LAND MANAGEMENT BY ELECTRIC UTILITIES
Organizational and Technical Constraints to Development and Use of Geographic Information Systems

by

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ABSTRACT

This thesis explores the issues, opportunities and dynamics involved in the development and use of Geographic Information Systems (GIS) by electric utilities in developed and developing countries for managing and processing information about their real estate properties. Utilities own a vast number of distinct properties widely dispersed across large regions. Given their competitive situations they need to bring together information about the resources available to install, operate and maintain their facilities efficiently and to locate vacant properties for siting additional facilities such as power plants, substations and transmission lines. Establishing parcel-based GIS to store land-based information for their properties will improve their ability to manage their properties and also reduce maintenance costs.

The central research questions involve the identification of technical and organizational constraints to the development and use of GIS by utilities for management of property records. The approach adopted in this research was to first compare the operating procedures used by utilities in developed and developing countries. The second step was to study the potential constraints that occurred during the development of a GIS in a developed country utility (Boston Edison Company). The third step was to evaluate the problems that may arise in developing the same type of system for a utility in developing country (Tata Electric Companies, in India). The conclusions of the thesis center around a comparative analysis of GIS adoption in the two different contexts.

The thesis finds that the approach adopted for developing a GIS by each utility is different, and the process of learning and scope of what is required to carry out the objectives of the system has affected the process of development for the system. Several factors explain this: the external conditions in which these utilities operate, the internal organizational circumstances, including the role of a an individual, the development approach, identification of users and their needs, definition of the scope of the system, desired applications of the GIS, and level of management support. The thesis recommends strategies that should be followed by electric utilities for successful development of a GIS.

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to
my father, whose soul guides me to a bright future
my mother, whose blessings are invaluable.

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CHAPTER 1

INTRODUCTION

Electric utilities generally operate in a competitive environment. In addition, their need to constantly upgrade, expand, and modernize their aging infrastructure as well as their operational and development requirements, make heavy demands for quick access to data on existing assets. To conduct their business, to retain their existing customers and to enter new markets, they use computer-based systems to gain a strategic edge to remain competitive and deliver efficient, high quality services. Besides this they acquire parcels of land over the years for one reason or another, and most of them hold onto exceedingly large tracts of land. This land is used for electrical production and transmission. This includes land under transmission lines, Right-of-Way lands, substation lots, land surrounding generating stations and nuclear sites, and flood easements. Keeping track of so much land and identifying land ownership and/or location of a property is not easy. Finding a map for a particular tract of property can be time consuming.

In developed countries, and more so in developing countries, the staff of these utilities responsible for management of these properties spend significant amounts of time collecting and collating information about their various assets (e.g., land and structures) and their locations. Yet, even as these utilities invest vast amounts of money to maintain, manage and optimize their facilities, they need accurate and timely information to help them manage their assets in a better way so as to ensure good service and forecast growth, and plan for the most efficient expansion of their infrastructure.

1.1 Electric Utilities in Developed Countries

To solve these problems, utilities in developed countries have generally shifted to a mechanized or computerized form of record keeping. Geographic Information Systems (GIS) are an information processing technology to input, store, manipulate, analyze and display spatial resource data to support operating procedures for various organizations. Geographic Information Systems are a technology that offers tremendous potential for satisfying many of the data management needs for land-based analysis that have been identified for the utilities. Through their automation and powerful information processing, mapping, and locational analysis capabilities, GISs can help reduce the costs and improve the efficiency of maintenance of properties owned by electric utilities in both developed and developing countries. They provide a versatile, interdisciplinary tool that is rapidly becoming an important vehicle for facilitating the automated analysis of spatial data and the improvement of land administration.

In light of the increasingly sophisticated management technologies that are now available, many utilities in developed countries have been increasingly using Automated Mapping/Facilities Management (AM/FM) systems to deal with the complex demands and information about geographically dispersed assets, events, and environments to improve their transmission and distribution operations. The AM/FM systems consist of an automated map with related database attributes, both related logically to the graphic elements of the Automated Management system.

Substitute the word "facilities" for "assets" (i.e., land records, structures, etc.) and the definition is tailormade for maintenance. For instance, accurate information about the existing facilities helps the utilities track down each major facility type, determine the expected returns on facilities investments, and identify future maintenance and replacement requirements.

There has been a staged growth in the use of computer-based systems by electric utilities, and a transition from Computer Aided Drafting (CAD) to Automated Mapping/Facilities Management (AM/FM) to the present increased use of Geographic Information Systems (GIS). Although CAD and AM/FM have been used by the engineering departments of the electric utilities to produce high quality drawings, lately there is a growing interest in systems that can do spatial as well as network analysis. So there has been a shift towards using GIS, which provides more powerful information processing with mapping and locational analysis capabilities. Even though utilities have been using various systems, most of them do not have timely and accessible records of their real estate properties, their facilities, Right-of-Ways etc; which make up a substantial part of their assets and on which depend their future plans for designing effective, cost-efficient utility land management programs and siting substations.

1.2 Electric Utilities in Developing Countries

In the developing countries, utilities have been using computer-based systems in order to increase efficiency and reduce duplication in their drafting section so that they can increase productivity on repetitive jobs. They use these systems for networking, which reduces the chance of data being corrupted, and has a defined growth path. Also, when they plan for a new development, the amount of time available for the design seems to shrink, but the amount of information desired increases. They currently use computer-based systems for distribution analysis with engineering data and for transformer load management. These systems have been the foundation for studies into the location of losses (technical and non-technical). The magnitude of losses, and the lowest-cost methods to reduce the losses. Most of these utilities are faced with a myriad of problems. Especially with the increase in demand for electricity, and rapid growth pressures, they have to increase their service capacities. The problems of collecting and collating information about their properties is little different from the utilities in the developed countries. These problems call for the use of GIS, in order to deal with the bottlenecks in routine operations and develop solutions to complex land management activities.

1.3 The Two Cases

Geographic Information Systems are technologically complex, expensive, and demand significant attention to workflow processes and organizational management. A thorough and consistent set of staffing responsibilities, workflow management procedures, file organization, database design, and supporting programming must be prepared early in the development of GIS. It is recommended that an early identification be made of the requirements for supporting the existing activities of utilities and also the projected short and long-term needs for the organizations that will use this system.

The two cases that have been selected for this research are: **1)** the Real Estate and Property Tax Division of Boston Edison Company, in Massachusetts, U.S. and

2) the Estate Department of Tata Electric Companies, in Bombay, India. The Boston Edison Company case was selected because my experience of developing a GIS-base real property management system and a prototype system for the above mentioned division was intriguing, and the issues that arose during the construction of the prototype needed to be critically investigated. Using a second case in the developing country was important because development of GIS requires a balance of technical and organizational strategies. In the development of a system, the organizational and management issues cannot be ignored, and examination of these issues can be better understood when different organizational contexts are used. The thesis will investigate three issues: **1)** the type of applications of GIS for electric utilities for property management in both developed and developing countries; **2)** the organizational constraints and resources available for implementing GIS; and **3)** the potential technical constraints in the development and use of GIS for electric utilities in both contexts.

1.4 Research Design

We will investigate these three issues in three steps. First we will use the literature that discusses the problems and dynamics associated with the development of GIS by electric utilities in the developed and developing countries. From this literature a conceptual framework has been selected, which is then used to compare and contrast the two cases.

In the next stage we will present the two cases, where we will be interested in identifying the structure of the organizations and the existing state of property records management. We examine operating procedures, resources available for assembling and storing these data, the hardware (if any), used by these organizations at present or planned in the future and the characteristics of this hardware, support available for the system (e.g., spare parts and trained personnel), and the availability of maps and documents for conversion to a digital format.

In the third stage we will compare and contrast the two cases using the conceptual framework as the background. The comparison will be done at two levels, one is prior to using GIS to identify similarities and differences, and the other is during the process of development of GIS. For the second level of comparison, we will identify the availability and accessibility of the type of data currently used by the land-oriented groups in the utilities and discuss what it takes organizationally to collect and collate the required information for the GIS. Since the organizational contexts in which Tata and Edison are embedded are different, the problems involved in developing/designing the GIS at Boston Edison Company were not the same as for Tata Electric Companies. Specific organizational needs determine the specific type of analysis and decision making context in which the system will be used.

Given the scarcity of written sources, we had to rely on interviews to acquire much of the relevant information. The fieldwork for the research consisted of nearly twenty-five interviews conducted over a period of one week in Boston Edison Company, and four weeks in Tata Electric Companies, with personnel from a wide variety of positions within the two departments of the two case study utilities. We also examined all the published material we could obtain --- annual reports, pamphlets, and so forth. Such (often promotional) information, of course, must be used very carefully, similarly an individual's information from interviews must also be carefully analyzed. An individual's information and perspective are influenced by his/her particular situation. On the whole those interviewed appeared candid and interested, in part probably because many people obviously like to discuss their work. In some instances we were forced to speculate because we felt that some personnel concealed or perhaps distorted information. The names of personnel interviewed for both cases appear in Appendix I of this thesis.

To facilitate the understanding of using GIS in different settings, we will be interested in the organizational and technical environments of the two cases. We will also investigate the existing organizational structure, administrative arrangements, and management procedures within the organizations and how they might change if this system is used; the staff support and attitude toward such changes and the challenges this system will raise to the traditional forms of administration, authority nature, and the form of work, giving importance to individual values and motivations.

Conclusion

The objective here is to unravel what it means to adopt an advanced information system such as GIS, in a large bureaucracy such as an electric utility in both developed and developing countries. The study will help in understanding how such technical innovation impacts both the performance of the system and the structure of the organization. Both the technological and organizational components of the utilities have to be balanced to improve performance. However, the performance of the utilities will not be the same in different places because the social environment and organizational settings will impact the effectiveness and use of this technology. Therefore, there is a need to look comparatively at the same technology in different settings (i.e., Boston Edison Company in a developed country and Tata Electric Companies in a developing country). Boston Edison will provide the basis for examining technical issues and questions of organizational changes. The comparison of the two cases has assisted in identifying the organizational consequences that might arise due to adoption of GIS for management of property records in a developing country.

Organization of Thesis

We will discuss the literature in Chapter 2, which will set the base for Chapter 3, where we present the conceptual framework selected for this analysis. We will then discuss the Boston Edison Company case in Chapter 4, which will be a descriptive case study chapter. The second case of Tata Electric Companies will be discussed in detail in Chapter 5, completing the background for the two cases. In Chapter 6, we then analyze the two cases using the conceptual framework from Chapter 3. Finally, we conclude in Chapter 7 by suggesting some possible design solutions, and their justifications.

CHAPTER 2

LITERATURE REVIEW

The literature on the use of Information Systems by electric utilities for management of property records is limited. We will use two broad bodies of literature, one on the use of Information Technology by electric utilities and the other on technology transfer. The first one will give a sense of the type of information needed by electric utilities to provide the right services and the types of systems used by them in the developed and developing countries. This will also justify the need for using Information Technology for supporting facilities management, and give a sense of why there has been a staged growth of Information Technology in the developed countries. The final sub-section will examine the adoption of Information Technology in the developing countries and how this is different.

In the second part we will talk about the organizational and technical constraints on the development and use of Information Technology. This will help analyze the relationship between technology, information and decision making and the implication of these findings in both developed and developing countries contexts. We also include literature on the methodologies recommended by GIS users in developed countries for suitable system development which will be useful in understanding the differences in operating procedures and needs of electric utilities in developed and developing countries.

2.1. Information Technology in Electric Utilities

Electric utilities in the developed countries are in the midst of modernizing and streamlining the way they do business in order to excel in a more competitive environment. Utilities are changing in terms of their operating procedures and delivery of services. Some of the information needed by utilities now include improved access to strategic information, increased data reliability, faster engineering turn-around time, improved communications and data security (Holland, 1989). As mentioned in Chapter 1, they have to improve their utilization of data and optimize the time personnel spend. Especially in the Engineering department where there is a need/requirement to use information to make informal business decisions. In addition, they own a large number of facilities maps which are required for many essential reasons like engineering, planning, work order preparation, and management information (Harris, 1989). They also have to manage, maintain and optimize their facilities, and expand and modernize their aging infrastructure. The use of accurate and timely information can help them in managing their assets in a better way so as to ensure good service at the lowest cost (Sipp, 1990). This information is used to forecast growth; to maintain, expand, upgrade their substations; and to plan for the most efficient expansion of the infrastructure. Again the overall issue is to focus on how to provide the right services to the customers at the lowest price.

2.1.1 Approaches to the Use of Information Technology by Electric Utilities in Developed Countries

Given the kind of problems that electric utilities have, in the developed countries they have been using different approaches for developing automated solutions. There are three main approaches that have been adopted by them to date:

1) One approach used to developing automated solutions has been Enterprise Planning. This approach considers a company's overall business issues, their critical functional requirements, as well as the current information systems environment (Holland, 1989).

2) The second approach has been to work on the conceptual design of a comprehensive integrated facilities and work management system to maintain information on electric distribution facilities. This system tracks data from the initial receipt of a customer request, through design of facilities, scheduling of work, field reporting, emergency operations, posting to property records, update of facilities records and abandonment or replacement (Bottiger, 1989).

3) The third approach is the Automated Mapping/Facilities Management (AM/FM) systems used by utilities. These are the foundation Information Systems for the engineering departments and provide the reference system for physical and attribute details on existing facilities (Sipp, 1989).

The main reason for automating facilities are well known that improved information access and increased data reliability mean better asset management. Given the competitive and changing environment in which utilities operate, there arises a need for them to use the latest technology that offers promise for improved support of facilities management. Due to the large geographic extent of their holdings, sophisticated information processing with mapping and locational capabilities is also desirable.

2.1.2 Evolution of Use of Geographic Information Systems in Electric Utilities

Growing out of the Automated Mapping/Facilities Mapping approach, the latest utility interest is in more sophisticated systems for spatial analysis. In this section we discuss this transition from Computer Aided Drafting (CAD) to Automated Mapping/Facilities Mapping (AM/FM) to Geographic Information Systems (GIS).

The first computer-based graphics were Computer Aided Drafting (CAD) packages, which satisfied the immediate need for producing high quality drawings. The drawings and maps produced by these drafting tools were created, maintained and referenced as independent entities; their relationship to other drawings or maps was not maintained by the system (Leonard, 1989). Throughout this path of development, CAD has been primarily viewed as stand-alone or partially integrated systems, first as a mapping and drafting productivity tool, later as a distribution Facilities Management tool.

The next stage of development of automation was the introduction of Automated Mapping Systems which took the drafting tools one step further by allowing the maps to be merged together. Correlation of multiple maps, analysis of large geographic areas and production of ad-hoc map areas were all facilitated by the Automated Management Systems. However, representations of the facilities (attributes) were maintained on other systems and paper documents. There was a need to relate the graphic information to the attribute information so AM/FM systems developers took the basic Automated Mapping Systems and added the ability to enter and maintain attribute data. The relationship of the map picture to corresponding attribute data was maintained by the system, and led to better data integrity and timeliness.

To date, GIS has been operated primarily by the mapping staff within Engineering Departments. As mentioned in Chapter 1, GIS technology provides powerful information processing beyond AM/FM Systems with both mapping and locational analysis capabilities, and electric utilities are now using GIS for other activities (e.g., Transmission and Distribution analysis). Despite the use of different systems by electric utilities, most of them today still have little or no real-time information about the properties they own and about the land in and close to their Right-of-Ways. Land makes up a substantial part of their assets and is a central factor in their future plans for siting additional facilities.

2.1.3 Use of Geographic Information Systems by Electric Utilities

The development process for automation by electric utilities has been from paper mapping to CAD to AM/FM systems to GIS and true models of real world distribution networks (Leonard, 1989). This is true for developed countries where Geographic Information Systems (GIS) are the latest wave of computer systems being developed at a large number of electric utilities. The development of CAD, AM/FM, and GIS started with the need to produce higher quality paper documents, especially drawings and map plates (Leonard, 1989). GIS is being adopted because its capabilities extend beyond that of Automated Mapping and Facilities Management. The utility managers, engineers and operating personnel require timely and easily accessible land and facility records for effective customer support and GIS can help in eliminating record duplication and errors. It helps coordinate information residing in offices throughout the utility, and access to many records which is usually limited by the knowledge and experience of the individual seeking the information. GIS also provides more accurate and up-to-date maps for Transmission and Distribution, as well as land and Right-of Way information. GIS technology is a powerful decision-support tool in the designing of effective, cost-efficient utility land management programs.

2.1.4 Geographic Information Systems-Based Real Estate Property

As mentioned in Chapter 1, utilities acquire parcels of land and, for one reason or another, most of them hold on to exceedingly large tracts of land in many governmental jurisdictions. This land is used for electrical production and land surrounding generating stations and nuclear sites; transmission and distribution, which includes land under transmission lines, Right-of-Way lands, and substation lots; and flood easements (Stutheit, 1990). Keeping track of so much land, finding the location or characteristics of a tract of property is usually a difficult task.

Utilities have to understand customer mix and the environmental concerns of people around proposed sites and existing land that they own. GIS has been used for a variety practical applications (e.g., opposition to a proposed corridor of a transmission line (Worrell, 1991). Utilities have used GIS for siting and evaluating alternative sites, to search files for the potentially impacted customers and notify them for meetings to attempt to reach an agreement acceptable to the community.

In a competitive economic climate there is a need to diversify and generate new sources of revenue. With increasing requirements for justifying facility locations, increased State and Federal government regulatory agency requirements, and heightened public environmental awareness and concern, the utilities are entering a new era in land planning and management.

2.1.5 Use of Information Technology by Electric Utilities in Developing Countries

Many electric utilities in developing countries are faced with a myriad of problems. The demand for electricity exceeds production capacity, and results in needs for rapid expansion of their services. Planning for expansion creates demands for information of their real estate properties for locating new generating stations and facilities. To date, these utilities have been using computer-based systems for network analysis and for increasing efficiency and reducing duplication in their drafting sections, but GIS has not been generally used for land management. In developing countries, GIS systems were first developed in the 1960's with the increased availability of mainframe computers and graphics terminals. These efforts were restrained by limitations of available hardware platforms and lack of reliable software. The major breakthroughs in cost, speed, and storage capacities and dramatic advances in GIS in the 1980's have now made GIS both practical and affordable (Levice and Landis, 1989). GIS technology is young, with technical innovations occurring continually. But it is being acquired rapidly by developing countries which have very different needs, values and resources than developed countries. While it is critical for electric utilities in developing countries to better manage their real estate property, there is a growing concern that GIS transfer and use may result in undesirable organizational consequences.

2.2 Organizational and Technical issues in the development of GIS in Developed Countries

The literature emphasizes two key issues in developing a GIS for any organization; technical constraints and organizational obstacles. The views expressed in the literature can be classified into two categories. One group emphasizes the organizational constraints to the development of GIS for an organization, and does not give any importance to technological constraints. Their view is that with advanced technology there will not be any technical constraints that will be significant, it is only the organizational issues that have a major impact on the development of GIS. The other group says that the technical and organizational choices have to be balanced. The second group also considers other variables which are important for developing a GIS including the size of the organization, the role of individuals (e.g., "champions"), environment of the organization, and training of the end users (Burrough, 1986). Both groups agree that there is a relationship between technology and the organizational context that make development of GIS often more complicated than first envisaged. This implies that during the development stages we must also consider the impact of human and organizational factors. This indicates that the nature of the relationship between technology, information, and organizational structure within a particular organization is important because GIS has the capacity to affect both operational strategic and management activities. The organizational factors that influence the development of

GIS are the diverse organizational contexts, the individuals involved, changes within the departments, and outside pressures (i.e., top management). So during the development of the system we have to understand the individual environment of the organization within which the system is being developed, and also the interaction of these typical qualities of the organization with the technology.

Advances in technology have facilitated the development of GIS, and, to a great extent, theoretical and conceptual developments have lagged behind the technology (Burrough, 1986). GIS is not an independent entity but is embedded within the organizational and institutional contexts within which it is located. With the incredible increase in sophistication of information technology, it is now possible and affordable to use technical and computer assistance to perform numerous tasks. These technologies, by giving access to large volumes of information in seconds, have altered the actual shape and character of many organizations.

Historically, the conceptual design needs of GIS have been either treated trivially due to a lack of understanding of the differences in the social and cultural values of the end user, or overlooked entirely, due to imperialistic motives (Headrick, 1988). Kramer and King view GIS as a package which includes not only hardware and software but also personnel skills, operational practices and management expectations (Kramer and King, 1985). According to Kramer and King there are three sets of organizational factors to be considered. They are the: 1) organizational context, which include both internal and external organizational context, 2) individual values and motivation (i.e., the extent to which individuals shape the way in which computer utilization develops within an organization); and 3) impact of changing internal (organizational structure, administrative arrangements and decision-making procedures) and external (relation to other agencies) organizational circumstances on the utilization of computers. Hirscheinn also views information systems as not being technical systems (which have behavioral and social consequences) but being social systems which rely on information technology for their function (Hirscheinn, 1985). However, this does not mean that technological choices made are related only to management, we have to consider the hardware, software and available technical support in an organization for developing GIS. Crain suggests that GISs require difficult balancing decisions between the relevant sub-technologies, data management, etc. (Crain, 1990). He argues that in the development of GIS, challenges related to the management of the organization arise even if prudent technological choices have been made. Some of these management issues he says are common to any use of altered or "advanced" technology. He further divides management into two categories; one is structural, which involves the necessary adaptation of organizational structure and information flow and the second is sociological, which has to do with the changing roles, power and quality of work of individuals.

Croswell identified a number of obstacles related to the technical side of the system design, development and use which he considers minor compared to the organizational problems. According to him the technical problems are overlooked and the most importance is given to organizational staffing and other factors (Croswell, 1989). On the other hand Lucas's view is that there is a tendency to concentrate on the technical aspects of systems and a tendency to overlook organizational behavior problems (Lucas, 1975). He views the designing of the system as a creative task involving behavioral and technical challenges. He identifies the following three as major problem areas in systems design:

1) Technical: This includes designing the system, writing programs, testing the systems, etc.

2) Organizational: These include user cooperation in design, resistance to change and modifications in the distribution of power among organization subunits.

3) Project Management: Management must coordinate users, the computer staff, possibly consultants, and must also manage development of a system.

Harris considers two major reasons for change in organizations; one is uncertainty (a central characteristic of organizational life) and the other is organizational readiness, which is brought about by introducing GIS (Harris, 1987). His view is that the active environment that surrounds the organizations results in complexities, interdependencies (including culture and technology) which are difficult to maintain. To reduce this uncertainty, training of end-users at an early stage is important. He suggests that before introducing GIS in an organization, readiness of the users is a vital factor and can spur resistance towards use of the system. It is evident from all of this discussion that for the development of any GIS, organizational factors are as important as other variables. Smaller organizations are less developed in terms of structure and functions and are prone to have slow development of systems (Raymond, 1990). The reason given for this is that they often do not have enough managerial and technical expertise in regard to the development, operation and usage of the system. However, no significant relationship has been found between the successful development of the system and the size of the organization.

2.2.1 Organizational and Technical Issues in Development of GIS in Developing Countries

The literature on the use of GIS in developing countries is limited, but there is literature on use of the Information Technology in developing countries. This review will help identify the factors in organizational, technical and cultural environments, which differ from the developed countries and may have importance for developing a GIS in developing countries. The literature raises issues about the importance of management support, ensuring institutionalization of Information Systems projects, and user training.

There is a common concern for transferring technology effectively to developing countries (Madu, 1989). Her view is that decisions about transferring the technology should include the identification of the active participants, studying the scope and limitations of traditional or existing technology, and determining the strengths and weaknesses of the country in terms of applications. In developing countries use of computer-based systems is not so commonplace and there is a concern that non-technological innovations such as organizational change, job design, Institutional restructuring and attitudinal reform must also be dealt with if information technology is used (Kishor, 1989).

Masser and Campbell identify three necessary conditions which must be met for designing, developing and using GIS in developing countries (Masser and Campbell, 1989). These include the existence of an overall information management strategy based on the user needs of the agency and the resources; the personal commitment of individuals at all levels of the organization with respect to overall leadership; general awareness and technical capabilities; and organizational and environmental stability in terms of personnel, administrative structures and environmental considerations. They also argue that the key to successful development of systems is user participation. The key factors that affect the use of Information Technology in developing countries include both internal and external factors. The internal factors include the physical and human resources infrastructure, and the external factors include the environmental challenges, issues of training, availability of information for developing GIS, and skilled personnel available (Sadowsky, 1989).

The developing country literature places emphasis primarily on the management issues (e.g., training and the roles of different actors in the process), rather than on technical questions. The literature consistently emphasizes the importance of management support for the use of Information Technology, particularly when the introduction of computers is part of a larger effort to change the way information is used in management. In certain cases, the concern is that when consultants leave the system fails to operate, so that there is a need to make users an integral part of the work that is being carried out. One way of doing it is to ensure that the top management takes responsibility for maintenance and operating costs. There is also emphasis on the importance of a champion, someone who has knowledge of computers and has enough influence to obtain top management interest and support. Usually the consultants work with this champion.

We have explored the technical and organizational issues that arise in developing a GIS. But before a GIS is set up, we need to find ways of going about setting it up for any organization. So it is important to work out in detail the type of system that will be suitable for a given set of applications. For this we need to make sure that the system matches the requirements of the organization. The kind of GIS adopted will have far-reaching effects on the way the organization works. So it is important that the management aspects of the problem be worked out thoroughly. A series of guidelines have been developed in the literature, to be followed to address the organizational and managerial aspects of GIS. Since development of GIS is one of the largest computing projects undertaken by most electric utilities, and the diversity of information, data relationships, and applications across the utilities business areas introduces a high-level complexity, success analysis of system specification requires using a structured methodology.

2.3. Methodologies for Suitable System Development

Acquisition of a major GIS should not be done without seriously considering the way in which the system will interact with the rest of the organization (Burrough, 1986). It is simply not enough to purchase a computer, a digitizer, a display device and some software and put it in a corner with some enthusiastic persons and then expect immediate results. A serious commitment to GIS implies a major impact on the whole organization. The organization as a whole needs to plan the ways in which it expects to run its information business over a period of several years. Often GIS projects have been developed by persons knowledgeable in the application field, but lacking substantial training in the design and development of the system (Burrough, 1986). To assist in the development of efficient, reliable, flexible and maintainable information systems, the past 20 years have seen numerous texts written in an effort to define suitable system development methodologies. However, each system is unique and there is invariably some uncertainty as to what the system requirements and user needs will be. Hence, there is a widespread use of pilot studies, allowing modifications to be made to the system during prototype development, and providing a gradual increase in education and understanding among system users and managers.

Some authors suggest the use of guidelines for developing a GIS. According to these studies, before setting up a GIS there are certain activities that need to be considered. These activities include identifying the users and their requirements; defining the scope of the application; technical choices that are made about the type of software, hardware etc.; and availability of finances in terms of initial investment funding and continued financial support. In addition to these, initial studies should consider the organizational aspects including need for trained staff for operating and using the GIS; the way the GIS will interact with the rest of the organization; the technical support available; and the costs of GIS in terms of input, storage, software for analysis and planning management.

Childress's view is that for developing GIS, project definition is a critical step and should take place between the initial feasibility study and the systems analysis and design phase (Childress, 1986). But Berger's view is that for development of GIS for any organization there is a need for executive support (i.e., management can motivate employees to produce more, attain greater achievement of goals, reduce costs, modify behavior etc). But there is virtually no mention of how middle-level and project-level managers can reverse this direction to influence or inspire top management (Berger, 1986). Many authors call for an assessment of organizational culture or preparedness before initiating an information system development project (Brown, Friedli and Delong, 1988). Saarinen believes organizations that are better able to adapt their structure achieve more benefits from information technology (Saarinen, 1987).

Recognizing that organizations differ in many ways, including in their decision-making processes, there are still similarities in the way that they fundamentally operate. By focussing on these similarities, guidelines can be established to help improve the probability of getting top management to approve proposed projects or actions. A detailed conceptual framework for a GIS is presented in Chapter 4, which this author has identified as appropriate to real estate/electric utility GIS adoption and development.

Conclusion

This literature review has given a broad view of organizational and technical issues that arise in various spheres of an organization when GIS is introduced in the developed and the developing countries. It has also helped emphasize the process of development of systems within a bureaucracy like an electric utility. In doing the analysis of the cases used in the study, our main concern will be to look at the organizational structure and environment in both developed and developing countries contexts. We will also have to consider the purpose for which GIS is used, the extent to which its capabilities are explored, and whether user participation is important in the development of the system. We will also keep in mind the history of the growth of other automated systems in electric utilities in order to understand the pattern of technical issues that the organizations have had to deal with. This will help in analyzing the organizational and technical issues that will be dealt with when GIS is developed.

CHAPTER 3

FRAMEWORK FOR ANALYSIS

The literature on use the of GIS by electric utilities in the developed and developing countries has raised several issues which will be of importance as we adopt a framework for analyzing the two cases. The literature emphasizes the development of GIS as being inclusive of hardware, software, personnel skills, management etc. It also allows us to identify the key actors in successful designing and development of GIS. The literature has helped in identifying certain top-down and bottom-up approaches for developing a GIS. We have selected a top-down approach framework because it helps reveal mandates, principal requirements, and decision making processes of an organization. Using this framework as the background the two cases will be analyzed. This will assist in evaluating the development of the GIS in different organizational contexts.

3.1 Framework

The conceptual framework selected here represents the key elements to be considered during design and development of GIS. The conceptual framework proposed by H.W.Calkins (1976), will be used as a tool for aiding the design of effective GIS's and for the comparison of the two cases, which means comparison of an 'ideal' system --- that described in the conceptual framework --- first with the system developed by the Real Estate and Property Tax Division of the Asset Management Department of the Boston Edison Company. The issues that arose during design and development will be described, and a discussion will follow on how the same problems can be dealt with in developing a similar system in a different organizational context (the Estate Department of the Tata Electric Companies in a developing country). The analysis and recommendations for the two cases will be developed by comparing both of them to this conceptual framework. This type of comparison is more valid than comparing just the two cases because:

1) The conceptual framework represents a more neutral position and thus allows each case to be analyzed in a more objective manner. This way we do not only analyze the system by evaluating whether the system has met its objectives as defined at the initial stage, but we also evaluate the possibility of applying the system to another set of problems and requirements.

2) The conceptual framework does not consider only the elements evident in the case studies; but also highlights the major issues that have arisen during design and development of other systems. This allows evaluation beyond the "within the inside-context" (i.e., only within stated objectives). It also helps identify steps omitted or factors not considered in the cases.

3) The conceptual framework also helps provide a structured perspective on the relationship between the organizational structure and the development of GIS.

3.2 Design Stages

In the framework developed by Calkins, the GIS design activities can be organized into four stages. In this section we will first give an overview of the four stages of development. In the following sections we will examine each of the four stages and each step for each stage in detail. The four stages are:

I) Description of Information system objectives and specifications.

II) Definition of organizational resources and constraints toward system development.

III) Generation and evaluation of alternative system designs.

IV) Overall evaluation of costs and benefits for system selection.

Feedback occurs at various stages of development and is important, making this a process of interdependent actions.

Stage I: Description of Information Systems Objectives and Needs

a). Identify users and their needs

The first step is to identify users and their needs. Once this is done, an outline of the decision system is made which includes the tasks to be performed and the data used in completing these tasks. Specifying what the client does that needs information is a necessary building block toward setting objectives for the system. In the definition of the system four elements are involved:

1) Identification of decision makers in the organization.

2) Identification of potential system users.

3) Identification of information-use objectives and

4) Establishment of the criteria for evaluating the performance of the users system.

Setting objectives is one of the most crucial points in GIS design because the objectives must offer direction for accurate determination of data requirements for the present and future activities of the user involved.

b). Determine data requirements

The next step is to determine the data requirements and geographic referencing needs based on solid identification of system objectives and constraints. Requirements cover not only existing activities but also those projected to exist in both the short and long term for the organization. To describe information and data requirements, it is important to develop the data-definition table which will include for each item, its associated characteristics such as classification scheme, scale, frequency of use of each data item, response time, accuracy and source. In addition, data items are to be weighted by use or importance, if frequency of use is foreseen to be great for individual elements.

c). Conduct Inventories

The next step involves conducting inventories of existing data sources and geographic referencing systems. Sometimes data is to be gathered from secondary sources and economic conditions prevent agencies from collecting their own data directly. As a result the availability of data poses a major constraint. Equal attention must be given to surveying the geographic referencing system that exists in the organization.

d). Formulation of System Specifications

These initial steps of Stage I serve as preliminaries to the next three activities. These three activities focus on formulation of system specification for data, analysis capabilities and output form, as well as the geographic referencing system. The purpose of these actions is to translate user objectives and data needs into system specifications suitable to support subsequent design and development activities.

These three activities are related to broad concepts associated with information systems: 1) input, storage, and data to be included in the system, including the geographic referencing system, and retrieval requirements; 2) analysis requirements; and 3) the form of information delivery and output. Once a complete set of system specifications has been formulated, an evaluation of the results is to be conducted. The purpose of such an analysis is to reach some conclusions about the specifications based on three parameters:

1) Effectiveness (whether the system meets system objectives);

2) Consistency (internal conformity between geographic referencing capabilities, data-set specifications and analysis and information delivery requirements);

3) Feasibility (subjective evaluation of reasonableness of the specifications).

The process of defining the objectives of the system indicates that the framework has to be used in an iterative fashion. After the first iteration, the developer, sponsor and user may be able to set general system specifications. With successive iterations, the factors involved in the design of the system objectives will become clearer. Especially the technological and financial constraints.

STAGE II: Definition of Organizational Resources and Constraints

a). Resources Available

This involves a full description of the physical-logical structure of spatial data-handling in the user's organization to be used in determining resources and constraints for system development. It is within these constraints that system development has to take place. Factors requiring consideration at this stage include the existing hardware and software facilities used by the organization, the present data handling capabilities and procedures within the organization, present activities that affect the organization and the attitudes and capabilities of the proposed users.

b). Organizational Aspects

The next step is to investigate the present skills of agency personnel in data handling. The organizational structure has a marked effect on the development of the system. Attitudes of agency personnel toward both computer and GIS development need to be assessed. Inter-organizational and intra-organizational agreements and cooperation are needed for design and operation of the system. The most important factor is the attitudes of the users, which help in assessing the impact of system development on an organization. Potential users or persons affected by the proposed system respond differently.

c). Management Issues

At this stage the management issues are to be considered, involving the following:

1). Recognizing the fact that the staff will change in the long-term, a staff plan is drawn out during the design and development of GIS. This step also addresses the questions of the total resources required (fiscal plan) for development and continuity of finances.

2). To gain support of the organization and continuity of the resources, the system has to be publicized so that the users may view its legitimacy. A major problem to overcome is the negative attitudes, and misconceptions that exist in the organization. So the advisers have to emphasize to the potential users intended uses of the system.

STAGE III: Generation of Alternative System Design

Once the products and conclusions from the first two stages are obtained the third stage involves the definition and a analysis of the relevant dimensions of the decision variables for the particular problems, and specification of the appropriate choices for each dimension. The steps to which this approach should be applied are the following:

1) Hardware and software requirements;

2) Data handling procedures;

3) Methods for implementation, user education and training procedures.

Choices about type of hardware involve questions about the characteristics of hardware, its use and how it is to be provided (i.e., in-house development or use of contractual agreements with outside suppliers). Methods for implementation involve the degree of centralization proposed for the system, organizational structure, and the operating environment in which the system will reside. This includes estimates of staff resources, management policies and funding programs.

STAGE IV: Evaluation of the System

Benefits, costs and impacts of the alternatives are compared for selecting the system to be implemented.

Technical considerations play an important role in the design process. They define, in many ways, the constraint set under which the system design must proceed, and must be faced squarely at the point when the functional requirements generated by the structured GIS design model are translated into a specific system design which will, in turn, be implemented in specific software and hardware.

Conclusion

Given this framework, we can now use it to help analyze the two cases. At each stage of development we will also look at the organizational influences. The issues that will be of importance to us while analyzing the cases are the objectives and overall strategy of the organizations, the hardware and software configurations used by them, and the operating procedures and approaches used by the organizations. We will also have evaluate the kind of support the project is getting from management and who is developing the system for them. In the next two Chapters we will analyze the two cases and use the framework from this Chapter.

CHAPTER 4

BOSTON EDISON COMPANY

In this chapter we describe the Boston Edison Company case. We first give background description of the electric utility, and then describe the environmental situations which have influenced the development and growth of the utility. Then we provide an overview of the company and its use of Information Technology within different departments, followed by a brief description of the Real Estate and Property Tax Division of the Asset Management Department which is responsible for managing the property records of the company. This discussion will include the structure of the department and their operating procedures.

Then we explain the perceived need for using GIS and the development process for setting up the system in terms of translating the data needs of the department into system specifications suitable to support their development activities. This analysis will help identify the company's activities and the constraints that could arise at each stage of development of GIS. At the end of the Chapter we describe the process of designing and developing the prototype system for testing the ideas for the specifications of the GIS. This will help us understand the influence of the external and internal contexts for the design, development and use of GIS for land management in the electric utility.

4.1 Background

Founded in 1885, Boston Edison Company was based on one of the earliest central-station generating systems in the State of Massachusetts. During the early years of the twentieth century, the company was providing reliable, increasingly inexpensive service to one of the fastest growing areas in the City of Boston by increasing centralized production. Its service areas have been consolidated in metropolitan Boston early on and it took no further steps toward regional integration and expansion. It is the smallest investor-owned utility in the U.S in terms of service area, population served and generating capacity. However, continuing innovation in the area of engineering has helped the company maintain a leadership position in the industry. Confined to an aging but diverse metropolitan area, the company deals with everything from large concentrations of liberal academics to stable, working-class ethnic communities (Roberts and Bluhn, 1981).

4.2 Environmental Challenges

Boston Edison Company has been very effective at meeting modern challenges, and has been building upon long-standing traditions of leadership in the areas of engineering, marketing, employment and public relations, and management. With the perspective of a century of business these traditions have never been clearer. Since it has no large-scale hydro or thermal capacity the company does not have large blocks of surplus power to sell or the need to recover the high fixed costs of dams or transmission lines. The company's slow growth during most of its existence reflects the slower-than-average growth in the demand for electricity in its service area from early 1930's through the early eighties (Roberts and Bluhn, 1981). The geographic location of Boston has made it less attractive to heavy industries, which are among the largest users of electricity. The resulting slow growth in demand has lead to relatively greater use of older and smaller units, instead of new generating capacity. This leads to increasing operating costs which in turn affects the customer prices. The political and environmental culture of Boston has influenced both the style and the direction of the company's development.

4.3 Use of Information Technology by Boston Edison Company

During the 1970's, significant gains were made in the area of computerization and dispatching. The Trouble Information Management System (TIMS) was created in 1970 to manage emergencies and the Supervisory Control and Data Acquisition System (SCADA) provided instantaneous and centralized system control. The company is continuing to adapt to customer's changing needs and expectations. Since 1977 the Transmission and Distribution engineering (Cohane, 1986) department of the company has been involved with computer graphics. Significant improvements in engineering productivity, with gains from two to five times over normal operations, is mainly credited to the implementation of Computer Aided Design at the company. The system represents a significant improvement and is used by several groups within the Engineering department (Cohane, 1986). For example, the Survey and Records Division uses the system to update system drawings, and the Design Drafting Division uses the facilities to revise electrical schematics for the station engineering and construction section.

With the significant boom in the economy of the State of Massachusetts in the 1980's, there has been a need for new substations, expansion of existing substations, and purchase of additional power. The burden is great to provide cost-effective design and drafting services , especially at a time when lowering customer costs is a system-wide requirement to prepare for the demands of a changing market environment (Meehan, 1988). The Company is now in the process of conversion of its Station Design and Drafting Operation from a manual shop to a Geographic Information System. The Engineering department is proceeding by first completing a pilot project. The project is called CAD-Image, and is now moving into its second phase, the Pilot Phase.

4.4 Organizational Structure of Asset Management Department

Compared to the other departments of the Company, the Asset Management Department is small, in terms of number of staff members, with only eight staff. This includes the Asset Management Manager, who is responsible for the performance of the department. The department has three divisions; the Real Estate and Property Taxes Division, the Risk Management Division, and the Corporate Investment and Executive Compensation Division. The Real Estate and Property Taxes Division (REPTD) is staffed with four people out of the eight. It is further divided into two groups, the Real Estate Division and the Real and Personal Property Tax group. The Real Estate group has three staff. One person deals with Property Management, and the activities involve managing the leased and rental properties, and procedural work for renewal of leases. The second person is responsible for Acquisition and Disposition of properties, including granting easements and license agreements on Company owned land. The third person deals with Land Management, including the management of excess property, encroachments, license activity on Company property and transmission line Right-of-Ways. The fourth person deals with the taxes on the real estate and personal properties of the Company.

4.5 Operating Procedures of the Real Estate and Property Tax Division

Boston Edison is an operating utility engaged principally in the generation, purchase, transmission, distribution and sale of electric energy. The company supplies electricity at retail to an area of approximately 590 square miles within 30 miles of Boston, encompassing the City of Boston and 39 surrounding cities and towns (Fig. B.1). The company also supplies electricity to other utilities and municipal electric departments at wholesale. The population of the territory served at retail is approximately 1,500,000. The company owns 5,700 acres of land situated on approximately 900 tax parcels of land, and has almost 200 miles of overhead electric transmission line Right-of-Way (Fig. B.2). The company also has permanent easement rights on an additional 2,500 acres of Right-of-Way.

Over the years, management by the Real Estate and Property Tax Division of properties owned by the Company has been tedious. They have accumulated a huge number of manually produced drawings, some of which date back to the 1920's, when some of the properties were acquired. These maps and drawings are subject to frequent revision. This is especially time consuming during a major addition to an existing substation, when they have to go through several hundred existing drawings to find one map. These maps depict many parcels, their location, physical condition, ownership and administrative features. Keeping track of so much land is not easy, and finding a map for a particular tract of property can be time consuming. In addition to this, as mentioned in Chapter 2, many times REPTD staff need to identify land ownership, location of properties, environmental features, and income generated from the properties in order to create strategic plans for achieving increased revenues. While meeting operational and environmental requirements the department has to notify the abutters within half a mile radius of the property or Right-of-Way for which a substation is proposed.

4.6 How the GIS Project Started

The REPTD Division is administered by employees, many of whom have been working in the office for nearly forty years and through years of experience they are able to locate or identify a property and the information about it through pure recollection of different activities over the years. When the CAD-Image project was in its initial stages of researching requirements and needs of the Design and Drafting Department, they approached the Real Estate and Property Tax Division (REPTD) to see the possibilities of participating in the project and sharing the total cost of the project. This offer was not accepted by the personnel at REPTD, because they did not want to change their manual operating system, which they were used to using over the past forty years. The cost/benefit analysis for the CAD-Image was carried out without considering REPTD as a part, the proposal was approved by the management of the Company and the pilot project was funded. Out of the personnel at REPTD, the two staff members of the division who deal with the management of leased and rental properties and the excess properties and right-of-way land, are both nearing retirement. The person who was responsible for the Acquisition and Disposition of the properties retired a year ago, and in his position a new person was recruited. This person worked for the Transmission and Distribution Department of the Company. This person became the GIS "champion" for the REPTD. As a new person he was not able to handle the numerous records and for him finding a particular property or sending notification to the abutters of Company property was both time consuming and tedious. Being familiar with the CAD-Image project of the

Design and Drafting Division of the Company, he considered GIS an ideal tool for cataloging company-owned land, identifying environmental features, ascertaining income generated by these properties and most, importantly, creating a strategic plan for long-term land use that achieves increased revenues, while meeting operational and environmental requirements (Watjen, interview, 1990). He concluded that GIS would help support a wide variety of technical and administrative utility applications, including locating problems in case of emergency, identifying affected areas and services or maintenance requirements, and Right-of-Way acquisition and management. This system would also be used to store land-based information for their service territories, data for their facilities, and tax records.

Since the Design and Drafting Division was preparing for the CAD-Image project, the Real Estate and Property Tax Division put forth their own separate proposal of including the land-based information in the CAD-Image project for supporting their activities. However, the priorities of the Design and Drafting Division were in areas of improving the distribution services of the company, and inclusion of the land-based information would have meant increases in the total cost of the project, and perhaps too big a project to handle that might involve delays in implementation of the Engineering GIS for the company. Also, the accuracy required by CAD-Image for the system was different from the accuracy required by REPTD. Due to limited resources and time constraints the Design and Drafting Division felt they could not capture the Company-owned land parcels as shown on the assessor's maps or the land ownership maps that the REPTD possesses. Their design was to include only the parcel boundaries required to define the extent of the parcel frontage (which is included as arcs in the coverage). No attributes would be associated with these arcs and the frontage information would be used only as background information. Without parcel boundaries, this would be insufficient to support the activities of the REPTD. So the "champion" in REPTD proposed a work plan for developing a separate GIS that would be a need-specific GIS. Before preparing the work plan, the "champion" had attended a few workshops on GIS applications and met with a number of GIS users, including public and private agencies, to get a sense of the capabilities of various systems and the cost of acquiring the same for supporting the needs of the division. Understanding that the progress of development is long-term and never ending if success is to be attained, he tried to gain strong support for the project from the staff involved with the activities of the division. A step by step plan for gaining and maintaining such support was mandatory for the ultimate approval of the project by the manager of the department. The support of the staff was not strong, except for the manager of the department who was supportive of developing a GIS for the division. The manager, along with the "champion", put forth the proposal to the management of the company for approval and funding. Approval was given by the Company management on the condition that the project would be funded only in stages as progress in the project was documented at each stage of development. Funding in this case was limited to supporting well-defined and well-argued requests for a given GIS configuration.

The plan was aimed at meeting the "champion's" needs, and not so directly the needs of the division. The plan was not detailed, and various other options were not fully investigated. Once funding was provided, the "champion" developed some ideas, based on his interaction and information about experiences of other users, about the requirements of the system. He established the basic framework for the accomplishment of the projects purpose, and set the work plan for a project consultant. The consultant was to be responsible for the successful designing and development of the GIS. I was hired in this role and was supposed to develop the system for the division.

4.7 Selection of Hardware and Software

As mentioned in Chapter 2, for developing GIS there are several different computer hardware and software configurations that can be used to attain the same system goals. The system designed initially sets the ranges for the magnitude, cost and performance, and these three criteria become more detailed as specific alternatives are weeded out. The selection of software, whether developed in-house or purchased, is worthy of detailed consideration in identifying alternative requirements. It is also important to ensure that the software is capable of meeting system specifications that are defined before the system is designed. Often GIS must handle large databases provide for levels of security on databases, and be compatible with the existing data sets, software, and on-going research and data collection projects. The software must have inputting capability for points, lines, polygons and attribute data. Software for database management must provide security and integrity of data, capabilities for complex data manipulation and analysis, transformations, etc. Data display should include report generation and map graphics.

As is common in single-department, employee-championed systems, the scale and scope of the GIS was underestimated in selecting hardware or the software and a PC/Compaq 386 was bought for the division. The software chosen was Arc/Info, which is a high end GIS and an older minicomputer package that has been adapted to run on the PC's at much reduced expense and compatibility. Arc/Info has the largest GIS market share, world-wide, and wide usage in the New England States.

4.8 Impact of the "champion"

From the literature it is evident that a "champion" is a person who typically has knowledge of the system which he or she proposes for the organization. Also, a "champion" is often enthusiastic and strongly motivated to attempt to move the organization towards adoption of the new technology. The "champion" often plans the development process and sometimes takes responsibility for developing the system successfully. However, the "champion" in this case, had only a little knowledge of GIS. This proved to be a problem for the development process, especially for designing the prototype system. The "champion" was not acquainted with all the ins and outs of GIS, not only with respect to its technical idiosyncrasies, but also in regard to the system's overall capabilities.

Some specific examples can illustrate the problem. In one case, the "champion" did not agree to have multiple data files in dBASE IV. He suggested that having just one data file would be "convenient." This is because he did not understand the advantage of having multiple data files and how they would be related. Another example is that the "champion" was that he wanted this system to support his activities, but did not want to spend his time to learn details about the system. This was seen in particular cases when he did not understand why the coverages were being transformed from digitized coordinates to real world coordinates, and why having a proper coordinate system for the source maps, especially the strip maps was important. When I would try to explain to him why it was important, his response was "I do not have time to learn this system, but I want to know what is being done and why, because I will be teaching the other staff members to use the system" (Watjen, Interview, 1990). This attitude affected the development of the GIS (and more so the prototype system), because at each stage of development he insisted on changing the design of the system to what he thought was right. Much time was spent changing the design every time the "champion" felt it was not right, and being a student working part-time on the project I was not fully committed to the project and could not spend time trying to train the "champion." Since he had made the management believe that investment for this system was not expensive, he did not want to hire a consultant (because the contractual agreements are always expensive), and by hiring me the cost of the project was much lower.

4.9 Process of Development

Since the software and hardware was already chosen , as the consultant to the project I first identified the needs of REPTD by interviewing users and observing the potential by identifying the required applications of the system. This assessment was based on the existing operating procedures of the division. The process of development involved the following:

4.9.1 Identification of the Users and Applications of GIS

The staff at REPTD would use the system for the production of maps and information on land parcels and work with the outputs developed by the system. The system would be used for three major applications, which included finding information on leased and rental properties, acquired and disposed properties including easement types, license agreements on Company property, and management of excess property, encroachments and license activity, etc. They would use the system to answer simple questions related to size, location and value associated with particular types of parcels, and the type of easements given to other companies or the easements that the Company has on other some other company's land. It would be used during instances when they got complaints from the abutters of their property or right-of-way and they have had to locate the owner of the property by the owner's address or by the name of the nearest street crossing, and they had to send someone down to that place to deal with the problem. They would rely on the mapping output produced by the system and also use the system to update and revise their spatial data sets to produce new maps. The function of the GIS for these personnel was to replace or augment traditional cartographic, and photogrammetric techniques, and to provide for more efficient creation of products analogous to those developed in the older hard copy, environment.

The identification of the users was supported by interviewing the staff of REPTD and gaining an initial impression of their requirements in terms of reports and maps. The process also included meeting other users of GIS (private consultants and public agencies), to analyze the applications of the GIS used by them. Since many of the agencies were using GIS for spatial analysis. An outline of the decision system was made including the tasks to be performed and the data to be used in completing them. I also specified the methods of handling and storing information to meet the needs of the division, based on the type of information required by them from the system. The objectives helped identify the data required for both present and future activities.

4.9.2 Definition of Required Applications

Examples of the applications required by REPTD staff were obtained from the present and potential users of the Division's data. These sample data sets included both the products that the users were currently applying in the form of paper maps and records, and also the staff's concepts and designs for new and desirable output that could be created by the GIS. By analyzing the existing maps and data sets and their use in terms of operating procedures, some initial impressions were created of the types of information, media, format and accuracy, that the GIS would be expected to have (e.g., the accuracy of digital data required by REPTD was determined to be about ten feet). The existing data and material that REPTD had included the deed documents, license agreements, and acquisition or sale records for each property. The staff provided information on aspects of their use of this information. For example, they required information on parcels within 300 feet of the Right-of Way boundaries. For this application, the accuracy needs were assessed, since this system would be used primarily for management of records and not land use analysis. After this, the output preferred by the users was identified, including the scale of map information, format of maps, and color requirements, types of reports (e.g., "white sheets", used by REPTD, which have information on a property and the rights the company has on the property). The final products identified for use by the staff would be in the form of reports, supported by some graphics.

4.9.3 Evaluation of Work Flow

Detailed information on the existing procedure of work, whether manual or automated, was gathered. The information was inclusive of the interviews with the personnel involved, (the managers, and professionals of the division). These interviews were supplemented by personal observation of their work, and by examining the applications of various data sets made by the staff. This step included identifying the specific types of data used, including the data structure, format, media representation and accuracy. Based on this analysis an adequate description of data types that the proposed GIS would manage and analyze was developed. Documentation concerning the costs of operating the system was developed, based on the data inputs, production processes and data outputs.

4.9.4 Designing the Database

Database design techniques depend in part on both the information needs identified during the user need assessment and the assessment of the existing information base. The data in a typical GIS database consists of spatial information and attribute information, linked together. To obtain maximum utility from the GIS, it was important to develop carefully both the structure of the classification systems used for the attributes, and the style and format of the spatial components. During classification and map design, data items that would be related to features were studied carefully and the design of the attribute data was done first. Then the spatial data formats and requirements were designed.

4.9.4.1 Designing the Attribute Data

To meet each of the data needs requirements, general categories of information and detailed classifications were developed. Consideration was given to the level of detail needed for each category. The classification schemes were structured to allow aggregation of classes at different levels to get a variety of maps. The classifications were developed with the goal of making them as similar as possible to the classification that the users knew and used. Since classifications developed for the GIS were to be expressed as numeric codes to facilitate computerized handling of the data, two levels of classifications were developed:

1) Classifications associated directly with the map features by a sequential code list;

2) The first-level descriptive codes mentioned above were followed by their qualitative or quantitative values expressed as numeric codes.

The database was structured to be used in dBASE IV. At this stage a decision had to be made about using this software, because data in Arc/Info could not be related to dBASE IV at the time. Finally, by meeting other users of GIS, using the latest version of Arc/Info (which has the capabilities of relating data in both Info and dBASE), dBASE was recommended because it was compatible with the PC that the division had purchased. This led to a change in the structure of the database (i.e., data related to the features shown in the coverages was stored in Info and the detailed attributes were stored in related DBASE tables). Different files were used for different types of records and were classified as follows:

* **Acquisition/Sales/Tax records:** This includes date of purchase or sale, grantor, grantee, book, page, area, cost, location of the property, type of property, tax history, etc.

* **Right-of-Way Fee Records:** This has information on acquisition parcels and mimics the information in the file drawers commonly used and referred to by the personnel in the department.

* **Easement Records:** This includes the easement type, form, area, length, width etc.
* **Land Records/Abutters:** This has information about the parcel number, name and address of owners within 300 feet of the Right-of-Way, area of property, etc.
* **Lease/Rent Records:** This includes lessor, lessee, agreement type, date, name etc.
* **Non Right-of-Way Fee Records:** This includes information on parcels owned by the Company outside the Right-of-Ways.

4.9.4.2 Designing the Spatial Data

Before collecting the data, the sources of data required for designing the database were identified. This step involved breaking down specific analysis requirements and the related data needs necessary to support specific functions. The first step was to review the existing digital data sets for incorporation within the proposed GIS. The literature on spatial data available from other agencies was reviewed, and after having decided on the type of digital data layers required, the total cost of capturing data was mitigated by contacting these agencies and buying certain attribute or topological data, (e.g., the Town Boundaries layer was obtained from MassGIS).

The data collection process for the digital data was the next stage of development towards an operational system. This process involved acquiring geographic information sources such as maps, books, reports and related documents that the department possessed and also some source maps that other agencies had (e.g., assessor's maps were acquired from the town assessor's office). For including the data in the GIS, each data item was reviewed and evaluated to establish the usefulness of that piece of data. Designing the spatial data involved identifying the layers/coverages that would be used by the department and the type of features in each layer. The digital data is comprised of coverages/layers showing the features of the properties which form a background for mapping purposes. These coverages are related to the attribute data in the database manager, where the majority of the descriptive attributes reside. The various coverages and the features in each coverage are:

* **Town/Tax Parcels:** These features include parcel boundaries, road crossings etc. These parcels are captured from the Town Assessor's maps, and the key features are the units which will be associated with the polygon and all the descriptive attributes for the parcels which are contained in the related DBASE attribute table. The boundaries of the parcels within 300 feet of the Right-of-Way boundaries will also be included in the coverage. The unique identification numbers used are the Map number and the lot number assigned by the Town. In cases where two Towns had similar parcel numbers, the map number on which the parcel is shown is also included in the unique identification number.

* **BECo Right-of-Way:** Features include acquisition parcels, nearest street crossing , railroad crossings, etc. The
Right-of-Way number and the BECo parcel number are the unique identification number for this coverage.

* **BECo Properties:** Features are all company owned parcels of land outside the Right-of-Way. The unique identification number will be the BECo parcel number.

* **Facilities Network:** Features are buildings and major structures on company property and Right-of-Ways. All descriptive attributes for the structure are to be stored in the related DBASE attribute tables. The DBASE item
Structure-Type will be the relate item to match with the correct parcel.

* **Easements:** The features include easements for underground telephone lines, natural gas pipelines, sewer, water, drainage or other easement.

* **TIGER/Line Files:** Features include political boundaries for areas such as cities, townships and counties, roads, railroads and streams. This coverage will be used as the base map for the prototype system, until more accurate and detailed base map of the CAD-Image project is ready for use.

There are several key technical issues associated with the design of the Arc/Info database. These issues merit consideration prior to the actual design because of their general nature and the large implications each offers to the design itself. These issues include decisions about the coordinate system, feature numbering schemes, data file types, feature attribute table contents, directory structuring, and considerations for handling a large database.

* **Coordinate System:**

The feature locations contained with the Asset Management Department Arc/Info database will be defined in terms of Massachusetts State Plane Northings and Eastings. The State Plane is a system developed by the U.S Geological Survey which, for the sake of mapping, asserts that, taken one by one, rectangles on the earth's surface covering one State or a portion of one State can be assumed to be flat and can thus be described adequately by a Cartesian coordinate system. The GIS database includes the entire service area of the company and the location of its properties surrounding this service area. Given this large area, an efficient means of data organization is required for GIS features. Arc/Info provides a mechanism for quick and efficient access to spatial features in any part of this database by means of its unique identification number.

*** Feature Numbering Schemes:**

All features in the GIS database are assigned a unique identification number. Most of the properties owned by the company have parcel numbers assigned by the company as the properties were acquired. These numbers provide links to the existing inventory database. The intent of storing all attributes in DBASE tables is to place additional importance on identification numbers because the identification numbers will relate items from the Arc/Info table to the DBASE table, (e.g, for the PARCEL.PAT table in Arc/Info, the item PARCEL-ID will relate to the DBASE Land Records/Abutters file). Given this data organization, it will be possible to access DBASE attributes at the ARC level of Arc/Info. The PARCEL-ID will be the unique identification for all tables, which means that when a coverage contains multiple parcels, all of them will have parcel numbers, but a single number will be unique for each.

*** Access to Data Dictionary:**

For efficiency of data storage, a data dictionary has been identified as part of the database structure. A typical example is STRUCTURE-TYPE, which contains detailed description of the types of structures on the company property. This is linked to the Land Records file by a STRUCTURE-TYPE code, which is a one-to-many relationship between the Structure-Type table and the Land Records/Abutters file. There will be a one-to-one relationship between the Land Records table and the parcel attribute table in Arc/Info. Given a selected structure, it will be possible to access data in the attribute data stored in Land Records/Abutters file.

*** Annotation:**

Annotation is used in Arc/Info for display of features that require graphic representation only. Thus annotation features have no associated attributes and have no topological significance. In most cases this feature type is used for display of descriptive text. Annotation is particularly useful for this purpose because of the flexibility in placement. For example, annotation can be placed anywhere within a coverage whereas ARCTEXT must be displayed with respect to an arc. But since the street names are an important feature for locating property, street name will be an attribute of the center line, displayed using the ARCTEXT command. The name displayed on the map products will be based on the database.

4.10 Designing the Prototype System

The first step was to select an area of diverse nature for the prototype system to test the design, and the database development explained earlier. The purpose of this project was to assemble parcel-based information from Boston Edison Company records into a single database on the PC; to create easy access to the information for inquiries by the management; and to graphically display information in the GIS-based system. The area chosen for developing the prototype system was the Town of Sudbury because of its appropriately diverse nature.

4.10.1 Attribute Data Development

As explained earlier, the data structures that were created were to be tested using the prototype, so the attribute data for the prototype system was based on the data structure designed for the GIS. The files used were the same and the records for the Town of Sudbury were input and results were obtained by designing some queries.

4.10.2 Spatial Data Development

The spatial data was developed by digitizing the source maps for the Town of Sudbury which the department already possessed. The source maps available were of two types. One type was the Town assessor's maps and the other was the Company Strip maps. The Town assessor's maps show the Town parcels and the boundary of the Company's Right-of Way. The Strip maps show the location of the acquisition parcels, the street crossings and railroad crossings, if any. The assessor's maps were to the scale of 1"=200' and on each map the State Plane Coordinates were shown. However, the strip maps were to the scale of 1"=100' and did not have any indicated Latitude/Longitude lines or State Plane Coordinates.

Graphic information on the maps can be used in the GIS by digitizing the maps manually, or by scanning paper maps or by purchasing coverages from outside sources. Attribute data is entered by direct input (keyboard) or with data from outside sources. The department did not have any digitizing tablet available so the work was done using outside resources. Digitizing was done manually using the Computer Aided Design package Atlas Draw, and involved using an input device called a digitizer. The map to be digitized was placed on the digitizing tablet and with the cursor the lines and points on the maps were traced. Labels were assigned to the map features by recording the primary names (i.e, the parcel numbers for the regions traced). This label was then related to the tabular information in the database manager used by the department. While digitizing the source maps, it was important to first identify the registration or control points. As mentioned earlier, the Town assessor's maps had State Plane Coordinates and these were used as the control points. The area to be digitized was shown on three different maps, so each map was digitized separately and the control points were used. The strip maps did not have any standard reference points, so certain points were chosen on the Right-of-Way boundary that were common on the assessor's maps, were used as the control points. While digitizing, emphasis was given to using a unique identification for each parcel digitized for both Town parcels and the company acquisition parcels. Once digitizing was complete, the files had to be converted to be usable in Arc/Info, and the files were converted using different conversion packages. The coverages now could be used in Arc/Info, but before doing that they had to be transformed from the digitizing units to the real world coordinates (the State Plane Coordinates). The strip maps were also transformed to the real world coordinates.

Conclusion

From the case description we have a clear picture of how the GIS was developed and how the prototype system was designed and developed. This discussion provides a view of why the REPTD required the GIS and what was done to achieve their objectives. The case described here provided me with insight into the development process of a GIS in a utility in a developed country context. We have seen that development of GIS involves a balance of technical and organizational considerations. But we cannot consider just the organizational issues because any technology use involves technical issues also. In the next Chapter we discuss the second case of Tata Electric Companies in India and describe similar issues.

CHAPTER 5

TATA ELECTRIC COMPANIES

In this Chapter we provide a detailed description of the second case of the Tata Electric Companies. We start by giving the background of the Companies, and their use of Information Technology in the developing country context. This is followed by a brief description of the Estate Department of the Companies which manages the property records. Next, we describe the structure of the department and its operating procedures, followed by a description of their need for GIS and the activities performed to date for the development of GIS. Finally, we describe the effort the Companies are making in getting together with other utilities to develop a multiparticipant GIS and the constraints in data collection, and the attitude of the management and the individuals within the organization towards the idea of using Geographic Information Systems.

5.1 Background

The continent of India has five large independent regional electricity grids (Fig. B.3). Electric generation is made up of both hydro and thermal power plants. The five regions have different combinations of hydro and thermal power generation. The western region has more hydro power than thermal power installed. The Tata Hydro-Electric Power Supply Co. Ltd., the Andhra Valley Power Supply Co. Ltd. and the Tata Power Co. Ltd., are collectively known as Tata Electric Companies and form one of the major power systems in Western India. The Companies commenced operations with the commissioning of the first hydro station at Khopoli in 1915 (Fig.

B.4). Over the years, two other hydro stations were established at Bhivpuri in 1922 and at Bhira in 1927 (Annual Report, 1989). Power from all these stations is interlinked and a unified central power system is operated. On the north-eastern spur of the island of Bombay, across from its bustling water front, lies the Trombay thermal power station of the Companies.

5.2 Environmental Challenges

The Companies generate power for railway traction, textile mills, refineries, fertilizer factories and other major industries. They supply power to consumers in the highly-industrialized area of the State of Maharashtra, including Bombay City, and their area of supply covers more than 1,242 miles, with a population of over 9 million. They also supply the bulk distributing licenses, which in turn provide power for domestic and commercial consumers. The reliability of power supply and the quality of service is extremely high, and the City of Bombay enjoys the reputation of having the best power supply in India.

5.3 Use of Information Technology by Tata Electric Companies

The Tata Electric system was started with a small capacity for servicing but over the years it has grown into a big network in which the need for close coordination of system operation is vital. This is achieved by the computerized power monitoring and control center of the Companies. The Load Dispatch Center is provided with two on-line process control computers interlinked with an interactive video display system. The computers control generation to meet the continuously changing system requirements, and are also used off-line for system studies and planning.

During 1989-90, the Companies entered into a Technology Transfer Agreement with the Indian Space Research Organization for the development of an Image Processing Systems for on-ground Satellite Data Processing. They sponsor employees to various programs conducted by leading institutions, which include training for using computers for transmission and distribution etc. The companies have a Central Training Department for their staff and have various training centers for the whole country. The Companies have a sister concern called Tata Consultancy, which develops software for use by the companies. They also have a Protection, Control, Communication and Automation Division which is responsible for maintenance of computer systems and hardware development. Tata Consultancy is also involved in developing hardware using the latest electronic devices for computers and their peripherals.

5.4 Organizational Structure of the Estate Department

The Estate Department of Tata Electric Companies is involved with the management of real estate property. The department has twenty staff members including the Chief Engineer, who is responsible for the performance of the department. The department is comprised of two divisions (Fig. 4 in Appendix I). The Bombay Division and Administrative Accounts handles records of property owned by the companies in the City of Bombay and all tax records. The Hydro Division manages the real estate property that is within the jurisdiction of the hydro divisions of the Companies. Each division has a Deputy Chief Estate Officer, but there is only one Assistant Estate Officer for both divisions. The next level of officers includes two Assistant Estate Officers, one for each division and a Senior Office

Assistant. The Senior Office Assistant is of the Union category, which means that he is assigned work by the Assistant Chief Estate Officer. There are two Office Assistants for the Hydro division and one for the Bombay division. These positions are also of the Union category and hence are assigned work by the Assistant Estate Officer. Besides this, the Bombay division has two Junior Office Assistants, who are also known as the Land Inspectors. There are two more Junior Office Assistants, who work with the Senior Office Assistant of both divisions. The work done by the land inspectors is not rigidly defined, they are mainly responsible for patrolling the properties and reporting any encroachments on vacant land of the Companies within one district of the State. Their work involves giving information to the Estate Department about any changes in the land records or the environmental features.

5.5 Operating Procedures of the Estate Department

The companies own and operate three hydro stations and one thermal station. Besides these facilities, they own 38,000 acres of land in six districts of Maharashtra, which includes area that comes under the lakes and dams used for the hydro stations during the dry season. This area covers 422 villages. The Tata Electric grid comprises over 621 miles of overhead and underground transmission circuits feeding fifteen receiving stations. The employees of the three Companies are provided with accommodation in the residential colonies set up by Tata Electric Companies The Companies have undertaken several projects/contracts in India, as well as outside India, mainly for erection, operation and maintenance of power generation and distribution facilities. The Transmission and Distribution network in Bombay is being strengthened by a high voltage ring. Electric networking is planned in certain areas, and new receiving stations are required.

Each company owns property and each parcel is indexed by the company name, the division in which it lies, and the survey number assigned by the government. The companies locate their properties by the nearest pole number and not the closest street number. Also, records of acquired land or easements is kept by indicating the pole numbers (e.g., acquired land: from pole #1 to pole #4 etc). The companies also keep records of leased properties (i.e., the apartments for accommodating the new employees or trainees, and the apartments in their own residential colonies). The tax records that are handled by the administration and accounts division of Bombay include the records of the taxes paid by the Companies to the Government and taxes paid by the farmers for cultivation of the vacant land that lies under the overhead transmission lines of the Companies. In the early years, the companies used to acquire the land under the overhead transmission lines (Right-of-way) and keep a record of the property thus owned. This is no longer the practice, but the company has the right to lease this land for cultivation of crops to the farmers. The Companies own a lot of land that is at present vacant and, according to government laws, if the companies do not use the land for the purpose specified during the purchase, it is to be surrendered to the government. These vacant properties are prone to encroachments, and in spite of the land inspectors patrolling these properties, there are a lot of encroachments. The Companies have to keep track of land they own in the villages and also in remote areas within some underdeveloped villages. Their owned land will be used for siting additional facilities for rural electrification, and for extending their transmission lines. Besides this, when the Companies have to acquire or dispose of a property, they have a tough time coordinating the three companies to get the proper records and a set of maps. The end result is that there is a lot of duplication that occurs between the three companies and the Estate Department. The Companies also have to keep tract of land they own in the villages and remote areas of Maharashtra, and the revenue they get from these properties. The land is purchased for future use in the electrification of rural areas (e.g., extending the underground and overhead transmission lines). The GIS will be primarily used for "what if" type analysis, particularly for selecting alternative properties for development. The applications of GIS will also include spatial and network analysis, analyzing the optimum use of vacant land, and selecting alternative properties for new facilities and land management activities.

5.6 How the Project Started

Two years ago (1989), the Estate Department was managed by an Estate Manager, who had been working in the department for nearly 30 years. During his time, there were a lot of properties acquired by the Companies and he had been involved with the transaction procedures, so he had knowledge of the location and ownership of the properties. Through years of experience, he was able to recollect the information on location of facilities and their characteristics. After his retirement, the staff of the Estate Department began to find it difficult to locate a property, and often problems of encroachments made it nearly impossible to find out how much land they actually owned in a village. To locate a facility or find its characteristics, the staff would spend a longer time compared to when the now retired Manager was in charge. The HTAG was assigned the task of researching the needs of each department for supporting their activities with computer-based systems. The need for the Estate Department to use computer-based systems arises when the Bombay Municipal Corporation plans to construct a bridge or develop the road network. If this project implementation requires changes in the corridors of some of the existing transmission lines, locating the existing transmission lines and the position of the poles is cumbersome, and locating an appropriate position corridor for changed lines and poles is not easily possible. GIS will then be useful for locating the position of the existing transmission lines, and for assessing and analyzing the impact of the changed lines on the surrounding properties. The final position of the poles with respect to the constructed structure of the Bombay Municipal Corporation would also be recorded digitally. Also, since the Tata Electric Companies have future plans for implementing a number of other projects, GIS will be useful for site suitability analysis for new generating stations, substations and receiving stations with respect to the existing transmission lines. Given these existing needs of the Estate Department, the HTAG put forth a proposal to management for developing a GIS. Since the department is covered by the "Business Critical Activity" clause of the Companies, the proposal was approved. This means that the department gets funding and full support from the management, because its activities are considered critical for the business of the Companies.

5.7 Multiparticipant GIS

The Companies, as the suppliers of wholesale electricity to other utilities in Maharashtra, have to work closely with other agencies. These other agencies include Maharashtra State Electricity Board, Bombay Municipal Corporation and the Bombay Suburban Electric Supply. Increasing demands to produce the best possible service has led to the other utilities in Bombay also planning to develop GIS. These utilities are expected to use data prudently, especially with applications involving expansion of their services, compliance with public law, information requests or mandates from public utility commissions, increasing competition and constantly evolving business practices. Thus information, economic, and technical necessities are the driving forces behind these utilities choosing to develop Information Technologies. Since all these agencies are located in the same geographic area, working together to develop a common-based GIS should be more economical. The HTAG of Tata Electric Companies have become the leaders ("champion") for this group of participants, and they have secured executive-level interest in the other agencies. The other agencies were approached by the HTAG, their interest solicited, and a multiparticipant group was formed.

Initially, an informal group was set up, with the organization becoming more formal over time. The work was done at two levels, executive and technical. At the executive level, issues such as funding, data development and ownership, and legalities were discussed and agreed upon. The World Bank financed the loan for the whole project and this required each of the participants to mortgage some of their vacant land. At the technical level, issues associated with database content, structure, organizational structure and day to day communications were agreed upon. The project required the participants to share the cost of the feasibility study. The criteria for participation included the following categories:

* **Geography:** A clearly defined geographic area and agreed upon by each agency, to be included in a common land database. This means that the area chosen should include many properties of these agencies.

* **Cost:** The ability of each participant to fund a share of the project while receiving fair value. The funding issues are currently being sorted out, so that the feasibility

study (that will be started once the consultants are selected) does not stall due to lack of finances.

* **Cooperation:** The ability to work together constructively and reach a written agreement. The agencies are aware of the fact that to do the feasibility study and the project, they have to work together until the end.

The agencies participated in a study to determine the multiparticipant project's technical and economic viability and the organizational commitment to such participation, especially in terms of financial contributions. For the feasibility study the agencies plan to use their existing source maps for the base-map data. Though the maps that one agency possesses do not necessarily match the maps of the other, the participants will select the maps that are required and request others from the village Talati (Assessor's office). Since each agency has a large number of records, including the Estate Department of Tata Electric Companies, which has nearly 100,000 land records. The participants' first priority is to develop the attribute data and to use the records they already possess. The development of the digital graphic data will be done next, since collecting the maps from a variety of sources and selecting the relevant maps will take time.

5.8 Hiring Outside Consultants

Due to the size and complexity of the project, it cannot be developed wholly in-house. There is no one agency knowledgeable enough to develop the system. However, Tata Electric Companies (the "champions" here) have sent global tenders so as to obtain professional consultants for the project. Outside expertise should speed the implementation significantly and lower the total costs. They want to hire consultants who can supply the following:

* Specialized expertise from previous projects;
* GIS-specific formal education to the users in all agencies so that it can be used once the consultants leave;
* Short-term labor contract (i.e., expertise required especially for short start up times, custom application building and system implementation).
* Schedule for faster development of project and quicker payback of money invested.

The feasibility study has to be completed in one year, and the project has to be completed in seven years.

The personnel from HTAG will be part of the development process. The selection of the hardware and the software is to be done by the consultants, but final approval has to come from HTAG. The Companies will subject these consultants to the closest management and supervision possible.

5.9 Data Collection Process

HTAG is already identifying the needs and requirements of the Estate Department for the project since they will be using their own data as well as accessing the data of the other agencies when required. The identification of the needs of the users is done by analyzing what currently exists (e.g., maps, records, procedures and decisions to be made), and comparing existing procedures with desired capabilities. HTAG is determining data requirements for the present and future activities of each user, and data requirements including geographic referencing, etc. The digital data will include records of land owned by the agencies, including easements, leases and rental properties. However, at present they are not interested in collecting information about properties abutting their properties.

5.10 Constraints in Collecting Data

There are various constraints to the availability of data, which include the following:

1) Administrative and time constraints --- Maps must be obtained from various government agencies. Since the properties that Tata Electric Companies own spread over 422 villages, obtaining accurate maps from each village is not an easy job. Some of the villages do not have proper maps or any numbering system for the parcels. The process of acquiring the maps is often very long and may take from three to five months. Most of the time, if the person who is in charge of providing the maps is given some commission for the job, he may deliver the maps sooner.

2) Confidentiality obstacles --- The maps that the Survey of India possesses are not for public use. Although the survey maps are accurate and show the location of all properties owned by the electric utilities, they are confidential, so Tata Electric Companies will have to begin with the maps they possess.

3) Continuity and cost constraints --- If data cannot be secured when needed, work stops and the project is delayed.

5.11 Condition of Source Base Maps

The source base maps that the Companies have do not match with maps that the Bombay Metropolitan Development Authority has. Also, always maps that Tata Electric Companies have do not match the ones that other agencies have. The Estate Department is making an effort to obtain all the maps they require and to update them so that they match. They are concerned about the village maps that they possess, because the maps often do not show the latitude/longitude lines and the road layout. Also, the Settlement Commissioner of Maharashtra is planning to develop a GIS showing all parcels owned by the State, and for this effort he has requested all the companies, including electric utilities, to give him a set of updated maps. At the point of this writing, Tata Electric Companies have updated maps showing the locations of their properties in nearly 389 villages out of the 422 total.

5.12 Attitude of Individuals

The staff of the Estate Department is being given demonstrations about the capabilities of the system by the HTAG. They are encouraged to familiarize themselves with computers and to take training courses for future use. The HTAG is making sure that the staff understand that this technology is being introduced for supporting the work of an individual, and not for replacing them. The staff is not resisting the introduction of the technology, because they feel that by the time the project is finished, they will be given the required training. They are also aware of the fact that in the past when new systems have been used in the other departments, the Companies have not replaced the staff with any new staff, but have trained the old staff. They want to use the system for management of property records and for analyzing the various ways in which they can use their vacant land.

5.13 Attitude of Management

Since the project has the full support of the management, they have made a fiscal plan that covers the total resources required for the development of the system. They are also fully publicizing the system to gain support of the staff in the Estate

Department. They are concerned with the organization as a whole, and decisions have been made with the entire organization's needs considered.

Conclusion

From the description of the two cases we are able to see how different approaches have been used for development of a GIS system. We have to keep in mind the differences in operating procedures of the utilities in the two cases. These differences help explain the organizational and technical constraints that will arise in both cases at various stages of development. In the next Chapter we analyze the two cases in detail and address the questions raised in the first Chapter.

CHAPTER 6

CASE ANALYSIS

In this chapter we analyze the two cases by comparing and contrasting them using the framework from Chapter 4 as a tool for comparison. We step through each stage of the framework and the activities to be performed for designing, developing and using a GIS, and examine whether similar activities have been performed in the two cases, and evaluate how different they are from each other. Since, I was personally involved in the development process of the GIS for Boston Edison Company, there is the possibility that I may have some bias in analyzing the case. But this analysis has been done while being as detached from the case as possible. This case analysis will help identify why certain activities differ between the two utilities, and how the activities carried out so far are geared towards getting the best results from developing the GIS.

6.1 STAGE I: Defining Objectives and Needs

6.1.1 Identify Users and their needs

As described in Chapter 4, the recommended first stage of designing a GIS is to identify the users and their needs, to specify what the client does that needs information, and to set the objectives for the system. Developing a GIS is one of the largest computing projects undertaken by most utilities, and the diversity of information, data relationships, and applications across the utility's business areas introduces a complexity that requires using a structured methodology. To begin, a feasibility study is very important (i.e., whether the system makes sense to the organization economically, technically and organizationally (Blaine, 1988). For the Boston Edison Company case, as described in Chapter 4, the approach of the Design and Drafting Department for the larger CAD-Image project was not considered viable by the staff at REPTD, and by the time the "champion" came into picture, the Design and Drafting Department had already put forth their proposal for CAD-Image to the company management. The management considered the project very important for the companys' business in terms of improving their transmission and distribution services and dealing with the over 12,000 engineering requests for changes per year within the distribution system. The external context (political and cultural environment) in which Boston Edison has operated has affected its growth and development. The rates of the utility are high, and the pressure for lowering these costs has increased recently due to the regional recession in the State of Massachusetts. The company is in the process of making changes aimed at lowering customer costs to prepare for the demands of a changing market environment. The management viewed the use of GIS as primarily for improving their services, with the transmission and distribution network as the central concern. Since they were not planning to expand their services, the Real Estate and Property Tax Division (REPTD) was not a central department to the company's mid-term goals. The large-scale GIS that is being implemented by the Design and Drafting Department does not fulfill the immediate needs of the REPTD, and this incompatibility has forced them to break away from the large company project, and to propose a GIS to suit only their needs.

A changing business environment, new competition to retain existing customers, and a push to enter into new markets is a fact of modern utility life. In this fast-paced environment many utilities are using GIS to gain a strategic edge in their drive to remain competitive and deliver efficient, high quality services (Engelken, 1990). This means that when identifying the potential users of GIS, we have to analyze the environment in which they operate.

In the Tata Electric Companies case, we have a utility operating in an area which is attractive to the heavy industries which are the largest users of electricity. The Companies are not under significant pressure to lower customer costs because their customers are the big industries in the State of Maharashtra and the public utilities to whom they sell electricity in bulk. Their current priorities include strengthening their Transmission and Distribution network and expanding their generation and distribution facilities. Due to this growth, the Estate Department for the Companies is therefore a more central department to their future success, since the information required for the location of their existing properties for siting new substations and facilities is available within this department. The activities of the Estate Department are critical for the business development of Tata Electric Companies and hence are receiving maximum support from all levels of management. Combined with economics of GIS on trend-setting utility, they ought to be really able to rap new technology effectively.

6.1.2 Determine Data Requirements

The most important activity for developing a GIS is to determine the requirements of the organization in terms of data items, and their associated characteristics and usage in the organization. To outline the scope of potential applications, such a data requirements analysis is necessary, since the kind of system required will depend on the kind of work for which it is to be used (Burrough, 1986). To determine the data requirements and the geographic referencing needs we have to analyze the existing activities and the projected activities that will exist in both the short and long term.

The users in CASE I, REPTD, are managing records of leases, rents, property easements, licenses, excess property, encroachments, and license activity on company property and transmission Right-of-Ways. They will not be carrying out any major project implementation of substations or transmission lines in the middle term. GIS will be used more as a database manager where the attribute data used will be an exact copy of the records used at present. Whereas, in CASE II, the Tata Electric Companies, besides managing the records of their own properties along transmission and distribution corridors, also maintain records of the Lakes and Dams and the residential colonies that they own. GIS will primarily be used for spatial analysis, environmental impact analysis, to perform "what if" type operations, and for the development of alternatives. Tata will require much data from outside sources, which will include showing the location of surrounding areas that which includes the location of forestland, number of houses within a given distance, location of wetland and agricultural land. This data will be used for planning where transmission lines will be extended, and how they will pass through various villages and jurisdictions, all of which have varying permitting rules. The facility attribute data will be of primary importance, as will the street network. However, they may be able to do much of this analysis with a relatively low locational precision.

So the user requirements for the two cases are very different, and hence the system design will be different in terms of input of data, database design, locational precision, and output requirements. The system requirements for REPTD will be for daily operations and will be much more routine and structured. Information access and use at the managerial and decision making levels of the division will be less well structured. For the Estate Department of the Tata Electric Companies, the principal uses will be more for siting and long-range planning.

6.1.3 Conducting Inventories

Conducting inventories means conducting a reconnaissance field survey, collecting existing data and source mapping, selecting the best data, and grouping and cataloging of existing data (Dangermond, 1990). This gives an idea of the geography of the study area, and some of the data required that may be ordered or acquired. Selection of data is done once the data requirements are determined, and grouping of data is generally done in the same way that the organization currently groups them. The availability of data for REPTD of CASE I is also different from the Estate Department of CASE II. Since Boston Edison Company is in a developed country, we assume that the availability of data will be easy and the source maps will be in good condition. But we are looking at a utility that owns land which covers nearly forty towns, and each town has a different numbering system, some of the towns do not have accurate parcel level data available. Also, with the towns undergoing development, there are a lot of changes in land ownerships, and the maps available are not always quickly updated to reflect these changes. But most of the time the data that is acquired from the Town Assessor's office is fairly accurate and updated. The State of Massachusetts also has a standardized geographic referencing system which is used on the Town's base maps. Although the data is fragmented and the town system in U.S. is inconsistent, it is still better than the situation in India because the problems of encroachments on vacant land and with the fast growing population the land use of surrounding parcels changes faster and the rate at which subdivisions of parcels takes place makes it difficult for Tata Electric Companies to keep track to the updated maps. The village maps often do not show any road layout, and are usually not updated, so that they do not match the development plans of the Development Authority. Also, since the Companies own land that covers almost 422 villages, coordinating the numbering system used by each village is difficult. The maps do not show any Latitude/Longitude lines or do not have any coordinate system.

The numbering system used by the two companies is also very different. In the first case, Boston Edison Company acquires parcels of land and numbers them as they are acquired. These numbers are then used as the unique identification numbers for geographic referencing. In the second case, the Companies acquire land and number it, but they use the Survey numbers assigned to parcels by the State as the unique identification for locating their properties. Tata Electric Companies are planning to survey (ground survey) their service areas for the accuracy of data and to get a sense of the geography. Boston Edison Company's CAD-Image project is not surveying their service areas for locating the properties, but just transmission lines and pole locations due to financial constraints. It is only the REPTD within the Company with a direct concern for parcel boundaries.

6.1.4 Formulation of System Specifications

A differentiation must be made between a GIS used mainly to create a hardcopy product and one that is meant to support analytical studies. When automation of a mass hardcopy production system is considered, the desired GIS product can be a close facsimile of the current products. Analytical procedures vary in different organizations and in the required end-products, (Technical Report 1). For each case, the analysis capabilities of the system, output forms required, storage capacity of the system based on the data requirements, and availability are to be determined.

The storage capacity of the system for REPTD of Boston Edison Companies was determined by the volume of data that would be used, which was not as large as the Estate Department of the Tata Electric Companies. Tata Electric Companies have lots of records because they own many properties over a larger region than Boston Edison Company. REPTD will use GIS principally for management of records and only in later years do they plan to use it for site suitability analysis. In this case, if the system is designed only for management of records, but after a few years, there will likely be problems of data storage capacity, additional source map acquisition, and improving personnel skills and increasing manpower. Moreover, the REPTD system has to be compatible with that of the CAD-Image system if it is to later use this better, more accurate base map.

Tata Electric will use GIS mainly for locating new generating stations and transmission lines as well as for management of records. For Tata Electric Companies, it is important to know the location of the underground cables, and the properties of other agencies including Bombay Municipal Corporation, Maharashtra State Electricity Board. Therefore, data input and storage capacity of the system is much more than REPTD system. Also, the project that Tata is proposing is a multiparticipant GIS with on-line help so that communication with other agencies is possible.

Given the different needs and requirements the applications of GIS for each case will also be different. Boston Edison will need reports, supported by maps showing the location of their existing properties. Tata Electric will require maps that show locations of existing new or proposed generating stations or transmission lines, and also the alternative locations, supplemented by environmental impact analysis and development of alternatives.

6.2 STAGE II: Organizational Resources and Constraints

6.2.1 Resources Available

When GIS's are developed, emphasis is placed on the resources already available within the organization in terms of hardware and software. If there already is hardware in place, with some data stored, then there is a need to see how this data can be incorporated within the data structure developed for the system. In both REPTD and Tata Electric cases computerization of records is not the norm, with many records maintained manually. IN CASE I, the tax records for all properties in the forty towns have been computerized on a PC. Also, the ease of use of a PC by the "champion" led to this department selecting this platform for their GIS. Moreover, the software commonly used by REPTD on the PC was also being used by a lot of other public and private agencies. Looking at the organizational structure of the department, we find that each staff person is assigned a single task and specializes in that field (e.g., one person deals with only the tax records for the company properties, another person deals with just the acquisition and disposition of properties, etc). There is a possibility that the person who manages the tax records will never require the graphic capabilities of GIS, and hence all staff members of REPTD will probably not make full use of the GIS.

In contrast when we look at CASE II, Tata Electric Companies have not used computer-based systems for any record keeping, infact till today they have not even used simple applications like word processors. Though they have a fairly good technical support system, which is the HTAG, but the non-availability of resources in terms of hardware and software may be problematic when the staff is given training. However, the organizational structure quite different. Tasks for the union category (as mentioned in Chapter 5) are not defined and one person can do any task assigned. Information required by each person varies and is not restricted, and each person requires information for different tasks.

6.2.2 Organizational Aspects

GIS's should not be developed without considering the way in which they will interact with the rest of the organization (Burrough, 1986). In this consideration we need to assess the present data handling capabilities and procedures within the organization, its activities, and the capabilities of the proposed users. For both our cases the personnel stated that they find it difficult to obtain accurate, timely and easily accessible records, and that the manual system makes it cumbersome for the personnel to rapidly identify land for ownership and location of various properties. For them, GIS is a system which can solve some of their problems, but there is the "fear of the unknown". They do not currently have the skills and the understanding of GIS and they find difficulty in visualizing how they are going to fit into the future with this technology. As mentioned in Chapter 5, the "champion's" lack of knowledge of GIS is affecting the project development and his resistance to learning or getting basic training is not favorable for the project. This is not seen in the CASE II because HTAG is the "champion" for the project and though they have no knowledge of GIS, they are ready to learn while the GIS is being developed and majority of the staff knows that they will be given training for using GIS.

6.2.3 Management Issues

Misperceptions of the implications of a change for one's own future role and responsibilities is a major cause of resistance in organizations. So if detail is provided to the personnel by a comprehensive description of the future, they are more able to understand what is desired and how they fit into the whole picture. In CASE I we do not find any effort being made to educate the staff about the system, and the existing staff themselves are not interested in learning. This is probably a result of the composition of the existing staff, including many people who are nearing their retirement. This puts them in a position where they think that by the time the project is completed, they will be leaving and will have nothing to do with it.

We see a similar attitude among the higher level staff at Tata Electric Companies, but not in the lower level staff, who are younger and plan to be in the organization for some time. However, the staff is encouraged to join and take training courses so that they can use the system when the project is completed. There exists an atmosphere of acceptance among the people involved, because there have been discussions concerning the system objectives and excepted system benefits, which serves to ease the fears and negative feelings toward the system development.

In the first case, the REPTD project is small compared to the CAD-Image project of the Design and Drafting Department of the Company, and the investment is not so high. The management of Boston Edison Company are not as concerned about the results of the REPTD project as they are about the big CAD-Image project. For the Tata Electric Companies case, the project is a very large scale project for the Companies and involves a lot of money, so the benefit accrued had to be obviously positive and hence the project is getting much management support and attention.

6.3 STAGE III: Generation of Alternative System Design

Having compared the cases in Stage I and II of the adopted framework, we will now see what decision variables or choices have led to selecting the hardware, software, data handling procedures, methods of implementation, user education and training procedures. We find that the support of the management and the availability of the finances have helped Tata Electric follow all of the steps in the first two stages of development. In the Boston Edison case, given the fact that one person is more interested in developing a GIS than the others, and the inability and lack of knowledge of this "champion" to define the scope of the system, the development stages of the framework have not been followed. This has affected the choices that have been made, particularly regarding the hardware and software. The belief of the "champion" that once the system is set up and made user friendly by the consultant, that the concerned staff will learn to operate it, has led to the users not getting trained or prepared for utilizing the system. This is not the case in Tata Electric

Companies, where the staff is already starting training and is expected to be part of the development process. HTAG is selling the idea to the department staff early on and incorporating the suggestions made by the users for alternative ways of developing the system.

6.4 STAGE IV: Evaluation of the System

Selecting the system which is appropriate in terms of benefits, costs and impacts on the staff is the next stage of development. Taking CASE I, we notice that the probability of using alternative systems was never considered, there was no attempt made to select among various vendors, or to test the software that would be used, because the "champion" had already decided on using the system which he had heard that others were using. There was no cost/benefit analysis done for the project. In contrast, for CASE II, the development of system is at a stage where they are considering the benefits and costs of different systems, the systems suggested by certain users or consultants, and also the ones that are generally available in the market. They are planning to use the one that their consultants suggest after an extensive user needs and alternative analysis, provided it supports their requirements and is within their budget.

6.5 PROTOTYPE SYSTEM: Development Stages

For certain agencies, a prototype system is helpful because it is difficult for users to produce detailed requirements and specifications that match what they ultimately want to do. By starting with a prototype system and utilizing it to develop data and functional requirements, many people get a end product with a better fit. This is true for the Boston Edison Company case, where the "champion" was not sure of what he wanted, so that developing a prototype was a good idea. However, his understanding is limited and he believes that by expanding the scope of the prototype, he can do the whole project using the same hardware capacity. This is obviously not possible because of hardware and software limitations, and scaling problem (i.e., strategy that works for two towns and 100 parcels may not be feasible and will require redesigning to handle 40 towns and 5,000 parcels), which is likely to lead to problems in the future. Moreover, the Real Estate and Property Tax Division had not carried out a feasibility study, and the first two stages of development were not followed according to our idealized top-down framework. This led to the final scope of the system being largely undefined. Instead of hiring a team of consultants, the "champion" hired me, a graduate student by profession, having some recent knowledge of GIS, but no relevant practical experience of developing a similar system. I was asked to develop the prototype GIS, and was also made aware of the limited resources for the project. It was made clear to me that the "champion" was not interested in step-by-step development of the final system, but in a quick prototype system. This prototype was being done to show upper management how efficient this system might be, what its capabilities could be, and how it might support the activities of the division, and how important it was that the project be financed.

However, I continued designing the system by attempting to follow the various stages of the framework. But the research from all these activities (e.g., a user needs assessment) was just documented and never actually carried out for the more extensive data collection required to see the full benefits of the final system. I was in a position to make some decisions, but could not make the "champion" do what I felt was required for the project to be expandable beyond the prototype to a complete system. The "champion" was the decision maker here. This can clearly be seen in one example when technical assistance was required for the hardware used by REPTD, but this activity could not be carried out because the management was not supportive, and was interested only in pushing for quicker response from the technicians. The likely reason for this was that the "champion" had already given the management the picture that the system was very efficient just as it was, and only required some data input for the prototype system to be operative. If the "champion" had put forth the request for technical support, upper management would have questioned him about the requirements for the system, which were more extensive than they had been led to believe.

Conclusion

The comparison between the two cases has allowed us look at issues that need of be considered during development of GIS, which include the challenging environment in which the organization operates, the size of the organization and its position relative to the top-level management, the similarity of needs to those of the management, the financial resources available, and also, but not the least, the position of the person who develops the system and its interest in developing the GIS. In the next Chapter we will address more directly the questions raised in Chapter 1, keeping in mind the issues that have been identified above. We will also make some recommendations for Boston Edison Company (i.e., what could have been done better), and possible recommended solutions for Tata Electric Companies (i.e., for developing a GIS in the future).

CHAPTER 7

POSSIBLE DESIGN SOLUTIONS AND RECOMMENDATIONS

The experience described in the two cases suggests that the challenges faced in the development process of GIS for an organization can be met to a large degree by considering and dealing with two important factors. These two factors are the **1)** impact of the changing external organizational conditions (i.e., environmental challenges and forces that affect the activities of the organization); and **2)** impact of the internal organizational circumstances, including the role of a "champion", the development approach, identification of users and their needs, definition of the scope of the system desired, applications of GIS, and level of management support. We might argue that the factors regarding the developed and developing countries experience could also have a significant impact on the development of GIS. But from our analysis of the two cases, it seems evident that the above mentioned factors are the fundamental issues across both contexts and that they must be dealt with for successful development of GIS in a bureaucracy like the electric utilities.

7.1 Impact of External Conditions

Significant environmental challenges currently affect the electric utilities and, given the competitive nature of their business, the economics of computing looks better and better as performance increases as computer-based systems are being adopted for efficiency gains, better service, and better management performance. From the analysis of the two cases, we find that automation is cost-effective and efficient in both cases, but that their organizational issues are different (i.e., facilities management for Boston Edison Company, expansion planning for Tata Electric Companies). The Boston Edison Company is in a situation where for a number of years it has not had the need to expand its services. From its past history we can see that the company has been growing slowly compared to other utilities in the U.S. Given this situation, it seems that the future plans of the company do not involve any major project implementation or expansion of services. So the Real Estate and Property Tax Division is unlikely to be carrying out activities that would require suitability analysis for siting substations or facilities. GIS in this case will be underutilized for policy and analysis.

In contrast, public utilities in India are not generally as progressive as Tata Electric Companies, so when we compare Tata Electric with these utilities, it stands out as a leading and progressive utility in the country. To keep up with fast demand growth, they are expanding their services and increasing the number of generating stations. So their activities will require selecting alternative sites for new facilities, doing suitability analysis, and network analysis. GIS in this case will be utilized extensively for policy, land use planning and analysis.

7.2 Impact of Internal Conditions

The case analysis has helped identify five factors that have had a significant impact on the development of GIS for both cases. First, it is evident that a bottom-up development effort like the REPTD system in Boston Edison is often slower, less thoroughly planned, more limited in scope, and that such efforts are often resource poor in terms of finances and personnel. Hence, they are more complex to orchestrate well, although they may be simpler in overall scope. This is also related to the support the lower-level group initially gets from the higher-level management who invest money for the project and then expect to see results fast. On the other hand, a top-down approach development effort like the Tata Electric Companies system's plan for GIS is likely to be a more complex system, but better planned, simpler to orchestrate and faster to start because of the resources available and management support.

Second, the "champion", a person who develops and promotes a GIS project for any organization, needs to be well educated. If the "champion" is not knowledgeable enough to develop a GIS system, then the project will stall and the development process will not be well defined and well structured. This has been the main problem during the development of the REPTD system.

Third, for any organization it is recommended that the process of developing GIS is recommended be well structured and well defined. In CASE I of (REPTD), the "champion" could not carry out an extensive research process for identifying the needs of the department and the translation of these needs to GIS because his knowledge of GIS was limited and the development of the system was a voluntary side project for him and not a full time task. If detailed research had been done for identifying the needs of the users it would have been found that GIS was not really required for this division. Given its existing activities, a relational database manager, supported by some simple mapping output capability, would have been more efficient and cost-effective. In CASE II, none of the personnel of the Estate Department or the HTAG has complete knowledge of GIS, but HTAG has been successful in identifying the needs of the Estate Department and hence setting the scope of the system. The goal of this approach is to ensure that when the system is operational, it will meet user needs, especially for using GIS as a tool for land use analysis.

Fourth, there is a need for the Real Estate and Property Tax Division of Boston Edison to state whether they want to use computer-based systems only for the management of records (i.e., automation) and notification, or for spatial analysis as well. The GIS for automation only will have a database of information on spatially distributed features, activities or events, which are defined as points, lines or regions; and procedures for collecting, storing, retrieving, analyzing and displaying such geographic data. But if the use of GIS is also for spatial analysis, then they will have to extend the scope of the GIS, redesign the structure of the system, and redefine the objectives of the system. This will require quite a different hardware and software configuration, organizational structure, and requirements in terms of trained personnel. The applications of GIS in CASE II, of Tata Electric Companies will be more varied, will require a variety of data types, and this data will primarily be used for spatial analysis. This means that the Estate Department will be an information intensive organization, will require a different hardware and software configuration, and will potentially see greater potential benefits from a coordinated multiparticipant GIS. Whether they can pull this off remains to be seen, and may well be an activity that is difficult in a developing country.

Finally, for the Boston Edison Company case, with the GIS installed there was a need to justify the legitimacy of the system. The problems encountered at each stage of development of the prototype system in terms of expanding the hard disk space, technical support required, and the resources available for creating spatial data, were numerous. The reason, again, was the "champion's" attitude, lack of upper management support and the level of importance given to the project. For CASE II, the management support is strong and the importance given to the project is much greater than the CASE I project, because the benefits of the project are considered to be crucial for the business activity of the Companies.

7.3 Recommendations

Our recommendations for developing GIS for both cases are addressed towards several different actors. First, we describe eight strategies which should be followed by the Real Estate and Property Tax Division of the Boston Edison Company to support immediate and medium term goals. For REPTD, we consider data management, updating procedures and applications of GIS, the role of outside consultants and training procedures. Second, we describe thirteen strategies which should be followed by the Estate Department of the Tata Electric Companies for developing GIS. These include the role of consultants, inter-agency strategies, support for use of GIS, management strategies and hardware and software configurations etc.

7.3.1 Recommendations for the Real Estate and Property Tax Division of Boston Edison

1) REPTD should first hire a person who has technical knowledge of GIS to support the "champion" before consultants are hired to develop the system. This person will be able to compare and evaluate the options the consultants offer and the trade-offs involved in the choices made.

2) Given the fact that neither the existing personnel nor the "champion" are knowledgeable enough to develop the system, REPTD should hire consultants who have relevant experience to electric utility GIS projects. They should specify to the consultants that the system has to be developed in such a way that later on they can access and use the data that CAD-Image will have on their workstations.

3) The consultants should design the system in such a way that access to the existing tax records is possible.

4) To mitigate the cost of the project, the consultants should use the source maps that REPTD possesses and get some other maps from the Town Assessor's offices in the various towns or the surveyor's office in Boston Edison.

5) REPTD should also wait for CAD-Image to develop their base map and then use the same base for showing the boundaries of their Right-of-Ways within the Company's service territory and the location of structures and poles on the Right-of-Ways.

6) The consultants should give training to the "champion" in terms of operating characteristics, assumptions concerning the data and manipulative functions, and reasonable expectations of system performance and limitations. Step by step development training should be given to the "champion".

7) The consultants should also give training to the users in the department. The existing staff will not be working on the GIS because most of them are retiring, so training should be given to new incoming staff. This training should include instruction on the use of the system in terms of operating characteristics, assumptions concerning the data and manipulative functions, reasonable expectations of system performance and limitations.

8) Showing the location of town parcels within 300 feet on either side of their Right-of-Way over time will involve changes in ownership of these parcels, further subdivisions and other changes. Someone must take the responsibility of getting updated information from the Town Assessor's office every one to two years and making the changes in the database. Without such a maintenance plan and updating, REPTD can use the Town/Tax Parcels coverage only as a map index sheet to refer to the proper map/block in a particular town, not for current ownership information.

7.3.2 Recommendations for the Estate Department of Tata Electric Companies

1) The multiparticipant GIS will demand big budget decisions, so the consortium should consider how they will share the costs for the project, how they will reach joint decisions, and what roles their individual organizations will be expected to play.

2) It is not satisfactory for Tata Electric Companies to use only local consulting companies or student consultants to build the GIS or its components (this may be a cheap solution but not necessarily reliable). But since they do not have anyone to develop the system in-house, they should prepare global tenders specifying the scope of services required to be performed, products to be delivered, and the conditions of procurement.

3) They should develop a methodology for identifying and describing the location of all source data, including documentation, continued access, and opportunities for change in data collection procedures.

4) They should evaluate the source data, particularly in terms of their applicability to the problems at hand and their accuracy and reliability.

5) Since Tata Electric Companies cannot afford to do a one-time, snapshot design, they should develop a strategy to discover needs and strategies during the development of the system. Hence, there must be a built-in development process that anticipates learning. They should find ways of getting end-users involved in the process of development early on.

6) The consultants should be selected on the basis of having relevant, practical and applicable experience to electric utility GIS projects, especially with use of GIS for planning and not only automation.

7) Once consultants are selected, development of the GIS should be done according to a framework similar to that used in this theses. Tata Electric Companies should compare and evaluate the options the hired consultants offer and seek information from other sources (e.g., Tata Consultancy). They should ask for alternatives and explanations of why one system configuration is recommended over another. With a broad range of options available to them, they will be better equipped to assess the trade-offs involved in their choice of strategies, rather than leaving their strategies solely up to the preference of the consultants.

8) The consultants should provide training to the users and the individuals in the HTAG, especially in the use of GIS as an analytical tool.

9) The consultants should provide samples of standard reports to the potential users to stimulate their interest in using GIS. HTAG should involve potential users in the system design process, in order to encourage them to think about the kind of data they will need and how they will want to use it. This will serve both to elicit information about how information will be used and to educate users about how increased access to information will support their work.

10) To maximize the usefulness of a GIS system, communications and coordination of participating agencies is very important. This coordination should be less dependent on a hierarchy within individual agencies, and more dependent on lateral communication among agencies.

11) To establish system management there should be two committees formed. The first committee should deal with technical issues. The High-Tech Applications group of the Tata Electric Companies should be the technical committee and could offer advisory leadership. It should have interested individuals who are technically qualified and should be involved with the development process of GIS. This committee should give confidence to both the management and the users in the Estate Department. This committee could handle the technical side of development and later recommend actions and positions to the executives. It would be part of the process of system design, development, implementation and operation. The second committee should be policy oriented. The individuals from the user community should form a policy-making group, so that they can receive and react to the recommendations of the technical committee. This group should formulate policy, and, in turn, make recommendations to the executive.

12) The hardware and software selected should allow easy access to data to facilitate use of information for analysis. The system should be expandable. That is, there should be an active market for software (in India) that runs on the system and it should account for a sufficient share of the market so that future hardware and software will have to be compatible with it. The system should be compatible with the organizational structure also.

13) Finally, the system should reflect the interdependencies of functions across the agencies. Each agency will be responsible for updating the information on their own properties, to help ensure access to the most current information in all systems across all of the coordinating user agencies.

Future Research

This thesis has identified many of the issues that arise in developing GIS. The stage of development in both cases was such that no analysis could be done to see how the projects would be implemented and what impact they would eventually have on the organizations. Further work would involve analyzing the implementation stages and analyzing at each stage the issues that arise. To do this we need to look at a few more cases in both the developed and developing countries. The study should be centered around two issues. The first is to see how far the environmental challenges affect the electric utilities and what effect that has on the development of Geo-information Systems and whether there is some relationship between the changes in the external conditions and the behavior of the organizations in terms of developing these systems. The second would be to find out how the process of development is carried out and how important the process of identifying users and defining the scope of the system is and what electric utilities should do for successful development of Geo-information Systems. This can be done by selecting a number of cases in both the developed as well as the developing countries. A larger number of cases will prevent us from being misled by a particular situation or a case.

Conclusion

The experience of the two cases clearly shows that to develop a GIS the most important factor is the learning and scope of what is required to carry out the objectives of the system. This is often related to the knowledge of that the "champion" of the project. Many factors, in addition to technology, must also be present for electric utilities to follow a well structured and well defined process of development. Important among these factors are the environmental challenges, management and organizational activities/operations that provide the basis for defining the scope and objectives of the GIS, access to up-to-date information, and hardware and software, etc.

The recommendations made in this final Chapter are intended to provide some additional resources. These recommendations if taken into consideration by electric utilities, should make it possible for them to strengthen the land management departments through access to more reliable and usable information.

APPENDIX A

List of Personnel Interviewed at Boston Edison Company

1) Real Estate and Property Tax Division

Mr. Anastasia, Manager, Asset Management Department
Mr. Watjen, Principal Real Estate Specialist
Mr. Bartley, Land Management Specialist (Retired 1990)
Mr. Mich, Acquisition and Disposition Specialist
Mr. Cox, Manager, Real Estate Division
Mr. O'Connor, Tax Specialist

2) Design Services and Drafting Division

Mr. Cohane, Engineer, Transmission and Distribution
Mr. Meehan, Head of Division
Mr. Stanley, Senior Engineer

List of Personnel Interviewed at Tata Electric Companies

1) High Tech Applications Group

Mr. Prabhu, Manager, HTAG
Mr. Vaze, Junior Engineer
Mr. Bharanwal, Senior Engineer

2) Estate Department

Mr. Engineer, Chief Engineer
Mr. Karnik, Deputy Chief Estate Officer, Bombay Division
Mr. Varghese, Deputy Chief Engineer, Hydro Division
Mr. Udas, Estate Manager (Retired 1988)
Mr. Balsara, Assistant Chief Estate Officer

3) Maharashtra State Electricity Board

Mr. Ambarge, Executive Engineer (Administration)

4) Bombay Electric Supply and Transport

Mr. Warang, Chief Engineer Corporate Planning Electric Supply

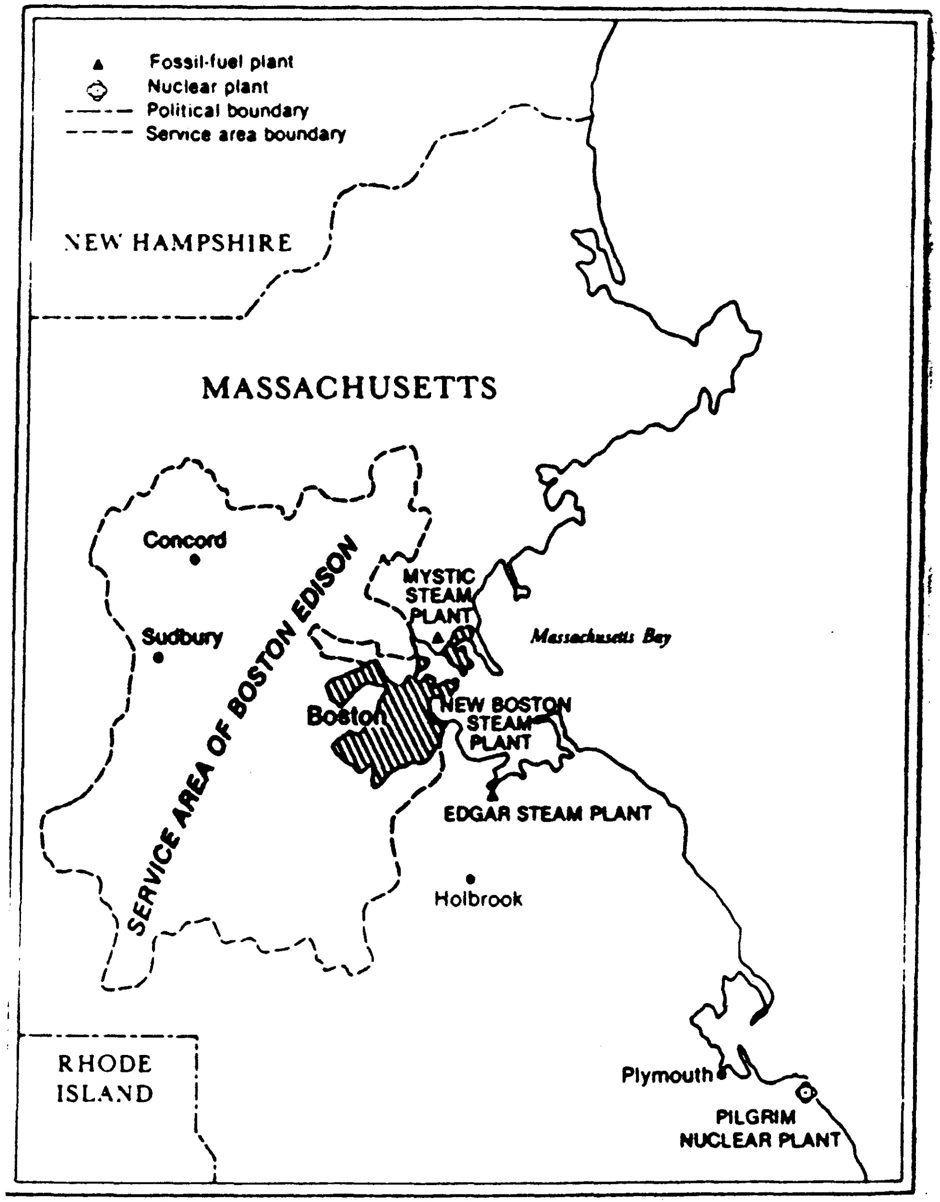
5) Bombay Suburban Electric Supply Limited

Mr. Karkaria, Senior Manager (Tech)

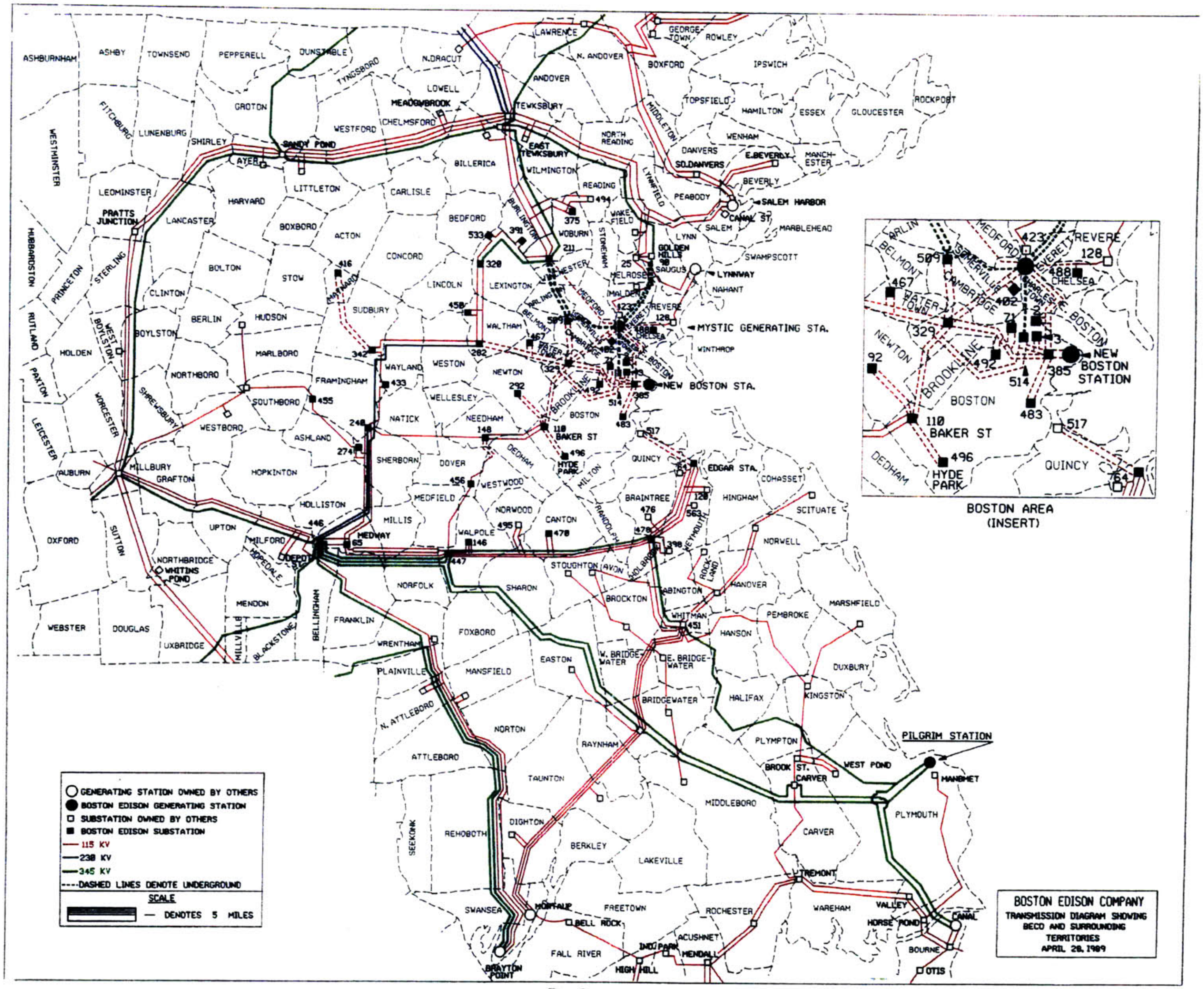
6) Settlement Commissioner of Maharashtra

Mr Navin Kumar

APPENDIX B


Fossil-fuel plant
Nuclear plant
Political boundary
Service area boundary
NEW HAMPSHIRE
MASSACHUSETTS
Concord
Sudbury
SERVICE AREA OF BOSTON EDISON
MYSTIC STEAM PLANT
Massachusetts Bay
Boston
NEW BOSTON STEAM PLANT
EDGAR STEAM PLANT
Holbrook
RHODE ISLAND
Plymouth
PILGRIM NUCLEAR PLANT

B.1


BOSTON EDISON COMPANY
TRANSMISSION DIAGRAM SHOWING BECO AND SURROUNDING TERRITORIES
APRIL 28, 1989
GENERATING STATION OWNED BY OTHERS
BOSTON EDISON GENERATING STATION
SUBSTATION OWNED BY OTHERS
BOSTON EDISON SUBSTATION
115 KV
230 KV
345 KV
DASHED LINES DENOTE UNDERGROUND
SCALE
DENOTES 5 MILES
BOSTON AREA (INSERT)
MYSTIC GENERATING STA.
NEW BOSTON STA.
NEW BOSTON STATION
PILGRIM STATION
SALEM HARBOR
CANAL ST
LYNNWAY
EDGAR STA.
BRAYTON POINT
MONTAUP
CANAL
SANDY POND
PRATTS JUNCTION
BAKER ST
HYDE PARK
ASHBURNHAM
ASHBY
TOWNSEND
PEPPERELL
DUNSTABLE
TYNGSBORO
N.DRACUT
LAWRENCE
N. ANDOVER
GEORGETOWN
ROWLEY
BOXFORD
IPSWICH
ANDOVER
LOWELL
MEADOWBROOK
CHELMSFORD
TEWKSBURY
EAST TEWKSBURY
TOPSFIELD
HAMILTON
ESSEX
GLOUCESTER
ROCKPORT
GROTON
WESTFORD
NORTH READING
MIDDLETON
WENHAM
DANVERS
SO.DANVERS
E.BEVERLY
BEVERLY
MANCHESTER
FITCHBURG
LUNENBURG
SHIRLEY
AYER
BILLERICA
WILMINGTON
READING
LYNNFIELD
PEABODY
WESTMINSTER
LEOMINSTER
LITTLETON
CARLISLE
HARVARD
LANCASTER
BOXBORO
ACTON
BEDFORD
BURLINGTON
WOBURN
WAKEFIELD
STONEHAM
SALEM
MARBLEHEAD
LYNN
SWAMPSCOTT
SAUGUS
NAHANT
HUBBARDSTON
PRINCETON
STERLING
BOLTON
STOW
CONCORD
LEXINGTON
WINCHESTER
MELROSE
MALDEN
REVERE
WINTHROP
CLINTON
BERLIN
HUDSON
MAYNARD
SUDBURY
LINCOLN
WALTHAM
RUTLAND
HOLDEN
WEST BOYLSTON
BOYLSTON
MARLBORO
WAYLAND
WESTON
NEWTON
NORTHBORO
FRAMINGHAM
PAXTON
WORCESTER
SHREWSBURY
SOUTHBORO
WESTBORO
NATICK
WELLESLEY
NEEDHAM
BOSTON
LEICESTER
ASHLAND
SHERBORN
DOVER
DEDHAM
MILTON
QUINCY
AUBURN
MILLBURY
GRAFTON
HOPKINTON
WESTWOOD
COHASSET
HINGHAM
HOLLISTON
MEDFIELD
NORWOOD
CANTON
BRAINTREE
RANDOLPH
SCITUATE
OXFORD
SUTTON
UPTON
MILFORD
MILLIS
MEDWAY
WALPOLE
NORWELL
WEYMOUTH
HOLBROOK
AVON
STOUGHTON
ROCKLAND
NORTHBRIDGE
WHITINS POND
HOPEDALE
NORFOLK
SHARON
ABINGTON
HANOVER
BROCKTON
MARSHFIELD
MENDON
BELLINGHAM
PEMBROKE
WHITMAN
WEBSTER
DOUGLAS
UXBRIDGE
BLACKSTONE
MILLVILLE
FRANKLIN
WRENTHAM
FOXBORO
EASTON
W. BRIDGEWATER
E. BRIDGEWATER
HANSON
DUXBURY
PLAINVILLE
MANSFIELD
BRIDGEWATER
HALIFAX
KINGSTON
N. ATTLEBORO
NORTON
RAYNHAM
PLYMPTON
WEST POND
MANOMET
ATTLEBORO
BROOK ST.
CARVER
TAUNTON
MIDDLEBORO
PLYMOUTH
SEEKONK
REHOBOTH
DIGHTON
BERKLEY
LAKEVILLE
TREMONT
SWANSEA
FREETOWN
ROCHESTER
WAREHAM
VALLEY
HORSE POND
BELL ROCK
ACUSHNET
BOURNE
FALL RIVER
IND. PARK
MENDALL
HIGH HILL
OTIS
CHELSEA
EVERETT
MEDFORD
SOMERVILLE
CAMBRIDGE
CHARLESTOWN
BELMONT
ARLINGTON
WATERTOWN
BROOKLINE
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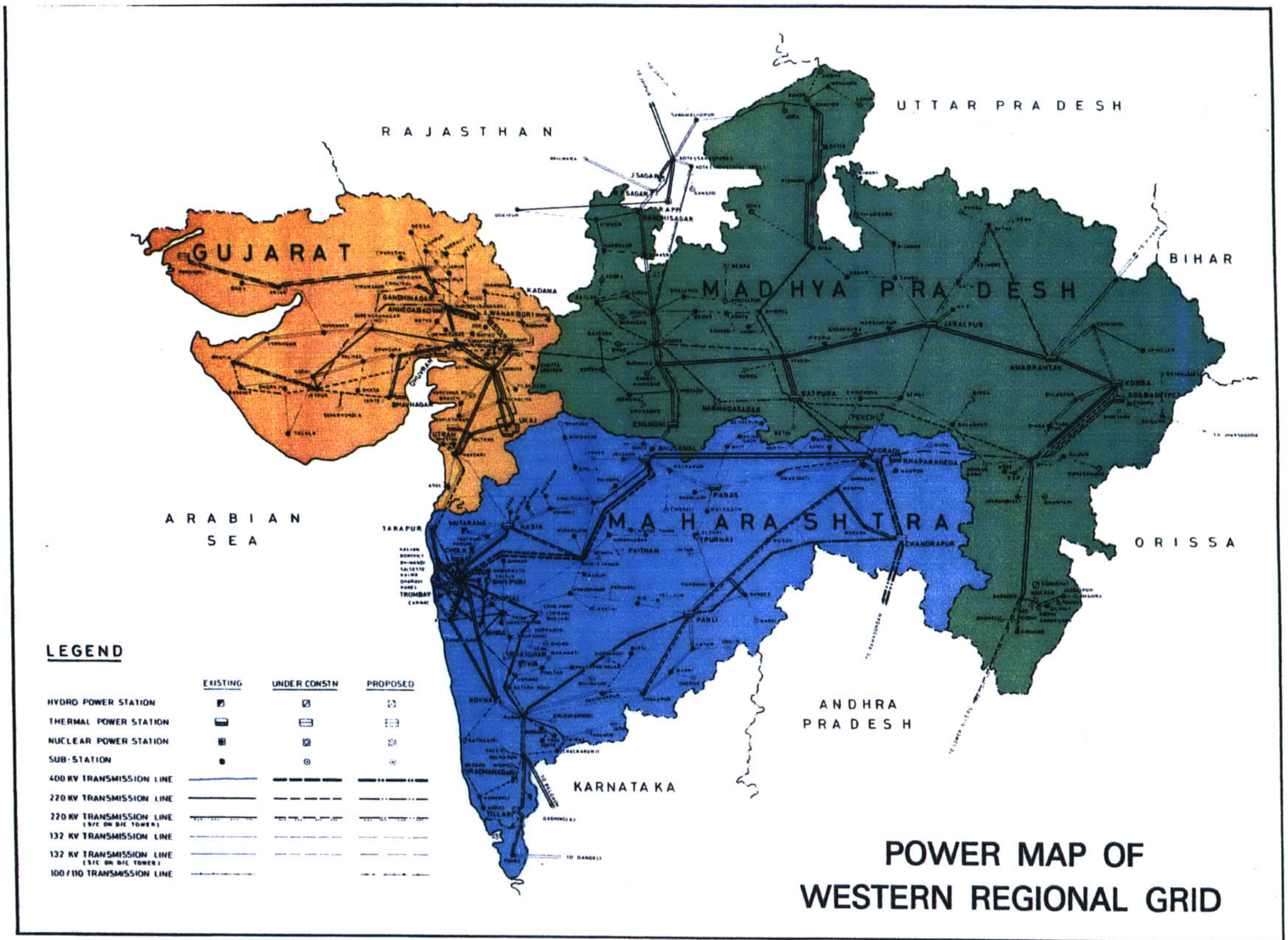
Electricity Regions
of India
New Delhi
Northern Region
Western Region
Eastern
Region
Calcutta
North-eastern
Region
Bombay
Southern
Region
Bangalore



POWER MAP OF WESTERN REGIONAL GRID

B.4

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