for distributing any of these services. Data can be located in distributed storage media. An application might send requests to several data access services located at different systems. A user might be provided with a single presentation service, which transparently accesses different distributed application services. This particular type of distributed services is known as a distributed system. The fundamental model with which the DCE is implemented is known as the *client server model* where a client, an application component sends requests to the server and the server performs the services in response to requests sent by the clients and the client receives the result of the services returned from the server. A major difficulty in the client server model and consequently in the DCE, is that many different standards apply. The implementation of different standards results in heterogeneity among the clients and the servers. The heterogeneity might vary from networking system, which links the clients and servers on the one hand, to the software applications, on the other hand (Groot and others, 2000). The heterogeneity aspect within the SOI set up is not the issue for designing a new system, as SOI is known for maintaining consistency in its standards. However this needs deliberation when data is to be accessed by the external users. For these types of potential users the heterogeneity issues can be resolved by making use of Indian NSDI infrastructure. It is also to be kept in mind that using modern technologies for generation of geoinformation at high resolutions will produce huge amount of data and management of the data requires systematic approach.

In this backdrop, this chapter begins with the proposed system architecture, which describes the recommended operational level strategic objectives at Circle directorate level the main work force of SOI and thereafter the conceptual architecture is introduced. This is followed by detailed description of various business processes involved to conceptualise such a system.

4.2. Proposed system architecture

The new technology has an integrating, decentralizing and customizing nature. The integrating nature has removed the traditional borders between various techniques involved in producing and using the geo data. The decentralizing nature allows integrated processes in a decentralised fashion. And the customising nature enables product diversity at low cost. This gives capability to develop new products, which are demand driven (Groot and others, 1994). The exploitation in this regards on innovative integration of existing information technology and modern mapping systems as well as modern management skills is going to enhance the availability, accessibility and use of geo data/information at an affordable cost.

With the advances in remote sensing technology (chapter1), the requirement to have geoinformation as a utility at high resolutions (chapter2) and analysis carried out in chapter3, the operational strategic objectives for the new system at *Circle directorate level* in consonance with the redefined vision of SOI (refer chapter1) can be identified and subsequently the conceptual architecture can be deduced.

4.2.1. Operational strategic objectives

Strategic objectives if identified correctly can provide the necessary direction for the new system. In view of the foregoing the recommended strategic objective of the proposed system as appreciated are as follows: -

1. To provide State wide topographical data coverage at high resolutions
2. Maintain the geo data based in a distributed environment based on modern database technology and ensure that it is most current and of suitable quality to meet the current and future needs of a wide range of users (called as customers).
3. Provide diverse products and services to meet the customer demands.
4. Provide information about the geoinformation products and services through metadata services.
5. To increase the efficiency and product diversity, the system to be flexible enough to adopt new technologies.
6. Continue to provide standard products as per the legal mandate.

4.2.2. The conceptual architecture of the proposed system

Based on the objectives derived, the proposed utility system proposed in this research logically can have the following essential components/sub systems: -

- *Data production sub system (DPS)*
- *Database management sub system (DBM)*
- *Utility services sub system (USR)*

The data from various production processes are stored and maintained in DBM. The DBM facilitates easy retrieval of data required for USR and provides efficient means for optimal reuse of existing data to support various production processes in DPS. The integration of DPS and DBM through USR conceptualises a *Geoinformation Utility System (GUS)*.

The fig 4.1 shows the conceptual architecture of a GUS.

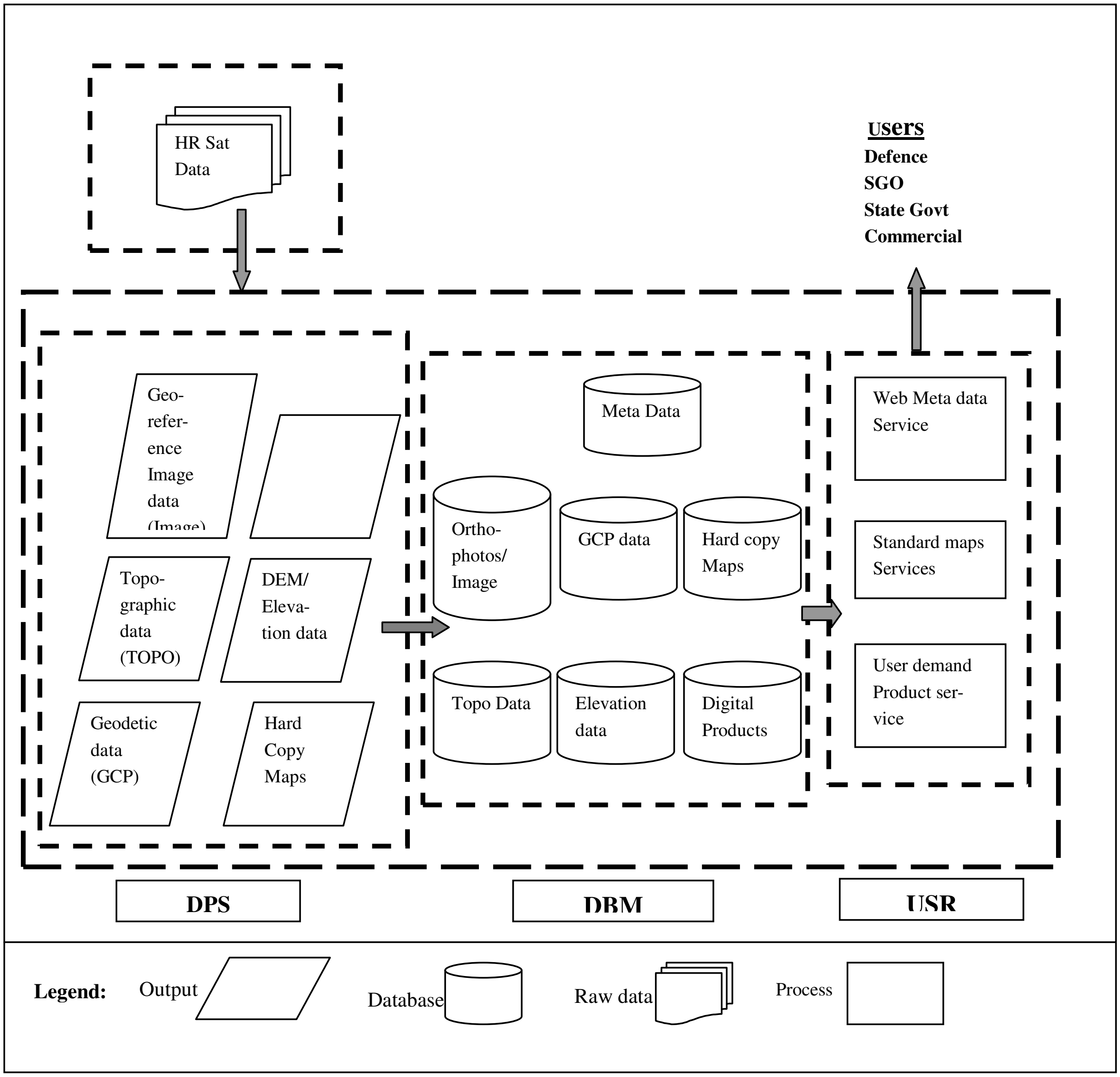

Figure 4.1: System architecture

4.2.3. The functionality of the proposed system

In this conceptual system of geoinformation production at high resolutions, the basic operations or activities have been identified and defined which provide the basic building blocks for a system to be realized from concept to the reality. The system is based on value chain concept where every subsequent activity adds value to the product with the result that every step in the process yields a product that can be delivered/offered to the customer (Radwan, 2001). The capability to acquire data for use in value addition is an integral part of the system. The functionality of the system is described as follows: -

Internal business environment

- External data: External raw data acquisition procedures mainly for aerial photos, satellite images from NRSA. The advancements in remote sensing technology like high-resolution satellite data, digital aerial photography, ALTM (chapter1) gives a business opportunity to SOI in the present GIS environment. Presently Ikonos data is being used by SOI as raw data for geoinformation production.

- *Data Production sub system (DPS):* The value addition and production of data to support the value addition as per the market demand is visualized here where the value chain concept is followed to produce the data using High resolution satellite data so as to include Geo referenced images, orthophotos, Topographical data, geodetic data, DEM/elevation data, hard copy/digital maps, etc. These products can be defined as base products. The innovative integration of various base products can results in new products. This leads to customisation as per user needs and the Utility services sub system (USR) has been designed to cater for these customized products.

- *Database management sub system (DBM)* Appreciating the huge amount of data being generated, for its effective use and ease of querying/retrieval of data from this huge repository, the various outputs as envisaged in Production level, is stored in a structured way in respective databases based on database management technology. This also avoids the duplication of data if we know where to find data in a real-time frame and hence supports the furtherance of efficient and cost effective production planning processes. For the benefit of the potential users a *metadata* is also conceptualised which contains the details of all the available products and services the system is offering and user has the options to choose from and the desired product/service is delivered to the user. It is proposed to provide the metadata initially through the Internet and may be in future through the network services of Indian NSDI.

- ***Utility Service sub system (USR)***: It's an efficient means for satisfying the user needs as a utility (refer chapter2) by exploiting the integrating nature of the present day technologies. The services include standard map and customized product services. The services could be offered through physical media in the initial phase. The physical media can be digital or hard copy maps as mandate service especially for defence needs and customised digital/hard products. The main function is to provide customised products and understand the market needs and requirement of new technology, methodologies and offer the much-required flexibility in present dynamic environment. The functionality of this subsystem gives the necessary aspect of providing the geoinformation as a utility. Since this sub system provides the functionality of *utility* to the system as a whole, it is more important to conceptualise the detailed design as compared to production processes and database management aspects.

External environment

The system interacts with raw data supplier NRSA, local Sate Govt departments, Defence, SOI Zonal office, SGO as shown in the fig 4.2.

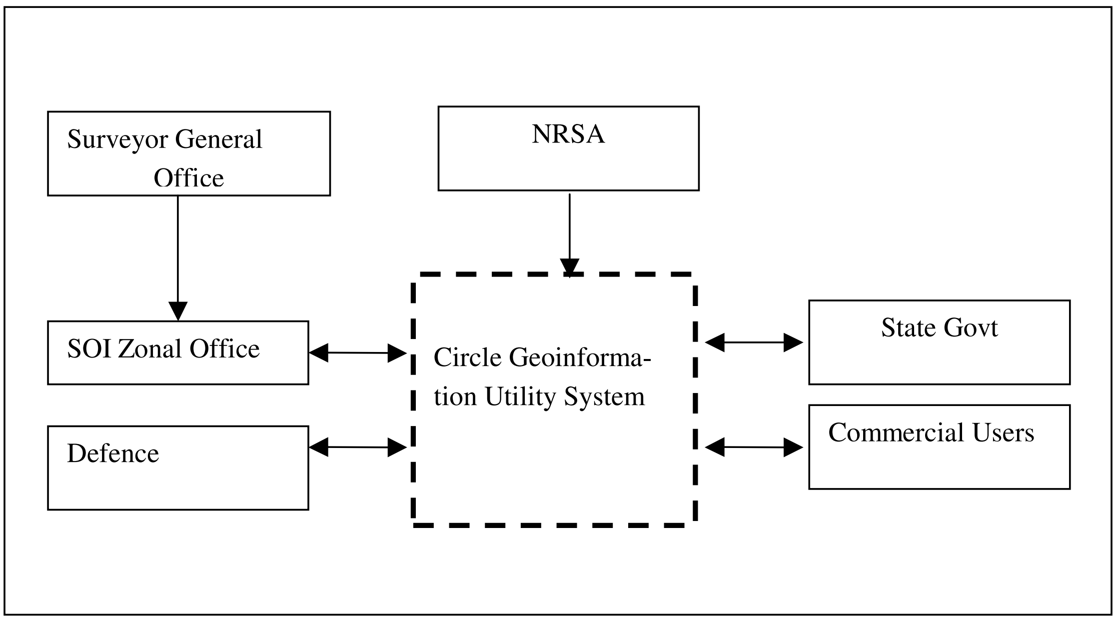

Figure 4.2: The external environment

The environment is discussed as under: -

- Raw data Supplying agencies

  The main supplier of raw data in the form of digital/analogue aerial photos, high-resolution satellite data is NRSA. They have online query options for availability of the products and thereafter a set procedure for supply of the data. The restriction imposed by the legislation cannot slowdown the process of delivery; as such the SOI itself is the official advisor to the Govt on these issues. Since NRSA is one of the main users of SOI core data, a memorandum of understanding in mutual exchange of data for the system can possibly speed up the process of delivery of this data to the proposed system.

- Defence department:
  The urgent needs of the defence can be addressed in real time as opposed to the existing system of centralized delivery especially when data is not available and takes months to acquire and process. The local defence organization can be in contact directly with the utility system and can be given priority.

- Local Govt Agencies: -
  They can directly get the data from the system, since the system will cater for the needs based on the geographical extent of a state in Indian context.

- Zonal survey Office/ Survey General's office:
  For planning, monitoring and optimisation of resources in a *region/across the country* and ensuring mutual cooperation among the various *circle directorates/ Zonal offices*.

- Commercial users:
  The supply of data/services will largely be influenced by the prevailing restriction policy. Information on alternate datum can be accessed by some of the users. The present issue is how best the information can be delivered to these types of users till the time a changed information/restriction policy is made. The release of 1:25,000 WGS84 series digital maps is one of the initiatives being taken. However its not clear whether information with respect to border areas/ costal areas can be accessed by these type of users that too at large scales.

4.2.4. The utility aspect of the system

The geoinformation production processes are realised through the enabling technologies and over the years, time tested methodologies with user-friendly interfaces are available to get the desired outputs. The outputs with respect to above have been managed in traditional manner but with increased productivity and consequently the organisations are satisfied with their achievements. From the existing data set doing a basic GIS operation s like querying, retrieving data, network analysis etc is not now considered as a complex operation. *The various activities involved in a process to produce standard data sets over a period of time are well defined and are continuously being refined by the GIS users.* This type of business processes does not assist in providing the *flexibility* to the system and while reacting to the external entities there is possibility of redesigning the entire system as compared to improving a system.

How do we evolve flexibility in a system, which reacts to the environment and maintains meaningful relationships (users, technology etc.) with it? The system has to be flexible enough to cater for the changes in user requirements, technology etc. to fulfil the customer needs we may require to adopt new technology/methodologies. To introduce these changes in the present set up (being static in nature) there is a possibility of redesigning the entire system As explained earlier the main purpose of designing a new system is to enhance accessibility, availability and use of geoinformation at an affordable cost that too as per user needs. How can this be achieved? This can be answered by identifying the business process that support the integrated flow of data between the components of the internal business environment mainly, production process sub system, database management sub system, and seamless integration with the external entities. The *Utility services sub system (USR)* is the key to flexibility, which helps in maintaining a meaningful relationship of the Utility system as whole with the external entities/ dynamic environment. In addition being the customer focussed, the subsystem can assist in providing a rational for adopting new technologies, methodologies, skills etc. The conceptual design of such a system that assists in realising a Geoinformation utility system is explained by using fig 4.3

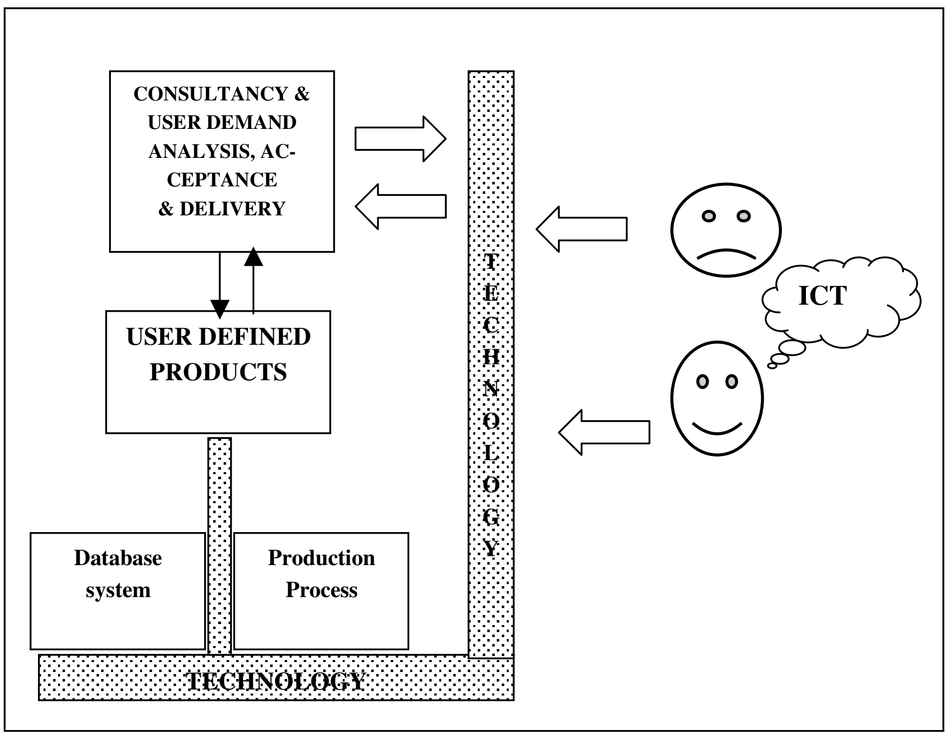

Figure 4.3 Integration through technology

The fig depicts the environment of conducting the business in a utility system. In the simplest way the user demand is analysed and accepted, followed by customized production process and thereafter the delivery of the user defined product and feedback from the customer. As earlier explained the technology has got the integration nature and from this fig it is seen that technology provides the foundation for integration of the basic components of a system i.e. data in database and business processes to perform some transformations on the datasets. The data is produced using well-defined and time-tested production processes. Technology also provides necessary link with the potential users and is main driving force behind the users ever growing expectations from a geoinformation system. By integration of the datasets and production processes user defined geoinformation products/services can be created. The user shown on top right is not able to decide the requirement and second user (smiley) who is better aware of the potentials of ICT, has high expectations from the service provider. Any changes in technology as well as user expectation because of technological impact effects all the well-defined activities supporting various business processes. Does this mean that we should redesign the system every time there is a change? The present day systems are static in nature and advancements in technologies are driving the NMA's to reengineer the system. But the external environment is highly dynamic and the systems should be able to adapt to the changing environment without doing the reengineering processes time and again. Introducing flexibility into the system so that it can respond to external environment in a meaningful way.

In the foregoing the design of such a sub system that provides flexibility to its parent system can be the solution where it can interact with the components of the parent system and provides the necessary rational to the planners/decision makers to adopt new technologies for augmenting/optimising the existing systems without reengineering the system time and again. With the help of above-mentioned scenario, a new sub system named *Utility services sub system* has been designed which can possibly provide the required *flexibility fo*r *enhanced availability, accessibility and use of geoinformation at affordable cost as an utility*

4.3. The conceptual design of Utility services sub system

4.3.1. The concept

The interaction of user with the system demands a type of consultancy service so that user is able to project the demand correctly and in the manner the system under stands the requirement best. This component provides means of integration of various production processes and existing data for the utmost user satisfaction. . This way every activity of the system can be fully exploited for optimal use. We can name such a system as *Planning & support sub sub system (**PS**)* (since a system is made of many components, which are generally termed as sub systems, or sub sub systems as the case may be). This system interacts with end users, data suppliers externally. This system interacts Internally with DPS, DBM and to provide product diversity, a new sub sub system *is to be conceptualised.* A new sub sub system in this system thinking process can be named as *Customisation & Analysis sub sub system (**CAS**)* .CAS interacts with PS, DBM and provides flexibility by initiating new processes. This in turn provides a research and development facility for use and adoption of new technologies, methodologies. CAS caters for customized product/services and the standard products/services are provided separately by DPS.

The system can act as a vital input for optimisation of standard production processes of DPS.

The fig 4.4 depicts such a scenario.

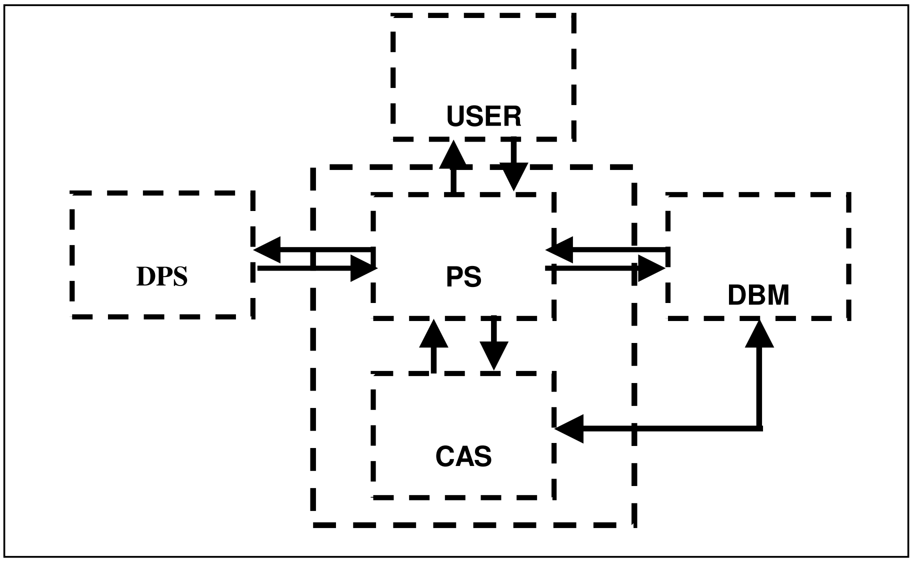

Figure 4.5: The USR environment

4.3.2. The design of the Utility services system (USR)

Based on conceptual explanation as in above paragraph the basic components of such a system identified are as under: -

- Planning and Support sub sub system (PS):
  The system plans the product specification and gives supports by getting readily available product directly from the DBM to the user.

- Customisation and analysis sub sub system (CAS):
  The system customizes the product and is flexible enough to adopt new technologies/methodologies without necessitating major changes in GUS.

The PS acts as a bridge between user and the customized production by CAS and can ensure quality checks by providing the product specifications. The product specifications are evolved as a result of interaction with users. The CAS provides a platform for innovative use of technologies, adopting new methodologies/ new technologies, where the ultimate aim is the customisation. Since The standard mandate production processes are done by DPS separately, and is not affected by the sudden spurt of user satisfaction or user focussed objectives. However the CAS can provide rational to DPS system to adopt new technologies. The fig 4.5 shows the conceptual design of such a system.

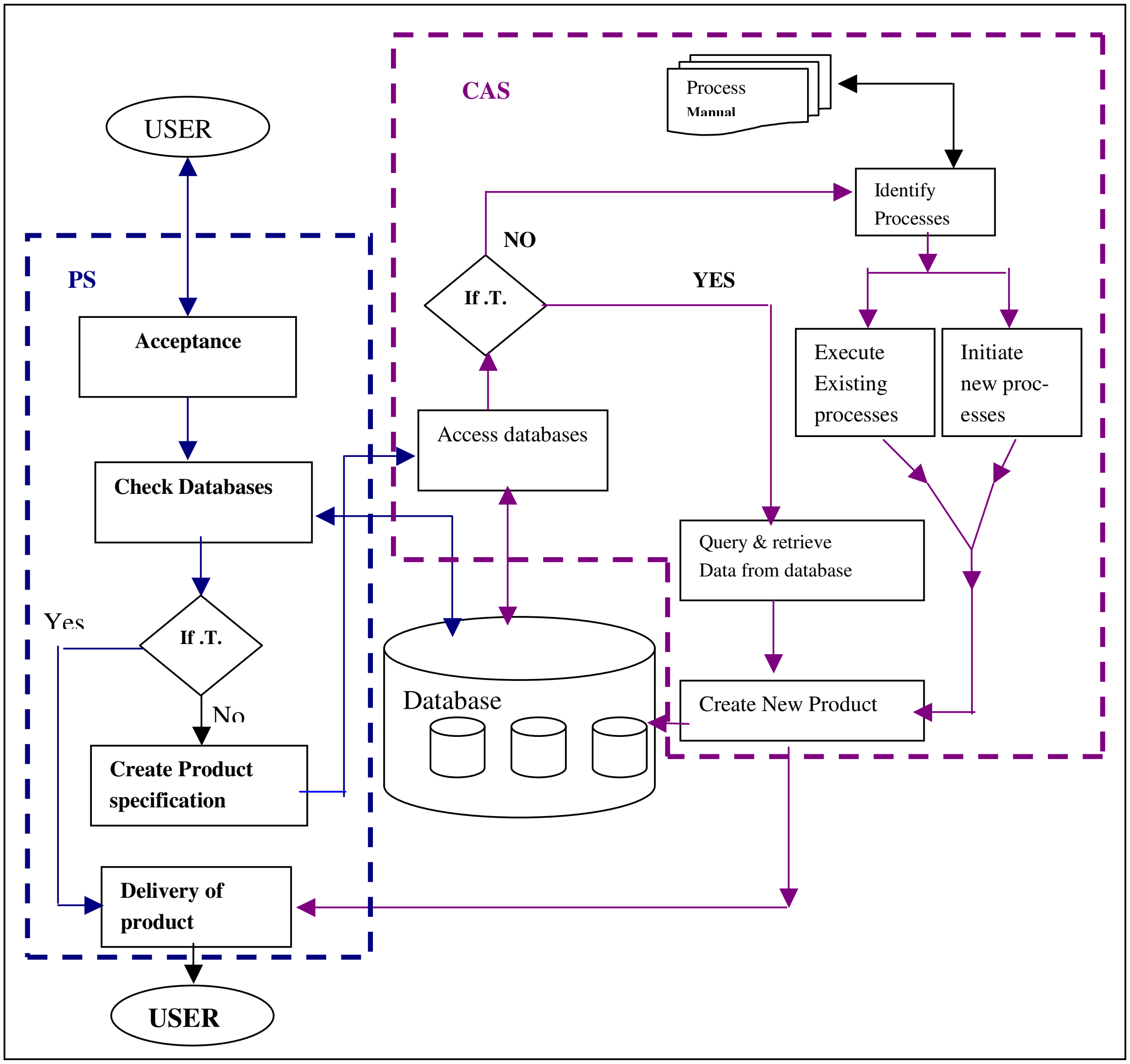

Figure 4.6: The Utility model of USR

The various processes of the system can be described as follows: -

- Planning and support system (PS)

  - Acceptance: The user requirements are analysed in this process and the nature and type of product is identified and modified if necessary at after providing the requisite consultancy with respect to the capabilities/limitations of the technology etc. The demand is formalised by way of signing an agreement with the user with respect to quality, pricing, time frame etc. The importance of copyrights, and security aspects especially for use of high-resolution information/data can be included as a part of the agreement.

- Check databases: The product is checked for availability from the existing database and if available is delivered to the user without any appreciable delay. In case it is not readily available, the specification of the required product are created by this system and then given to CAS for initiating the supporting processes.
- Delivery: The product is received from CAS and checked for quality/accuracy and then delivered to the customer as per the agreement document. The mode of delivery can be through physical media as explained earlier or through the networking.

- Customisation and analysis sub sub system (CAS)

  - Access database: On receipt of product specification from PS, the system analyses the specification and then checks for the suitable data from the databases (DBM) and in case the suitable data is available identifies the necessary query / retrieve operations required. In case of non-availability/suitability of data from DBM the request is sent to identifying processes.
  - Identifying the processes: depending on the product specifications received from PS, the suitability of initiating the existing processes is checked from the process manual. CAS maintains the process manual where all standard operating procedures are documented. In case the existing processes fulfil the requirement then the request is passed on for execution, otherwise initiating a new process that may require new technology or methodology or both is planned and then sent for execution. The new process is then documented in the process manual.
  - Execution of processes The processes are executed here and the output is a new product. The outcome of new processes are tested and refined at this stage. The new processes can become vital inputs even for our standard production processes. The products created here are then stored in DBM.

5. Changes required in SOI to implement such a system

5.1. Introduction

The changes required for supporting the implementation, where system is flexible and adapts well to the dynamic environment requires changes in organisational set up and introduction of suitable technology. This chapter will try to highlight the recommended changes required In the organisational set up of SOI to support the various components of the system and use of suitable technology in DCE where integration, and decentralisation of resources are implemented to provide utility services to the users.

5.2. Changes recommended in the organizational set up

The existing organisational structure is based on survey parties and circle directorates and which form the main work force for SOI. The requirement of having a Circle directorate covering the geographical extent of a state (chapet3) is an important step towards the efficient and timely provisioning of geoinformation. It is therefore recommended to have circle directorates for each of the 28 states of India. The proposed organisational structure to support various components of the proposed geoinformation utility system is as shown in fig 5.1.The names have been derived /used based on the functionality of various components of the GUS. The role with respect to the structure as shown in the fig5.1 is explained as follows: -

- **Planning & Commercial wing:** functions as per the requirements of PS component (or sub system) of USR
- **Production Groups:** The role is to produce basic data sets in support of DPS. Depending on the geographical extent a Circle may have two or more groups. The group has the following wings(wings are composed of skilled manpower who execute the basic GIS and surveying tasks) to support various production processes:-

  - **GIS Wing:** For basic GIS operations
  - **DBM wing:** For management of data in a structures way based on DBMS technology and maintain a metadata for the products.
  - **Field wing:** for field survey, field completion etc. It is recommended to have at least two such wings as extensive field surveying may be required initially to produce high-resolution data.
- **Service Group:** Performs the tasks in support of CAS sub system. The functionality and importance of CAS has already been explained in chapter 4. The service group interacts with all the groups and wings. The group provides the capability of innovation and can regroup resources from DPS and DBM systems for creating a new dataset as a geoinformation product.

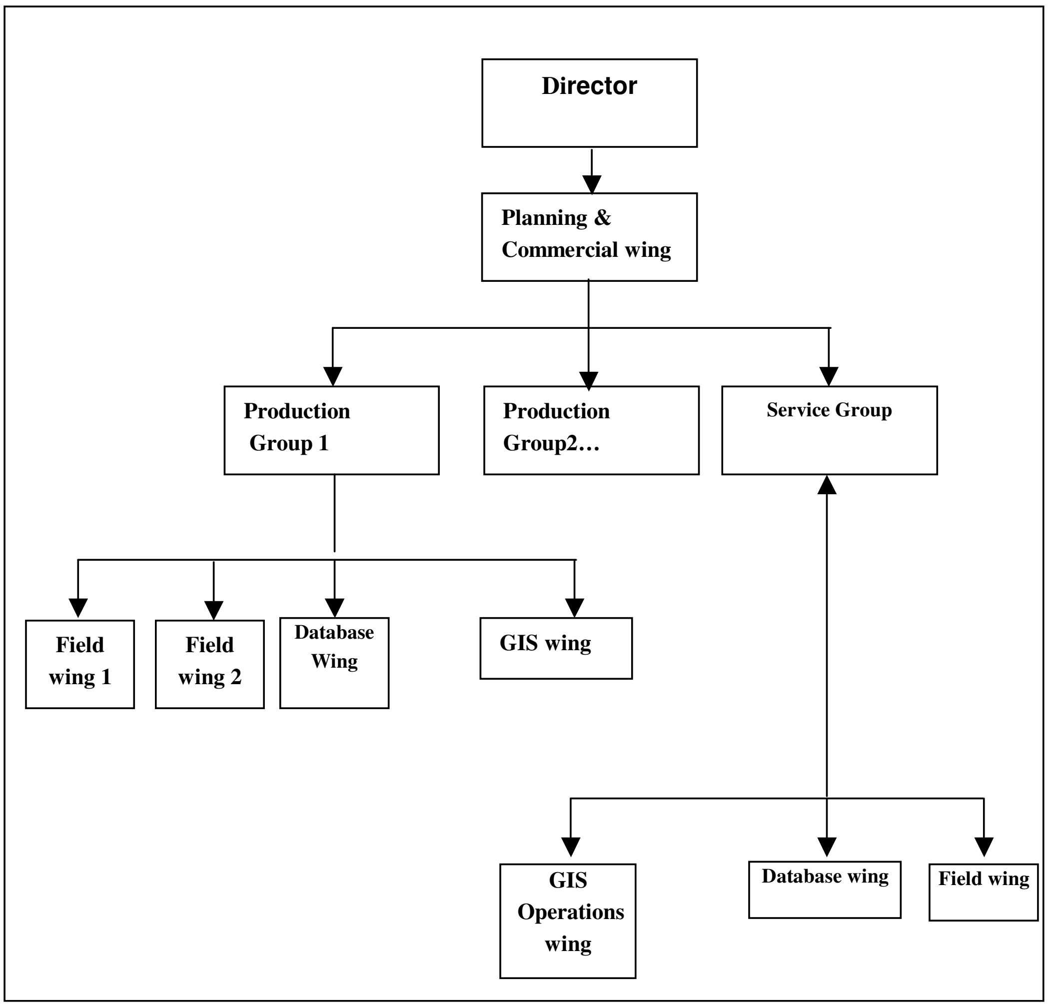

Figure 5.1 The proposed structure

5.3. What technology to implement this system

As explained earlier the management of data is the main issue, which needs to be resolved in order to have better accessibility to data/services for optimal use at desired time, place and affordable cost (i.e. data sharing/exchange/transmission). Secondly Geoinformation infrastructures can function effectively when reliable and efficient information and communication technologies (ICT) are in place. The salient aspects of technology and the conceptual architecture to support the implementation are briefly explained in succeeding paragraphs.

5.3.1. Computer networks

Large databases have to be linked for transfer/sharing of data. The data sharing/transfer /exchange has been made possible by making use of computer networking technology where autonomous computers are interconnected through a transmission media. The transmission media includes guided media such as coaxial cables, fibre optics and unguided media such as satellite communication systems radio, microwaves and lasers. Each of these media has its own characteristics in terms of capacity to handle data traffic on the network, costs, installation and maintenance. Based on the scale at which the transmission technology operates, networks have been classified as local area networks (LAN), Metropolitan area networks (MANs), wide area networks (WANs) and at a global scale they are called *Internet* works (internet). Networks of up to size of about 1 Km are known as LANs, up to a size of about 10 kms as MANs, and for larger areas, such as countries/regions, its known as WANs. The whole system of networking in WAN essentially comprises of interconnection of LANs (Fig 5.2). Interconnection between different LANs is provided by a special computer called *route*r that connects the LAN to a communication subnet, which in turn, connects to other LANs (Groot, 2000). Analogous to WAN where router connects LANs, within an internetwork, the gateways connect WANs. The computers communicate with each other through network software.

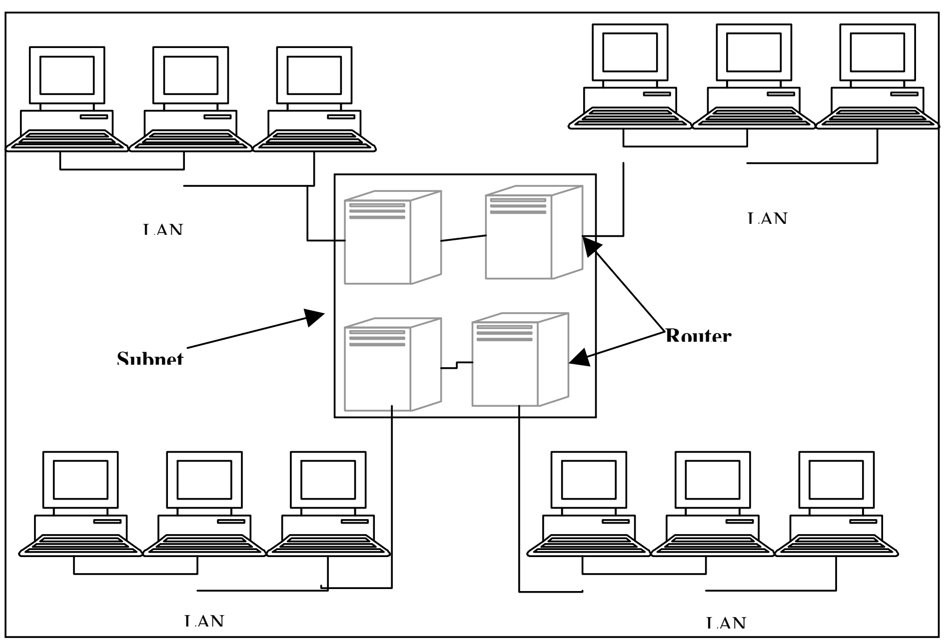

Figure 5.2 Wide area network

5.3.2. Database technology

The technology consists of an organized collection of data called database and a software package called database management system (DBMS) for building and maintenance of the database.
The advantage of using this technology includes persistency, efficient storage management,
Data recovery, data security, concurrency control, ad hoc query support etc. Transactions are operations that move a database from one consistent state to another consistent state. If transaction is not successful, the database is returned to the consistent state (called recovery). To avoid inconsistencies caused by concurrent read write operations to the database by many users accessing the database at the same time, a concurrency control mechanism is employed by the DBMS. This gives every user the impression that he/she is the only one accessing the database. A DBMS allows multiple users with different rights for accessing the database (data security). In the context of SOI, the databases are going to be distributed over different Circle Directorates in different locations, in the organisational hierarchy. This entails a distributed database system where numbers of sites are interconnected through a communication network with each site running an autonomous DBMS. The heterogeneity aspect is not an issue in this environment as the data generated using high-resolution satellite has recently been adopted by SOI.

5.3.3. The conceptual networking architecture

To exploit the integrating, decentralising nature of the technology as discussed the proposed networking architecture for a GUS is shown in Fig 5.3

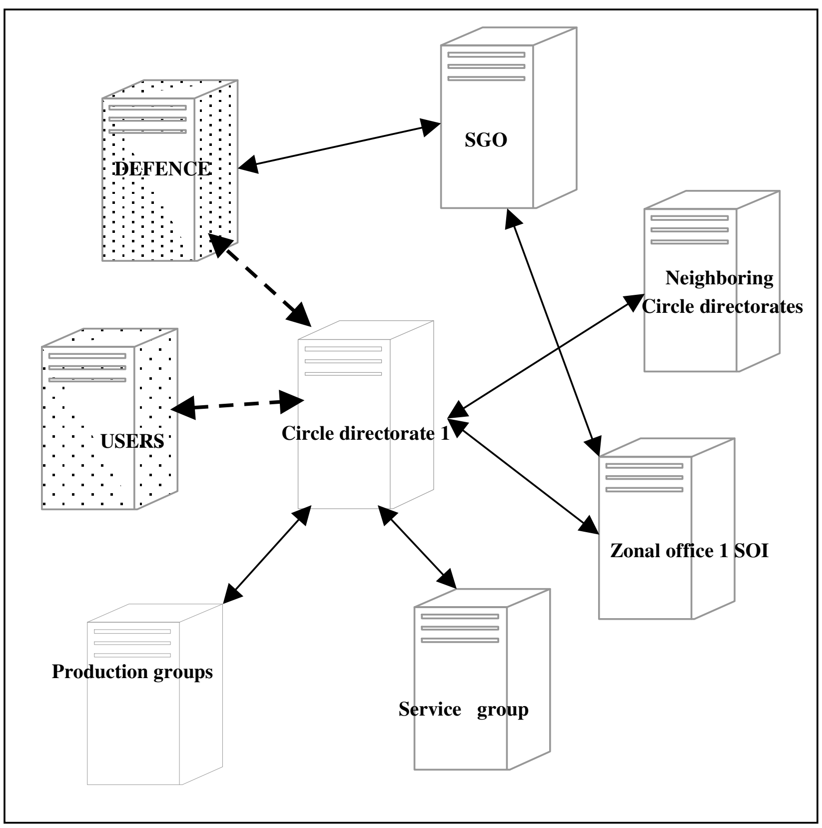

Figure 5.3 The Circle information Node

The conceptual architecture shows the following: -

- An ideal *DCE* where Circle directorates are integrated vertically downwards with production and service groups working under it, and with Zonal office, SGO in the SOI hierarchy. At the same time horizontal the horizontal integration with neighbouring directorates. The environment is free of any heterogeneity factors.
- The extension of DCE, here the users, defence department can interact with the system may be by using the infrastructure of Indian NSDI to resolve the heterogeneity issues. Presently interaction through the physical media is recommended.

6. A scenario for GI products

6.1. Introduction

This chapter demonstrates how sample data created using high-resolution satellite data can support the processes of the proposed system (only as example) and how the reorganised structure fits into this process of creating geoinformation (GI) products. The details of study area, data used are given as under: -

- Study area: Dehradun city, state capital of Uttranchal state of India, 250 Kms approximately, north east of Delhi.
- Data used: Ikonos pan data

  GCP coordinates with centimetre accuracy after post processing of GPS data (using IGS data). GCP's chosen were easily identified on both image to be transferred and the ground. The points chosen were having strong contrast with their background on image, distinct from the surroundings and were small enough in extent for accurate determination of their location on image. Total 39 GCP's were chosen well distributed throughout the image.
- Projection system: WGS84
- Object classes extracted: Only planimetric details
  - Geo referenced image with RMSE 2.34 meters.
  - Main road network
  - Streets
  - Drainage network showing various dry streams
  - Railway line
  - Annotation layers showing the names of important areas /points.
- Software/hardware used:
  - Erdas imagine for geo referencing and feature extraction.
  - Geodetic GPS for GPS observation
  - IGS data for post processing of GPS data.
  - Burnese software for post processing of GPS data using precise ephemeris, pole data from IGS.

6.2. The user interaction with GUS for GI products

In the scenario explained below it is assumed that the basic data in value chain concept to include geo referenced image, vector layers of classes, GCP's have been stored in databases based on DBMS technology. This may require design of schemas for data storage, access, retrieval, update, and data security and user-friendly interfaces for accesses.

- The user interacts with Planning and commercial wing of the Circle Directorate and places the demand. In this example say user demands image map of Dehradun city showing road network and built up area so that user can analyse the expansion pattern of the city. The demand is designated as a GI product, say "Dehradun built up-2003"product..
- The wing initiates the system processes of PS sub sub system of USR sub system and finds the product is not available in DBM and process for creating product specification is initiated and thereafter the request goes to CAS system.
- The CAS system through Accesses database process checks the DBM and finds the data to meet the product requirement (Geo-referenced map, main road network, streets and built up area vector layers).
- The query and retrieve processes creates the new product (fig 6.1).
- The product is stored in database and simultaneously sent to PS sub sub system where delivery of product process is initiated which can include the payments, feedback etc. the PS system is able to record user preferences and trade offs
- In case of data is not available the CAS identifies processes from the process manual and then accordingly initiates the processes. This can include acquisition of raw data from NRSA, Field observations/field completion tasks as identified in standard production processes of DPS. In case of having the requirement to identify new processes, e.g.; for DEM creation ALTM data may be required and superimposed on the present planimetric data. The CAS designs the processes firstly to process the ALTM data and then possible integration with the existing planimetric data. The options to hire consultants or training of personnel to handle new data can be undertaken.

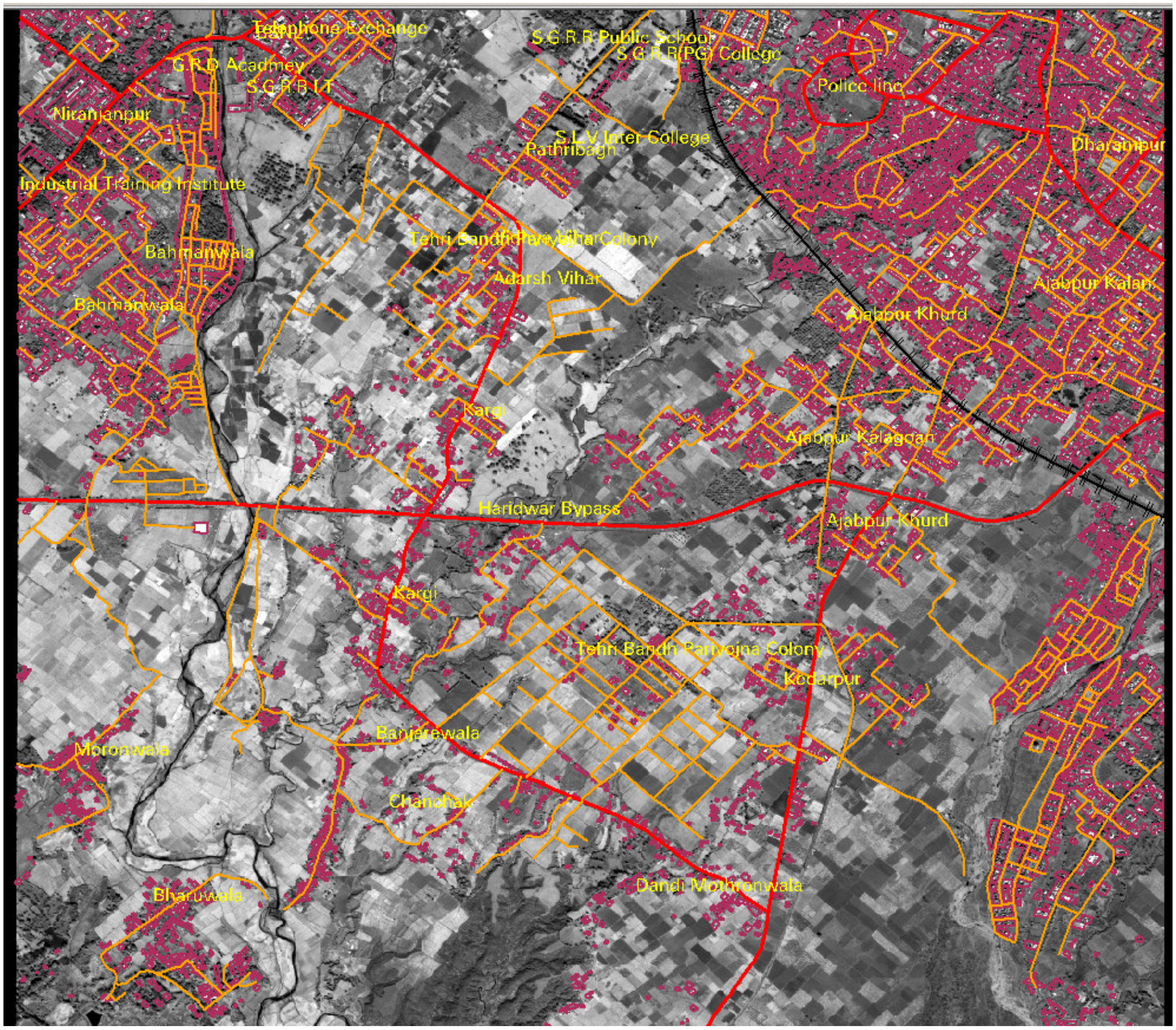

Figure 6.1:"Dehradun built up-2003" GI product

Legend:

Main Roads

Streets

Built Up Area

Railway line

6.3. Conclusion

The above example is the simplest way of conveying the potential of enabling technologies. The process of moving from *concept to reality* requires sincere efforts and sound judgement on part of decision makers and a management perspective

The success of providing geoinformation as a utility is based on the key factors to include:

- Skill of using GIS software
- Adequate knowledge of Geography and surveying principles*: SOI has an edge over other users of GIS and hence the capability for optimal exploitation of enabling technologies.*
- Management of data for timely retrieval, ease of updation.
- Management of resources for enhanced response.

The innovative use of technology using the proposed GUS system (and the new organisational structure to support the system) can result in fulfilling the requirements of providing a utility (chapter2) and SOI has the necessary skill and will to implement such a system in consonance with its redefined vision (chapter1).

7. Conclusion and recommendations

The product diversity and customer focussed products /services in geoinformation industry is completely new strategy and the requirement of having geoinformation at high resolutions for sustained growth and economic development The need has been felt for timely availability of geoinformation in all areas for efficient planning and decision making. The reengineering of SOI is being progressed to meet the business challenges provided by firstly the enabling technologies, followed by the expansion in application domains of geoinformation and high expectations from the users due to affordable and easy to use GIS tools. The user today is more sophisticated and better aware of product quality requirements and thus is making unprecedented demands on NMA's. In this regard India has taken concrete steps like the re-engineering of SOI and NSDI initiative, to face the impending challenges. The research was conducted for elaborating new concepts and methodologies which will be beneficial since SOI is in its transition from conventional digital mapping to a new approach of creation of geoinformation product, in view of its redefined vision for this century. The conclusions and recommendations are given in the following paragraphs.

7.1. Conclusions

- Currently, SOI is organised to produce standard mandate products and is not customer oriented as per the situation analysis carried out in chapter 3. Further it does not have requisite set up dedicated to each state in India. The analysis suggests having a system, which can survive in the highly dynamic environment and be able to adopt new technologies without re engineering every time the technology changes. The analysis suggests that a system should be capable of using data and processes in a combination, which can provide flexibility. The list of possible actions necessitates the requirement of a system, which can provide geoinformation as utility.
- The conceptual design of GUS has been made based on the operational strategies derived from the situation analysis and the using geoinformation as utility (chapter 2) while incorporating the integrating, decentralising and customising nature of technology.
- The standard production processes (DPS) is visualised to be functioning independently to meet the mandate requirement and the USR fulfils the present day requirement of having a customer-focused approach. The CAS of USR provides the necessary rational and flexibility to adopt new technologies and methodologies in an utility environment
- The new organisational structure conceptualised for Circle directorate can provide the necessary support to the proposed GUS.
- The proposed system will strengthen the Indian NSDI initiative and secondly the GUS can use the metadata services of NSDI to provide the necessary information about the products /services.

7.2. Recommendations

- One of the most important tasks is to have a structured way of managing the huge data that is going to be generated/created using the present day high-resolution data acquisition technologies. Consequently SOI has to take initiative to develop information nodes based on DBMS in each of the Circle directorates. Linking of the information nodes through ICT in a distributed environment can follow this. This way SOI can provide a network of well dispersed interconnected information nodes all over the country.
- Once the information nodes are functional and able to share/integrate data from other information nodes in SOI set up, the agency server of SOI (chapter1) can provide the basic building block for infrastructure set up of Indian NSDI.
- It is also recommended that other stake holders of Indian NSDI should develop the information nodes well dispersed all over the country. Otherwise the information highway as conceptualised in the initiative will be like building a highway in the heart of Sahara desert with very few and dispersed utilities/facilities connected by this highway. The recovery and backup services on such a highway can be a nightmare to the users.

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