INFRASTRUCTURE INFORMATION REQUIREMENTS IN THE MARITIME PROVINCES: AN ANALYSIS

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PREFACE

In order to make our extensive series of technical reports more readily available, we have scanned the old master copies and produced electronic versions in Portable Document Format. The quality of the images varies depending on the quality of the originals. The images have not been converted to searchable text.

INFRASTRUCTURE INFORMATION REQUIREMENTS
IN THE MARITIME PROVINCES : AN ANALYSIS

A Study

by

The Department of Surveying Engineering

for

The Land Registration and Information Service

Council of Maritime Premiers

June, 1976

Preface and Acknowledgements

This study is one of a series of background studies undertaken for the Council of Maritime Premiers at the request of the Land Registration and Information Service.

Mr. Neil MacNaughton of the LRIS staff collaborated with faculty members of the Department of Surveying Engineering at U.N.B. in the preparation of the report, however the full responsibility for the contents of the report rests with two faculty members: Dr. A. Chrzanowski and Professor A.C. Hamilton.

The study team wish to acknowledge the whole hearted cooperation of all those who contributed information to the study. Two groups merit special mention:

i. The participants in the Workshop held at U.N.B., June 30 - July 3, 1975 and in particular those from outside the Maritimes who acted as resource persons namely, Mr. N. Riley, Cape Town, S.A.; Dr. G. Konecny, Hannover, W. Germany; Mr. R.A. Smith, Toronto, and Mr. Y. Dubé, Montreal.

ii. The members of the Halifax Utilities Coordinating Committee who met with the study team.

Those of the above groups who also completed the questionnaire merit special thanks.

AC Hamilton

A.C. Hamilton.

June 15, 1976

INFRASTRUCTURE INFORMATION REQUIREMENTS

IN THE MARITIME PROVINCES : AN ANALYSIS

INFRASTRUCTURE INFORMATION REQUIREMENTS IN THE MARITIME PROVINCES : AN ANALYSIS.

SUMMARY

The term infrastructure as used in this study means the stationary physical man-made elements of our environment such as public utility equipment, transportation and communication networks, and buildings.

The objective of the study was to outline the main components of an information system on infrastructure in the Maritime Provinces and to outline in a general way the steps to be taken in the establishment of such a system. At the start of the study a workshop was organized at which representatives of the major infrastructure agencies in the Maritimes participated. Following the workshop a questionnaire was circulated to the participating agencies and in some cases more detailed discussions took place. From this consultation it was concluded that there are two foci for infrastructure information: one is at the broad regional level where information is needed for operations and for planning; the other is at the urban or metropolitan level where quite detailed infrastructure information is needed for a multitude of purposes.

Progress reports on four computer-based systems being developed by federal agencies were reviewed along with reports on three commercially available interactive graphic systems. From these reviews and taking account of information systems in the planning stage in the power and telecommunications sectors it is recommended that steps should be taken as soon as possible on the development of a regional infrastructure information system.

To put the urban information problem in perspective a comprehensive review of some of the more advanced systems in cities elsewhere, mainly in Europe, was made. The main conclusion from this review was consistent with the consensus of representatives of the utility agencies in Halifax and Dartmouth - namely that a good graphical (map-based) system is a necessary first step before a computer-based system can be introduced.

Several specific recommendations are made on steps that should be taken to develop these systems.

1 INTRODUCTION

1.1 BACKGROUND

As the infrastructure system for our society becomes more and more complex, more and more costly, and more and more essential, the need to have a complete, accurate, and up-to-date information system on the existing infrastructure is slowly becoming apparent. In particular the need is being recognized to have the positional information concerning all elements of the infrastructure filed in such a way that an operations manager, an operational planner, a regional planner, an administrator, or an executive decision maker can be presented with a clear picture of the current situation and those elements which are subject to changes in any situation.

Canadian federal agencies have been amassing data for years but this data is too generalized for the study of specific regional problems of the Maritimes. By focussing on the need to improve the land tenure records of the Maritimes, as a first step to better land management, the Council of Maritime Premiers established the Land Registration and Information Service. LRIS began on April 1, 1973 on a ten year program to implement a simplified system of guaranteed land titles replacing an outdated registry system based on metes and bounds descriptions. Those who are familiar with the LRIS program will recall that it is designed to have four phases:

Phase I - The establishment of a secondary control system of coordinates;
Phase II - The production of medium and large scale maps;
Phase III - The implementation of an improved system of land registration; and
Phase IV - The development of a land information service (land data bank) based on the land information acquired in the other phases.

This study is one of a series of exploratory studies that is necessary in the development of Phase IV. Similar studies are being conducted in other land related fields such as mapping, assessment, environment and socio-economics.

A frequent problem in information management is the absence of the specific location of data elements. This study was initiated to explore the requirements of an infrastructure information system, and in doing so, to determine the "spin-off" benefits of positional coordinates, topographic and property mapping, and an improved land registration system in an infrastructure information system.

1.2 DEFINITIONS

There is much new jargon associated with any new technology. Three such terms are used repeatedly in this study. The definitions that we are adopting are as follows.

Infrastructure - One dictionary defines infrastructure as "*the permanent foundation or essential elements of a structure, system, plan of operations etc. distinguished from suprastructure*". Another dictionary defines it as "*the essential elements of a system or structure, composed of bases of which some, usually complex, network or structure is built; example ...... N.A.T.O.'s infrastructure of airfields and* *pipelines in different member states....*" Within the LRIS context it was desirable to identify under one heading all of the "physical plant" necessary for the activities of our way of life. At first the word "utilities" was suggested, however, in common usage utilities tends to be restricted to water, sewer, power and telephones. Sometimes telephones are not included in the colloquial definition of utilities. By using the word infrastructure, it is possible to include not only water, sewer, power, telecommunications, and buildings, but other man-made features such as transportation networks. By our definition, infrastructure then includes all the man-made features of our landscape.

Data Bank and Data Base - A data bank is defined as a file of data that is stored on some machine-readable medium such that elements can be selected as required. On the other hand, a data base is a much more flexible entity. Data may be put into the data base in some particular sequence, but it can be manipulated, combined with other data and analysed. The information that can be retrieved from the data base is much more than a simple selection of the elements that were put in. The Canadian Geographic Information System can be cited as one example of a data base. In the next chapter other systems that fit the definition of a data base are discussed.

1.3 THE OBJECTIVE OF THE STUDY

As noted above, this study is undertaken as one of the first steps in Phase IV in the LRIS program. In the terms of reference for the study the objective was:

"*To outline the main components of an information system on infrastructure in the Maritime Provinces and to outline in a general way the steps to be taken in the establishment of such a system.*"

Although it was not stated explicitly, it was implicit that the study would focus on the problem of *locating* the elements of the infrastructure system. This is not to imply that there are not many other important aspects to an infrastructure information system. It is recognized that other infrastructure component information such as type of material, load capacity, date of installation, maintenance records and many other items are all significant attributes. However, location is recognized as the best attribute by which different types of infrastructure elements may be correlated and therefore locating is basic to any infrastructure information system.

1.4 THE APPROACH TO THE STUDY

A study on infrastructure information is essentially a design problem. In most problems there are examples of similar designs elsewhere and the designers' task is to adapt a design to local needs, local resources, and local customs. For example, an architect who is about to design a library for a city can go look at other libraries and decide how he will adapt to the location, the needs and the resources of the city in question. Another example might be a systems analyst designing a computerized payroll system, where the analyst can look at other payroll systems and then decide how to adapt to the needs and the special requirements of the agency in question. The task in this study is more challenging because there is no computerized infrastructure information system functioning anywhere as yet. There are various manual versions of utility information systems, and there is a variety of computer graphic systems that will display a utilities cadastre or utilities information system. The fact remains that the system design problem that we are tackling has not yet been satisfactorily solved anywhere else.

In view of this it was decided: that we must do at least a cursory review of the state of the art of computer technology; that we should look at the major developments on land related information systems in Canada; and that we should look at the developments in the utilities field in some of the more advanced countries of the world.

We were aware that practical day to day problems completely overshadow conceptual and theoretical aspects of the problem of large information systems. As information systems are dependent on people we recognized that it was essential to involve officials of at least some of the agencies who have relevant data and who will be users of any system that may be developed. To open discussions with appropriate representatives of relevant agencies, we organized a four day workshop. The workshop established the contacts by which we were able to proceed toward the main objective of the study, namely, to identify the main components of an infrastructure information system for the Maritime Provinces. In Chapter 3 the workshop and the information stemming from it are discussed in considerable detail.

Finally, having reviewed the state of the art of computer technology, having reviewed the progress on relevant system developments in Canada and elsewhere and having discussed the needs of the various agencies of the Maritimes we were able to formulate models as a basis for further discussion. The models are presented in Chapter 5 and Chapter 6.

1.5 THE PHASE IV ROLE OF LRIS

As mentioned previously the activities to be conducted under Phase IV of the LRIS program are still very much at the exploratory stage. One emerging line of thought is that under Phase IV LRIS would assume the role of a coordinator and a broker between the managers of various files and the generalized users who occasionally require selective information from these files. An oversimplified drawing indicating the flow of data under this arrangement is shown in Diagram 1-1.

The term producer-user is intended to describe agencies that generate extensive and detailed files for their own use.

As shown in Diagram 1-1, groups of agencies might have a mutual interest in some elements of data. One such group might be those having a common interest

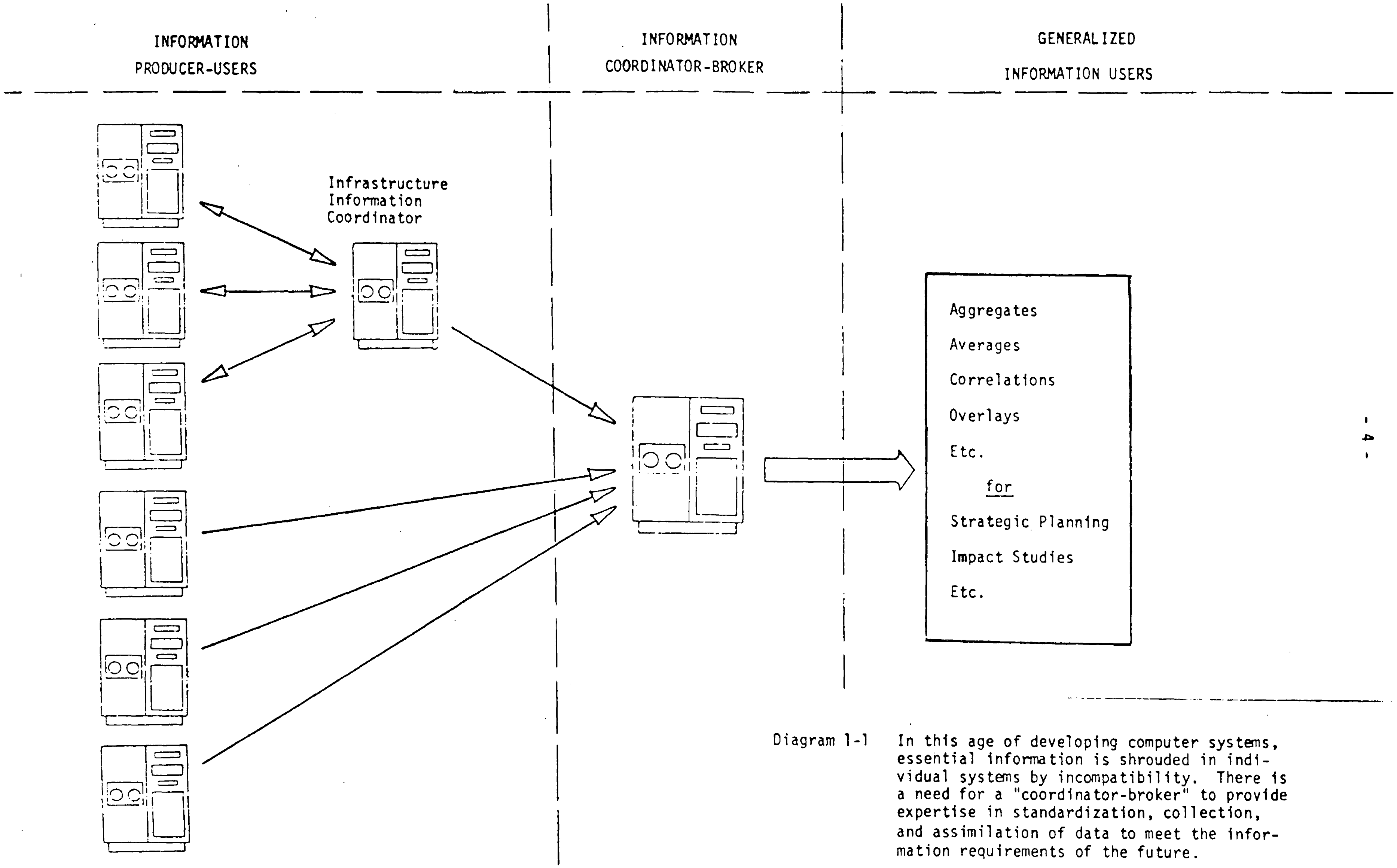

Diagram 1-1 In this age of developing computer systems, essential information is shrouded in individual systems by incompatibility. There is a need for a "coordinator-broker" to provide expertise in standardization, collection, and assimilation of data to meet the information requirements of the future.

in the infrastructure. Cooperation among these agencies could result in an infrastructure inter-agency group file or data bank. The inter-agency files would contain selected up-to-date overlays of common interest data which would be available to the contributing agencies and to an information coordinator on behalf of the generalized users. Examples or models of this idea are discussed in Chapter 6. Although the role of the coordinator-broker has not been clearly defined, it is the role visualized for LRIS under Phase IV of the program. The rationale for the specialized activity of the coordinator-broker is that certain elements in the inter-agency group files, as well as selected details of the agency files would be of great value from time to time for generalized uses such as planners, researchers and data collectors for macro information systems. The function of the broker would be to maintain the expertise, to develop special purpose software capable of extracting relevant data from the agency and inter-agency files, and to combine data from many sources to give the information in the form that is needed by the generalized user.

The coordinator-broker's role is designated as a special activity because it is a burden that should not be imposed upon the producer-user. It is assumed that an information brokerage service is of no direct benefit to the producer-users. It is a service, a "spin-off", to others. Generalized users are specialists in their fields of activity, and they do not have the expertise in information management, nor the experience with the data, that is needed to extract, and process the generalized information that they require.

Why should the producer-users cooperate with the coordinator-broker when there is no benefit to them? One answer is that the producer-users may sometimes become generalized users of other files. As full participating partners in the brokerage arrangement they are thus eligible to draw on the resources of the system. As a further inducement to the producer-users to participate in this integrated system , it is proposed that the services and the expertise of the coordinator-broker be made available to the producer-users for the establishment and the maintenance of inter-agency group files. In some circumstances their services could be made available for the establishment and maintenance of the agency files. It should be stressed that this does not imply that the ownership or the responsibility for the agency files or the inter-agency group files would reside in full or in part with the coordinator-broker. In the interest of data integrity, the responsibility of the data files must rest fully on the producer-users themselves.

The broker concept as explained above, illutrates how the system will operate after it is developed. During the development stage, the coordinator role will be dominant. Developing an information system that will be benefitial to all user groups requires extensive coordination of all the producer user agencies, as well as the generalized information users.

The generalized user, as a customer of the information system, has no data to contribute to the system but needs data from various files and at random intervals. The strategic or long-range planner is the first type of generalized user that comes to mind. Other users would be those doing impact studies, economic studies, or a wide-range of "broad-brush" studies.

Planners quote the figure of 70% as the proportion of their expenditure and effort that goes into collecting data for their work. Under this concept of an integrated information system, the planner's information could be available in an orderly process from on-going files via the coordinator-broker.

Here a note of caution is inserted. The concept visualized here cannot be achieved in a short time. As in the building of any substantial structure: there must be a clear definition of the concept; there must be a detailed plan prepared; there must be a firm foundation layed; and the structure must be completed. This study is an attempt to define the concept only. The road to a fully integrated system is long and strewn with pitfalls.

1.6 AN IDEALIZED INFRASTRUCTURE INFORMATION SYSTEM

Ideally every relevant scrap of information on all of the infrastructure in a region such as a metropolitan region, would be stored in a computer memory. Any selection of this data could be called up on a visual display unit (V.D.U.), and a hard copy (a paper print) could be made immediately if desired. The selection might be of all the items in a specific area such as a street intersection or it might be all the units of one class of items such as all of the sewer networks, all of the telephone lines, or all of the schools. Via the coordinator-broker the infrastructure information system could be linked to other data banks to give cross-correlations such as the residence location of all kindergarten age children or all people over 65 years of age.

The technology to achieve this ideal exists, just as it exists to send a man to the moon. This raises the difficult question: "When does it cease to be a luxury and become a necessary tool?"

In subsequent chapters the "state of the art" will be reviewed briefly. The infrastructure information requirements within the Maritimes will be identified and categorized. For some elements of the infrastructure there is a good argument in favor of proceeding immediately with a computerized system and for others a longer view should be taken.

Chapter 2, on technology and methodology, has been included to give a broader view on the subject of system development generally. In other words Chapter 2 should indicate the order of magnitude of the problem. Those who already have this perspective may choose to skip Chapter 2 and proceed to the report on the workshop on infrastructure information in Chapter 3.

2 Technology and Methodology

2.1 HARDWARE AND SOFTWARE (EQUIPMENT AND PROGRAMS)

The electronic computer has been talked about so much, its power has been boasted about so much, and its shortcomings have been criticized so much that the average person doesn't know what to believe. There are cases where the potential of the computer has been over-sold causing the computer to be introduced prematurely with the inevitable effect that it does not live up to its promise either in usefulness or in cost effectiveness. Thus a realistic perspective on the computer is needed when one is attempting to visualize information systems over the long term.

There are enough systems (hardware and software) now in existence to demonstrate that the major problems in connection with infrastructure information are not insurmountable. Unfortunately, hardware and software are not sufficient to make a successful system. There are other essential elements. Two of the most important of these are:

i. The procedures and the channels to collect data in a complete and correct form;

ii. The availability of personnel, not only to operate the system, but to provide the input and to utilize the output.

In subsequent chapters these two topics will be discussed in considerable detail.

2.1.1 Equipment

In Diagram 2-1, the basic pieces of equipment necessary for the operation of a digital graphic system are displayed. As indicated in the diagram the three primary functions are input, storage and processing, and output. The principal items necessary for each of these functions will be discussed briefly.

2.1.1.1 Input

i. Digitizing units Digitization means the translation of point and line positions on a plan or map into a machine readable format. There are many types of digitizers. The ones currently on the market require an operator to place a cursor on points or to "trace" the cursor along lines. Sensors within the equipment itself translate the position of the cursor into plane coordinates. Moving the cursor manually is a time-consuming operation and considerable difficulty has been experienced in getting error-free input into digital systems. There are research reports on semi-automated digitizing units but as yet no semi-automated units are on the market. It is, of course, implicit that the data being digitized must already have been surveyed and compiled in some form of map. Intuitively, it would seem to be preferable to collect the data in digital form and eliminate the need for a separate digitizing operation.

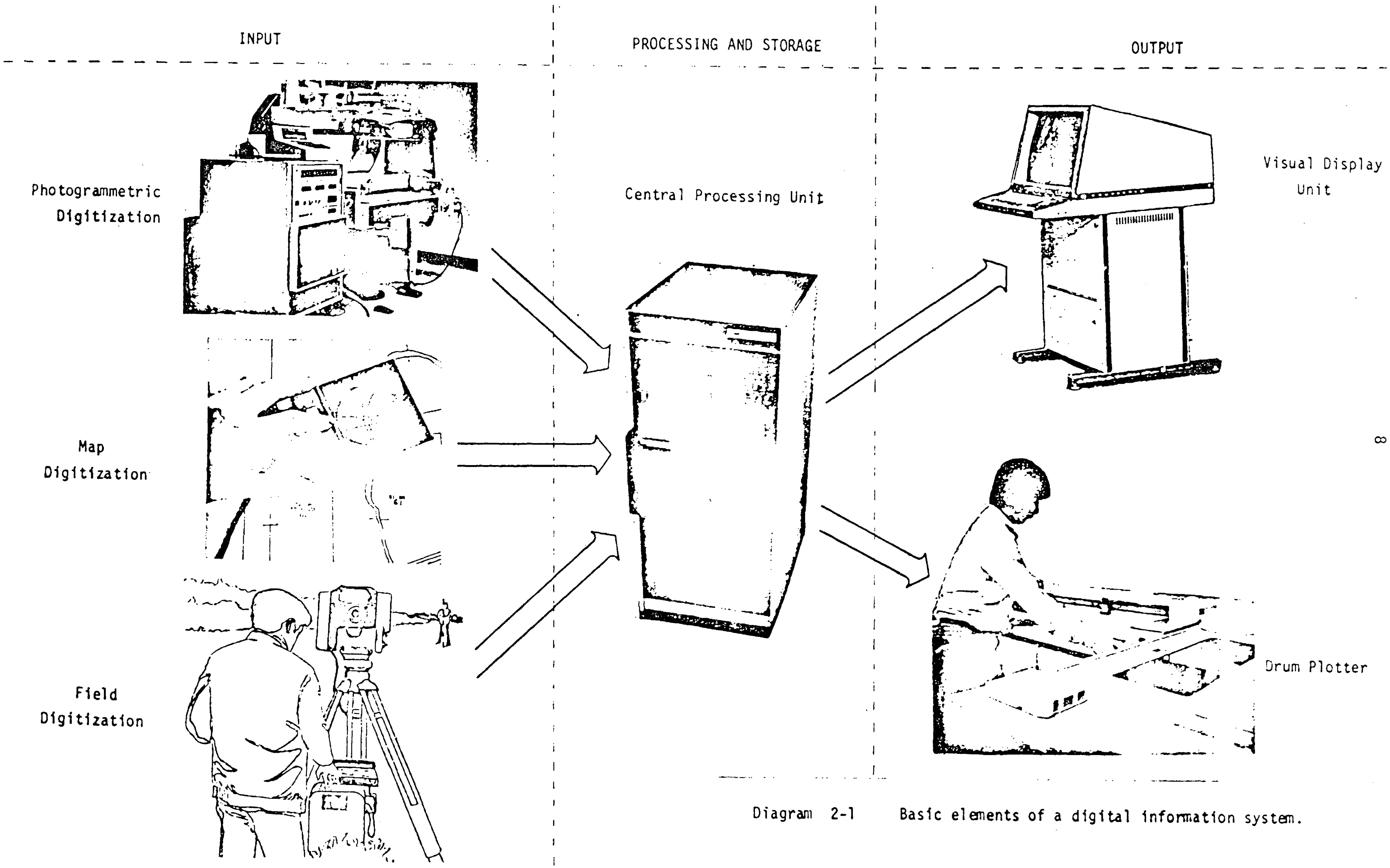

Diagram 2-1 Basic elements of a digital information system.

ii. Stereoplotters with Digital Read-Out In its normal mode of operation, a stereoplotter drives a pencil which draws the map features identified by the operator of the instrument. Encoders which are attached to the driving mechanism of the stereoplotter record the coordinates of the features in a machine readable format. For those features which can be identified on the photography and therefore in the stereoplotter, this method provides a reasonably economical solution to the input problem. Currently it costs approximately 20% extra to get a digital record when a map is being compiled photogrammetrically. The weakness of this method is that a large percentage of the infrastructure elements are either not visible or cannot be positively identified on the aerial photograph. Even on large scale urban photographs, underground utilities are not visible and many significant surface features are either too small to be seen or are obscured by trees, parked cars or tall buildings.

iii. Field Surveys Ground surveying or direct measurement of feature positions was the only source of data for mapping prior to the introduction of photogrammetry. The traditional methods of ground surveying, using conventional instruments such as transits, tapes, levels and stadia rods, is a labor-intensive and costly method of collecting data. New generations of field instruments are revolutionizing field surveys. Electro-magnetic instruments are used to measure distances quickly and accurately. Built-in mini-computers calculate horizontal distances at the "touch of a button" in the field.

This is a brief review of input options. In Chapter 6 the input alternatives are outlined in greater detail.

2.1.1.2 Storage and processing

There has been a series of dramatic improvements in computer hardware from the vacuum tube arithmetic units and magnetic drum memories of the early 1950's to the microprocessing units of the mid 1970's. The May 1975 issue of Scientific American describes a computer module containing the memory and processing unit of a modern LSI-11 minicomputer. The module has 65 000 "bits" of memory and more than 110 000 transistors, it can be carried in a suitcase and lists at approximately $1,000. Computer specialists are now talking of "zero-cost hardware", meaning that the cost of computer hardware will be negligible in comparison with the input, output and software costs of a computer system.

2.1.1.3 Output

A variety of computer-driven plotting tables have been available for several years. Those of the highest quality are capable of drawing at a much higher precision and many times faster than a skilled draftsman. Recent developments are promising further increases in the speed of plotting. Considering the standard "first order" plotters which are on the market now, the cost of plotting is a relatively small proportion of the total cost of operating a computer graphics system. These plotters, sometimes described as automatic drafting machines, are well suited for the plotting of complete map manuscripts but they are not at all suitable for interactive operations. The cartographic operator cannot interfere with the plotter or make changes while the plotter is in "plot mode". Thus if an error is observed it is necessary to make changes in the input tape, process this tape through the computer, and then have the plotter redraw the map. For interactive graphics, that is for tasks such as editing and revising map manuscripts, a Video Display Unit (V.D.U.) is needed. This is essentially a cathode ray tube, similar to a television tube, directly linked to a computer and equipped with a keyboard. With this arrangement the cartographic operator can key in instructions to correct errors that appear on the V.D.U. and the corrected map is immediately displayed. This capability is available in the General Purpose Systems that are discussed in sub-section 2.2.3.

2.1.2 Computer Programs

All the equipment discussed in the preceding section is of value only if there are the computer programs (software) to make it do something useful.

Hardware is readily identifiable in the mind of the layman because it is visible and tangible. The layman is easily misled in a discussion on software. A computer program on paper consists of flow charts and listings of coded instructions meticulously designed for an exacting idiot. A software package is generally made up of many subroutines which are standard sequences of coding which instruct the computer to do routine tasks. Lower level subroutines, such as those to drive a plotter, are fairly standard and usually they are included with the purchase of a plotter.

File structure design is even more fundamental to an efficient computer system than the actual programming of the subroutines. File structure is the arrangement of the data in the computer memory. An unsuitable file structure can make retrieval so expensive that the system must be abandoned. The design of the file structure should be done jointly by a computer system specialist and by those in the discipline for which the system is being designed.

In general, there is one line of coding for each entry in the program. The number of entries may be only a few hundred words for a very simple program or it may exceed one million for a sophisticated "Information Management System". Examining 50 000 lines of coding is of little help to the layman in evaluating a system. Watching a computer while it is processing data is of less value. Even by looking at the output the layman can be easily deceived. Hence it is not surprising that computer software systems are frequently oversold.

There are two ways to reduce the risk of being oversold. The first is to have a highly qualified independent evaluator assess the claims that are made for a software system, and the second is to make a thorough evaluation of the entire system from raw data to useful output. Here it should be noted that the entire hardware and software system is only the data management element of a much larger and more complex information system consisting of initial data entry, data management, edit and up-date, and information output. All these elements must be considered when evaluating a system.

In order to provide some perspective on the "state of the art" of system development, a brief review of several major land related systems is presented in the next section.

2.2 RELEVANT CANADIAN DEVELOPMENTS

Of all the Canadian computer systems that have been developed, only those that can store and display graphic information are of interest to this study. These systems can be grouped into two categories:

i. systems designed to solve a specific problem; (an example of such a specific problem is the display of land inventory data). These systems have generally been "in-house" developments by governmental agencies who could afford to invest a million dollars or more in research and development. Usually part of the justification for the expenditure has been that the system would be useful to other agencies.

ii. systems designed for "general-purpose" application. (They are usually developed by industry and marketed as a combined hardware and software package, with or without the addition of features specially designed for the customer.)

Some examples from each category will be discussed in the following subsection.

2.2.1 Review of Major Developments on National Land Related Information Systems in Canada

The extracts cited in the first three parts of this subsection are taken from the PROCEEDINGS OF SYMPOSIUM ON GEOGRAPHIC INFORMATION PROCESSING edited by Dr. Fraser Taylor and available from the Geography Department, Carleton University, Ottawa.

2.2.1.1 The Canada Geographic Information System (C.G.I.S.) : Canada Land Inventory

This was the first large land-related data base development in Canada. It is still, by far, the largest such development.

The following extracts, taken from a paper by W. Switzer included in the Proceedings mentioned above, give some indication of the purpose and the current status of this development.

"C.G.I.S. is a computer system to read, to store, to manipulate and to provide facilities for the analysis of mapped information."

"Originally C.G.I.S. was designed to meet the needs of the Canada Land Inventory.....The system as designed and implemented today meets the needs of the C.L.E. but also provides a mechanism or a tool for resource managers, land use planners and others with similar requirements.

"The objectives of C.G.I.S. were defined in the following terms: firstly, to present data in a form required for land use planning at the local, regional, provincial and national level..... secondly, the objective was to design a system which would collect and store from maps and statistical tables in a form that could be quickly analyzed.....Thirdly, the objective was to permit concise and compact data storage allowing comparisons within and between sectors with output in mapped or tabular form.....Fourthly, another objective was to permit comparison of data for given regions and the correlation of socio-economic or other data on a selective basis. This system does provide for a link with data such as that provided by Statistics Canada and other socio-economic data could be added if it had a geographic reference."

".....In 1966-1967, IBM Canada was commissioned to provide the necessary software, computer programs that is, and hardware to construct such a system..... By 1969 the first maps were in the data base and a retrieval system was first demonstrated. This was a very crude system at the time; difficult to run and totally unreliable. It was not until 1971 that the system entered full-scale production on a routine basis.....In 1974 the interactive graphics system was first demonstrated at a conference in Montreal. In 1976 83 per cent of all the Canada Land Inventory data at the 1:250 000 scale is in the data base....."

"In general the system was designed to handle line, point and area data. For the purposes of this discussion we will define point data as a value, a reading at a particular geographic location, eg. a sounding. Highways, railroads, pipelines etc. are regarded as line data, where the line has no meaning other than to separate areas. It is the bounded figure that is significant and has attribute associated with it. The current implementation of the system only includes area data. The point data capability should be added within the coming year and line data will seriously be considered. The system is capable of accepting, for area data, complex descriptors for each of the defined areas or, as we prefer to call them, polygons....."

"What does the data base look like? The data base has two components: one, the image or visual information, that is, the data necessary to define the bounded figures or the polygons which contain nothing but the line data; the second is the information that contains the description of each of the polygons of each of the bounded areas. It includes such things as its description identifier, the area in acres or in hectares and the centroid of where it is physically located. The perimeter of the area can be calculated."

"The first application illustrated a study of some aspects of rural land use change in an urban region. Specifically this data is for the Ottawa area. It was mapped at the 1:50 000 scale and we have land use for 1964, 1968, and 1973 with agricultural capability and the recreational capability fo the land. The methodology involved again is to overlay all the data sets to produce a composite, to convert the data base into a graphics data base which can be retrieved interactively and then to present the data to a researcher at a graphics terminal. You can see the importance of the overlay capability in C.G.I.S. It is used in virtually every request that we satisfy. The requirements always seem to be to provide data on a unit different than that from which it was originally collected. The system provides that capability. A table and map is produced on the screen beside which is a hard copy unit. By pushing a button on the terminal you immediately receive a paper copy of what is on the screen....."

"To summarize, what has been the investment to date? We are talking of an investment in the order of 300 to 400 man years and 8 to 10 million dollars over 10 years to provide an operational geographical information system. It is not a simple task to develop such capabilities. It requires a resource commitment to finally build a system that is capable of meeting many of the needs of resource managers, land use planners and other decision makers."

2.2.1.2 The Geographically Referenced Data Storage and Retrieval system (G.R.D.S.R.) : Statistic Canada

The following extracts were taken from a report by S. Witiuk.

"The GRDSR system is the result of five years of intensive research and development by Statistics Canada over the period 1967-1972 in response to the demands for increasing data munipulation and retrieval flexibility....."

"The spatial data sub-systems, from measurement to packaging, operate on two levels of resolution. The socio-economic data base framework has the population and household levels; the spatial framework has as its micro-area building block's the Enumeration Area (EA) and the Block-Face."

"For the purpose of automated population selection, mapping and spatial analysis, each building block is generalized to a point description. For the Block-Face, the centroid is located with a 22 meter perpendicular offset from the mid-point of the line segment(s) composing the Block-Face.....In the case of the Enumeration Area, the geographic centre of the region is not used since the uniformity assumption is not as valid due to the variety of topographic and cultural factors. Thus the'population weighted' centre is identified by manual methods and used to identify the population centroid of each E.A.

"The geocoding process is applied to both the Block-Face (urban geocoding) and the Enumeration Area (rural geocoding) building blocks. Since the goal of urban geocoding is not only to provide a machine-processable value for the Block-Face centroid, but also to automatically assign questionnaires to the appropriate Block-Face, a street network-oriented base map is converted into machine-processable form via digitization and street coding. Features in these Area Master Files (AMF's) are: street names and types; civic address ranges by Block-Face; 'Point Features' such as hospitals and Government buildings; rivers; municipal boundaries; intersection node identifiers; and railroads. Each entity has a positional indicator, namely a (Zone, X,Y) value within the Universal Transverse Mercator (UTM) projection system. Thus, each of these features can be represented graphically....."

".....In the case of rural geocoding, the only feature that is 'encoded' is the Enumeration Area identifier and the UTM (Z,X,Y) values of the centroid....."

2.2.1.3 The Geographic Information System : National Capital Commission (N.C.C.)

The C.G.I.S. and G.R.D.S.R. systems mentioned above are nation-wide in scope and are intended primarily to produce data for the generalized user however, the N.C.C. system was developed by and for an information producer-user. The N.C.C. system was designed for use in one city and primarily for unaggregated data. As the infrastructure study is primarily concerned with the producer-user aspect of data, the N.C.C. system is of particular interest. Therefore, several pages from a report by D.C. Symons are included.

"The National Capital Information System is an integrated system designed to provide timely and accurate information, from a detailed time-series data base, about the National Capital Region. This region of 1800 square miles has a population of approximately 750 000 and includes both urban and rural land areas.

"The program includes six subsystems, of which the first four are identified in this text. They are:

- The data base, which consists of municipal assessment and census records, street files, and event files such as vital statistics, location of fire calls and other social and economic information.

- A geocoding system is a means by which land ownership parcels are geographically identified.

- A retrieval subsystem, which consists of a generalized file management/ filed retrieval system using an English-like command language.

- A graphic display subsystem, for mapping retrieved data by such methods as SYMAP, Plot 3-D, line graphs, as well as plotting planimetric property ownership maps.

- A model subsystem which is a series of mathematical models designed to use the time-series data base.

- A capital improvements subsystem designed to provide information on scheduling of public capital investment projects in the National Capitol Region.

"DATA BASE: Reference System: In order to furnish users with information from the data base, and within the arbitrary geometric shape specified, a geographic reference is required to which data may be referenced or coded. While the accuracy of the spatial framework will vary in accord with the precision of the mapping adopted, there are three general characteristics the system must have to permit data retrieval.

1. The data must be identified geographically in its most disaggregated form.
2. The data must be identified by a geographic code.
3. The location of each data set must be unique.

"To relate data concerning land, buildings, and the services they require, it is necessary to adopt a uniform reference system to precisely and uniquely identify their location in the National Capital Region. A geographic grid consisting of parallels of latitude and lines of longitude provides the overall control grid for the region. When this grid is projected onto a plane surface it gives it unique numerical values for any location.

"The National Capital Region falls entirely within zone 9. When legal survey work is done in Ontario using a coordinate system the 3^{0} Modified Transverse Mercator projection is mandatory. For large scale mapping, the National Capital Commission Surveys Section uses the 3^{0} MTM system exclusively for both legal surveying and photogrammetric mapping projects. Although there is no provincial regulation in Quebec legally defining the use of a specific map projection current practice established by the Department of Lands and Forests is to use the 3^{0} MTM grid system....."

"DATA BASE Description: The property data to be identified by geographic code is carried on the file in its most disaggregated form. This includes the information for each ownership parcel which will be keyed to the coordinate system. This data, in part acquired from municipal assessment records, combines the unique property identifiers used by the assessor, and includes property address, legal description, file number and roll number. Each of these identifiers serves a special purpose, and while they may be shown on local assessment maps, they are not suitable for retrieval on a geographic basis.

"Because the property information is essential for the tax base of the municipality, records of this type will be updated annually. Information on persons is required by the municipality for the purpose of preparing electoral and jury lists as well as to determine school support classification. These records are usually updated annually. Thus the data base has a built-in legal requirement to be maintained in an accurate and current status.

"Table I, following, shows the extent of the data base in millions of characters. Approximately 270 000 land ownership parcels are included in the property records. Table II indicates the size of the data base and change file needed for examination of a time-series data base.

DATA BASE: NATIONAL CAPITAL REGION N.C.C. Table I

Record Type	Record Length	Number of Records	Total (millions of characters)
property	440	270,000	119.7
sales	160	204,000	32.6
buildings	160	272,000	43.5
establishments	80	54,000	4.3
households	80	249,000	19.9
persons	240	660,000	178.4
events	variable	variable	181.4
topographic maps	variable	variable	125.0
cadastral maps	variable	variable	12.8
			717.6

SIZE OF DATA BASE AND CHANGE FILE BY YEARS N.C.C. Table II

Year		Data Base	Base Year File	Change File
		Millions of Characters		
1971		700	700	
1972		717	717	76
1973		746	717	155
1974		776	717	238
1975	ESTIMATE	807	717	323
1976	"	839	839	89
1977	"	873	839	182
1978	"	907	839	278
1979	"	944	839	379
1980	"	982	982	104

" PARCEL GEOCODING: The parcel geocoding system is a means by which urban data may be geographically identified and then retrieved from within any arbitrary polygon, circle or area of intersection of these geometric shapes. Specifically, parcel geocoding refers to the application of 3^{o} MTM coordinates to individual property ownerships and assessment parcels in both urban and rural land areas so that all land and water, public and private, is included.

"It should be noted that the procedures described are general in nature and may be applied to any geographically located information. Because the system has this characteristic, it may be applied to a wide range of urban (and rural) operations and analysis such as the following:

i. Urban redevelopment studies.
ii. Public and private housing analysis.
iii. Determination school service areas.
iv. Real estate registration.
v. Land acquisition programs.
vi. Mapping for municipal services, public utilities, and assessment.
vii. Analysis of social, economic, health data in user specified arbitrary areas.

"In order to provide unique geographic identity for each ownership parcel in the region in a form suitable for computer retrieval, three components are required:

i. An automated assessment and municipal census file.
ii. Base maps showing ownership parcels with 3^{o} MTM control.
iii. The ability to allocate coordinate values to parcels.
iv. Computer programs capable of both generating map plots and providing random access retrieval on the basis of coordinate values.

"Parcel Geocoding: 3^{o} MTM coordinate values are recorded for each parcel and are keyed into the data base by means of the parcel identification or roll number. 40" square cadastral base map with 3^{o} coordinate control is used as a source document. The following information is recorded by means of a programmable X,Y coordinate digitizer.

i. Map Identification:

a. The minimum and maximum X,Y map coordinates.
b. Map control points, usually four, 3^{o} MTM value.
c. Scaling control points.
d. Map number and scale.
e. Adjacent map numbers.

ii. Property Identification:

a. Roll number.
b. Parcel centroid.
c. Property boundary coordinates.

This information is adequate to provide a geocoded file of assessed land by relating coordinates and roll number. While this file geographically identifies assessed land, it may not identify roads, streets, intersections or other land not listed on the tax rolls. In an urban centre this may be as much as 30% of the land area. In order to assure that all land is identified, the following additional information is recorded:

iii. Block Identification:

a. Block number.

b. Block boundary coordinates (these are the same as property boundary coordinates and are recorded only once).

c. Block face sequence number.

d. Block face identification, street name, river, railway, etc.

"The digitizing process was extended to capture the coordinate values of the property boundaries. The addition of these coordinate points to the file increases the time required for digitizing by about 20%. However significant cost savings were realized because the data was displayed in map form by means of an inkline plotter with editing and error correction done visually from the map plot.

iv. Street and Intersection Identification: All information needed to uniquely identify streets, street intersections and other non-assessed land is derived directly from coordinate values previously recorded for properties and blocks. With the addition of coordinate values for each block corner or change in street direction, the system gives a complete description of the polygons enclosing both street segments and intersections. The centroids of these polygons may be calculated if required. As part of the graphic display subsystem a plot program was developed which displays the captured data in a graphic form. This program is used to plot the data for edit purposes as well as the production of property ownership maps and has the capability to assemble map section into a composite map contiguous with the arbitrary retrieval polygon.

"The geocoding system produces a geocoded file with all information in the data base keyed to unique geographic locations. The geocoded file has the following characteristics:

i. All land (and water) within the boundaries of a political subdivision is identified.

ii. All property ownership parcels have a centroid with 3^{o} MTM values.

iii. All property boundaries are recorded in 3^{o} MTM values.

iv. City blocks are considered as polygons with all vertices having coordinate values.

v. Street segments are considered as polygons with all vertices having coordinate values.

vi. Street intersections are considered as polygons with all vertices having coordinate values.

"Retrieval: The geocoded data base consists of a number of files keyed together, so that any data in the data base may be retrieved and easily cross-referenced. The ability to do this greatly reduces the need to force together data that is not frequently needed with data from two or more different files. The primary technique employed in a multi-file retrieval is to search one file to find data to use as parameters to condition the search of another file. The file is structured geographically, within political subdivisions, on the basis of the 3° MTM coordinate values of centroids. User requests must include the following:

i. Special dimension eg. any arbitrary geometric figure.

ii. Time dimension eg. the calendar year.

iii. The data required.

iv. Statistical operations to be performed: eg. range from list of disaggregated data to statistical analysis.

v. The form of final presentation: tabular listing, graph, tonal map, output from inkline plotter, or CRT.

"The user may specify the spatial dimension in a number of ways, and the system is designed to retrieve data whose points fall within defined areas. These include:

i. Interior area of an arbitrary polygon.

ii. Area of intersection of two arbitrary polygons.

iii. Area of a circle.

iv. Area of intersection of two circles.

v. Area of intersection of a circle and a polygon.

"In addition, algorithms to determine the relation of centroids and other X, Y coordinates to boundaries, have been written for the purpose of assisting the user and providing system flexibility. These include:

i. Determination of the X, Y coordinate value of the intersection of two lines.

ii. Determination of the X, Y coordinate value of the points of intersection of a line and a circle.

iii. Determination of the coordinate value of intersection of a point and a line.

iv. Determination of the coincidence of two points.

"Street Address Directory: The basic building block for the system is the ownership parcel. The data base, with centroids for each parcel, may be used to create a location directory. The location will show all dwellings even if they do not have a civic or street address, by ascending order (or descending) along a street. If desired, the location directory may be produced for one block face only. This "location directory" may be created for rural areas and for any other area where rural route numbers or box numbers exist. Street address anomalies such as non-sequential civic house numbers are not a problem as addresses are retrieved from the data base and listed in sequence. The location or address directory may be used to relate non-geocoded data files to the base file by means of address matching software.

"The advantages of the system maybe summarized as follows:

i. The system is not tied to civic address and therefore may be used in rural areas and municipalities. Thus the system may be extended to include non-urban data.

ii. A "location directory" may be created in a form most suitable for the user's need. For example, this may be a directory of land ownership parcels by block or a directory of dwelling units by block face. Other types of directories are possible and are not limited by a lack of civic address. In rural municipalities, a "location directory" may list land ownership or dwelling units in a specified direction along a rural route.

iii. The system is computationally simple and avoids the need to define address ranges for block faces. Anomalies in addressing are avoided.

iv. The system may be used to identify and record the location of municipal services and public utilities, railway lines or other siginficant physical features such as rivers.

v. The system may be used to describe street segments and intersections in a form suitable for computer mapping.

vi. Experience has been that the system has been less costly and easier to implement than originally estimated.

"The system is not without certain problems, most of which can be overcome by effective administration and operations planning.

i. Adequate mapping is required in all areas to be geocoded. Today's assessment maps may be modified to fit the coordinate control, usually without serious loss in quality. Rural areas, however, frequently do not have any assessment maps and the more rugged terrain is more costly to map, even using photogrammetric techniques such as orthophoto mapping.

"Precise planimetric maps are required in metropolitan regions, for purposes other than geocoding and it is hoped that new mapping of this type will be integrated into the control network.

ii. Both data quality and equality varies greatly across the region. For example, the use of alphabetic coding for important data items increases the difficulty of using computerized statistical routines. The advent of regional governments of both Quebec and Ontario may help standardize coding and classification of information.

"Data Management System: Integrated with the retrieval system is a data management system, a prerequisite if large amount of urban information are to be used effectively. This requires that attention be given to standardization of data definitions, identification, classification and collection. It also permits the addition and deletion of data elements, and new components as experience and conditions change.

"The basic purpose of data management system is to provide data base creation, data base restructuring, data base maintenance, retrieval and report generation. The facilities provided by D.M.S. are designed for use by a wide range of users. The basic level language is designed primarily to allow novice users to query the data bases, to construct procedures containing simple or complex retrieval, sort, compute, and report facilities to produce ad hoc or recurring reports, and to execute pre-stored procedures written in either the basic or full level languages. The full level of the data management system language extends the facilities provided in the basic level to a full procedural programming language.

"Graphics: The effectiveness of user oriented systems depends on the fragile process of communication and cooperation. The graphics system is primarily a means to deliver to the end user statistical information and other data in a form which can be easily understood. The success of the information system is due in part to the capability to deliver user acceptable graphics.

"Property ownership maps have been described earlier in this paper. Parallel to this work a semi-automatic topographic map system has been developed. A coordinate digitizer is used to capture data directly from a photogrammetric plotter and record the data directly on magnetic tape.

"The magnetic tape containing all of the necessary X, Y and Z data along with its related topographic coding, can also be considered as a map. The system places this map (magnetic tape) onto a digital plotter system in order to produce any number of bi-products, some of which could be conventional two-dimensional representations of the terrain on paper. Each of these bi-products can then be produced to the scale, content, density, symbol, area, and in a state as requested by the map user.

"This differs from the conventional map and it does introduce much more flexibility into the mapping process:

. maps can now be continuously updated eg. by means of computer manipulation of data;

. it will be possible to update small scale maps from those produce at a larger scale;

. it directly relates the map to a data base consisting of multi-storage files with social and economic information;

. the map in digital form be used to generate the same topographic information into any variety of projections eg. perspective views of highway in line drawing; sections, sewer profiles, etc;

. it will be possible to coordinate automated property ownership maps with topographic data showing evidence of land occupation.

"The system of information is not simply an inventory of data but a time-related dynamic flow in which the information is displayed in a variety of patterns over time. Also information flows reveal interfaces that are inter-, intra-, and extragovernmental in character and it is these communication interfaces which create the challenge to the designer of the system.

"Clearly, the development of effective, user-oriented systems depend on the very fragile processes of communication and cooperation.

"A successful system requires a commitment from management, and a sensitive imaginative management as well. When should a decision be made to abandon a programming project and start in a new direction? To what degree will systems development plans be affected by an external event such as an energy shortage, and how soon can such effects be evaluated? Clearly, issues such as these require the most able management talent in the organization -- presumably the most senior management -- and require that time be taken to review plans and be informed as to the content and extent of the program." ".....it is estimated that over the past five years approximately $1,000,000 has been spent and one hundred man-years expended".

2.2.1.4 The Canadian Automated Cartography Data System : Surveys and Mapping Branch, Department of Energy, Mines and Resources.

Extracts from a paper by Zarzycki, Linders and Harris give an indication of the purpose and the operation of the Canadian Automated Cartography Data System. This paper is published in the Proceedings of the Conference of Commonwealth Syrvey Officers, 1975 available from the Directorate of Overseas Surveys, Tolworth, Surrey, U.K.

"The principle objective of the original version of the system was the economic production of high-quality and highly accurate fair drawings of the 1:50 000 scale National Topographic Series maps. The system used table digitizers for data collection and a digital drafting table for data display in a real-time mode of operation. The aim was to combine the capabilities of the human cartographer with the enormous computational power of the computer....."

"The drafting machine draws the graphic from a computer controlled cartographic digital data file. The feature to be drafted can be automatically selected as can the symbolization, the scale, the projection etc. Moreover, since the 1:50 000 map acts as the foundation for many thematic maps, the extension of the system is evolving as a general purpose cartographic facility. Thus, the version of the software now being completed accomodates the needs of other areas, eg. those of the Geological Survey maps."

2.2.2 Comments on the Systems Summarized Above

2.2.2.1 General Comments

Although the Canadian Geographic Information System, the Geographically Referenced Data Storage and Retrieval System, and the Canadian Automated Cartography System are all national in scope, they are relevant in at least two ways to anyone concerned with regional systems. Firstly, it is probable that there is a mutual interest in certain data elements and secondly, by studying the experience with these systems, it is likely that certain pitfalls can be avoided. The National Capital Commission Information System is of direct interest to anyone planning the development of a regional or urban system because it is confined to one metropolitan region. The N.C.C. development received support from the Central Mortgage and Housing Corporation to demonstrate what could be done in a medium-sized (500 000±) metropolitan region. For this reason lengthy extracts from the report by Symons were included in part three of section 2.2.1. Regrettably the software developed at the N.C.C. has not been documented adequately to permit its use elsewhere. Some software capability to compile maps of underground utilities has been written but it is not yet part of the N.C.C. data base. However, in view of the fact that property topographic and socio-economic data are being included in the N.C.C. data base, it merits careful study by any group that is starting on the development of an urban information system.

2.2.2.2 System development costs

Obviously the development cost is related to the complexity of the system and the size of the data base. The C.G.I.S. system at eight to ten million dollars and 300 to 400 person years is the most costly system of its type for which figures are available in Canada. No figures on the cost of the development of the Automated Cartography System have been released, however, one can estimate that it is comparable to the one million dollars and 100 person years quoted for the N.C.C. system. Although there is some useful production from these systems, both are still quite definitely in the development stage.

2.2.2.3 System Cost-Benefit Ratio

Cost-benefit ratio is a subject which most information system developers perfer to avoid. The study was unable to find reliable documentation on cost-benefits from informal duscussion with various workers in this field.

In their papers and progress reports, systems development teams tend to emphasize the strengths of their systems. The fact that no team has yet made any strong claims of person-hour savings in production leads one to suspect they have not achieved any significant reduction. If there is no immediate cost reduction, it is logical to ask the question "Why digital graphics?" Some of the reasons were mentioned in the extracts cited above and some came up in the discussions with those who are considering digital graphics and those who are working on the development of digital graphic systems. These are summarized as follows:

i. New capabilities; Computer graphics can make possible tasks that are virtually impossible by manual methods. Many examples of this can be cited in the experience of Statistics Canada and Canada Land Inventory.

ii. Time; Many tasks cannot be completed manually in the time that is available.

iii. Up-dating; Conventional maps are static once they are issued. When changes occur, it is impossible to add the changes to all the copies that have been issued; it is difficult and very costly to reprint a map and distribute it every time there is a change. Thus there is no practical way of satisfying the user who needs up-to-date information by conventional methods. By having a digital data base linked to V.D.U.'s it is now possible to satisfy this type of requirement - to give the user a "dynamic" map.

iv. Revision; The conventional method of up-dating is by revision on a cyclic basis. It is anticipated that for many map series - particularly multi-colour series - the cyclic revision practice will continue. However, if there is a data bank for the maps and if the data bank is kept up-to-date it will be possible to make the revision in less time and at lower cost than by manual graphic methods.

v. Building for the future; Many benefits such as time series analysis will only be realized when we have had digital files built up for many years. Therefore, the longer we delay the start of file building the longer we defer the benefits from this type of analysis.

2.2.3 Examples of General Purpose Systems Available Commercially

2.2.3.1 Intermap

The Intermap system is marketed by Instronics Ltd. of Stittsville, Ontario. The system was developed by the Graphic Systems Design and Application Group of the Electrical Engineering Department, University of Saskatchewan, Saskatoon, in cooperation with Dynamap Ltd., Saskatoon.

Dependent on the hardware and software configurations of the system Intermap can be used in the following three applications:

i. digitizing from a table digitizer or a photogrammetric instrument;

ii. manipulating and editing digital mapping data;

iii. storage and retrieval of data as a geographic information system.

Intermap is a "dedicated" system in that only one user at a time can use the system, (i.e. no time sharing is possible). The system is controlled by a PDP8e computer which has 8 k word core memory (maximum), each word is 12 bits. All of the above applications require at least one "on-line" disk unit (1.6 x 10^6 words) and a magnetic tape unit. One, (or preferably two) Tektronix 611 display units are needed.

The system has some of the most advanced interactive editing features presently available on the market such as the positioning of attribute names in refresh mode, connection and erasure of features, and drawing features at different thicknesses or with different symbols. These features are made possible through special hardware modifications on the Tektronix display unit.

Intermap, as it stands, is well suited to one user for fast storage and retrieval of the data in the three applications which are listed above. It is not suitable for a data management system. The computer word length of 12 bits is not common for other computer models and this may result in additional software being required to handle data from other systems. The Intermap software does not "lend itself" to modifications by a user for his particular requirements.

The cost of a complete stand-alone Intermap configuration including disk drive, magnetic tape drive, PDP8e controller, Gradicon digitizer and software is currently $109,000.00.

2.2.3.2 M & S

The M & S System was developed by M & S Computing, Inc., Huntsville, Ala. The M & S System is an Interactive Graphics Design System which was designed primarily for engineering applications. Therefore digital mapping and geographic information system applications are secondary considerations. The M & S system runs under the standard operating system of the control computer, which allows the users to apply or develop the software which suits their particular application. The software was designed to be modular in structure. Recent involvement of M & S Inc. with some mapping organizations (particularly for large scale city maps) should result in more software development for mapping purposes. The hardware components of the system are all "off-the-shelf" components with minimum hardware modifications by M & S Inc.

The system is controlled by a PDP-11/35 computer (16 bit word computer) the memory of which can be expanded to 128 k words. It is claimed that the system can control up to eight terminals on a time sharing basis. The terminals can be digitizing stations and/or editing stations and on "on-line" plotter. No figures are available for the response time when eight terminals are used simultaneously. Research is being carried out by M & S to develop new techniques to reduce the search time of disk storage. A "disk filter" has just been developed for this purpose.

A basic M & S system for digital mapping (inputting and editing of digital data) will consist of a PDP 11 computer with "on-line" disk storage, two CRT display units (one Tektronix 611 and one Tektronix 4014), a digitizer with a menu tablet, and a hard copy unit or a drum plotter. The computer memory can be as large as 128 k words and the disk storage up to 88 m bytes.

The cost of this hardware ranges between $145,000 to $230,000, depending on the particular models of components selected. The cost of the software is about $35,000. The software is usually marketed together with some or all of the hardware components which are assembled and tested by M & S Inc.

The software allows basic interactive graphic functions not particularly designed for cartographic applications as in the case of the Intermap system. It also allows storage of the information in the form of overlays (up to 32 in number). All the overlays can pertain to one map sheet.

2.2.3.3. CALMA

The CALMA system is marketed by CALMA Company, Reston, Virginia. CALMA is a "stand-alone" system built for interactive engineering applications. The system presently has more software facilities for digital mapping applications than the M & S system. CALMA is being used in the handling of geological and topographical maps by the oil industry in the U.S., and in large scale city mapping by some gas companies.

CALMA uses a powerful tree data structure. The system is controlled by one of the Data General computers (the Nova and, more recently, the Eclipse model). Some of the hardware components, such as the table digitizer, and all the interfaces are built by CALMA. (Hardware maintenance of the system is preferably controlled by CALMA and not by manufacturers of the individual components). The system software does not run under the general operating system of the computer and the users are not encouraged to modify the software. However, particular applications can be implemented by a special macro programming language named Command Programming Language. This allow a user to chain a number of instructions already existing in the system into functions and to chain individual functions into complex functions.

The system allows up to five terminals. The terminals can be any combination of digitizing, displaying and editing stations. (The response time if more than one terminal is used may not be satisfactory). A drum and/or a flat bed plotter can also be driven by the system. As it stands, the system is quite suitable for large scale urban mapping and for storage of information in alphanumeric form related to a geographical base. The system uses 48-bit precision of X and Y coordinates (which allows more than nine decimal digits for each value).

A "stand-alone" system consisting of an Eclipse computer (32 k core memory, 16-bit word length) with hardware multiply/divide, "on-line" disk storage of 25 m bytes, a 9 track magnetic tape, an editing station (consisting of a CRT display and menu tablet) and a Calcamp 936 plotter costs about $170 000.

2.3 THE PEOPLE PROBLEM

Success in the introduction of a new way of doing things is more dependent on the people involved than on the "state of the art" of the new technology. Many enormous cost overruns have been incurred in introducing new technology because the people problems were not adequately identified and solved.

Although the study team has no expertise in the field of personnel management it does recognize the potential for problems due to people when a system conversion is undertaken. Attention is drawn to the personnel management problem to ensure that in any eventual development of an infrastructure system, this problem will not be overlooked.

There are many dimensions to the people problem, but we shall consider three people groups: the managers; the development team; and those affected by the new technology. Concepts, skills and attitudes are three attributes of system conversion that are critical at the time of conversion. The following matrix shows the importance of these attributes for each of the identified groups.

	Concepts	Skills	Attitudes
Managers	* * *	*	* *
Development Team	* * *	* * *	* * *
Those Affected by the System	* *	*	* * *

NOTE: The number of stars indicates the relative importance of each attribute for each group.

The required characteristics for each group will be discussed briefly.

2.3.1 Managers

It is not trite or trivial to say that managers rarely understand the full implication of a computerized system. On one hand, they may regard it as just a few pieces of equipment: equipment that hopefully will be a bit more economical than their present system. On the other hand, they may expect miracles immediately. In practice they are likely to be disillusioned on both counts. In the short term, digital graphics is unlikely to be more economical and certainly will not bring about a miraculous improvement. What digital graphics is likely to do is to stimulate changes throughout the organization.

The major challenge to management is timing. If new concepts are resisted, the organization develops the reputation of being obsolete, out-of-date, and stagnant and consequently the more progressive individuals leave for a more stimulating environment. When new concepts are introduced prematurely, some individuals feel threatened and there is passive resistance leading to delays, additional costs, confusion and frustration. Time spent in thinking about a new system is not time wasted. All of the concepts must be fully understood by the managers.

2.3.2 The Systems Development Team

Whether the organization is buying a package of hardware and software or buying hardware units and building its own software, the organization needs a team of research calibre people. If a hardware and software package is bought, the development team can be much smaller. Whether a package is bought or developed, imagination, initiative, creativity and productivity are required. Staffing the research and development group entirely by transfers from a typical production staff is a sure road to failure. A combination of innovators with a few progressive production-oriented people has the best potential for success.

2.3.3 Those Affected by the System

As discussed above, the impact of a computerized system is likely to be extensive, and the full benefits of the system will not be achieved if there is active or even passive resistance to it. The significance of those people responsible for collecting the data for up-dating must be studied in detail.

2.3.4 Recommendations re "People"

The people problem is critical to the successful implementation of a new system therefore it is essential to:

i. ensure that the entire management understands and supports the concept;

ii. ensure that the development team is sufficiently talented and energetic to get the job done;

iii. ensure that all those affected understand the system and are motivated to work with the system rather than against it.

2.4 CONCLUSIONS AND COMMENTS ARISING FROM THIS REVIEW OF TECHNOLOGY AND METHODOLOGY

i. Conclusions: *For a price it is possible to do virtually anything one wishes with spatial data.*

Comment: One must look very carefully at potential systems to ensure that they will be worth the investment. Managers, in their enthusiasm to get funding for a new system, all too often have submitted over-optimistic schedules and budgets. Although they have, in fact, made good progress from a research and development point of view, they are discredited because they failed to meet time and budget commitments.

ii. Conclusion: *The cost of developing a large data management system is very high.*

Comment: Independent development of such a system should be considered only if an adequate system is not available commercially. Transfer of systems from other agencies is possible but tends to be accompanied by many problems.

iii. Conclusion: *Unless there is some "motive force" - some day-to-day need a geographic data base is likely to remain a technological novelty - something that is interesting but not relevant.*

Comment: To appreciate this concept one can ask the question "Why is it that a computerized payroll or an airline's reservation system can be kept up-to-date whereas geographical systems tend to be months or years behind?" The reason is that irate employees on payday or irate passengers at an airline's check-in counter provide the "motive force" that spurs management to maintain the system at a reasonable level of usefulness.

iv. Conclusion: *Agencies who have used computerized systems just to replace manual procedures have not, in the short term, been able to demonstrate significant person-hour savings.*

Comment: A computerized system should only be introduced if there is (are) objective(s) other than to save person-hours on present procedures.

v. Conclusion: *Fragments of spatial data are of negligible value to a comprehensive data base.*

Comment: A "crash" program to digitize all the data for a region is needed in order to make a geographic data base functional as quickly as possible.

vi. Conclusion: *The people problem is critical to the successful implementation of a new system.*

Comment: It is necessary to ensure: that the entire management team understands and supports the concept; that the development team is sufficiently talented and energetic to get the job done; that all those affected understand the system and are motivated to work with the system rather than against it.

These all sound like "motherhood" recommendations but they are spelled out because of their importance.

vii. Conclusion: *By focusing entirely on hardware and software problems, some developments have lost sight of the user and his needs and have omitted up-dating procedures.*

Comment: For an infrastructure information system the following is suggested:

- Identify the users and define their requirements.
- Develop the up-dating procedure.
- Design the method for the initial "capture" of the data.
- Make a decision on the hardware - software package.
- Review all preceding steps.
- Contract for the hardware - software package and for the initial data collection.

3 THE WORKSHOP ON INFRASTRUCTURE INFORMATION SYSTEMS

3.1 THE RATIONALE FOR HOLDING A WORKSHOP

In a society where needs are not realized until they become demands, the practical day-to-day problems overshadow conceptual and theoretical aspects of infrastructure information systems. On the other hand, an infrastructure information system cannot be successfully designed in a ivory tower. In view of these thoughts, it was decided early in this study to involve officials from as many as possible of the agencies that have relevant data or will be users of any system that may be developed. Specifically, it was proposed that a short workshop session should be held with the following representation.

i. Resource persons: a few people who have either:
   a) a broad knowledge of integrated manual systems or,
   b) progressed to the testing stage of computerized system.

ii. Representatives from Maritime Agencies that have relevant data and who would be users of an integrated system.

iii. One or two representatives from LRIS.

iv. Two faculty members from the Department of Surveying Engineering, U.N.B.

The objective of the workshop was to stimulate discussion on infrastructure elements and from this discussion to define those that were of sufficient interest to warrant inclusion in an infrastructure information system. Another equally important objective was to initiate dialogue between LRIS and the various agencies concerned with infrastructure information in the Maritime Provinces.

The workshop was held at U.N.B. June 30 to July 3, 1975. Highlights of the workshop proceedings are given in the subsequent sections. These sections contain summarized and paraphrased presentations by the workshop participants.

3.2 INTRODUCTION BY W.F. ROBERTS

The Land Registration and Information Service has a ten year program (1973-1983) to implement an improved land titles system in the Maritime Provinces, and to examine means of exploiting the full potential of this improved land titles system as an information base. The program is divided into the following four phases.

Phase I - The establishment of a network of second order control survey markers. This phase should be complete in 1977.

Phase II - The production of medium scale regional maps and large scale urban maps. This phase should be complete in 1983.

Phase III - The implementation of an improved land titles system. This phase is in the development stage.

Phase IV - The development of a land based information system. This phase is in the study stage.

The phases are interdependent in that each phase depends on the previous ones. The land parcels of the new land titles system are considered the natural base for land related information. Infrastructure information is in increasing demand in our society. This information is also land related, and therefore LRIS has commissioned this study to investigate the interrelationship of infrastructure information and the LRIS program.

Many agencies want the same data relating to land, people, resources and infrastructure. The role of LRIS should be to provide an information management service in the Maritime region to reduce the duplication of effort. Knowledge has been gained on the land tenure, land assessment, and to some extent on resource inventory computer files. At this time we need answers to questions on infrastructure computer files. Some of the questions are listed below.

- Exactly what should be an infrastructure computer file?
- Should an infrastructure information system be graphic or digital?
- How would infrastructure computer files relate to other computer files?
- Who would use the information?

3.3 PRESENTATIONS BY RESOURCE PERSONS

3.3.1 Neville Riley - South Africa

The presentation was a summary of a paper presented at the C.I.S. convention in Fredericton, June 1975, and an explanation of the information system now in operation in Cape Town. The purpose of the C.I.S. paper was to emphasize the need for a "place-related" data system. "Place-related" in this sense means that all the data is referenced or related to a specific coordinate location. Any information system must have location referencing of the data in order to do automated computer searching specified by position or area.

When establishing a system there must be a clear understanding of what will be required of it: for example, if no provisions are made for digital data storage, changing the system will be very difficult at a later date. The requirements should be carefully studied before implementation. The South African system was developed to aid planning: not only urban and regional planning; but any decision making that requires up-to-date physical information. The most difficult aspect of planning is the continuous changing of situations. In many cases, by the time recommendations are implemented the facts upon which the recommendations were based are not correct. Effective planning requires the most up-to-date information and continuous monitoring of the situation. Planning requires a more scientific methodology. The systematic approach to planning may be compared to four steps of a medical doctor's study of a patient's condition, namely: examination of the problem; prognosis of the situation if no action is taken; analysis of possible actions; synthesis of recommended actions.

Three basic elements of any type of land-related system are land use activity, the basic spatial unit, and people. With these elements in mind, the three types of information systems considered for Cape Town are listed below.

i. Activity systems (based on land use)
ii. Grid systems (based on 1 km. grids)
iii. "Place-related" systems (based on land parcels)

The "place-related" system was selected because the land parcel is an integral part of any development. Each parcel is addressed by a geocode made up of the x and y coordinates to the nearest metre of the approximate center of the parcel. In a geocode system information in a grid square is stored compactly in one section of the computer file which is very convenient for information searching and manipulation. The benefits of the system are:

i. up-to-date information;
ii. rapid graphic output;
iii. storage of wide range of inter-related information;
iv. flexibility; and
v. "on-line" inquiry.

Information on the utilities in Cape Town is available only on independent, non-coordinated maps and plans. The digitization of these maps and plans is planned.

We must always remember that no matter how sophisticated a system becomes, the decisions must still be human. However, the decisions should at least be based on reliable, up-to-date information.

3.3.2 Dr. G. Konecny - West Germany

Information and mapping needs have always been closely linked to economic evolution as the predominant activity of the society changes. In the pre-industrial society, agriculture was the predominant activity. In the industrial society, the manufacture of goods is the predominant activity. As the trend indicates today, the predominant activity of a post-industrial society will be the supply of services. The requirements in map detail have increased as society evolves. Crude small scale maps were adequate for agricultural societies, but today detailed large scale urban maps are required for the management of a modern service industry.

It is the complexity of human and resource relationships that has created the mess that we are in now. To illustrate the dangers, consider the City of Bombay where there is no large scale mapping in a city of 5 000 000 people and only five surveyors. The city officials of Bombay would like to adopt a geographical information system, but it appears impossible in the present state of confusion. As a result, they are seriously considering building a new city.

Of course Bombay is an extreme situation, but there is definitely a need for large scale mapping to restore order in other cities.

West Germany is developing a land related information system that will be based on land parcels, however, there is presently no attempt to include utility information in the system. The utilities are the responsibility of the individual cities, and they are well referenced to grid coordinates by city regulations.

The data on utility surveys is collected and maintained in a systematic fashion, but the main problem is that it takes considerable time to get the up-dated information on the maps. If it becomes necessary in the future to automate the utility information, it should be relatively easy because the data exists in a complete and coordinated format. A future automated utility information system would be maintained independently of the main land related information system. The coding would probably follow the same concept as the main system. That is, the individual item code would be a combination of a geocode (which identifies a grid square) and a sequential number (which identifies the particular item in that grid square).

There is a general feeling in West Germany that automated information systems should be very precise, and therefore much care is required in the system development and information maintenance.

3.3.3 Dr. Proszynski - Poland

At the Washington meeting 1974 - Study Group D. (Commission VI) of the 14th Congress of the Federation of International Surveyors passed a resolution that included two objectives for the 1977 meeting in Stockholm:

i. To elaborate the general principles for the establishment of a cadastre for underground services;

ii. To develop special methods for graphical documentation of underground services using data banks.

Dr. Adam Chrzanowski is the Canadian representative to Commission VI, and he will receive a proposal for discussion on underground survey standards. The National representatives will study the proposal and prepare for discussion at the 1977 conference. A copy of standards on codes and symbols for underground services will also come to Dr. Chrzanowski.

In Europe there is much more emphasis on construction surveys than here in Canada. In very old cities properties are referenced by old buildings, and therefore the location of buildings is considered as important as property boundaries. Survey crews headed by an engineer or senior technician check construction progress frequently and "as-built" plans of all construction are required by law. In Poland, utility designs are studies by all the utility agencies before it is approved. The most frequent urban scale in Poland is 1:500, although 1:200 and 1:250 are also used. The Canadian and European survey approaches appear to be at the two extremes of the scale. Perhaps the best approach would be a compromise.

3.3.4 Yvon Dubé - City of Montreal

Montreal has a utility mapping program at a scale of 1" = 20'. The mapping is a complete area coverage (not just street maps) and the map sheets are oriented on the Quebec Hydro grid.

The mapping program began in 1954 and it took six years to make initial maps of the utilities for the city (excluding recent annexed areas of Montreal). The initial mapping was a uniform representation of the existing plans and records. Today the program has a staff of 14. The maps are updated every six months, but there is no regular method of recording the revisions.

In 1964 field inspections were initiated and from that time those map edifications that have been field inspected are marked by an asterisk. The utility agencies cooperate by supplying the mapping office with copies of work orders each morning so that the map inspection crews can do on-site inspections of underground utilities while the trenches are open.

The maps are not integrated in a grid coordinate reference system. The utility features are referenced to street lines and curbs. The relative positions of the utilities are represented graphically on the maps. Only a few horizontal dimensions are given on the maps. Invert values (depth measurement) are shown on the maps as measured from the existing ground surface. Elevations are not referenced to a fixed vertical datum.

Montreal recently annexed three surrounding communities which do not have utility mapping and their records are either poor or non-existent. The old city area has 4500 maps that are 24"x36" in size.

The Montreal utility maps are used daily by many city departments in applications such as right of way representation, diagrams for tender calls and operational reference maps. Experience has shown that any project requires answers to two basic questions: what is in the street?, and where is it in the street?

Because a lot of effort and expense has gone into graphical utility mapping there is considerable pressure to stay with the graphical method rather than to convert to a digital mapping system.

3.3.5 Ralph Smith - Metropolitan Toronto

Metropolitan Toronto is a regional municipality of 240 square miles and a population of 2 500 000. The regional municipality is made up of six local municipalities, one of which is the City of Toronto. This means that there are two levels of municipal government, regional and local. In some instances, the regional government is comparable to a wholesaler and the local government is comparable to the retailer. For example, the regional government is responsible for the collection and purification of water which is in turn sold to the local governments, and vice-versa in the case of sewage. Both Metro Toronto and the City of Toronto have public utility coordinating committees to promote cooperation in utility affairs. Metropolitan Toronto was established in 1953 and its Utility Coordinating Committee was set up in 1954. The Metro Committee is only concerned with the area surrounding the City of Toronto.

The City of Toronto has about 75% of its 40-50 square miles mapped at 1" = 20' but presently the update costs are using all the budget and therefore no new areas are being mapped. A utility mapping program was initiated in the Metro area by an expansion of the city map grid. This mapping was referenced only to curbs and street lines, causing the occurrence of map orientation and overlap problems as various survey constractors worked on the map simultaneously. One noteworthy acheievement of the early coordinating efforts was the acceptance of standard utility location on new streets and roads. However, difficulty was experienced in the regulation of these standards because of the changing widths of right of ways.

In 1958 discussions among concerned agencies expressed a need for consistent vertical and horizontal control networks. In 1959 the Federal government established vertical and horizontal networks in the area. The regional government then densified the control, and today there are about 10 000 monuments in the area.

In 1957 strip road mapping was started at 1" = 20' but was later changed to 1" = 40' to merge with an overlay system. The Roads Department was eatablished with the takeover of 300 miles of aeterial highways and the mapping role was transferred to a mapping committee. Within the past year a centralized mapping agency for Metro Toronto was established. This agency is responsible for quality control on control surveys and base mapping.

The responsibility for utility data remains with the Public Utility Coordinating Committee. The Roads Department plans to store the utility data associated with the roads in the department system and the Roads Department is encouraging the utility agencies to consider computer approaches in data manipulation.

The computer programs that the Roads Department have developed are tailored to the urban setting (i.e. they try to merge the new road design into the existing features to minimize the disruption of the urban topography and hardware). When a design has been accepted, it is stored in digital form for future digital applications.

The workable urban scale is the traditional engineering scale of 1" = 40'. Planners and administrators may prefer scales of 1:1000 or 1:2000.

A great benefit of digital mapping is that information may be stored at a scale of 1 to 1 at the field survey accuracy, and later may be computer plotted at any desired scale. Angles and distances of engineering layouts may be conveniently and accurately printed out from digital mapping information, which is much better than having engineers scale the values from 1:480 maps.

Special surveys are not required to prepare "as-built" highway plans because the Metro Roads Department survey crews maintain quality control checks on the construction to ensure that the works conform to the design. Only exceptional variations are allowed.

In the utility mapping program the survey contractors reference the invert measurements of utility installations to the elevation datum that was established by the Federal Government. The horizontal positions are marked on the maps by scaling the location from existing street information already shown on the maps.

Provincially, there is very little coordination of utility mapping programs. The system as described here is only used by the regional municipality of Metro Toronto. For the most part, municipal departments of various cities are headed by engineers who graduated 20 years ago and worked very hard to establish the present systems. Where these systems are operating, it is difficult to convince directors that there may be a better approach.

In mapping derived from aerial photographs, much effort goes into representing all topographical features at the same degree of accuracy. The results is that some features are mapped more accurately than necessary and other features are not accurate enough. In digital mapping an accuracy code could inform the user of the reliability of the data.

The present plans in the Metro Roads Department are to digitally overlay the strip aerial maps, street line information, property line information and "as-built" information. The Roads Department is trying to convince the utility agencies that it is to their benefit to supply utility information in a compatible form.

3.4 REGIONAL AGENCY PRESENTATIONS OF INFORMATION NEEDS

3.4.1 Urban and Underground Utilities

3.4.1.1 City of Halifax - Dave Fox

The public and politicians expect the municipal service administrator to have detailed information on all municipal utilities at his fingertips. For political reasons works must be completed in limited time frames which do not allow adequate time to search out information on existing utilities. This situation sometimes results in installation of inadequate services or breakage of existing underground services.

The utility coordinating committee in Halifax has helped to coordinate the efforts of the participating agencies, but it does not provide the information exchange that is necessary. The utilities are willing to cooperate in an information system but some agency must take the lead to establish the system.

Funding of long term programs is very difficult at the municipal level, because urban taxpayers are very critical of expenditures and they want tangible results in the short term.

The points that should be remembered in the design of an urban information system are:

i. the existing information needs a common "wavelength" or format of communications;
ii. the data retrieved from the system must be at the users desired level;
iii. the users will have to be educated in computer techniques;
iv. the system must be efficient (i.e. "the user must get the most for his money");
v. the information must be geared to answer the questions of the general public;
vi. above all, the information must be in a usable form.

3.4.1.2 Public Service Commission (Halifax Water) - Bill Gates

The Public Service Commission is very interested in the LRIS Land Titles Program, because the P.S.C. is the largest land owner in the city of Halifax. It is hoped that the LRIS program may help P.S.C. to manage its water easements, many of which are on private land. Beginning in 1973 all new easements are being referenced to the provincial grid, and the pipelines are being tied to the easement boundaries. Likewise, newly purchased properties are coordinated in the provincial grid.

Prior to 1945 when the corporation was established, most of the underground water line information was very poor or non-existent. After 1945, customer connections were referenced to the left front corner of each building where a new service was installed. This referencing is in the form of offset distances (at the basement, at the shut-off valve, and at the street line) measured from the line of sight along the left hand end of the house as viewed from the street. The P.S.C. is careful in the measurement of vertical profiles of new water mains and "as-built" profiles are required in contracts for new water mains. Horizontal locations are referenced to permanent structures. Recently, water mains are being referenced to the provincial grid.

Looking at the future, the P.S.C. would like to have three dimensional coordinates at all directional changes in the pipelines. As telephones and hydro are now placing more underground plant, vertical alignment is becoming very critical.

The working scale for mapping of water utility information is 1" = 40'. The P.S.C. requires the information on the other city utilities for planning, design, construction and maintenance. The problem in the past has been that no one agency has had the funds to initiate a central information system.

3.4.2 Highways

3.4.2.1 N.B. Department of Transportation - Dave Loukes

A prime concern in planning is land ownership and land cost and therefore the Department of Transportation is interested in the LRIS land tenure data. Some types of data that the department might supply to an infrastructure information system are:

i. coordinates, alignment and profile of all highways; (presently there is much concern on how this information could be collected.)

ii. controlled access data;

iii. control lines and restrictive agreements;

iv. location of bridges and culverts;

v.. location of signs, lights and guiderails.

Individual properties in the LRIS land tenure file should be referenced to a geocode in order that planners could easily access land parcels and their attributes within proposed areas of new highway locations. Two benefits of such an information system should be a reduction in information search time, and an increase in the reliability of the data.

The Department of Transportation could use an infrastructure information system to manage data of internal interest only, such as sufficiency rating data and straight line diagrams. The straight line diagram is a graphic representation of the highway that serves as a base on which road construction, rating section, right of way widths, horizontal and vertical geometry, road intersections, and traffic accident data is assembled.

3.4.3 Planning

3.4.3.1 N.S. Community Planning - Chris Lloyd and Gregg Haverstook

There is a need for a centralized accessable data bank relating to the natural and man-made environments, with monitor and update capability. The data should be referenced to geocodes for cross referencing data by position. Information needed by N.S. planners on individual parcels is given in the following list.

i. File number
ii. Geocode number
iii. Property size
iv. Ownership
v. Land use
vi. Building description
vii. Assessed value and year of assessment
viii. Market value

An information system should be expandable because all of the applications are not recognized at the system design stage. Planners should be able to retrieve data at their desired level of detail, which means that the system should have the capability of manipulating the data to meet the users requirements.

Infrastructure is a very broad term and care should be taken in its application. LRIS should be more "public" about its activities in order to eliminate duplication of effort. Data acquisition is estimated to be one third of the cost of a planning project.

3.4.3.2 N.B. Community Planning - Harold Tait

The function of the Community Planning Branch is the preparation of comprehensive land use plans. Three branch activities of probable interest to the workshop are:

i. subdivision control;
ii. consultation with agencies on location of utilities in new subdivision developments;
iii. building bylaw control.

The Department of Municipal Affairs collects a broad range of data as illustrated in this table.

Branch	Type of Data
Municipal Services	fiscal
Assessment Branch	buildings & land
Municipal Engineering	sewer & water systems
Community Planning Branch	land use

All of this data could be effectively computerized but the problem in the past has been in coordinating of effort to eliminate duplication.

When designing large information systems it is important to remember that the system must have adequate retrieval capability.

Mr. Jellinek, the Director of Community Planning Branch, could not attend the workshop but he prepared a note as follows: "The Community Planning Branch requires a computerized system whereby all the activities that take place on land can be banked and retrieved not only as global figures but also in terms of space. Thus it is important for the planning process not only to know that 25% of the houses in a municipality are poor, but are these 25% of the houses located in one area or are they spread uniformly throughout the municipality? It is this space specific aspect that is so important in the planning process."

3.4.3.3 City of Fredericton - Bill Thompson

Planners should strongly support any agency that promotes the sharing of common interest information. Urban planning is more specific and therefore more complex than regional planning. Consequently, more detailed information is necessary.

Planning should be simple and serve the people. For example, a land owner should be able to go to the planning office and get specific answers about the planned future of the area in which his land is located.

We must be specific about what we want out of the information system. We have to straighten out priorities (i.e. which is more important: effective land use planning or zoning?). Development controls and restrictive agreements must be included in the information system. National standards in zoning, land use, fire protection, and zone descriptions should be considered before inputting data to a system.

For planning we need the following information elements.

i. topography
ii. ownership
iii. existing land use
iv. building conditions
v. future land use
vi. accurate property location

Additional information that might be maintained on municipal property files are:

fire flow
water pressure
sewer capacity
lot size
residential density
lot occupancy
type of fire coverage

There is a need to integrate subdivision regulations with zoning and land use regulations.

3.4.4 Power

3.4.1.1 N.B. Power

N.B. Power has many isolated information systems which are uncorrelated and have little or no cross reference capability. When the need arises for a new type of data output, rather than simply extracting the data from existing systems, often a complete new system has to be established. N.B. Power has been aware of this problem for some time and this year a pilot project is being started in the Chatham district to experiment with a new approach. The N.B. Power requirements of an information system are:

i. "on-line" data display;
ii. updating that is geared to input by the local service man doing the installation or maintenance;
iii. maintenance of history records on electrical devices;
iv. analysis of abnormal conditions;
v. automated correction techniques;
vi. forecast projections of future requirements.

The specifications, history records and location data of electrical devices in an information system would make possible automated of "trouble shooting" abnormal conditions to shorten or even prevent outages. If customer or installation addresses were referenced to geocodes, it could streamline service disruption reporting and repair dispatch.

N.B. Power needs the location data of other utilities to reduce "dig up" interruption of other underground services, and therefore want to integrate efforts with other agencies to develop computer overlays of the infrastructure. It is hoped that the pilot project in Chatham will sort out the realistic and idealistic functions of a computer based information system.

Maps have traditionally been the medium for positional information. N.B. Power needs reliable maps, but does not intend to get into the mapping business. Digital data storage appears to be an attractive alternative to traditional hard copy maps.

3.4.5 Telephones

3.4.5.1 N.B. Telephone - Nelson Day

N.B. Telephone works in close association with N.B. Power in that the companies have some 220 000 jointly owned poles and efforts are continually being made to increase joint use activities. Most of the new outside plant construction is co-located with power facilities. The company is frequently dealing with the N.B. Department of Transportation because most of the plant is located on highway right of ways.

N.B. Telephone is interested in the LRIS land parcel file in regard to managing easement information. The telephone toll line easements are well surveyed and recorded but the exchange distribution easements are not normally surveyed and are not regularly recorded. There are several series of telephone plant maps at various scales that are unrelated positionally, but that should be correlated somehow to a common base.

Any information system must be flexible because new applications will arise. Street addresses and telephone numbers referenced by geocodes would be very useful.

3.4.5.2 Maritime Telegraph and Telephone - Colin Latham

The Maritime Telegraph and Telephone Company is interested in all infrastructure information because M.T. & T. plant is everywhere. The Company wants reliable information to reduce dig-up disruption of service. The financial aspect of dig-up disruption is not as critical as the service disruption to the telephone customer. M.T. & T. would welcome a modern information system that would save money. As in most systems, the implementation costs are very large in the short term.

User compatibility is another serious problem. The area of common interest among user agencies might be very small in comparison to the entire system of infrastructure information.

The Company is now having retrieval difficulties on detailed information. The positional information on older underground installations is very limited, however, there are means of locating it (i.e. electro-magnetic detection devices). Efforts are being made to improve manual plant records. There is a problem of poorly recorded telephone easements. Pole numbering is confusing and the Company is now assigning street addresses in urban areas.

There is a special project underway in the field of customer records and billing. Geocodes are considered to be a good means of reference for customer records.

3.5 LIST OF PARTICIPANTS

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PLANNING AND MUNICIPAL AFFAIRS

N.S. - Mr. Chris Lloyd
- Mr. Gregg Haverstook

N.B. - Mr. Harold Tait

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City of Fredericton (Planning) -
Mr. Bill Thompson

MSUA - M. Laval Lavalée

HIGHWAYS

N.B. - Mr. Drew Robertson
- Mr. David Loukes

URBAN AND UNDERGROUND UTILITIES

City of Halifax - Mr. David Fox

P.S.C. (Water) - Mr. W.H. Gates

4 INFRASTRUCTURE INFORMATION IN THE MARITIME PROVINCES : PROJECTED REQUIREMENTS

4.1 QUESTIONNAIRE ON INFRASTRUCTURE REQUIREMENTS

4.1.1 Objectives and Style of the Questionnaire

At the conclusion of the four day workshop on infrastructure information, the consensus of the participants was that dialogue on the subject should continue. A questionnaire was suggested as a natural means of assimilating ideas and opinions on infrastructure information systems. The objectives of the questionnaire were:

i. to collect independent responses on infrastructure problems.
ii. to stimulate thought on infrastructure information systems.
iii. to continue dialogue on the subject.

The topic is new in the sense that no comprehensive system on infrastructure exists. Consequently, a non-restrictive style of questionnaire was selected whereby the respondents were asked to select the information components that are of concern to their agency. The questionnaire had six parts to be completed for each identified component of infrastructure information. The parts are summarized in the following list.

i. Identify the information component.
ii. Indicate the necessity of the information in three phases: planning; design and construction; operation and maintenance.
iii. State the percentage of information obtained from internal and external sources.
iv. Describe the method of obtaining the information.
v. State if present methods provide all the necessary information.
vi. Indicate satisfaction of present methods considering cost, time and accuracy.

A request was also made for general comments on the questionnaire and/or infrastructure information.

Circulation of the questionnaire was limited to the ten participating groups of the workshop because the questionnaire was intended to be an extension of the workshop.

4.1.2 Information Components Identified by the Respondents

A total of 54 information components were identified by the respondents, but many were similar and could be grouped under 31 generalized headings. By applying our definition of infrastructure it was found that ten of the 31 groups were non-infrastructure components. The 31 group headings and the responding agencies are presented in matrix form in Table 4-1.

4.1.3 Results and Interpretation

Part I - The purpose of this part was simply to state the information component.

TABLE 4-1

	City of Halifax (Engineering)	P.S.C. (Water - Halifax)	City of Fredericton (Planning)	Community Planning - N.S.	N.B. Department of Transportation	Maritime Tel.& Tel.	N.B. Telephone	N.B. Power
			Planning					
INFRASTRUCTURE ITEMS	Urban			Regional				
Electric power plant	*	*			*		*	
Telephone plant	*	*			*		**	*
Water system	*			*				*
Sewer system	*	*		*				*
Ownership of utility poles							*	
Combined utility plans	*							*
Utility easements					*	*	*	
Proposed utility improvements				*				
Location of buildings					*	*		
Rural house counts							*	
Building conditions				*				
Housing starts				*				
Street and road lines	*				*			
Street maintenance inventory	*							
Street and road hardware inventory	*				*	*		
Railway crossings							*	
Remote telephone tower sites							*	
Topography	*	*		*				*
Bridges and culverts					**			
Vertical profiles of roadways					**			
Horizontal geometry of roadways					*			
NON - INFRASTRUCTURE ITEMS								
Demography				*				
Land tenure				*	**			
Zoning	*							
Land use				*				
Soils and rock profiles	*							
Local improvement charges	*							
Subdivision approvals				*				
Traffic accident data	*							
Construction estimates	*							
General- physical, social, economic, environmental			*		*			

Fifteen of the 54 information components are included in the ten non-infrastructure groups. In evaluating the questionnaires, the infrastructure and non-infrastructure components as well as the combination of both were considered separately.

A	Infrastructure components	(41 components under 21 headings)
B	Non-infrastructure components	(13 components under 10 headings)
C	All components of A and B combined	(54 components)

Part II - Here the respondents were requested to check the degrees of necessity as essential, desirable, or not needed for each component in the three phases of planning, design and construction, and operations and maintenance. The results are presented in Table 4-2 as percentages in each degree of necessity.

DEGREES OF INFORMATION NECESSITY

TABLE 4-2

	Percentages									Information Necessity Units
	Essential			Desirable			Not Needed			
	A	B	C	A	B	C	A	B	C	
Planning	49	40	46	44	33	41	7	27	13	142 A 113 B 133 C
Design & Construction	92	83	90	8	17	10	0	0	0	192 A 183 B 190 C
Operations & Maintenance	53	46	51	44	23	39	3	31	10	150 A 115 B 141 C

As a comparative measure of the degree of information necessity, weights were assigned to the three degrees: two for essential; one for desirable and zero for not needed. The percentages in the Table 4-2 were multiplied by their respective weight and summed up horizontally to arrive at the values in the extreme right hand column. For ease in interpretation these values were standardized to the lowest value and are presented in Table 4-3.

Table 4-3 - Information Necessity Units (standardized to the lowest value)

	Infrastructure A	Non-Infrastructure B	Combined C
Planning	1.3	1.0	1.2
Design & Construction	1.7	1.6	1.7
Operation & Maintenance	1.3	1.0	1.2

In column A, the infrastructure components, it is shown that information is needed 30% more in design and construction than in planning or in operation and maintenance. Conversely in column B, the non-infrastructure components, we see that information is needed 60% more in design and construction than in planning or in operation and maintenance. If these values are representative, it is concluded that information is more essential in all the phases for infrastructure components than for non-infrastructure components.

By totaling columns A and B, it is concluded that infrastructure information is 20% more essential than non-infrastructure information in the overall operation.

Part III - This part asked for the percentage of information that is obtained within the agency and the percentage that is obtained outside the agency. The results are as follows:

	A (Infrastructure)	B (Non-infrastructure)	C (All components)
Sample Size	41	13	54
within (average %)	59%	70%	62%
outside (average %)	41%	30%	38%

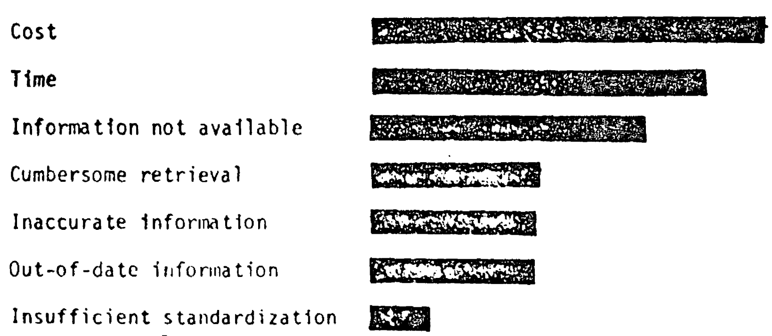
Part IV - Part IV asked for details on the methods of obtaining information. The answers are brief and general and they are in a form that is difficult to tabulate.

Part V - Here the respondents were asked to state whether they obtain all the information that they require; and if not, to state why.

The results of the first part are as follows:

	A (Infrastructure)	B (Non-infrastructure)	C (All components)
Sample Size	34	13	47
Yes	59%	53%	57%
No	41%	47%	43%

The reasons given for not obtaining all the necessary information were generalized into 7 groups and a bar chart indicates the frequencies of the reasons.



Part VI - Part VI asked if they were satisfied with methods of obtaining the information with regard to cost, time and accuracy. The percentages of negative answers are given in this table.

(Not satisfied with present methods)

	A Infrastructure	B Non-infrastructure	C All components
Cost	53%	58%	54%
Time	64%	77%	67%
Accuracy	54%	47%	52%

4.1.4 Conclusions

The following conclusions are based on the infrastructure components (group A).

i. Information is only 30% more essential in the design and construction phase than in the planning phase or the operations and maintenance phases.

ii. About 60% of the information is obtained from internal agency sources.

iii. In 4 out of 10 cases all the necessary information is not obtained.

iv. Present information methods are about 60% unsatisfactory with regard to cost, time and accuracy.

These conclusions should not be accepted as being representative of the whole because of the small sample size (input from only eight agencies). The value of the questionnaire is in its thought stimulation. At this time the study team considers thought stimulation to be more benefitial than statistics. The individual responses to the questionnaire provide insight into infrastructure problems that is helpful in the continuing dialogue with the agencies.

4.1.5 Comments of the Respondents

The last part of the questionnaire asked for general comments on infrastructure information. Some of the comments are quoted as follows.

Dave Fox - City of Halifax

"In terms of the needs of the City of Halifax, the information system should be able to supply us with all information necessary to plan, design, maintain and bill any basic engineering project. We need a graphic presentation at various scales in both horizontal and vertical spheres. We would most commonly use 1" = 40' utilizing 1" = 20' at intersections and other cluttered areas. The system must be able to quickly sift through large volumes of material and accurately present that which is relevant.

"The problems arise in arriving at a degree of accuracy that is acceptable to all the organizations concerned. There will also be problems for the City in determining what information is usable to the system to start with, as many of the existing records are confusing, contradictory and downright incorrect.

"For the City some of the information needs are pressing; in particular the inventory for street maintenance. We need to have a system to make five year projections for scheduling and costs. The billing system for local improvements is time consuming and cumbersome, and backlogs can develop easily.

"It would also be hoped that basic engineering information and department documentation could be stored in the system so that methods, dates, agreements and other information could be quickly retrieved.

"The whole concept could prove invaluable to the City in terms of saved man hours and accuracy. Cost, we would assume, could be the largest negative factor."

Ray Fiske - Nova Scotia Power Corporation

In regard to Nova Scotia Power problem in the City of Halifax.

i. "There is also the City Works Department that requires information on our own underground and even overhead plant "on which we have notes only". There is "not time to transcribe and give them a map."

ii. "The present solution is contact with the man in charge of each particular job."

iii. "We need a central agency or group who does mapping" and that has "the combined services" to keep maps up-to-date and to "supply copies fast and at a reasonable cost."

Colin Latham - Maritime Telegraph and Telephone

"All agencies have their own vested interest and their own requirements for information on infrastructure. Each one differs from the other by a small amount.

" It required someone with no vested interests such as LRIS to get specific details on the information (such as this questionnaire). Then produce the information and test it on the users. Then by a process of iteration arrive at the final solution.

" I think you are on the right track."

Jim Reardon - Public Service Commission of Halifax

Infrastructure Information Problems

"We do not have a great problem in procuring any information needed in connection with our new underground installation. We find that the other utilities in Halifax are most cooperative when information is required."

Solutions to Information Problems

"The easiest solution would be a new set of 1" = 40' aerials with adequate detail on plans such as the location of all underground services and above ground appurtenances. This could be accomplished fairly easy and quickly if the funds were available to carry out this work."

Nelson Day - New Brunswick Telephone Company

"The whole Atlantic area needs the efficiency that would result from a properly planned and executed computer based geographical data system." ..... "it must be cheaper to have basic data bank costs shared - to have basic system design shared between 3 or 4 provinces.

" I feel that it is desirable to have the 'Public Sector' lead off in such endeavours where so many services, organizations and civil departments will benefit. Private industry should bear its fair share of costs, in proportion to value received as well as the cost of inputting its specific data of use only to itself. (Cable Terminal Location). Main runs of water, sewer, power, telephone, petro pipe in the underground are of concern to all and should be part of base cost. Shut-offs, transformers, etc, are specific to the utility concerned.

" Geo-coding seems to be most useful data input method. Must be common system for whole area, not just New Brunswick. I think this thing is much bigger and more important in the long run than most people realize.

" Everything metric from start.

" A basic system oriented along transportation routes would be more useful to most utilities. As compared to Pure Grid System, however, metropolitan areas could be handled on a Grid System. Can we have both? Most of New Brunswick is 'Rural' or uninhabited. If we decide on the theoretically supperior 'Pure Grid' system, we must establish some way to organize data at locations where people live. Need some form of grouping that is based on population, houses or something more personal than latitudes and longitudes or their equivalent."

4.2 USER GROUPS

4.2.1 Electric Power

From the discussions during the workshop and from evaluation of the questionnaires, it is apparent that electric power agencies are one of the major producer-users of infrastructure information. It is recognized that the problems facing all power distribution agencies are basically the same. Varying historical factors may cause one agency to be more concerned with certain problems than other agencies are at a given point in time. N.B. Power is currently investigating a Geographic Data Base System and so far as can be ascertained, it is the only power agency in the Maritimes that is conducting such an investigation at this time. Because the N.B. Power investigation complements the work of this study, it is reported in considerable detail.

4.2.1.1 Extracts from N.B. Power report

In October, 1974 a study entitled "A Report on the Correlation of Systems Development to the Distribution Division's Objectives" was written jointly by laymen and administration of the Distribution Division.
Extracts from this report are quoted here in order to emphasize the complexity and the importance of a Geographic Data Base to N.B. Power. The reader is warned that these extracts are taken out of context and any difficulty in comprehending a quotation should be attributed to the lack of context.

In the report, the historical situation within N.B. Power leading to the definition of data base requirements is reviewed. In order to indicate the scope of the system which they had in mind, the authors compiled the following preliminary list of elements for a data base.

Geographic Boundary Overlays:

N.B. counties
Municipal boundaries
Branches of N.B. Power
Districts of N.B. Power
Service areas of N.B. Power
Customer service areas of N.B. Power
Properties
Customer location

Topographic Overlays:

Highways
Streets
Railroads
Rivers and navigable waters
Access roads
Bridges

Plant Overlays:

Generation plants
Terminals and switch yards
Transmission lines
Sub-transmission lines
Sub-stations
Distribution primary lines
Distribution secondary lines
Apparatus
Customer equipment and apparatus

Several quotations from the report are cited below to give an indication of the impact expected from the implementation of the Geographic Data Base System.

"The major change that would affect our accounting systems would be the change from grouped accounts in the various property ledgers to that of a ledger for the accounts at a location....."

".....for the distribution divisions assets.....each structure tied in with the geographic location would have a history of age, original values in various accounts, depreciation rate, present value, etc. This would mean that information for a particular distribution feeder or section of a feeder down to an individual structure could be accessed....."(In N.B. Power terminology a feeder is a section of line supplied by a sub-station).

"Better planning decisions could be made in assessing the need to rebuild versus maintain. Also the system would give immediate book values that could be up-dated to 'Reproduction Cost New Depreciated' (R.C.N.D.) by assigining present day costs to the actual structure in use."

"For the planning point of view alternative courses of action could be reviewed as to effects much more easily with terminals at offices where the planning is done....."

"It is also expected with the estimation being tied in closely with the District Work Order (D.W.O.) system that paper flows can be reduced and information management up-graded....."

"The customer billing system if it were indexed to a grid reference number would allow technical staff to develop any or all of the aspects evolving from known loads at a particular point.....this would allow much more effective monitoring of electrical system levels with direct customer benefits due to reduced outages and damage claims....."

"If the C.T.A.S. (Central Telephone Answering Service) operators had direct access to customer files they would be able to supply much better information to the dispatchers on the location and extent of trouble. They would also be able to handle more calls in a given time. As the data is entered into the computer, it would be able to give immediate reports on the status of the system ..... The supplying of information to the news media would also be more pertinent and precise....."

"It is expected that interruptions will be handled much more quickly because of the increased information that can be passed on to the serviceman especially regarding the location of the customer and on the parameter of the circuit supplying him service....."

"If there is a need for alternate feeds or other electrical circuit modification then load flows can be made for the new set-up. Access to customer billing data by the load flow program will provide values of current and voltages to ensure that the proposed operation is viable. Access into the data base will also allow data on equipment and apparatus name plates to be available on demand to check out loading and other limitations involved in the operation of the circuit....."

"The status of the electrical system can be kept current. Inputs on the operation of switches, breakers, the location of normally open points, etc.....can mean a large reduction in the work of up-dating display boards and present operating diagrams. By taking a "hard copy" of the visual display on the video tube, switching plans can be recorded for history. By having some logic checks built into switching software programs, possible errors can be rectified."

"The assessment of present levels of reliability and the development of new standards could be facilitated.....for example, the outage levels in some form of frequency and duration statistics could be requested on the basis of municipal boundaries or counties, etc....."

"It will also be able to provide outage rates on components which will be meaningful in the planning stage of new projects and re-builts....."

"Proposed circuit layouts will be able to be checked on the basis of reliability versus cost. Changes in outage rates of components could be compared by classes on the basis of manufacturer, age, rating, etc. This would improve the decision making process on purchases, layouts, special maintenance, etc....."

"Study of losses become more pertinent as the cost of those losses have increased -- due to increased fuel costs. Accumulation of sales information on a feeder compared to the energy supplied by a sub-station will add to the probability of making better decisions....."

"Additions of apparatus and their locations on the feeders will be able to be checked more closely and on a standard basis by a common computer program rather than by rule-of-thumb....."

"Data will be stored on ownership of lines, planned projects and resulting percentage of ownership of joint use facilities. This will render unnecessary the physical surveys of poles every few years to set payments as required by our joint-use agreement with the N.B. Telephone Comapny Ltd....."

"A history of required tree trimming, inspections, etc. will help in the locating of protective devices....."

"New maintenance programs can be put into effect more easily with the aid of a geographic data base as the quality of components and their location can be assessed on a up-to-date basis....."

4.2.1.2 Comments on the N.B. Power study

As the study quoted above was prepared for internal use only, much of the background was taken for granted. Discussions with N.B. Power officials clarified: that economic pressure dictated optimum use be made of all power sources and of all equipment; that optimum use of power sources and equipment dictated the need for a Central Dispatch System; that a Central Dispatch System dictated the need for a complete and flexible data base; that a flexible data base dictated the need for a Geographic Data Base; that a Geographic Data Base is by definition a data base in which the location of all elements is defined by coordinates.

From the extracts cited above it is readily apparent that many of the elements in the proposed power data base are of interest only to N.B. Power and would in fact be considered as confidential. On the other hand, as will be discussed in the subsequent sub-sections of this chapter, many of the elements required by N.B. Power are also required for the telecommunications network and for the topographical mapping program.

4.2.2 Telecommunications

4.2.2.1 Discussions with the Atlantic Provinces Telecommunications Council (A.P.T.C.)

The Atlantic Provinces Telecommunications Council (A.P.T.C.), a consortium of the four telephone companies of the Atlantic provinces, has formed a group to develop a Customer Records and Billing (C.R.B.) system that can be used by all four companies. As the A.P.T.C. is promoting a unity of approach and the pooling of resources, the objectives of the A.P.T.C. are very similar to those of the Council of Maritime Premiers. The (C.R.B.) project is jointly funded by the New Brunswick Telephone Company, the Maritime Telegraph and Telephone Company, The Island Telephone Company and the Newfoundland Telephone Company on a cost-sharing basis that is proportional to the gross revenue of the companies.

The Customer Records and Billing project is spearheaded by a task force of eight members which has been working for two years in Halifax. Initial implementation of the C.R.B. system is expected in 1977. The task force has a mandate to make necessary changes in existing procedures within the telephone companies.

Discussions with Mr. Jamer and Mr. Morse of the C.R.B. group, clearly established the need for reliable location description in a telephone information system. Traditional postal addresses are not adequate because: in the cities and towns, street names are subject to change at the whim of local authorities and; in the country, rural routes are so extensive that they are, to all intents and purposes, meaningless.

The basic components in a telephone information system are customers, equipment and telephone numbers. It is often assumed that the telephone number is a natural link between the customer and the equipment but this is not the case because:subscribers are sometimes permitted to retain their telephone numbers when they move and; one number might be used for several remote extensions. Telephone numbers do lend themselves to computer systems in that they are unique and can be easily arranged in a sequential fashion, although the sequence does not necessarily have to be continuous.

Telephone companies have traditionally used telephone numbers to identify customer accounts, but this approach has its shortcomings. For the first time in North America, the C.R.B. project plans to use a unique, sequential and non-structured number to identify the customer accounts. This will allow one account number to serve for several telephone numbers.

The basic elements of telephone equipment are the lines, poles and cable access points. The C.R.B. people feel that the service access point is the best element to use in a cross reference with the customer. They also believe that two dimentional coordinates are the best means of identifying the access points because coordinates are unique, and equipment and/or customers within specified areas may be quickly identified by a computer file search.

Access points on overhead cables are generally close to or on a pole and the access points for buried cables are at the terminal posts. Therefore coordinate values for utility poles and terminal post could provide the access point locations.

Two properties of positional coordinates in relation to an information system are stated below.

i. Coordinates are <u>invariant</u>. That is, they are not subject to any arbitrary change. Given that an adequate coordinate survey network has been established anyone can at any time determine the coordinates of a point.

ii. Coordinates are <u>unique</u> for each location. Except for the special case of high rise apartments, there is no change of position duplication. Several teams at various locations can be determining coordinate values without danger of duplication of coordinates.

Storage of infrastructure information by coordinate identifiers will enable efficient computer searching of location dependent information by the user specifying the area of interest. Two dimensional coordinates would not be continuous because only a few of the possible coordinate values would be used. Therefore, it is apparent that coordinates will have to be "addressed" by a continuous sequence of numbers or "keys". (This is a routine computer technique to conserve storage and memory space). New coordinate values from edit and up-date procedures would be indexed in a pending file. Periodically the main and pending files would be resorted to make the coordinates sequential and the keys sequential and continuous.

The basic information components to a telephone information system appear to be telephone numbers; customer account numbers; two dimensional coordinates for poles or terminal posts; and two dimensional coordinates for buildings having telephones. An effective telephone information system must have the capability of rapid cross reference of these components in order to gain quick access to detailed information. Inquiry to the system as discussed above would be based on telephone number, customer account number or geographical position.

As mentioned in Chapter 2, the file structure in an integral part of any computer system design. Considering the file structure at this study stage may be premature, but it helps to point out necessary cross reference links among the files. Possible file structures for a telephone system are shown in Diagram 4-1.

Access locations and building coordinates are shown as separate files for the following reasons.

i. More than one telephone in a building may be assigned identical building coordinates, but they may have different access locations.

ii. An access location is the natural base for a file containing such information as cable numbers, wire pairs assignment, and other equipment related items.

iii. If new building coordinates were up-dated by an electric power installation,which generally preceeds the telephone installation, the coordinates would be helpful in assigning the telephone connection work order to the proper access point.

iv. Building coordinates might be considered as an additional "fringe benefit" that would not necessarily have to be initially included in an information system.

The method now used to assign a pair of wires to a new customer utilizes the "nearest neighbour concept" and existing pole numbers. All new telephone line equipment is in the form of multiple pairs of small insulate wires wrapped in cables. The number of pairs can vary from 25 in rural cables to several hundred in urban cables. Upon receiving a request for service, the assigning personnel asks the caller for the name and telephone number of the nearest neighbour. The assigner then locates a card filed under the telephone number which refers to a book containing the record of the connection: Each pair of wires in the cable line has a number and the available pair numbers are allotted in blocks to certain access points on the cables. The assigner locates the telephone number of the neighbour in this book and notes which access point was used for that telephone number. The next available pair of wires is then assigned to the new customer. The book also shows the number of the telephone pole nearest to the access point. The assigner now has sufficient information to write up the work order for the installation. In many cases, the installer finds that the closest neighbour is actually many poles from the new service and he has to request a re-assignment of pairs.

In this manual system there is no warning technique, or "flags" to note a rapid depletion of available wire pairs. If the assigning system were automated, forecasts of shortages could allow time to rectify these situations.

POSSIBLE FILE STRUCTURES

1. | Telephone # | ↑(2) Cust. Acct. # | ↑(4) Index : Ser. Address : | ↑(3) Index : Access Location : | etc.

2. | Cust. Acct # | ↑(1) Telephone #(s) | ↑(4) Index : Ser. Address : | Cust. Name, Dir. Address | Billing Postal Address | etc.
   Inverted alphabetic list

3. | Index : Access Location* (terminal coordinates) | ↑(1) Telephone #(s) & pair #(s) | Cable # | Unused pair #(s) | etc.

4. | Index : Service Address* (building coordinates | ↑(1) Telephone #(s) | etc.

* Sorted and pending files which are periodically resorted by coordinate values.

Components of Telephone

Infrastructure information

1. telephone #
2. customer account
3. access point or pole location
4. building or service location

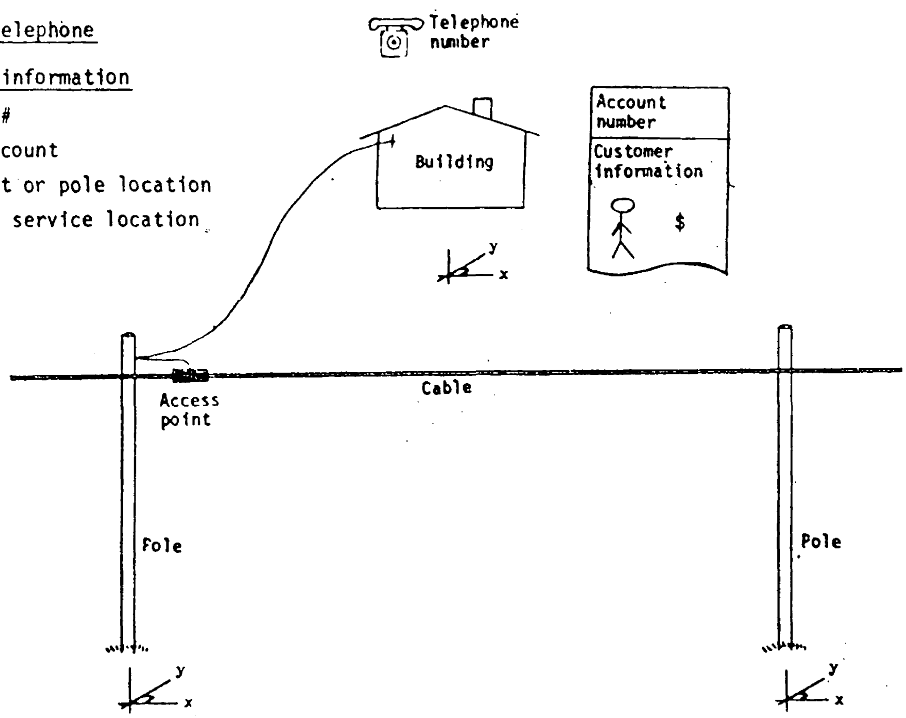


Diagram 4-1

The usual result of a shortage is that new customers are placed on party lines with other customers many miles away. Occasionally a new customer is told that there is no service available because the cable is loaded to capacity, but the records have failed to make reference to other cables on the same poles. (see diagram below)

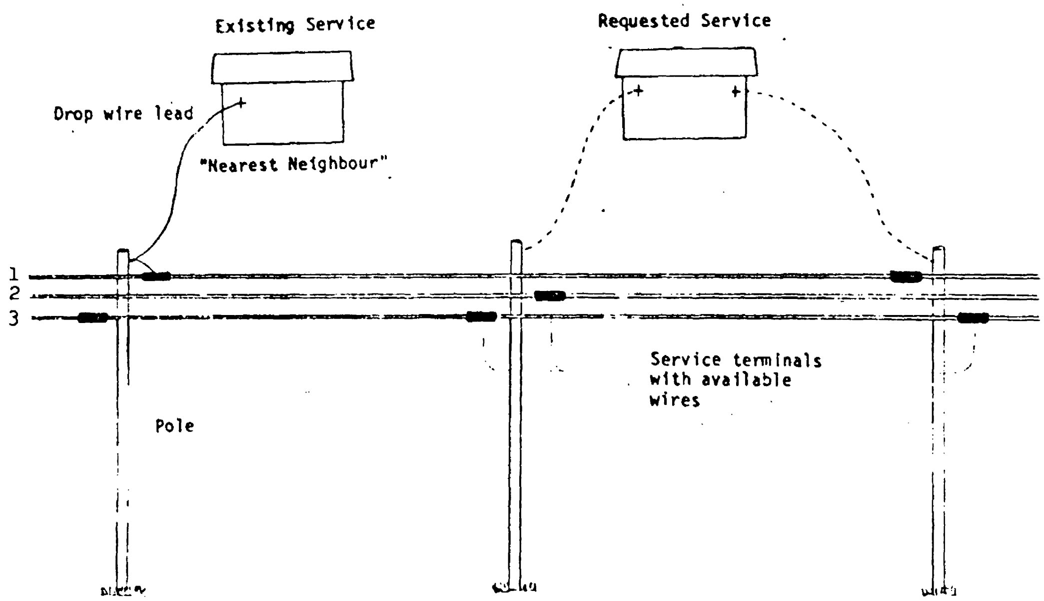


Diagram 4-2 Cable 1 is loaded to capacity. A "nearest neighbour" search of the records will indicate no available service, because there is no reference in the present assigning records to additional cables on the same poles.

Cable telephone service can only be tapped at access points. If utility poles were coordinated, the access points could be given the positional coordinates of the nearest pole. The assigning of pairs could then be done by searching the access coordinate file for the closest access point, and/or access points within a given distance of the new customer.

The coordination of access points and an on-line equipment information system opens previously unthought of options. For instances, the turnaround time on inquiry might be sufficiently fast for the service man to make the inquiry based on an "on-the-spot" assessment of the situation.

There is a definite trend in decreasing costs of switching equipment and a continual cost insrease in material and labour for cable installation and maintenance. The inevitable result will be a trend to smaller switching units to serve smaller areas.

In heavy growth areas, there may be wide-spread reallocation of switching centers to accommodate the trend to smaller areas. It is a simple matter to decide that all the customers from a given point along a cable will be assigned to a different switching center, but the identification of the customer from the present records system has proven by experience to be very difficult. The capability of identifying all the telephone numbers and accounts affected at each terminal located in a specified areas would be a great asset in the reallocation of switching centers.

The foregoing has been an enlargement of discussions with Don Jamer and John Morse of the Atlantic Provinces Telecommunication Council. The following part of this sub-section is a written submission by Don Jamer which summarizes the telecommunication requirements.

4.2.2.2 Submission from A.P.T.C.

General

"Telephone company potential uses of digitized base maps fall into two broad categories. The first requirement is in the area of Engineering additions, changes, etc. to Outside Plant facilities. Due to the degree of accuracy required in locating such items as buried conduit in densely developed urban areas, it would not likely be practical to initially develop base maps at such a detailed level.

"The second area where digitized base maps would prove useful is in the area we can broadly categorize as "administrative". The degree of accuracy required in this instance is substantially more flexible. In urban areas, street names and civic numbers serve us reasonably well. However, there are several problems with this method. Local governing bodies tend to be somewhat careless in establishing street names, and in re-naming streets. The problems this can create with computerized files are quite disturbing. Compound this situation with inconsistent spelling, several different streets named identically in the same city, and we have a puzzle which baffles today's most sophisticated computer systems. Any attempt to establish computer files which are accessible by address - given these inconsistencies - is bound to meet with disaster."

Conclusions

"Our analysis of the problem has resulted in two basic conclusions. First, a means of location identification must be established which is either unchangeable, or cannot be changed without our (eg. telephone company) knowledge. Secondly, the location identification for a specific location must be readily obtainable by any member of the general public. The tremendous potential of a location identification method which would meet these two basic criteria should be immediately obvious. The large number of potential users of such a system - power companies, telephone companies, law enforcement agencies, delivery agents, highway maintenance personnel, etc. - suggest an undertaking much broader than any one corporation could be expected to undertake.

"In addition, the ability to relate a specific location identification to a graphic representation of adjacent landmarks (digital map presentation) would provide the capability of relating data conventionally stored on computer files to various geographic areas."

How

"Such a system could be established (eg.) by clearly labelling each utility pole with a number which would locate the pole on, (eg.) a Universal Transverse Mercator (UTM) grid. Alternatively, conventional pole numbers could be retained and the UTM grid location reference maintained on a conventional on-line computer file to permit locating the pole on a digitially stored map presentation. The degree of accuracy of the grid reference for the pole would not be particularly critical as the prime purpose of such a system would be to identify a location to within 2000 to 5000 square feet."

Benefits

"The benefits available to the telephone company with such a system would be substantial, and would include the following:

- simple, accurate, location of customer's premises (especially in rural areas)
- ability to track development and demand on facilities in selected geographical areas
- ability to accurately maintain records on telephone equipment left on customer premises
- better use of outside plant facilities in multi-party use of same cable pair
- easy location of nearest available cable pair to provide service to new customer
- constant tracking of % fill on various sections of cable routes
- substantially improved vehicle scheduling and routing
- improvement in usefulness of telephone directories by producing directories which better serve the geographical area within which the customer resides
- better planning of additions to outside plant facilities
- simplified calculation of mileages for local mileage, inter-exchange mileage, etc."

4.2.3 Transportation

The comments and observations of this section are meant to be general, however, the terminology and examples are those of the New Brunswick Department of Transportation.

Construction has had and will continue to have exacting requirements for information, particularly map information. Since this type of information requirement is project-oriented, it is not an appropriate topic for consideration in a discussion of an on-going data base. The question of whether or not a digital file is needed for design and construction application is purely an internal matter. Fifty to 100 miles per year may fall in the new construction category whereas the New Brunswick highway network totals in excess of 13 000 miles.

In selecting those elements of highway information that might be included in an infrastructure data base, we must consider the elements that are being used frequently, such as those factors which contribute to sufficiency rating. Sufficiency rating is a measure of the roadway ability to perform its function. The N.B. Department of Transportation has a program whereby the arterial and collector routes are photographed on the ground by a camera mounted on top of a vehicle (a frame is exposed for every 40 feet travelled). These terrestial photographs, the original design drawings and a variety of other information provide the elements necessary for the calculation of the sufficiency ratings. The input information is coded and the sufficiency ratings are determined by a computer program.

Graphic representations of highway statistics are also compiled on sheets under the title "Road Life Study". Each sheet represents a "control section" which is an arbitrary length of highway (usually less than 12 miles) between two easily identified points such as a bridge or an intersection. The roadlife study sheets show the type and year of construction, sufficiency rating sections, width of right of way, surface and roadbed widths, degree and length of horizontal curves, grades, a straight line diagram of the road, mileage to 0.001 mile for all features shown, and accident data for each year. A reduced segment of a roadlife study sheet is included as diagram 4-3. The straight line diagrams are provided to the R.C.M.P. who report accidents in terms of distance from identifiable points.

When the road life study system was established, there was obviously no advantage in coordinating the highway alignments. However, if the digital infrastructure system being outlined in this study is developed, coordinated alignments could be of mutual advantage to highways and to other agencies. Coordinated highway alignments would allow appropriate data in the sufficiency rating data base to be incorporated in the infrastructure data base and vice versa.

Along certain arterial highways the department maintains what is termed "control lines" and "control access". "Control lines" are areas or strips of land adjacent to the highway right of ways within which housing or commercial developments are not permitted. "Control access" refers to a section of highway along which access roads are not permitted. Although "control lines" and "control access" are invisible and hence not normally included in topographic mapping, it is being suggested that they are relevant to an infrastructure data base. This is because "control lines" and "control access" fall in that category of information which is needed by those who are concerned with what can be done and what cannot be done in regard to alterations of the infrastructure.

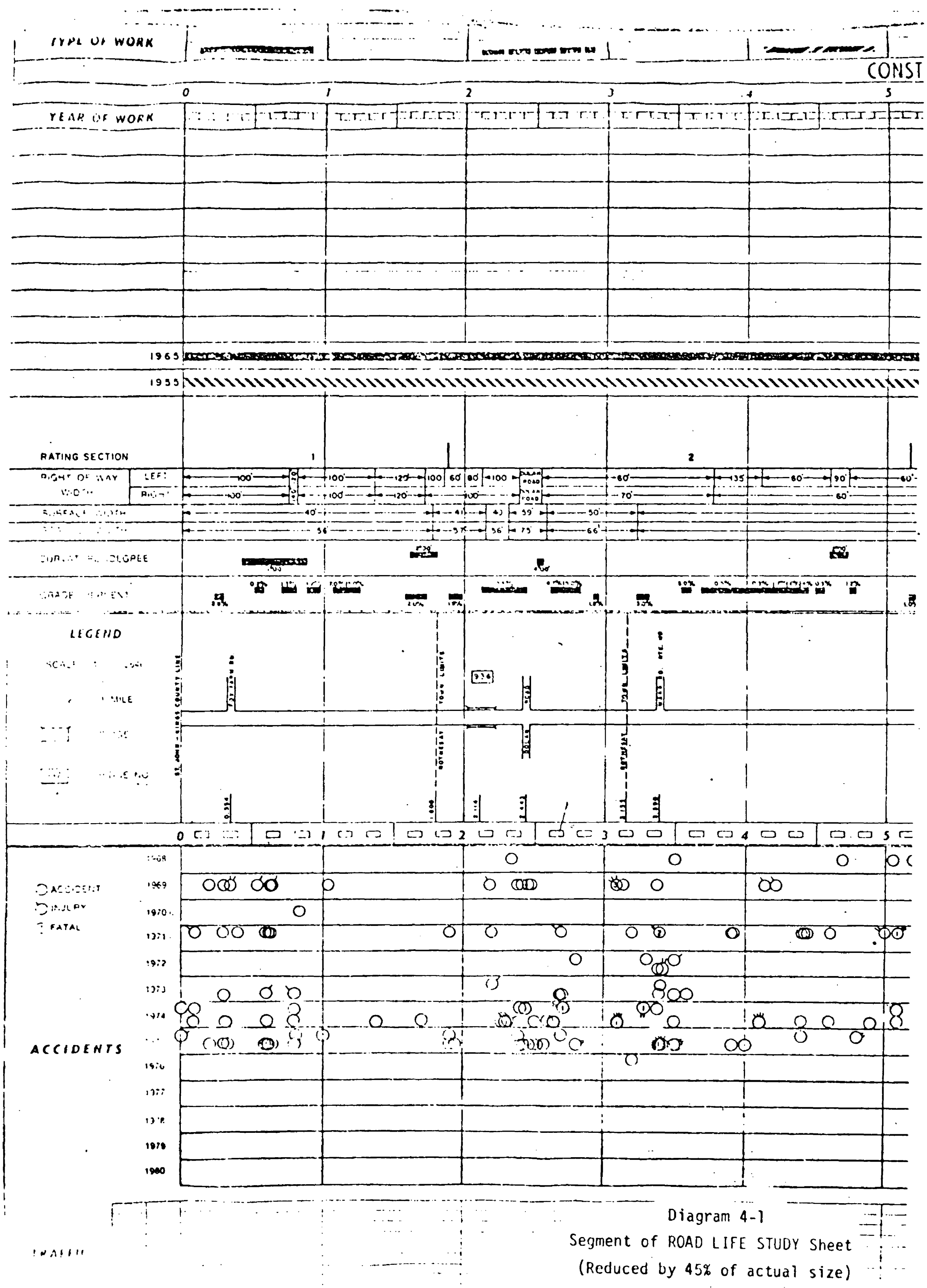


Diagram 4-1

Segment of ROAD LIFE STUDY Sheet

(Reduced by 45% of actual size)

An infrastructure information system cannot be feasibly designed to provide all the detailed information necessary for new highway construction. On the other hand, details of surveys for new construction and the design drawings could serve as valuable documents for up-dating this information system.

In summary, although the road network is an integral part of infrastructure information and the general location of the road network is needed as background for the more dynamic aspects of the infrastructure, it has not yet been possible to identify the need by the highways agencies for output from an infrastructure data base.

4.2.4 Topographic Mapping : The Phase II Role of LRIS

As discussed in Chapter 1, there are four phases to the LRIS Program. To be consistent with the title of the organization "Land Registration and Information Service" one would expect that land registration was the major role of the organization. From this it follows that Phase I and II are supportative phases to Phase III, the land registration phase, and that Phase IV is an enhancement, or an extension of the land registration phase. Topographic mapping has been identified and accepted as a necessary function of Phase II activities. As noted in Chapter I, another study, somewhat similar to this one, is being conducted by the Department of Surveying Engineering to identify the requirements for the long term cartographic program in the Maritime Provinces.

Preliminary conclusions from the cartographic study indicate that a topographic data base suitable for producing maps is necessary in the range 1:5000 to 1:20 000. More specific conclusions as to scale are still under discussion. The requirements defined in the cartographic study are derived from an analysis of questionnaires completed by "economic users". An economic user is defined as one who needs a map in his business activities and who, if he cannot get a map readily off the shelf, will spend at least a modest amount in improvising for his map needs. In this era most "economic users" of maps cannot afford and probably do not need an on-line digital system. Nevertheless, they do need up-to-date topographic maps, and in the future many will undoubtedly develop a capability to use topographic information in a digital format. The on-going requirement for up-to-date maps and the anticipated requirement for digital maps lead to the conclusion that at the very least those classes of features subject to frequent change should be in a digital data base.

It is recognized that topographic mapping is not a user agency similar to electric power or telecommunications. We can think of topographic mapping as representing the requirements of the public. From the discussion in Chapter 2 and as corroborated in the cartographic study, a digital data base has many advantages over graphic methods from the point of view of up-dating a map series. In Chapter 5 it will be shown that the mapping requirement is quite similar to the power and telecommunication requirements. By considering the topographic mapping requirement in this light, a viable inter-agency digital data base becomes feasible.

4.2.5 Urban : Halifax and Dartmouth Utility Coordinating Committees

4.2.5.1 Background of H.U.C.C. and D.U.C.C.

Utility coordinating committees have been formed in the cities of Halifax and Dartmouth to promote cooperation among the utility agencies in the planning, design and construction of new infrastructure. Most of the projects involve more than one agency and most are subject to the approval of the city engineering department.

Monthly meetings of the coordinating committees provide continuous updates on projects and a "vehicle" to air problems at the working level rather than at the political level. Naturally there is much frustration among these agencies but the committees develop a cooperative spirit whereby many potentially large problems are solved by a telephone call. The member agencies of the committees are listed below.

Halifax Utility Coordinating Committee (H.U.C.C.)

City of Halifax (Engineering & Works Department)
Public Service Commission (Water)
Nova Scotia Power Corporation
Maritime Telephone & Telegraph

Dartmouth Utility Coordinating Committee (D.U.C.C.)

City of Dartmouth (Engineering Department)
Nova Scotia Power Corporation
Maritime Telephone & Telegraph

4.2.5.2 H.U.C.C. and D.U.C.C. Infrastructure Meeting

A joint meeting with the Halifax and Dartmouth Utility Coordinating Committees was held to identify the infrastructure information needs of both cities. The consensus of the H.U.C.C. and D.U.C.C. members was that there is a pressing need for utility mapping on a common base map at the 1 : 500 scale. The information data base concept was recognized, but it was considered secondary to the mapping need.

Points expressed at the meeting are summarized below under the headings of utility mapping and on information data base.

On Utility Mapping:

i. any new mapping system should be metric;
ii. the most desirable scale is 1:500;
iii. street maps would be adequate, but total map coverage would be preferable;
iv. within H.U.C.C. it has been proposed that the City could take the

responsibility of compiling the composite utility maps and also of maintaining the up-dates because the city already approves all street openings by permits;

v. the major obstacle to a joint utility mapping program has been the agreement on cost sharing;

vi. the utility mapping should be done by a separately established group with the mapping as their sole responsibility;

vii. it will be necessary to promote uniformity of scales;

viii. presently a utility inventory is being prepared for downtown Halifax showing power, telephone, street lighting, and fire alarms at 1" : 100' but more detail cannot be shown on the plans because the scale is too small;

ix. field personnel of the mapping agency should be available to make positional ties for the various agencies whenever necessary, however, there may be difficulty scheduling the work. Therefore, it may be more advantageous for each agency to have its own field people.

On an Infrastructure Data Base:

i. the customer records and billing people of Maritime Telephone and Telegraph are interested in the LRIS new land titles information;

ii. up-date might be easier in digital format than in the graphic format;

iii. Maritime Telephone and Telegraph does not need the positional accuracy that is possible with a digital system;

iv. the power distribution people in Halifax and Dartmouth do not presently need sophisticated computer modeling;

v. perhaps we can grow into the digital application once we have the positional problems solved on a common scale base;

vi. generally it was agreed that a data base would be very useful to planners.

4.2.5.3 Interviews with H.U.C.C. and D.U.C.C. Agencies

Following the H.U.C.C. and D.U.C.C. meeting, interviews were held with the five agencies represented at the meeting. The objectives of the interviews were:

i. to explore the information exchange among the infrastructure agencies;

ii. to establish what information each agency has;

iii. to study the organization of the information;

iv. to acquire present yearly information costs;

v. to inquire about accuracy of the data;

vi. to determine retrieval costs in the present systems.

An outline was prepared for the interviews to achieve uniformity of the results. The guide-line included a few general questions followed by specific questions to be answered on groups of information elements that have similar properties. In most interviews, two groups of information elements were chosen (ie. overhead and underground plant was a sufficient breakdown for the Power and Telephone groups).

The general questions reemphasized that the most desirable scale for urban mapping is 1 : 500 and possibly 1 : 200 in congested areas. The majority of the persons interviewed would prefer total mapping coverage as opposed to street area coverage, provided the costs were not significantly increased for total coverage. The majority expressed a desire to have at least the fronts of the buildings shown on the maps. As cited in Chapter 5, there appears to be a universal trend towards total or grid coverage, rather than street line coverage.

Information retrieval appeared to be an insignificant part of design in that most agencies knew where their records were, and when they needed other agency records they relied on the cooperation of the other groups to search out available information. Generally there is a lack of confidence in existing records because most records have no provision for up-date. Many are design drawings and the term "as-built" has unfortunately become a joke. From the five agencies interviewed it can be roughly detected that 60% of information retrieval is for internal agency requests and 40% of information retrieval is for external agency requests.

Assuming that up-to-date 1:500 topographic maps showing only the features that could be identified from the aerial photographs were available for Halifax, the agencies were asked to estimate what percentage of the missing features could be plotted from existing plans and records and what percentage would have to be field checked or surveyed. The average reply was that 44% could be plotted from office information and the remaining 56% would have to be field checked or surveyed. These percentages are somewhat of an educated guess because the Halifax utility people have had experience plotting their plant on 1:480 topographic mapping that the city had compiled from 1959 photography.

The five agencies gave answers to the specific questions of the interview guide-line on nine general information groups as shown in Table 4-4. Without an in-depth study of the situation it is very difficult to get realistic answers to the type of questions that were asked in the interview. For instance, the question on the percentage of the plant that has positional information is dependent on a standard acceptance of what constitutes positional information. In this case perhaps it is more significant to say that there is no positional information for 30% of the sewers in Halifax and no positional information for 40% of the street lines and street hardware and so on across the table.

In asking the agencies about the frequency and time involved in utility information searching, it was clearly indicated to be of negligable consideration. The plans, drawings, and records are usually readily available. The problem is in the reliability of the data. Little or no up-date coupled with the dilemma of "design or as-built" are the main problems.

The estimates of the number of man-days it would take to plot the

Table 4-4 INTERVIEWS WITH HALIFAX AND DARTMOUTH UTILITY AGENCY REPRESENTATIVES

	CITY OF HALIFAX		CITY OF DARTMOUTH		P.S.C.	N.S.P.C.		MT & T		
	Sewers	Street line & hardware	Street lines	Underground Sewer & Water	Water	Underground	Overhead	Over-head	Under-ground	TOTALS
% of plant having positional records	70%	60%	15%	15%	70%	10%	20%	80%	50%	
% of plant tied to N.S. control	5%	7%	10%	0	5%	-	-	0	5%	
Man-days per sheet to transfer existing utility information to <u>one</u> base map	1.5	10	5	-	1	-	-	-	1	
% of works contracted	10%	-	-	75%	95%	100%	50%	0	100%	
% of "as-built" prepared	(question of validity)	-	-	15%	95%	50%	7%	0	5%	
Size of system	260 mi.	220 mi.	136 mi.	320 mi.	220 mi.	75 mi.	900 mi.	-	-	
Yearly field survey expenditures	$45 000	$45 000	$36 000	$36 000	$85 000	$8000	$10 000	-	-	$265 000
Yearly drafting expenditures	16 000	20 000	8 000	12 000	15 000	7000	5 000	-	-	83 000
Yearly expenditures on N.S.L.S. services	-	25 000	0	0	-	0	0	0	20 000	45 000
										$393 000

<u>NOTE:</u> The $393 000 is the total "in-house" expenditures on surveys and drafting along with the cost of surveys farmed out to Nova Scotia Land Surveys in Halifax and Dartmouth.
The total does not include the hidden survey costs in large construction contracts.

the existing Halifax infrastructure information on a composite utility map sheet is given as 15 man days. The map sheet was assumed to be the same format as the old 1:480 city topographic map sheets which covered 28 acres.

1	man day for water
1.5	man days for sewers
10	man days for street lines and street hardware
1	man day for telephones (estimating 5 plats at 2 hours each)
1.5	man days for electric power (judging from the sample plans)
15	man days @ $60/day = $900 or about $30/acre or ½ man day/acre.

This estimate is a first approximation. The only way to get realistic estimates is by an actual test project. It should be pointed out that the approach being discussed here would only provide a semi-accurate positional inventory of the infrastructure. The inventory would be based on identifiable features on aerial photograph images as correlated with existing utility records (no field editing).

It is interesting to note from Table 4-4 that most of the utility works are contracted. Undoubtedly, the construction industry is another group that should be very interested in infrastructure information.

Most of the comments on "as-built" drawings were similar in that many design drawings have been labeled "as-built" when in fact there have been alterations. Consequently, the "as-built" label is questionable. At the Public Service Commission 95% of the works are contracted, but the P.S.C. has an inspector on the job who also takes the measurements for "as-built" drawings and even plots his own profiles.

An attempt was made to determine the yearly infrastructure information costs in Halifax and Dartmouth. Including in-house surveying and drafting as well as contracted surveys, but excluding the surveying costs on contracted works, a total of $393 000 was arrived at.

4.2.5.4 Halifax-Dartmouth : suggested site for further investigation

There is a consensus among the utility groups in Halifax-Dartmouth that up-to-date topographical maps, comparable to the 1960 maps (1" = 40') of the Halifax Pennisula, are needed as the first step towards an integrated utilities information system. This is consistent with the pattern in European cities as discussed in considerable detail in the next chapter.

New mapping is only the first part of the solution. The value of a map to a user depreciates with time almost as rapidly as the value of an automobile. The second part of the solution then is the implementation of an effective means of continuous up-dating. It is in this regard that digital graphics may contribute to the solution.

The basic topographic features such as water courses, contours and the majority of highways and streets change very little. It is changes in buildings, roadway dimensions and "street hardware" that create the need for map up-dating. If these changes can be added to maps as they occur there would not be the need for new photogrammetric mapping every few years. Users would also have "complete" maps at all times.

The application of digital information systems in the urban setting should be closely studied along with the development of conventional graphic systems. Where a worthwhile application of digital graphics is recognized, it could be implemented to complement the existing graphic system.

As the Halifax-Dartmouth metropolitan area is the largest one in the Maritimes, it is the one in which the infrastructure information problem is most acute. From this it follows that Halifax-Dartmouth is the logical area for further investigation and possibly for a pilot project on urban infrastructure information systems in the Maritimes.

4.3 CONCLUSIONS AND COMMENTS

4.3.1 Conclusions

From a review of the minutes of the workshop, an analysis of the questionnaires and the user submissions it is concluded that *there are three distinct, identifiable levels at which infrastructure information is required.* These are:

i *A complete, detailed, accurate utilities-oriented positional information system (equivalent to a map scale 1:500) is needed in the larger metropolitan areas;* this requirement will be discussed in Chapter 5.

ii *A computerized data base at moderate accuracy (approximately equivalent to 1 : 10 000 scale mapping) is needed for those elements of infrastructure that occur throughout the entire region, namely power networks, telecommunication networks, transportation networks and buildings;* this requirement will be discussed in greater detail in Chapter 6.

iii *There is a need for generalized infrastructure information for regional planning, impact studies and other users of generalized information.* If the regional system defined above was established, the need for generalized information could be met quite readily through the services of the coordinator-broker (as outlined in Chapter 1).

4.3.2 General Comments

It is recognized that many other infrastructure information producers and/or users exist in the Maritime Provinces and that ultimately they will become producers and users of any new systems that are devised. It is also recognized that they have a large number of problems more pressing than the development of new systems of handling infrastructure information. In view of the fact that any of the systems proposed in this report will be in the research and development stage for several years, we trust that these other potential producer-users should not feel left out at this stage; there will be time for them to become involved at later dates. Specifically, it is recognized that the Nova Scotia Power Corporation and the Prince Edward Island Power Commission are interested in infrastructure information but, for various valid reasons, it has not yet become as acute a problem with them as it has with N.B. Power.

Similarly, with respect to the urban information systems, it is recognized that other cities such as Moncton and St. John have infrastructure information needs. Whereas the Halifax-Dartmouth area is considerably larger the need for better infrastructure information has become more acute there than in the other metropolitan regions. It is anticipated that the other metropolitan regions will be able to learn from the lessons gained in any pilot study that is conducted in the Halifax-Dartmouth area.

5 URBAN INFRASTRUCTURE INFORMATION : OVERVIEW AND RECOMMENDATIONS

5.1 INTRODUCTION

The need for a systematic documentation (registration) of the underground utilities was recognized in some European cities over 60 years ago. The oldest tradition is in Switzerland, where the first cadastre of underground utilities was established in the small city of Olten in 1915, followed by the initiation of the systematic mapping of infrastructure details in the city of Basel in 1917. Presently, almost all the cities in the world have some kind of documentation of the underground utilities but not many have an information system which works reasonably well. Very few cities have a centralized information system being kept up-to-date and satisfying all the needs of the utility agencies, planners, engineering companies and other users. There is no one city with a 'perfect' system.

The last 20 years have been marked by an intensified search in many countries for an ideal model for the infrastructure information system. Most of the old working systems were based on large scale "strip maps" of the utilities along the streets (1:500, 1:250 or similar scales), and these were not always correlated with topographic and property maps. About ten years ago most of the cities with advanced cadastres of the utilities started changing from the street or strip map systems to complete coverage with grid maps. The grid maps at scales of 1:500, 1:250 or 1:200 were based on enlargements of the common basic city maps, which are usually in scales of 1:1000 or 1:500, being either the full topographical maps or only property (land cadastre) maps.

The last five years have brought an intensified research in the computerization of the information systems and a trend towards the use of a digital cadastre of the underground utilities.

Switzerland, Poland, West Germany, Hungary and Czechoslovakia are presently the most active European countries trying to improve and modernize their information systems on infrastructure. Bulgaria, Yugoslavia, Holland and Sweden are also interested. Canadian cities, particularly Montreal, Ottawa and Toronto, have been working intensively in the last few years on the establishment of a cadastre of the underground utilities. Each of these cities already has a system working but the systems are different in each city.

Obviously, there is a lot of research and experimental work being done in many countries. An international working group (group D) on mapping of underground utilities was established a few years ago at the Commission VI (Engineering Surveys) of the Federation of International Surveyors (FIG) in order to coordinate the research and to bring together those interested. The group is led by Mr. K. Kollar of Czechoslovakia. His address is Hastolsk 12, Praha, Czechoslovakia. A number of papers on the subject of the cadastre of underground utilities were presented at the FIG congresses of 1971 (Wiesbaden) and 1974 (Washington). Five conferences on the subject of urban mapping, including the problems of underground utilities, were held in Poland between 1967 and 1974. Two conferences were held in Canada, one in Toronto (1970), and the other in Ottawa (1972). There are several recent books and manuals on urban surveying and on engineering surveys dealing with the subject.

All the above materials have been studied for this report in order to summarize and evaluate the status and trends in mapping of underground utilities in different countries and different cities. The studies of the conference proceedings, books and other articles have been supplemented by personal visits to a number of city offices and utility agencies in different countries and by private correspondence.

Unfortunately most of the available source material is not in the English language. A summary of the more important findings from the most recent source material is given in subsequent sections, followed by conclusions and recommendations.

5.2 LIST OF SOURCE MATERIALS

The following materials have been used in the study:

Books

Bramorski K. et al, Geodezka Miejska (Urban Surveying - Polish) PPWK, WARSAW, Poland, 1974.

Krumphanzl V. and Michalcak O., Inzenyrska Geodezie (Engineering Surveying - in Czech) Vol 11, Praha, 1975.

Conference Proceedings

International conference of "The Role of Surveying in the Management of Underground Utilities in Urban Areas" (in Polish), Lodz, Poland, May 1974.

The XIVth International Congress of Surveyors (FIG), Commission 6, Washington 1974.

The VIIIth International Congress of Surveyors, Commission 6, Wiesbaden 1971.

Conference on "Urban Surveying" (in Polish), Chorzow, Poland, October 1972.

Conference on "Actual Problems in Geodesy" (in Polish), Nowy Sacz, Poland, 1971.

Conference on "Selected Problems in Surveying, Cartography and Land Management in Urban Areas" (in Polish), Nowy Sacz, Poland, 1971.

Conference on "Basic Urban Map", Warsaw, June 1967.

Workshop on Infrastructure Information Systems, UNB, June 1975.

Personal Visits

Material was collected from the following cities (1973-75):

Basel, Switzerland
Zürich, Switzerland
Bern, Switzerland
Munich, West Germany
Montreal
Toronto
Ottawa
Halifax
Warsaw, Poland
Kraków, Poland
Rio de Janeiro, Brazil
Cincinnati, USA
Helsinki, Finland

All the above material is available at the University of New Brunswick in the Department of Surveying Engineering.

5.3 BOOK SUMMARY : "URBAN SURVEYING" - BY K. BRAMORSKI ET AL.

The book consits of 19 chapters with a total of 800 pages, and deals with all aspects of urban surveys including: land management in urban areas, city control surveys, urban cartography, photogrammetric mapping, tunneling surveys, construction surveys, introduction to urban planning, subdivision designs, surveys, etc.

Chapters 10 and 11 deal with planning, construction surveys and the cadastre of underground utilities. Abstracts of these two chapters with some quotations are given below.

According to an instruction of the Ministry of Municipal Management (in Poland), the full inventory of the underground and overhead utilities includes the following kinds of inventories.

i. Detail surveying inventory.
ii. Branch inventory.
iii. Economic and financial inventory.

The detail surveying inventory procedure includes:

i. Determination of the type and function of the utility.
ii. Mapping of the entire utility system.
iii. Measurements of dimensions of certain elements of the utility plant.

"All the documents of the surveying inventory are kept in surveying institutions (city survey offices, urban surveying companies or county surveying offices)".

"The surveying inventory should in principle be made after the utility is constructed but before it is covered". This type of inventory is called an as-built inventory. Some cities have governmental or municipal regulations that require all the new utilities have the as-built inventory, (e.g. Warsaw since 1953).

If the as-built inventory cannot be made before the utility is covered, then the surveying inventory must be based on surveys using electronic locators through available accesses such as man-holes, or by digging special exploratory trenches.

The branch inventory is usually done by the corresponding utility agency but often (as in the cities of Poznan, Lodz and Koszalin) it is done by survey companies together with a specialist from the utility agency. The branch inventory is as a rule made before the new utility is covered. The inventory included the type of material and dimensions of pipes and conduits, the type and location of junctions of conduits and the type of their sealings, the type and dimensions of the exposed hardware such as man-holes or hydrants, the rating information such as pressure of water, gas or steam, the characteristics of cables, diameters and voltages, the year of construction of the conduit, its actual usefulness, technical sketches, description of technological processes and finally, the plotting of the recorded utility on a branch map according to branch standards.

Maps of utilities are divided into two groups: survey maps; and branch maps.

i. Survey maps made by surveying agencies:

- are based on as-built surveys made before the utility is covered which yields the most accurate maps;
- are compiled maps using as-built surveys of the visable hardware but after the coverage of the utility; (The underground is obtained by field surveys through man-holes, by electronic locators and partially from information available from branch inventories. These maps are less accurate but if trenches are used for checking, the maps may be improved almost to the standard described above).
- are based on the design of the utility location by the survey agency; (The location of the utility is then inspected by the survey agency during the construction. Practice shows that these maps may show large deviations from the as-built situation).
- or are compiled almost entirely from the information obtained from branch inventories with some location checks at exposed or easy accessable parts of the utilities. (These maps are generally of a poor accuracy and should be treated as index maps only).

ii. Branch maps are made by branches and are supplemented by field measurements, profiles, sketches and description. Their use is very limited in preparing the survey maps, because the identification of the utility element positions is sometimes impossible or unreliable.

The survey maps are usually made in scales 1:200 or 1:250 for core areas and 1:500 for other areas. They are usually street maps (route maps) compiled from enlarged basic city maps which are either 1:500 or 1:100. Recently, there is a tendency to plot the utilities on the sheet (grid) maps enlarged directly from the basic maps. All the measurements for the detail survey inventory of the mapped underground utilities must be tied to the city control network. The orthogonal or polar method measurements from the traverse sides or traverse stations is made. Linear measurements must be done within ± 1cm. Height measurements must be within ± 1mm for sewers but can be less accurate for other utilities. The positioning of utilities in the branch inventory surveys is done usually by linear intersections to existing topographical details. Therefore, the identification of the position at a later time may be difficult.

There are several detailed governmental or municipal instructions and specifications in Poland dealing with:

i. the details to be shown on the utility maps;
ii. the symbols to be used on different scales of maps, along with the dimensions of the symbols;
iii. the procedures of field surveys;
iv. the design of the underground utilities.

These specifications are merely listed in the book and the author does not elaborate on them.

Electronic locators are very frequently used in mapping old utilities or when checking the branch maps. There are over ten different models of locators for locating various utilities. Locational accuracy of the locators is about ± 10cm horizontally and ± 20cm vertically. The book devotes about 30 pages to the electronic location.

Methods of measurements of different types of utilities are detailed in the book. It is emphasized that mapping of the utilities solely on the basis of the visible surface features and the branches' inventory is absolutely inadequate. One should map the actual axis of the utility. This may differ quite considerably in its location from the axis defined by the surface features.

Safety regulations (methan gas in sewer systems, high voltage in cables, high pressure of hot steam etc.) are discussed in the book and it is emphasized that they should be known by the survey crews.

Three examples are given in the book dealing with the organization procedures connected with planning, design and construction of underground utilities in Poland.

5.4 BOOK SUMMARY "ENGINEERING SURVEYS" - BY KRUMPHANZL ET AL.

Surveys and mapping of underground utilities is described on 22 pages, out of which 16 deal with the electronic location of utilities.

A brief history of international conferences on the cadastre of underground utilities is given, which explains the creation in 1969 of the working group D of the FIG (International Federation of Surveyors).

Basel, Bern, Luzern and Warsaw are listed as the cities with a complete cadastre. In the Warsaw system, the design and supervision of the location of the utility during its construction is done by survey agencies and measurements of all the new utilities are done before the utility is covered. In Basel, the survey crew is sent to each construction site on a telephone call from a particular branch. Maps are 1:200 in a form of street maps derived from the city basic maps of 1:500, and they are made on the Cronaflex film in one colour. In Luzern, maps are 1:250. The city survey office coordinates the planning of underground utilities and keeps all the evidence. In Bern, maps are also on Cronaflex, but in colours. The street maps are being replaced by the sheet maps.

In Czechoslovakia, the district complex maps of utilities are done in 1:5000 and detail in 1:500. Generally a cadastre of underground utilities is made in scales 1:200 to 1:500 on enlargements of basic property (cadastral) or topographic city maps. An overlay system is frequently used. Positional accuracy are 5 to 15 cm and elevation accuracies are from 2 to 5 cm. There is a need for legislation to establish a centralized system of information. Warsaw is cited as an example on the advantages of a centralized system.

5.5 SUMMARY OF PAPERS PRESENTED AT THE INTERNATIONAL CONFERENCE IN LODZ IN 1974

Twelve papers were presented by representatives of Poland, Switzerland, Czechoslovakia and Hungary. Four of the more important papers are summarized below. The available proceedings have been published in the Polish language.

"Role of Surveying in the Management of Underground Utilities in Urban Areas" - by W. Klopocinski

The author lists the services that belong to the technical infrastructure as water, sewer system, electricity, gas, heating, pipelines, transportation and communication. The city of Warsaw employs 593 engineers and technicians (1973) in the Surveying Service for the technical infrastructure.

The services that surveying provides at the various stages of projects and are given in the paper as follows.

Stage	Surveying Services Provided
Preliminary planning	Basic maps
	Maps of routes for transportation studies
Design	Geometry of streets (center lines, curbs)
	Complex project of underground utilities
	Issuance of the localization of the lines in the street
	Coordination of the technical projects
Construction	Lay-out of the geometry of the streets
	Lay-out of the utility lines
	Mapping of the "as-built" plans
	Checking the project with the "as-built"
	Preparation or permits for changes
	Up-dating of the maps
Exploitation	Maintenance of the cadastre of utilities.

Changes up to ± 20cm are permitted in the localization between the design and the "as-built". Larger changes require an analysis: "Why?" and "is it possible?" The surveyor has a power and duty to change the position of the utility if it was not built in the place as designed.

"Twenty Years of Experience in the Inventory of Underground Utilities" by J. Friedli and A König.

The paper describes mapping of underground utilities in the city of Bern in Switzerland. According to data of 1972, the population of Bern was 160,000 with 370 km of roads, 270 km of gas pipes, 360 km of water conduits, 960 km of electric cables and 370 km of sewers.

Mapping started in 1954 in a form of "street maps" in the scale 1:200. In 1968 there were 300 maps in a form of long sheets with a width of 30 cm or 60 cm. Difficulties in the use of the "sheet maps" led to a change in the system. In 1969 it was decided to re-map the entire city in a "raster" system covering the entire area. The maps at 1:200 are enlarged photocopies of the individual cadastral maps at 1:500 taken from the so called "eternal books" of the land registration system. The enlarged photocopies are produced in a pale-grey colour and only details such as symbols, survey points and curbs (i.e. details which are useful in field location of the utilities), are drawn in black ink. Only horizontal positioning of utilities is represented because there are rigid rules about the depth of individual utilities. The maps are 84 x 60 cm on sheets 100 x 66 cm so that the mapped area may be enlarged to 94 cm (20 m in the field) if an important intersection would be cut into two maps.

Production of a 84 x 60 cm map of underground utilities consumes the following number of man hours.

Type of Survey:	Field:	Offices:	TOTAL
Topography (from 1:500)	-	10	10
Sewer	16	6	22
Telephone	5	15	20
Cable vision	3	4	7
Electricity	6	16	22
Gas and water	12	16	28
TOTAL	42 hours	67 hours	109 hours

Mapping is done either before the cover (in new developments) or on the basis of the visible surface hardware complemented by the branches' maps and sketches.

Different colours are used for different utilities, but the utilities which are mapped from the branch maps only are drawn in black. Different symbols allow the use of black and white copies of the multi-colour maps.

"Surveying Documentation of Realization of Construction in Czechoslovakia" by J. Simek

The author gives first a brief review of the status on the surveying inventory of underground utilities in different countries, as highlighted in the following paragraphs.

"The oldest tradition in this respect is Switzerland where already in 1915 in a small town of Olten and later on in Basel in 1917 systematic decumentations of underground utilities were initiated."

In West Germany, surveying agencies elaborated a proposal for the cadastre of underground utilities using a plastic film of a basic map at 1:500 and a computerized file of the utilities. The use of photogrammetry has been investigated as a means to map about 50% of the visible surface features. The city of Dortmund is mostly mapped on "Pokalon" (a plastic film produced in West Germany).

East Germany does not have any advanced centralized systems. They have started thinking about it.

"In Poland, the Ministry of Interior and Ministry of the Urban Management ordered in 1965 a uniform documentation of all the utilities in all cities. Maps of streets at scales 1:250 and 1:500 are used showing the surface details and underground utilities including heights and some descriptions. Review maps are made at 1:1000 and smaller scales. Mapping and maintenance of the cadastre is carried on by the state surveying services."

Since 1968, for some cities in Yugoslavia the situation is similar to that of Poland. State regulations govern the documentation which is carried on by survey agencies. The city of Beograd has 20 technicians for that purpose. Initial costs are covered by the city but up-dating and maintenance of the cadastre is covered by the utility agencies.

Until 1965, the situation in Czechoslovakia on underground mapping was very poor. Each utility branch had their own maps but these were not correlated with others, and were in different scales. In 1965 a technical map of Prague was ordered by the Office of the Chief Architect. The mapping will cover the whole city by 1980 on 1556 sheets at 1:500 and on 647 sheets at 1:1000. A cadastral map of 1:1000 serves as a basic map for the enlargements into 1:500. The map shows the topography, situation details on the surface and the whole infrastructure. The topography included heights of points and contours. The map is made in nine colours according to special Czechoslovakian specifications. All the new utilities are mapped "as-built" before they are covered. There are some problems in obtaining the information on the new construction from the branches.

The situations in other cities is given below.

Cities	Situation
Bratislava	The utility branches make the mapping themselves, usually at 1:1000
Bern	There are varying map scales and projections for different parts of the city
Pilzno	The branches do separate mapping. Central mapping at 1:500 will be initiated soon
Pardubice	Central mapping was initiated in 1964 on 187 sheets at 1:500 (enlarged from 1:1000 cadastral maps). The utilities are in 6 colours on a transparent film. The mapping will be completed in 1980.
Hradec Kralove	A technical map was initiated in 1968 on 300 sheets at 1:500. Property numbers are included, as well as, heights of buildings (number of floors), and the type of street cover. This mapping has a two year production cycle.
Olomouc	Here one complex map in nine colours plus transparent originals for each utility are given to the branches for up-dating. The up-dating transparencies are sent back to a central survey office which is in charge of the complex map.

In 1974 there was supposed to be new legislation in Czechoslovakia which would coordinate and regulate the technical mapping at the national level, for urban areas and for regional utilities. The regional technical maps are in the scale of 1:5000. The urban maps will be made at 1:500 and 1:250 for the core areas.

"The Cadastre of Terrain Registration as a Segment of a City Data Bank" by A. Wroblewski and T. Rybicki

The paper describes the information system on infrastructure being developed as a sub-system of a general data bank (general information system) in the city of Warsaw. The information system will be based on the already existing detail data on the infrastructure. The data is available from the city survey services and utility agencies. Diagram 5-1 shows the flow of information in the infrastructure sub-system.

The only portions of information that will be computerized are those which are needed for: decisions concerning a large urban district (in the order of 50 Ha area); and answering questions concerned with the possibility of connecting a new customer to the utility network.

A system of graphical maps at 1:500 and 1:250 are the basis for the positional information. The maps are made by a special surveying service which is responsible for the planning and execution of proper positioning of the infrastructure details.

The system of maps consists of original plotting manuscripts, field survey files and the following list of thematic transparencies.

i. Topography of the surface
ii. Underground utilities (existing and planned)
iii. Realization of urbanistic projects
iv. Properties
v. Geodetic network

These transparencies are a basis for making multi-colour maps for different purposes.

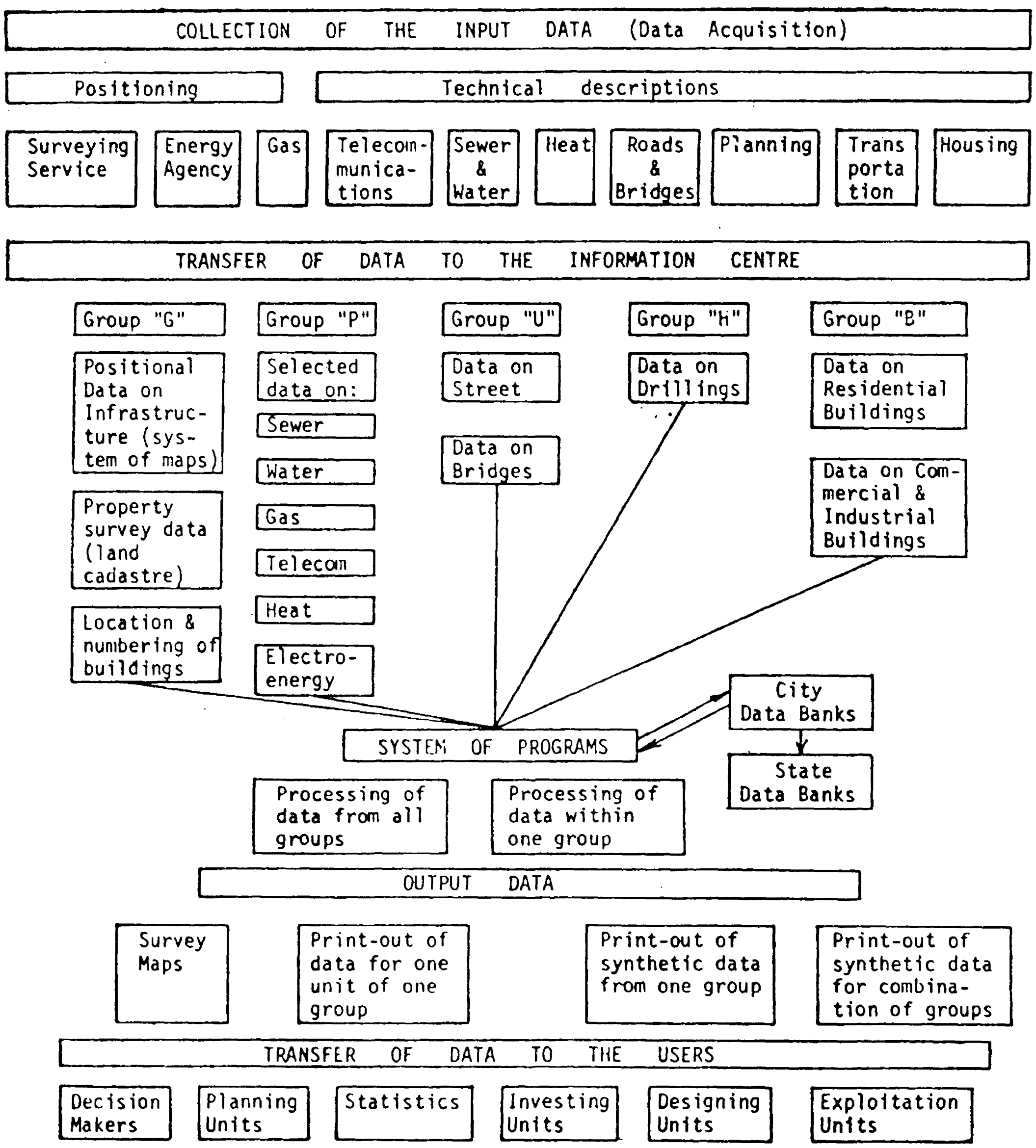
Underground utilities are numbered according to the division of the city into districts and urbanistic regions. The number also indicates the type and function of the utility. This type of numbering has sometimes proven to be inconvenient when searching for the utility on a map. In the future, the coordinates of characteristic points of the utilities will be used as the indicators. Right now, all the utility surveys are connected to the city control network.

The paper emphasizes that on the basis of the author's experience, *it would be impossible to start thinking about any information system without having the graphical maps of the existing infrastructure first.*

Diagram 5-1

INFORMATION FLOW IN THE INFRASTRUCTURE

INFORMATION SUB-SYSTEM



5.6 SUMMARY OF PAPERS PRESENTED AT THE FIG CONGRESS, WASHINGTON, 1974

A report on the activity of the working group D of Commission VI was given by Mr. Kollar, Chairman of the group, and three papers were presented. The activities of the group between 1971 (the date of the previous FIG Congress) and 1974 included the organization of two workshops in Czechoslovakia (on mapping of underground utilities) and the organization of the International Conference in Poland. A bibliography on underground utilities has been collected from nine countries for the period 1972-73. The group has been working on the creation of an International Information Centre on the status and research on the subject in different countries.

One of the three papers presented at the FIG Congress was the same paper as already summarized in 5.5. Another paper was of a very general nature. The third one, presented in English, is a very interesting one and it is summarized in detail here.

"A New Uniform Registration System of Public Services in Hungary" by S. Katona (Hungary)

The paper gives an overview of problems and possible solutions connected with information systems on public utilities. It also gives a proposal for a nationwide instruction for the information system covering all the Hungarian cities. The instruction has been based on an extensive pilot project which was completed in 1974. At that time, it was expected that a full cadastre of underground and overhead utilities in the whole country should be ready in 12 years. Thought had been given to making a numerical cadastre but it was realized that it would be too expensive and graphical mapping has been adopted as an intermediate solution. The graphical cadastre is arranged, however, in such a way that it will be possible to use the collected data in a numerical system in the future.

The contents of the proposed cadastre are listed below.

i. transparencies of individual utilities at the scale 1:4000
ii. complex map transparencies of utilities at 1:500
iii. branch maps of individual utilities at 1:500
iv. detail drawings
v. and data sheets (description files).

The up-dating and maintenance of the cadastre will be done in two systems: a central registration (responsible for the complex maps); and branch registration. All the utility agencies must by law supply information on any proposed new utilities to the central registration office, which coordinates the work between individual agencies (branches). All the field surveys and mapping of the utilities must be done in a uniform way according to the national instructions and specifications. New surveys are done by individual agencies who have to send their maps to the central registry office once a month for up-dating the complex maps.

Positional accuracy of mapping in both vertical and horizontal plane is required to be within 10 to 20 cm, with an exception for gravitation conduits (e.g. sewer) in which an accuracy in elevation of 1 to 2 cm is required. The extensive use of electronic utility locators is emphasized in the paper.

Mapping is done in the city coordinate systems using enlarged maps from the existing basic city maps at 1:1000 and 1:2000. Diagram 5-2 shows a sample of the overview map at 1:4000. Diagram 5-3 shows the sequence in which the maps at 1:500 are derived. The complex map shows utilities in different colours. Diagram 5-4 shows a sample of the complex mapping (black and white copy of the original multi-colour one) and Diagram 5-5 shows a sample of a branch map. The paper gives many interesting details on the content of the maps and organizational procedures in the collection and exchange of the information.

5.7 CONCLUSIONS

5.7.1 Need for an Integrated Information System in Urban Areas

The large number of cities which are presently involved in the development of the infrastructure information systems and the large number of conferences, symposia and discussions on the topic are the best indicators of how important it is for the modern society to have an integrated infrastructure information system.

The initial cost in the establishment of the information system is high but the experience of the cities which already have a working system (e.g. Basel, Warsaw and others) shows that the cost is quickly recovered. The integrated information system gives many benefits for the municipality mainly by:

i. shortening the time necessary for planning and design of the new utilities due to the readily available complex information on the location and quality of the existing utilities;

ii. minimizing the damage to the existing utilities caused by excavations during reconstruction works, when the information on the location of the utilities is available and easily accessible;

iii. providing for better and faster general planning of new urban developments as a result of correlated information on all the existing infrastructure;

iv. providing easier maintenance and faster repairs of the utility services;

v. increasing safety factor for construction workers.

5.7.2 Graphical or Numerical Information Systems?

Examples in the previous chapters indicate that all the presently working

Diagram 5-2

A sample of the "sketch" map 1:4000 for sewers.

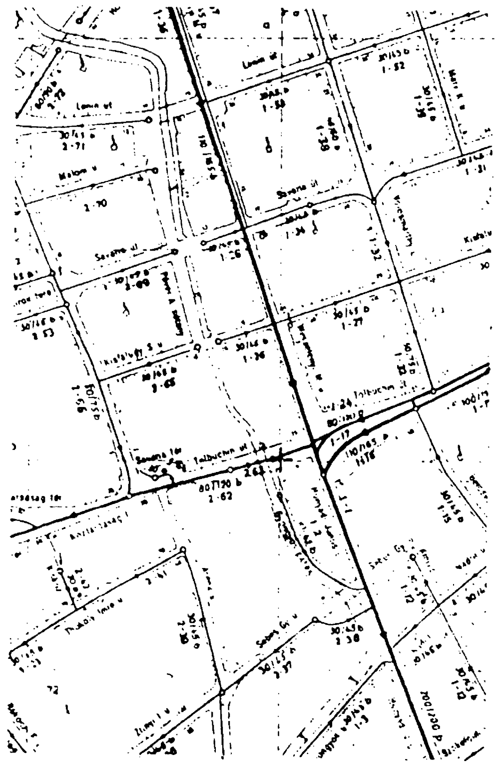


Diagram 5-3

The sequence of the map production

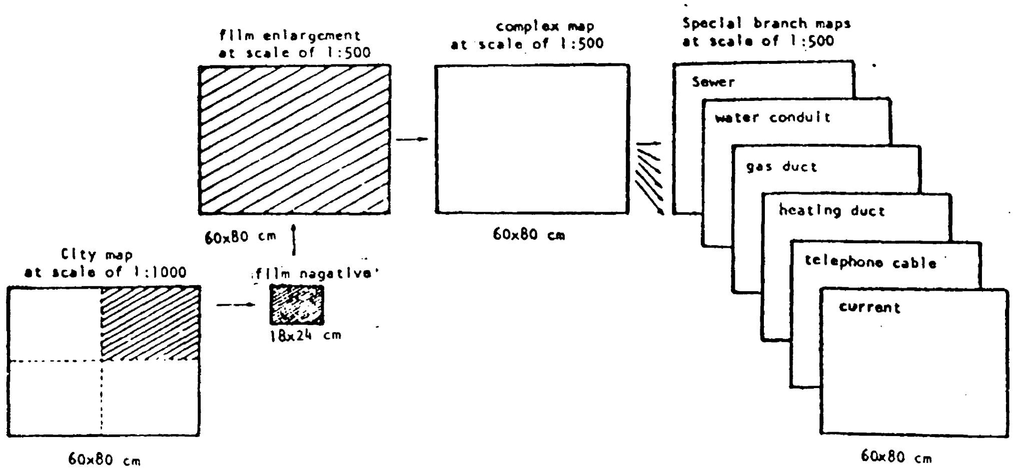
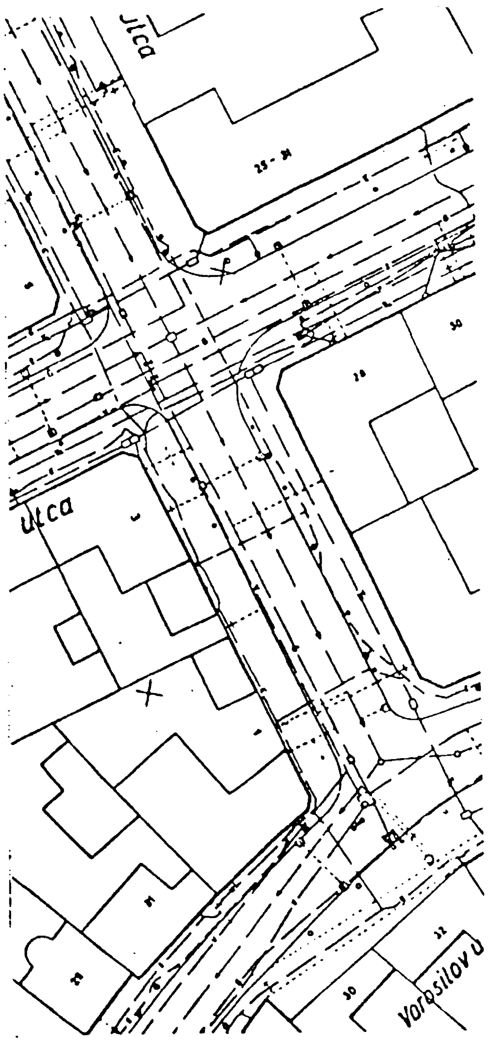
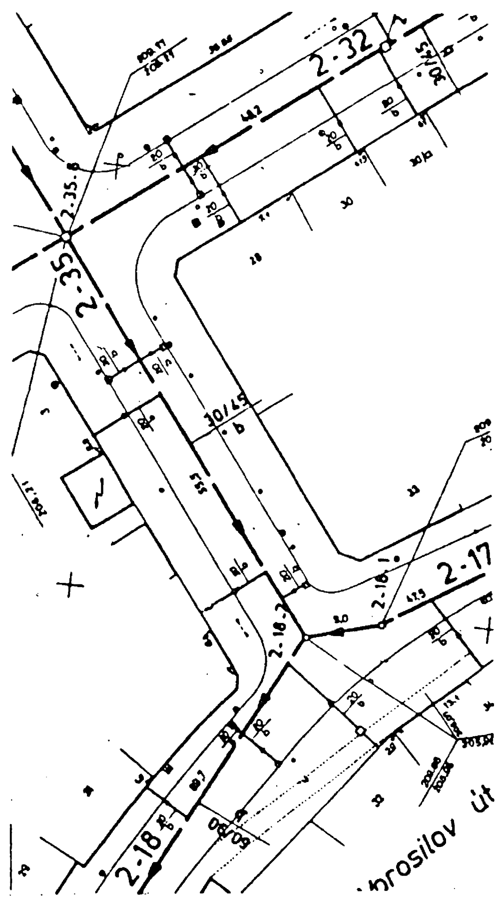


Diagram 5-4



A sample of the complex map 1:500

Diagram 5-5



A sample of the branch map (sewer)

information systems are based on graphical maps of the infrastructure supplemented by description files. There is a general trend towards computerization of the systems but there is no general agreement that complete computerization is really needed or that it would be beneficial in urban areas at the present time. There is no one city development that can be cited as a model study case. There is a general agreement that the cities which are just starting to develop an information system have to base the positional information on graphical maps of underground and overhead utilities employing a common basic map of the surface situation.

Numerical mapping may be the next step in the development of the information system but it seems to be impossible to organize the system in a numerical way without going through the graphical mapping first. It is a question of handling the tremendous amount of positional data in an orderly and visible way. Once the graphical maps of all the existing utilities are complete, then the up-dating process may be done in a numerical way only.

5.7.3 Organization of the Integrated Information System

The examples described in previous chapters show that there are many possible ways of organizing and maintaining the information system. It seems to be clear, however, that those systems are the best in which a survey office acts as a central agency for collecting the information on the infrastructure, production of maps, maintenance and up-dating of the system. In an extreme case, such as the city of Warsaw, the city survey office is also responsible for planning and execution of the locations of the new utilities.

5.7.4 Types of Maps

Scales at 1:500 or larger are required for urban information mapping. Comparison of strip maps along the streets with the grid section maps shows that the latter are much more advantageous for handling an information system for the whole city.

Enlargements of basic city maps at the scale of 1:1000 or similar are adequate for the infrastructure systems. However, one has to remember to take into consideration the thickness of lines and symbols of the basic maps.

In many cities it has been found that the transparent sheets of a stable plastic material are the best for direct plotting of information (as in up-dating) and for direct reproduction (copying). The enlargements of the basic city maps are reproduced directly on the transparencies. The underground and overhead utilities are directly plotted on the transparencies because scribing techniques are too slow and too expensive for the comparatively small number of copies required. The original transparent manuscripts serve directly as a master for the copies. This makes it possible to keep up-dating of the maps almost continuously.

5.7.5 Location of the Infrastructure Details

Experience has shown that the infrastructure maps, which are made on a basis of existing position information from the files of individual branches, are incomplete, have many errors and are not reliable. Photogrammetric mapping is inadequate, gives no more than about 20% information on the utilities location and ground identification of the utilities is always required. Reliable maps have to be made on the basis of ground surveys by a qualified survey crew and according to set specifications.

As a rule, the best systems are those in which the up-dating information on the location of the new utilities is based on the ground survey "as-built" before the utility is covered. Electronic locators of underground utilities play a very important role in mapping old underground utilities that were not surveyed before they were covered.

The ground survey of the utilities is expensive. In the city of Bern it takes about eight man hours of the field surveys per one acre of the core area of the city.

5.8 RECOMMENDATIONS

5.8.1 General Recommendations

The examples of infrastructure information systems in different cities, the conclusions in section 5.7, as well as other source materials listed in section 5.2, lead to the following recommendations for those cities which do not have, at the present time, any type of integrated information system:

i. The development program of the infrastructure information system should be initiated as soon as possible. Delay produces losses to the urban community and makes it more difficult and more expensive in the future to establish the system due to the rapid expansion of the utilities.

ii. Whereas there is a lack of experience and examples of functioning computerized information systems, the graphical maps of the infrastructure must be used, at least in the first stage, as the basis for development of the information system in urban areas.

iii. The development of the graphical system should be designed in such a way that the information collected for the production of graphical maps could easily be computerized in the future if a numerical system would become feasable. The digitization of the data should be possible both from the graphical maps and from the field surveys because one cannot predict at the present time which way will be less expensive in the future.

iv. The development of the information system should be based on the policy that the three basic components of the system are of equal importance.

These basic components are:

- the collection of the information on the existing infrastructure;
- the display and accessibility of the information;
- the maintenance and up-dating of the system.

All the three components must function equally well, or the system will not work. One should also keep in mind that it is better to have less detailed but more exact and up-to-date information than to have more detailed but incorrect and out-of-date information.

v. On the basis of the conclusions in section 5.7 and the above recommendations, the following steps in organizing the information system seem to be inevitable.

a. Organize a mapping committee. It should consist of representatives of the utility and planning agencies. The committee would provide a steering role and would be responsible for the establishment of the information system. At the first stage, the activity of the committee must be sponsored either by the municipality, or by a higher authority. Once the system is working, the expense should be shared by the users.

b. Establish a set of standards and specifications for the system. This would be the responsibility of the mapping committee.

c. Provide a continuing liaison between the mapping committee and the agency that is responsible for the large scale urban mapping. The scale, content, accuracy and symbols of the basic maps should be selected in such a way that the enlarged maps would be suitable for direct plotting of the utilities in reference to the existing details of the surface. Some research on the map requirements is needed prior to the discussion.

d. Establish a survey team to map the existing utilities by mapping whatever is possible directly by ground surveys. The agencies' files may be used only for a verification of the information and for plotting some details which are unaccessible in the field. The surveys should be tied to the existing city control so that coordinates of the utility details could be calculated if a numerical system would become feasible.

e. Establish a set of regulations for surveys of new utilities. This can be done simultaneously with the mapping of existing utilities. New surveys could be done by the mapping committee, by the agencies or by contract but all of them should use the same survey specifications. Legislation in this respect is necessary.

f. Follow the approach of the Hungarian example (see section 5.6) or similar examples in the method of preparation of maps and in the exchange of information between the mapping committee and utility agencies.

5.8.2 Specific Recommendations

5.8.2.1 Recommendations for LRIS

Although the full extent of the Phase II role of LRIS (see sub-section 4.2.4) has not been clearly defined, present indications are that the priority in topographic mapping is to support the land registration program. From this it follows that LRIS topographic mapping will not, in the normal course of events, serve as an adequate base for utility mapping.

Consequently two specific recommendations are put forward.

i. *LRIS should indicate clearly to all concerned the largest scale and the highest quality of topographic mapping that LRIS requires to support a land registration program.*

ii. *Prior to initiating large scale mapping (or map revision) of a city, LRIS should announce the program it is planning and indicate to the cities its willingness to participate in a shared-cost program of the mapping that would meet all of the cities' requirements.*

5.8.2.2 Recommendations for Halifax-Dartmouth

As explained in part 4 of sub-section 4.2.5, the area of Halifax-Dartmouth is undoubtedly the most logical Maritime setting for a pilot project on an urban information system. Since the conclusions drawn from the examples of cities with advanced development of information systems (section 5.7) coincide with findings from discussions with the Halifax and Dartmouth Utility Coordinating Committees (sub-section 4.2.5), the following recommendation is put forward.

A separate study is needed to determine how the general recommendations listed in sub-section 5.8.1 (specifically recommendation v dealing with the steps in the organization of an information system) could be adopted to the specific conditions of the Halifax-Dartmouth area.

6 Regional Infrastructure Information System Model

6.1 INTRODUCTION

In Chapter 4 it was concluded that a regional data base is needed containing those elements of infrastructure - such as power and telecommunication networks and structures - that occur throughout the entire region. In this chapter the content of the information and its organization are investigated.

6.2 THE REFERENCE "KEY" OF AN INFORMATION SYSTEM

The first step in information system design is the selection of the most suitable references or "keys" by which to file the data. For instance, consider the Customer Records and Billing project as described in Chapter 4, where telephone numbers, account numbers and service coordinates are cited as the three keys needed to file and retrieve telephone data.

In order to keep the complexity of a regional infrastructure information system to a minimum, the system should have one basic key. Based on the findings of this report, that basic key could be the individual features of the infrastructure such as buildings, utility poles, bridges, roadways, towers and so on. Some of these examples can be defined positionally as a point while others such as roadways need a sequence of points.

Endorsement of "features" as the key to an infrastructure system may appear to be contrary to present thought on the LRIS Phase IV which promotes the land parcel as the "basic building block" of a land data bank. The rationale for the land parcel having been chosen as the basic identification for the LRIS program is given in this excerpt from a paper by W.F. Roberts.

"There is an inherent division between micro-level and macro-level data types. In order to tie together these two types, some intermediary step is clearly needed, one that will allow geographic aggregation to conform to larger areas, but will not compromise the integrity of the micro-scale data. This go-between must be micro-scale, bear some sensible relationship to the macro-scale data, and will hopefully be of some general value on its own.

"To us, the land parcel, as a geographic unit, seems to meet all these criteria. Parcels of reasonable size may be aggregated, through centroid calculation, to match resource, census and other macro-scale data. The parcel is also small enough to mesh well with the micro-level information. We believe that the land parcel is the ideal building block for the operation of several data types worthwhile by themselves, notably assessment data, land titles data, and possibly some types of network data."

The authors of this report acknowledge the land parcel as the most basic key to a land data bank, which manages such elements as land tenure, assessment, zoning and planning. However, regional network infrastructure systems lend themselves to feature referencing rather than to land parcel referencing.

Neville Riley, in his paper "Place-Related Systems for Data Assimilation", stresses the need to have information referenced by position. He also states that the soundest unit on which to base an information system is the individual land parcel because all activity can be related to a land parcel which is positioned by a geocode. (Mr. Riley's Cape Town "Place-Related System" does not include infrastructure information as it is described in this study).

If LRIS is to provide the capability of automated data retrieval specified by position, the property mapping information of Phase III will have to be digitized (either in the form of digitized property boundaries or geocoded land parcels). The question of property boundary digitization vs geocodes or approximate centroids is much broader than the terms of reference of this study. However, it is only with property boundary digitization that feature related points in an infrastructure system can be automatically cross referenced to land parcels.

A system must satisfy the requirements of its prime users, and having studied those requirements it is shown that the key for the information files must be the individual infrastructure features.

Diagram 6-1 shows a possible information exchange. The left side of the page shows information elements with feature "keys" and the right side of the page shows information elements with parcel "keys". The diagram depicts the important role of property mapping in providing the link between feature related and parcel related information.

6.3 REGIONAL INFRASTRUCTURE DATA BASE - A LOCATIONAL INDEX

When managers, operations people, or planners are confronted with a new problem, frequently the first step is to acquire the most up-to-date detailed map of the area of concern. The map provides a base first to visualize and study the problem and second to design and implement a solution.

In complex problems the coordinator-broker should have the capability of assembling an up-to-date map of the land parcels and the infrastructure along with the reference keys with which to draw more detailed information

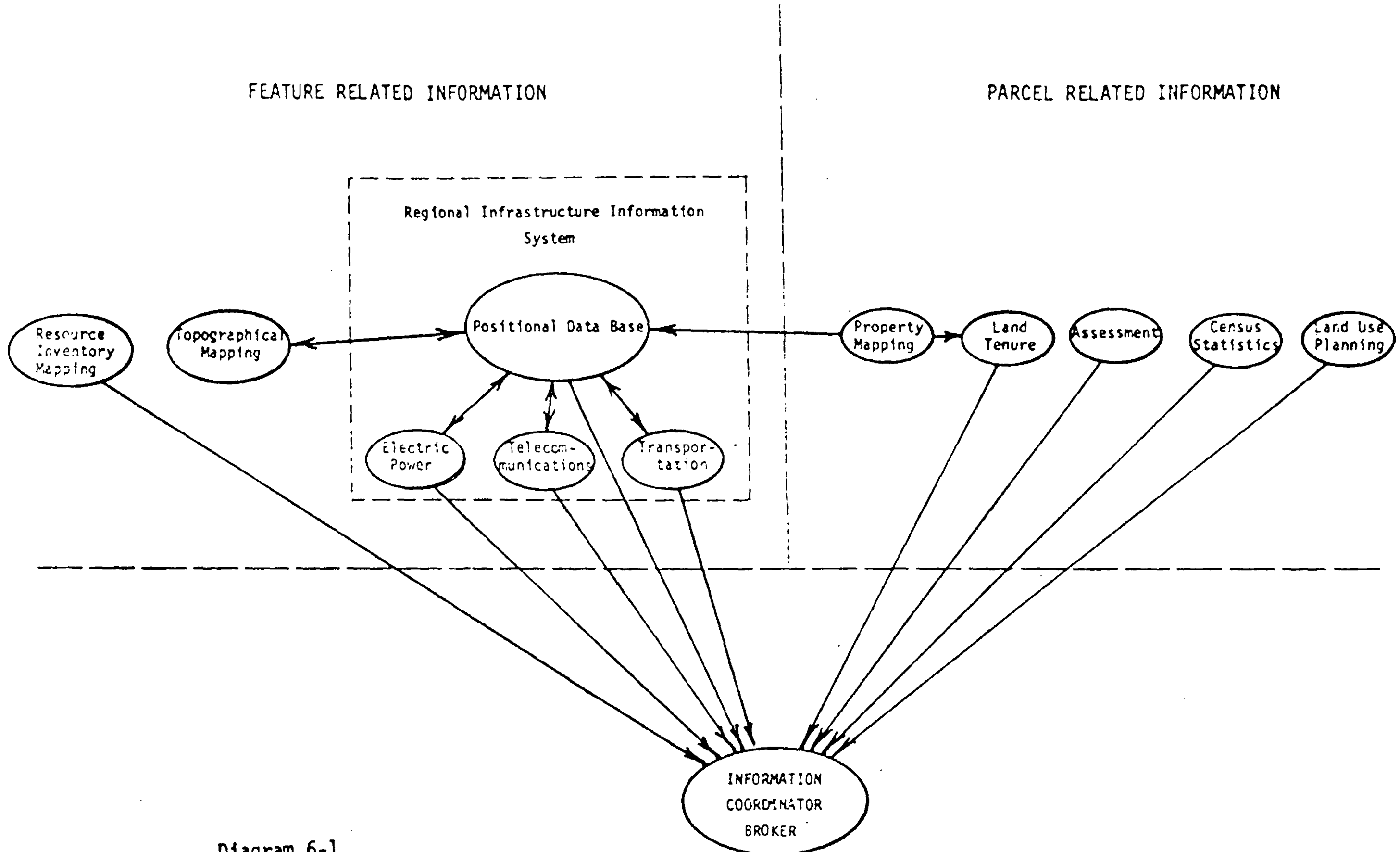


Diagram 6-1

These information elements associated with people and land are closely related to land parcels. Infrastructure information as well as most mapping are closely related to physical features. Two information systems could be developed, one based on parcels and the other based on features.

on land tenure, assessment, regional network systems, as well as any other information that can be related to the land parcels or features.

The primary role of an infrastructure information system is to provide the specific or generalized user with a reliable and up-to-date index of "What" infrastructure is present in a given area and "Where" in that area the infrastructure is positioned. This data base should be an index by position which automatically answers the "Where?" question, along with basic descriptive information to answer the "Where?" question. Given the answers to these questions, a user can make a specific request to the proper agency for any additional detailed information that may be needed.

In Diagram 6-1 we see how a positional data base could provide the contributing agencies and the information broker with an index to regional infrastructure information. The organization of the positional data base will be discussed later in this chapter.

6.4 SELECTED PHYSICAL FEATURES

Before discussing a model of an information system, we must establish which physical features are to be included in a regional infrastructure data base. Of equal importance to this discussion is the establishment of the type of geometrical description used to define each feature (i.e. a building may be represented as a closed polygon showing the exact shape, position and orientation of the structure or it may be represented by a standardized symbol plotted around an approximate centroid point). The following is a proposed list of infrastructure features and possible geometrical description.

Features	Geometrical Description
i. Buildings	Point-symbol or polygon (depending on size)
ii. Transportation Routes	
(a) Roadways	Centerline alignment and roadbed width
(b) Railways	Centerline alignment
(c) Bridges	Point-symbol or polygon
iii. Electric Power Equipment	
(a) Poles	Point
(b) Transmission Structures	Point
(c) Transformer & Switching Stations	Point or polygon (depending on size)
iv. Telephone Equipment	
(a) Poles	Point
(b) Terminal posts for buried cables	Point
(c) Carrier system towers	Point
(d) Switching centers	Point or polygon (depending on size)

v. Water Boundaries

(a) Rivers and streams	Point of roadway or utility crossing and width (accurate digitization and storage of entire watershed systems could be very expensive)
(b) Lakes, bays and coastlines	Line segments

vi. Political Boundaries

(a) International, Provincial, County, Municipal	Line segments
(b) Utility tarrif boundaries	Line segments

This list has been prepared in consideration of three major applications of a regional, positional, digital data base, namely: utility operations, administration and planning; medium scale map up-dating; and regional planning.

The features listed under ii, v and vi (a) are traditional map features. These features are necessary along with their associated toponymy for background enhancement in an infrastructure information system.

As this background is required for operations rather than for construction and design, there is no need for high accuracy. Tentatively it is suggested that accuracy corresponding to that of features on a 1:10 000 map would be a good first approximation. Nevertheless, it is not implied that the data base would correspond with a conventional 1:10 000 map. In Canada, medium scale maps have been compiled almost entirely by photogrammetric methods for the last couple of generations, hence the content of the map has been in part dictated by what could be mapped by photogrammetry. Elements such as utility poles could not be identified reliably by the photogrammetric compilation process hence they were omitted. In effect, a new type of medium scale map is being proposed. The data base will be the basic map and anything that is drawn on paper will be one of many possible selected presentations from the data base. This constitutes a basically different approach to mapping.

6.5 EXAMPLE : BERWICK CORNER, N.B.

To illustrate how the infrastructure features might appear on a visual display unit of an information system, some graphic representations were made. A section of the Trans-Canada was chosen which passes through Berwick Corner, five miles north of Sussex, New Brunswick. The infrastructure information was interpreted in the field by a member of the study group using the LRIS orthophoto map enlarged to an approximate scale of 1:5000 as a base. The utility poles and new buildings were plotted by estimation. The utility poles, buildings, highways, and streams were then traced on to a master copy as shown in Diagram 6-2. It should be noted that this method of data collection was used as a quick means of presenting some real information as an illustration, and therefore is not suggested to be the most suitable method of data acquisition or representation.

Two important information items that were not included in the feature list of the preceding section are the utility poles, line connections and the building classifications (i.e. residential, commercial, industrial, farm etc.).

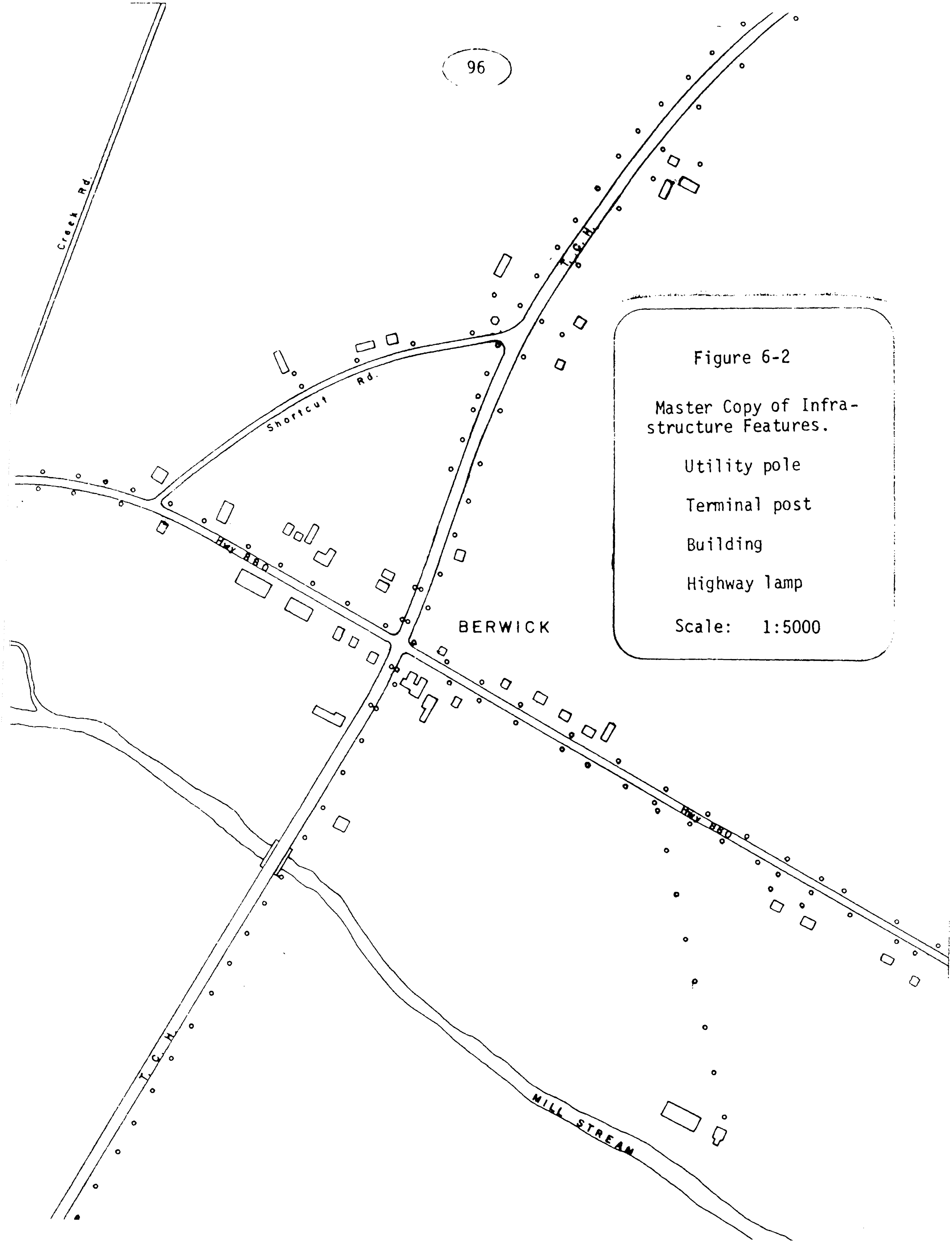


Figure 6-2

Master Copy of Infrastructure Features.

Utility pole

Terminal post

Building

Highway lamp

Scale: 1:5000

These items should be available in an infrastructure data base.

The design of the regional data base should clearly indicate the levels of detail that should be provided to the data base by each agency. For example, an electric power agency might provide the regional data base with transmission lines and primary lines but not provide the secondary lines because they may not be needed by the other agencies (secondary lines being the low voltage distribution lines from the small pole transformers to the buildings). Similarly a telephone agency might provide the pole connection of multipair cablesand open wire lines, and the terminal connection of buried cables, but not provide "drop wire" connection to the buildings.

The following figures of the Berwick area illustrate how these suggested levels of detail might appear.

Diagram 6-3 shows the electric power primary lines

Diagram 6-4 shows the telephone aerial and buried cables and open wire lines

Diagram 6-5 shows the residential buildings.

In a digital system, virtually any combination of the data could be requested for display on a visual display unit at a specified scale. Having selected the most suitable presentation of the data, the user could then make a "hard" copy.

We have been considering the feature related information, but what about the parcel related information? Diagram 6-6 shows a overlay of the Berwick property mapping information on the basic infrastructure. If all this information were available in digital format, the feature and parcel data could be called up on a V.D.U. and displayed as in Diagram 6-6. Cross referencing of feature related and parcel related information could be done manually by simply viewing the V.D.U. and noting the parcel numbers of interest, thus eliminating the need for computer searching. Therefore we can easily see how the regional data base could serve as a locational index to more detailed information.

Additional detail on the electric power secondary lines and telephone "drop wire" lines was also collected at Berwick, and it is illustrated in Diagram 6-7 and 6-8. As a matter of interest, the field information in the Berwick example was collected in two hours by one person.

6.6 A REGIONAL POSITIONAL DIGITAL DATA BASE

6.6.1 Separate Agency Data Bases

A general data base would have to serve different utility agencies with varying needs. Unfortunately, diversity of purpose coupled with a pressing need for detailed information for day to day operation often leads to a

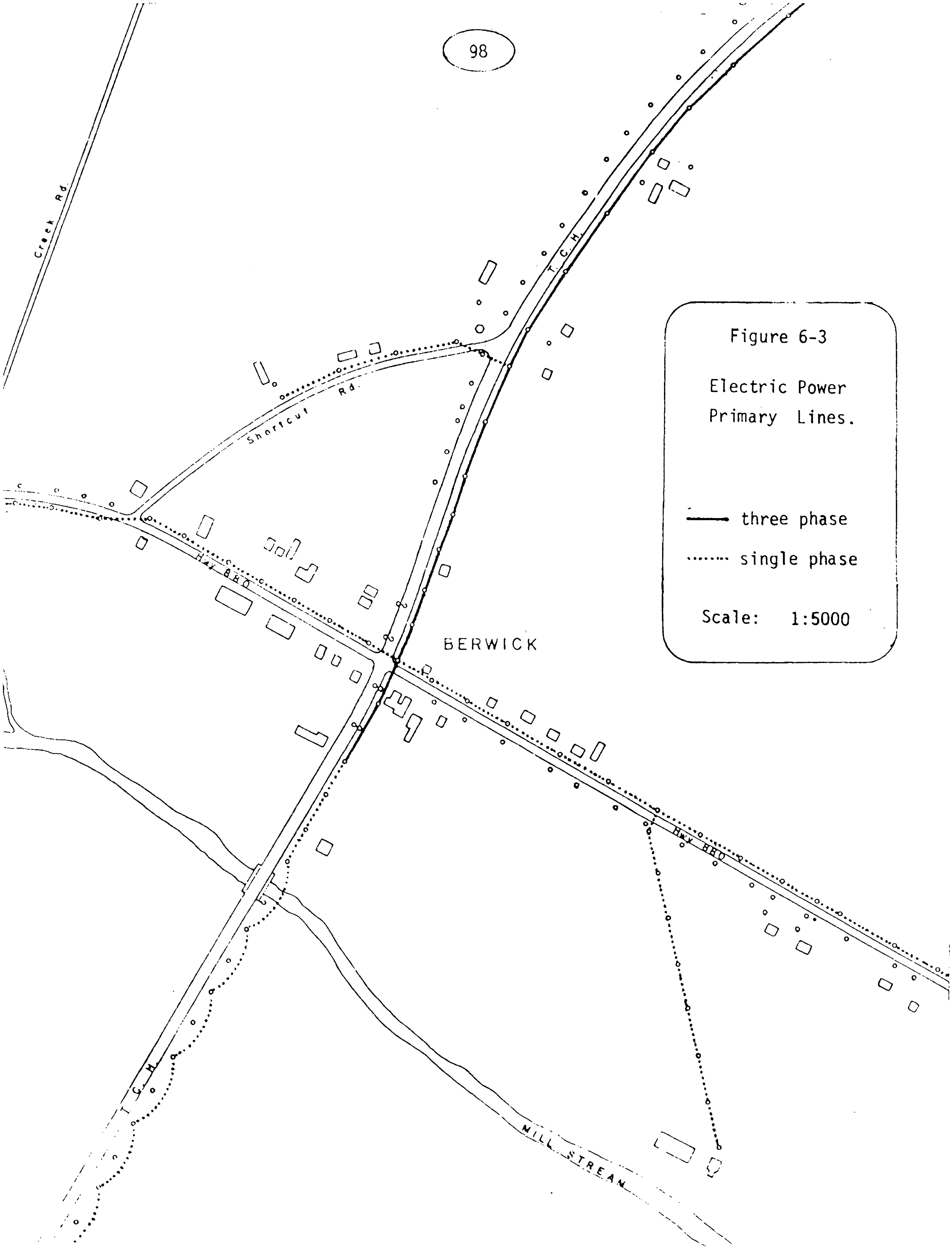


Figure 6-3

Electric Power Primary Lines.

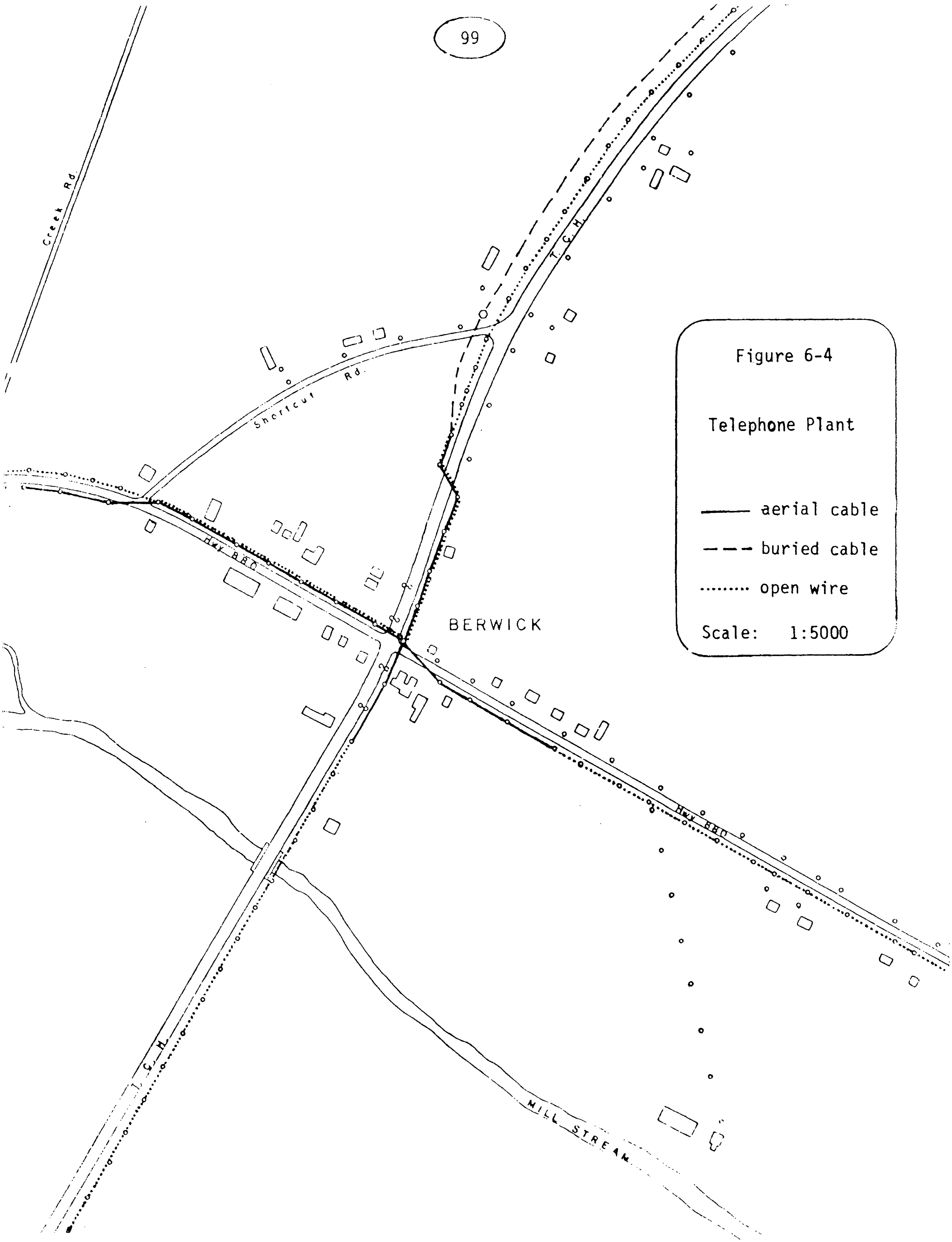


Figure 6-4

Telephone Plant

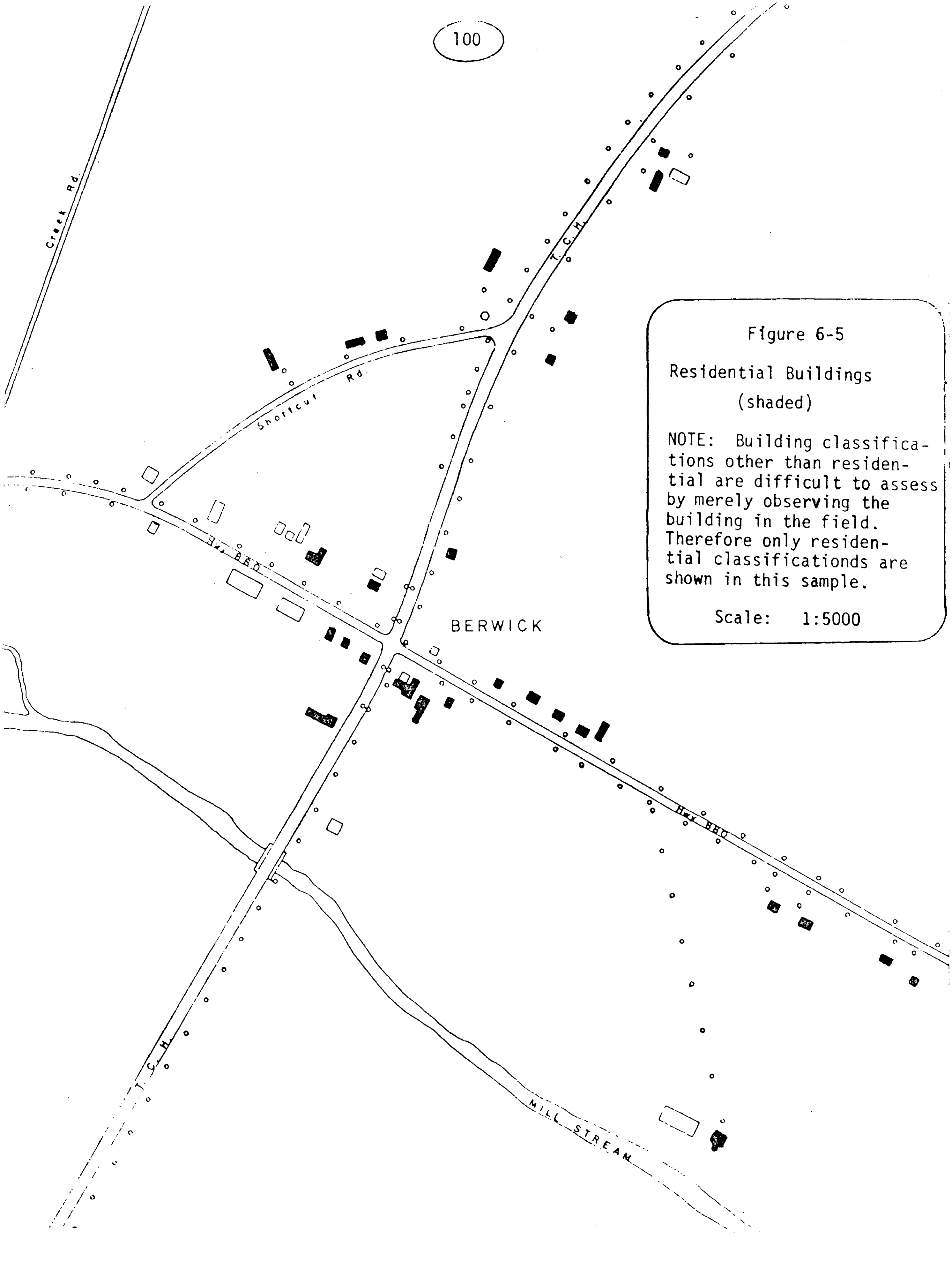


Figure 6-5

Residential Buildings
(shaded)

NOTE: Building classifications other than residential are difficult to assess by merely observing the building in the field. Therefore only residential classificationds are shown in this sample.

Scale: 1:5000

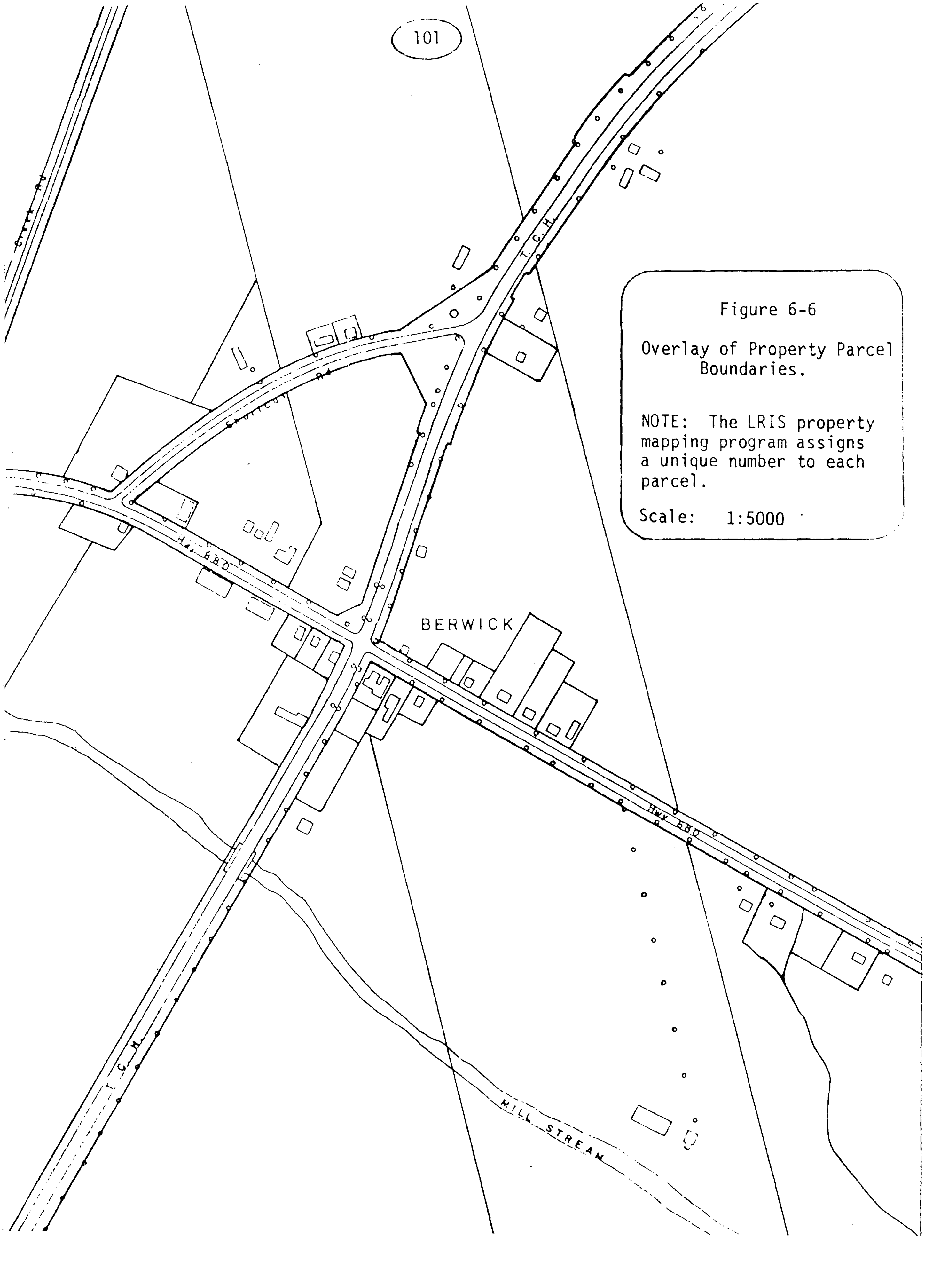


Figure 6-6

Overlay of Property Parcel Boundaries.

NOTE: The LRIS property mapping program assigns a unique number to each parcel.

Scale: 1:5000

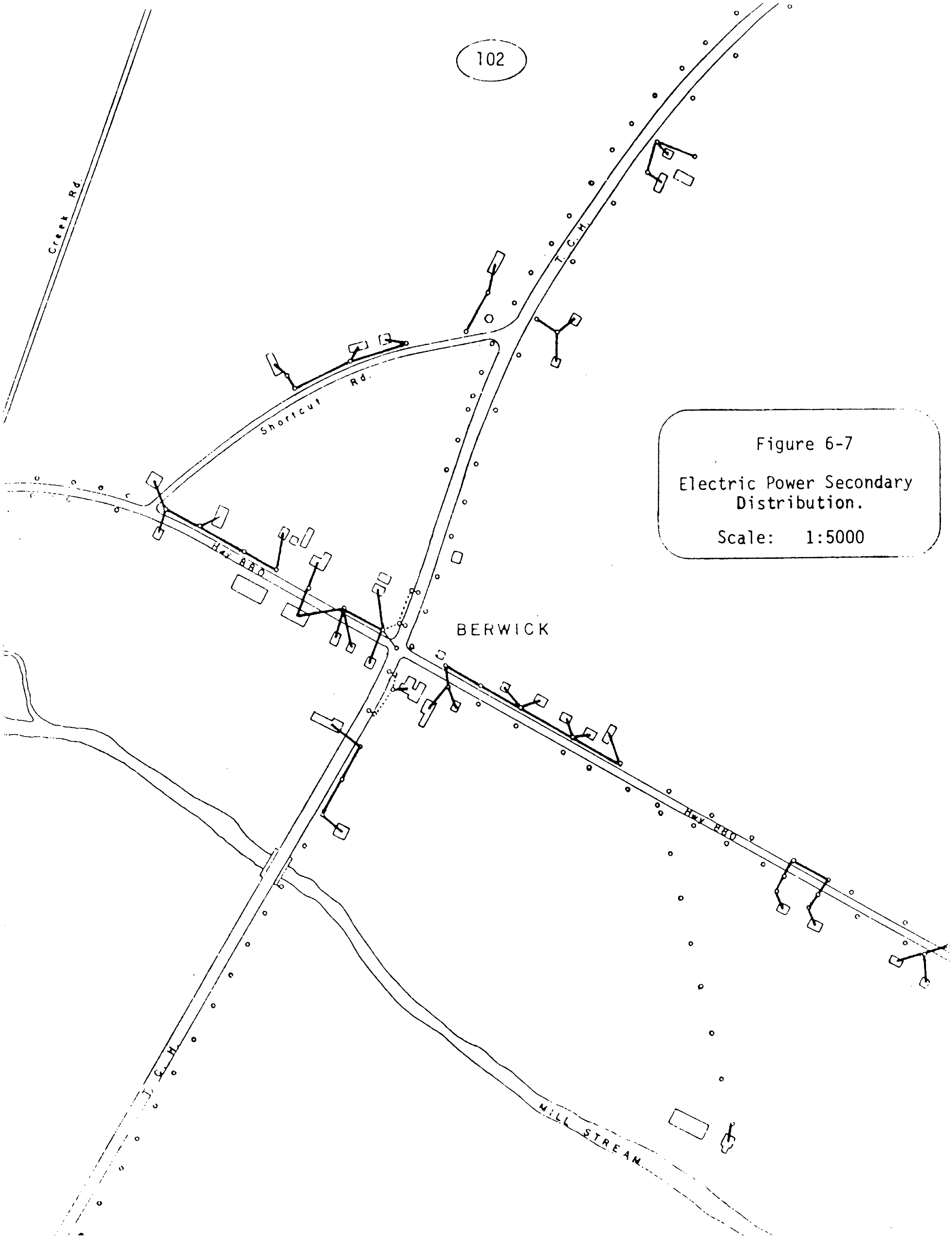


Figure 6-7

Electric Power Secondary Distribution.

Scale: 1:5000

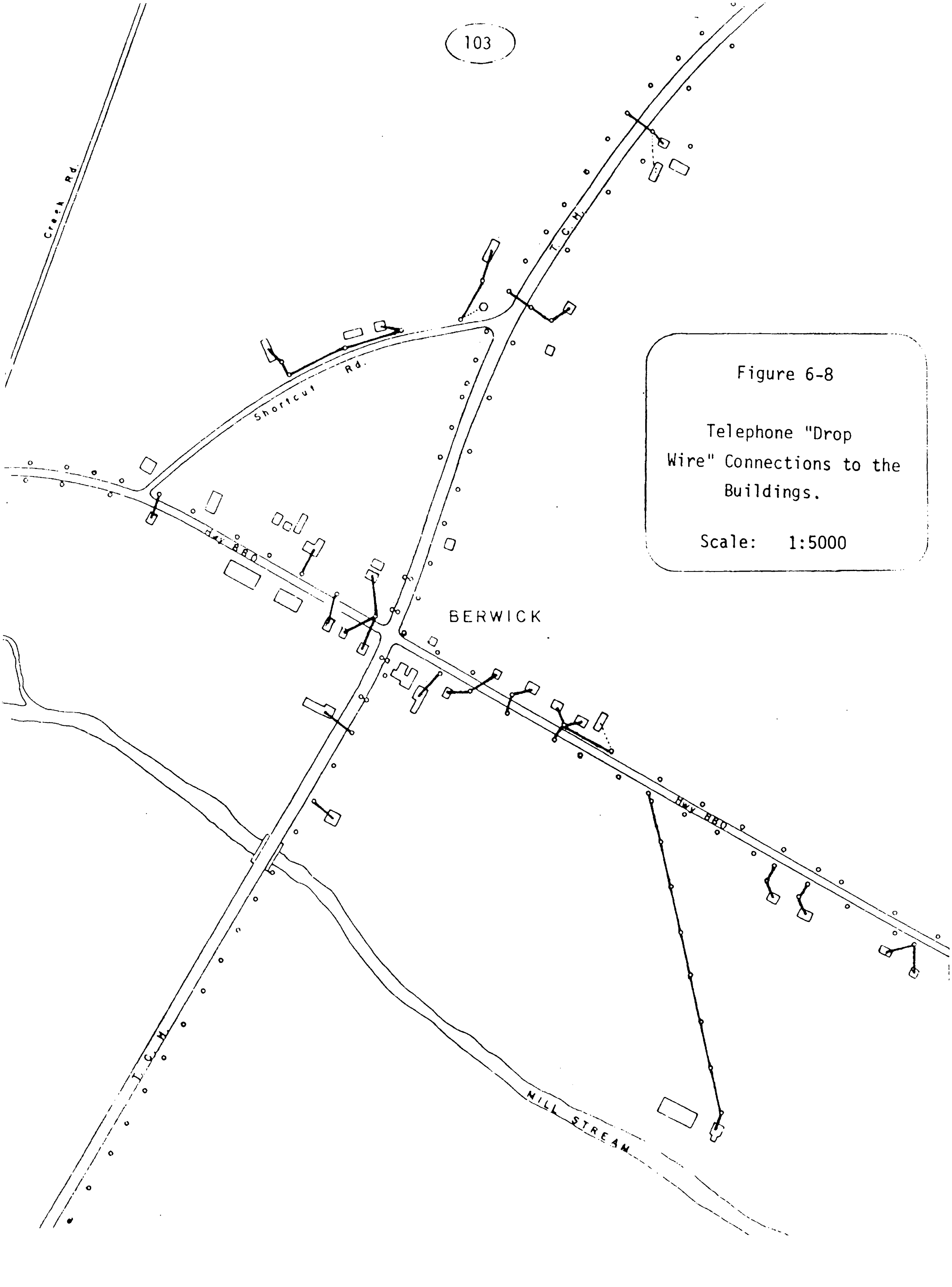


Figure 6-8

Telephone "Drop Wire" Connections to the Buildings.

Scale: 1:5000

fragmented approach to information system design and data collection. The net results are several sets of data which are not compatible and for which there is not capability of up-dating.

Although there may be diversity in approach, experience has shown that information systems are much more effective where the responsibility for data integrity rests solely within one agency.

The problem is a two-sided one with data compatibility favouring a joint agency venture on one side and data integrity favouring individual agency ventures on the other side. Data integrity is the most critical because if the information in a system cannot be trusted, the system is sure to fail. A proper balance between data integrity and data compatibility is the key to a useful regional positional data base.

The most logical approach appears to be an information exchange where compatibility will be controlled by standards and the responsibility for data collection and up-date will rest squarely on the shoulders of the individual agencies. Of course there will be the problem of interconnecting various computer systems. We are told that interconnection of mini-computers can be a serious but not an insurmountable problem.

The importance of data compatibility cannot be over-emphasized. Designing systems to have this compatibility is dependent on a knowledge and acceptance of the level of detail and tolerances which are desirable for data transfer from system to system. This study outlines these information levels in general, but a more extensive investigation of the topic is needed.

Diagram 6-9 shows how separate infrastructure data bases might exchange positional information to support and utilize a regional positional digital data base. The information being exchanged in Diagram 6-9 is positional coordinate values of infrastructure features, along with other attributes.

6.6.2 Possible Organizational Arrangements for the Maintenance of the Regional Digital Data Base

It would be premature to come out categorically in favour of one specific organizational design for the maintenance of the data base. However, it is felt that if the concept is valid, then the appropriate organizational structure can be found. Four possible models are outlined briefly.

6.6.2.1 The "Consortium" Model

This model is illustrated schematically in Diagram 6-10. In the model, a digital positional data base could be established by a jointly funded organization, or consortium, made up of personnel from each cooperating agency who are familiar with the internal procedures of each agency. The role of the

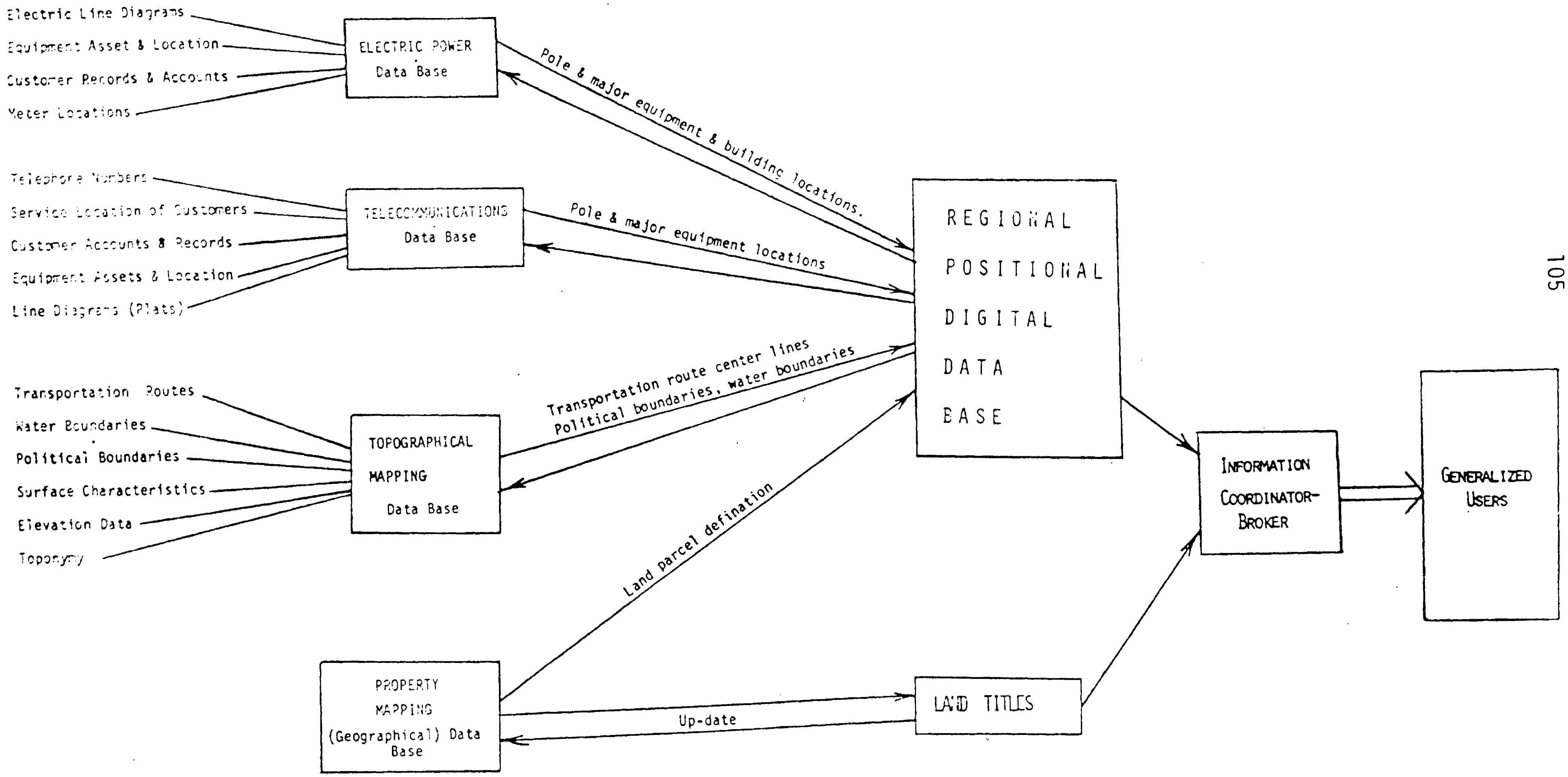


Diagram 6-9 Possible exchange of positional information in a regional digital data base concept.

consortium would be to provide an on-line up-dated digital infrastructure information to the cooperating agencies as well as to the general users via an information broker. The supply of the up-dated data would be the responsibility of each agency. The consortium would also be responsible for the maintenance of standards on the input data.

6.6.2.2 The "Commercial" Model

This model is basically the same as the consortium model, and therefore Diagram 6-10 also applies to this model. It is given the title, "Commercial" because it is based on the assumption that one agency would accept the prime responsibility for the data base and it would "buy" up-dating data from the producer-user agencies or from any other source where the data is available. Then it would, in effect, "sell" intergrated data back to the producer-user agencies as they needed it. Whether or not actual accounts would be kept on the information exchange is purely hypothetical at this time. The terms "buy" and "sell" as they are used here are purposely exaggerated to illutrate the method by which the system would function. Some motivation must be provided to agencies that are producing data to ensure that what they do provide will meet specifications of timeliness and of quality. If this motivation is not provided, the system has a poor chance of success. Similarly, if the system cannot provide complete and up-to-date information as needed, the system is doomed to fail because the users will find an alternate source. Having found that alternate source, they are not likely to be willing to go back and try the system again.

6.6.2.3 The "Transfer on Request" Model

In this model each agency generating data will agree to conform to common standards and would also agree to pass copies of their data to the other agencies upon request. The model is illustrated by Diagram 6-11. The objective would be to have each participating agency end up with identical files; needless to say, considerable optimism is needed to expect that this will happen.

6.6.2.4 The "Mapping" Model

In this model, illustrated by Diagram 6-12, a topographic mapping group assumes the role of a digital data base coordinator. The up-dating of feature changes is the key issue in an infrastructure information system and these same changes in the infrastructure create the need for up-dating medium scale mapping. All indications are that mapping will eventually become digital, and this model represents a partial digital mapping system. The up-dating of those features which compose the culture plate (overlay) of a topographic map could be automated to a digital mode while basic map content including such items as vegetation, water boundaries, and contours could be mapped by conventional graphic methods.

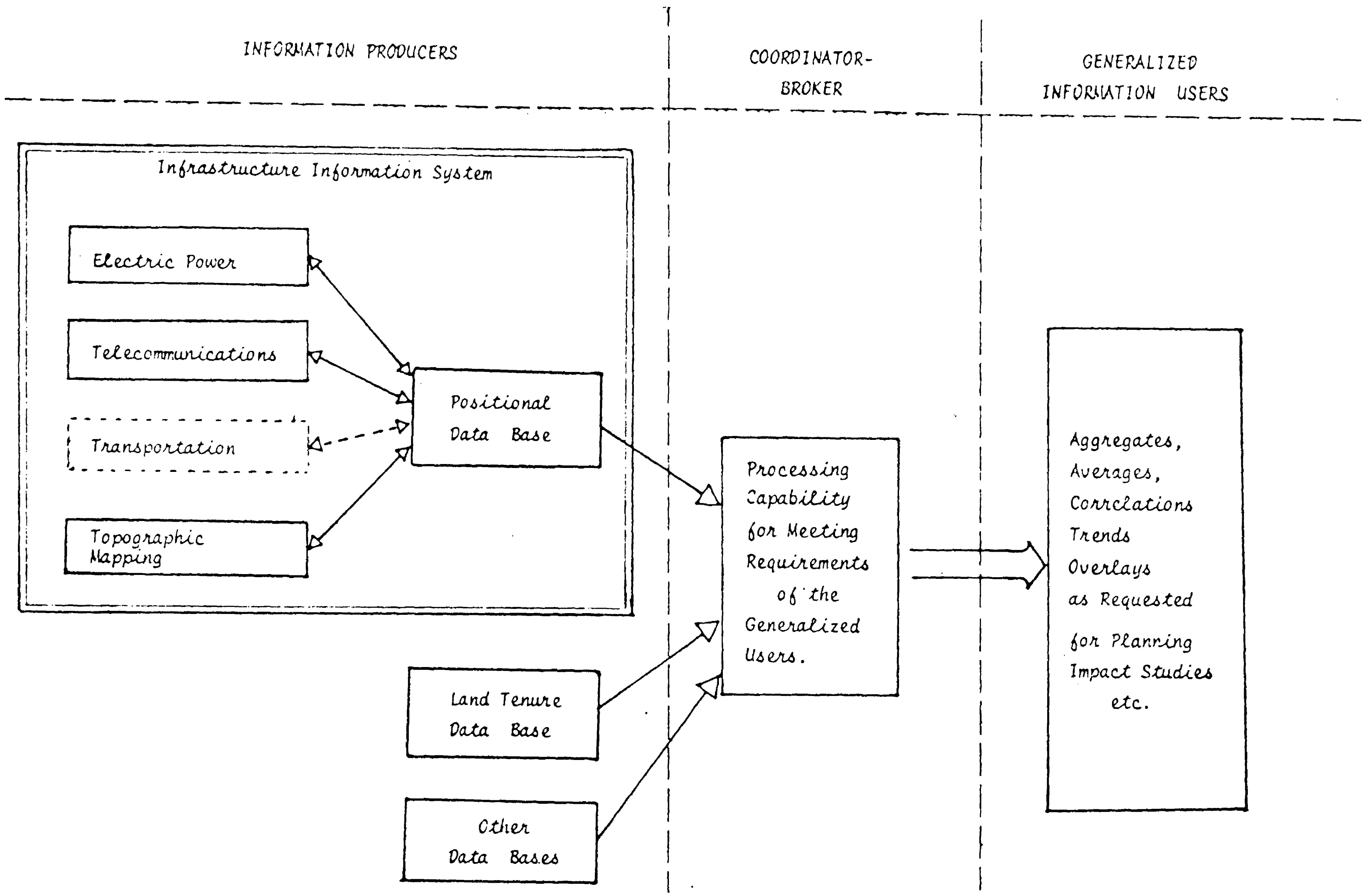


Diagram 6-10 "Consortium" and "Commercial" Models. In this organizational structure the positional data base is maintained by a separate unit that is responsible for the standardization and correlation of the information.

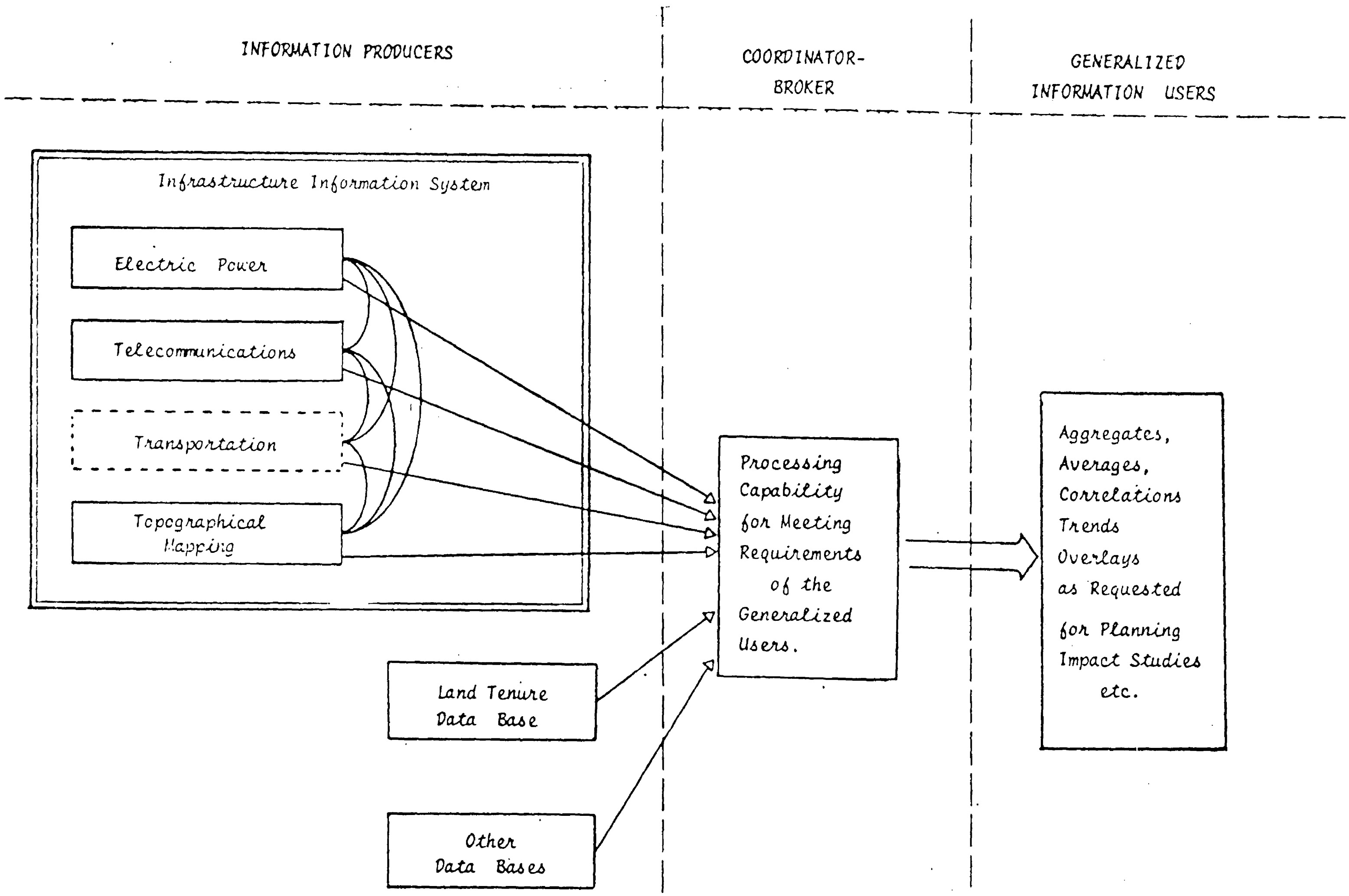


Diagram 6-11 "Transfer on Request" Model. Here each agency maintains its own data base and independently collects the data that it needs from the other agencies.

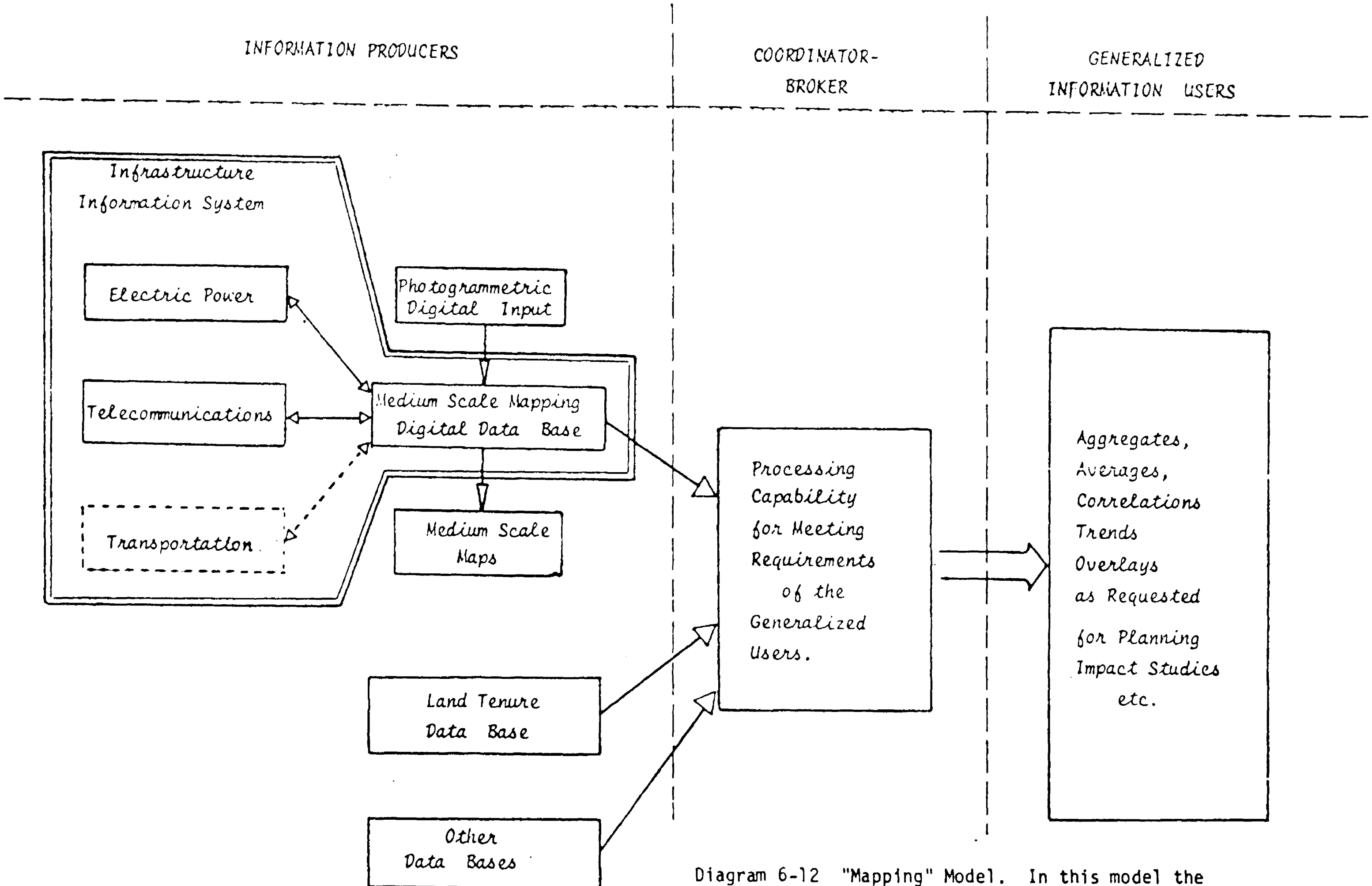


Diagram 6-12 "Mapping" Model. In this model the agency that is responsible for topographic mapping assumes the responsibility of data standardization and correlating by incorporating infrastructure data (supplied by cooperating agencies) into the topographic mapping process.

6.6.3 Comments on Possible Organization Structures

These four possible organization structures have been described briefly simply to illustrate that there are a variety of ways in which the organizational problem can be resolved. There are advantages and disadvantages to each of these four alternatives and undoubtedly other alternatives could be devised. The important point to note here is that if a concept is sound then the structure can be found to implement it; on the other hand if a concept is not valid it would be futile to spend time defining the structure to implement it. When considering organizational structure, emphasis on information up-dating should be foremost because a good solution to the up-dating problem is essential to the success of a modern data base system.

6.7 UP-DATING

6.7.1 A Common Problem

Up-dating or map revision has been the bane of map makers since the beginning of cartography. If mapping agencies are to provide the information service to society that it needs, and that it is entitled to, conventional methods can no longer be tolerated.

Breakthroughs are required to overcome two extremely difficult problems:

i. the collection of data on changes in map content requires some economical form of continuous up-dating; and
ii. the reproduction process, especially the lithographic process, requires an economical means of reproducing small quantities of multi-colour maps.

The solution to the first problem can be found in a cooperative approach to data collection by agencies who have a direct interest in the maintenance of an up-to-date digital data base. This is considered as a feasible solution to the map up-dating or map revision problem because virtually all of the changes in map content occur in the infrastructure features. If a method can be found for continuously up-dating the infrastructure features, then basically the problem can be solved. It is recognized that this solution is conceptual only and a great deal of detail on organization and specifications is needed before any program can be initiated.

Although the second problem is not within the terms of reference of this study, a couple of concepts are expressed that might provide a solution to the problem of economically reproducing small quantities of maps.

i. The acceptance of one colour process such as ozalid or diazo, or a reproduction technique such as screen printing would be economical for small runs.

ii. Another possible solution is the stock piling of incomplete maps. A press run in colours could be made of the static map features such as grid lines, contours, water boundaries and vegetation. Then, on demand, the infrastructure features could be overprinted in black in smaller runs. It is realized that problems in "registration" due to paper shrinkage would occur. Nevertheless, the goal of providing up-to-date information in an attractive informative format must be pursued until it is achieved.

6.7.2 Possible Up-Dating Procedures

As discussed above, the key to success of any system that is implemented is in the design of a sound up-dating procedure. Some specific suggestions are outlined below.

i. N.B. Power employs a "detailer" to do on-site planning of all power connection and small line extensions. The detailer originates work orders for all extensions and connections. In the course of his duty the detailer specifies where any new poles should be placed as well as specifying where the conduit "mast" should be placed on the building that is receiving a new service. For this purpose the detailer makes length measurements to indicate to the lineman approximately how much wire will be needed and essentially how the job will be done. This information has to be set down on paper for the guidance of the lineman. There does not appear to be any insuperable obstacle to having this information flow into the data base. Thus a continuous up-dating, not only of new pole installations by the Power Commission but also of approximate locations of new buildings would be provided. As virtually all residences and all industrial and commercial buildings are wired for power, only a very few geographically isolated buildings would be omitted.

ii. The trend with respect to utility poles is to have as many joint-use poles as possible. This means that a significant number of poles are installed by the Telephone Company, and again as with the Power Commission, someone from the "Outside Plant" division inspects the site and designates where poles are to be placed. It is suggested that copies of these instructions could also serve as input to a data base.

iii. Modern highway construction or reconstruction is preceded by complete right-of-way surveys and detailed topographic mapping; from this information the design plans are made and the construction is carried out. "As-built" plans are the ideal source of data for up-dating the digital data base with respect to highway information. This is only applicable to 50 to 100 miles of highway each year but it covers the areas of extensive infrastructure changes as a result of highway construction. The problem of local and private roads is one for which a good up-dating procedure is not readily obvious as yet.

6.7.3 General Comment on the Up-Dating Problem

One may well ask why the information mentioned above has not been used in the past for map revision. The short answer to this question is that the problem of handling this data in a manual form was formidable; there was always doubt as to where the data would fit onto the map. Up-dating procedures based on various source documents are now possible because of the growing acceptance of grid coordinate referencing of plans and sketches. The fundamental plan, the plan where development starts, is the registered sub-division plan which is prepared by a provincial land surveyor. Under modern survey procedure the coordinates of all lot corners are surveyed to a high degree of accuracy. The lot corners or legal markers are referenced to more permanent control survey markers which are placed along highways in Phase I of the LRIS program. Using these legal markers and control markers as a frame-work and using even very rough estimating methods, the coordinates of all the features that are of interest to the infrastructure data base can be obtained very readily. Similarly, the coordinates of highway plans, right-of-way plans and construction plans provide a dense frame-work of coordinates by which additional information can be readily coordinated and thus put in a form suitable for immediate integration in the data base. Without the coordinate frame-work this integration of data from a wide variety of sources simply would not be possible.

6.8 THE INITIAL COLLECTION OF THE DATA

Discussion of this task has been purposely deferred until alternatives for the organizational structures were presented and until a possible up-dating method was outlined. There are several possibilities for the initial collection of the data. One can digitize anything that can be identified on the existing maps and then do a "field check" to add the missing items. Conversely one can take an existing map to the field and make sure all the information is plotted on the map or photo map and then digitize the complete map. In view of the fact that digitizing even the essential elements of the infrastructure data base in the Province of New Brunswick alone is likely to cost in the order of one half million dollars, it is not unrealistic to suggest that a lot of pilot study work should be done using a variety of alternatives to find which in fact is the most economical. Some of these alternatives are listed below.

i. Field surveys tied to ground control
ii. Digitization from a map
iii. Direct digitization of objects from a stereographic model
iv. Digitization on field-edited base maps
v. Digitization by field marking features on enlarged photographs and correlating photo coordinates with map coordinates in an analytical plotter

vi. Terrestial photographs along roadways.

To come to firm conclusions as to which of these alternatives would be most efficient is well beyond the scope of this report; a few, brief off-the-cuff remarks follow:

i. Field surveys tied to ground control

This method naturally yields the highest accuracy of digital information. If this accurate information is translated to a graphical form and digitized from the graphic format, the accuracy will be lost. Therefore ground measured positional information of features should be input directly to the data base. Conventional methods of ground surveying for regional infrastructure information would be unreasonably expensive. However, the development of inertial positioning systems may make accurate and economic ground surveying of infrastructure features possible within five years. If inertial positioning does develop quickly then the concept of an infrastructure data base should be well thought out so as to take advantage of this new technology without delay.

ii. Digitization from a map

We can only digitize those features that appear on the map; on medium scale maps, (i.e. 1:10 000) the utility poles and some of the buildings are not shown and therefore cannot be digitized. Maps are generally out-of-date to some extent even at the time they are published and the situation gets increasingly worse until a revision is made. Initial input by this method can be expected to be significantly out-of-date.

iii. Direct digitization of objects from stereographic models

The only features that can be digitized from the stereographic models are those that can be positively identified by the photogrammetric operator. A photograph scale of 1:10 000 is necessary to see the utility poles, but the cost of special scale photography, aerotriangulation and model set-up for just the utility pole information could not be economically justified. The telephone terminal posts for buried cables would not be visable at a 1:10 000 photograph scale. Digitization from stereographic models would make possible the recording of elevation data for such special application as the determination of highway grades.

iv. Digitization on field-edited base maps

In this method topographic maps would be taken to the field and up-dated prior to digitization. Features such as utility poles that could not be mapped at the medium scale would be plotted on the base maps during the field edit and digitized along with the mapped features. Orthophoto maps provide a better base map for field interpretation than line maps, because detail such as trees, row of bushes, changes in vegetation, fences, small buildings, and so on are very useful in interpolating positions of features that are not visable on the orthophoto. In some cases faint shadows of utility poles are visable on the orthophoto maps at the 1:10 000 scale, and this evidence of location is readily verified by a field edit. When plotting such fine detail as utility poles, the base map should be enlarged for better interpretation of the orthophoto maps and for adequate provision of paper space on which to mark the detail.

v. Digitization by field marking features on enlarged photographs and correlating photo coordinates with map coordinates in an analytical plotter

Here enlarged photographs would be taken to the field for editing and marking of features that are not visible on the photographs. Enlarged photographs are clearer than enlarged orthophoto maps, and therefore the feature interpretation is more accurate and complete. This method could be used anytime after the aerotriangulation adjustment is complete, which means that digitization might actually preceed the production of maps. It is likely that digitization by correlation of photo and map coordinates will be slower than direct digitization, because the photogrammetric operator would have to position the coordinatograph on the enlarged photograph as well as set the proper elevation in the stereographic model before making the correlation. As with digitization from the stereo model, elevations of the points would be readily available.

vi. Terrestial photographs along roadways

The New Brunswick Department of Transportation has photographed the arterial and collector highways of the province by a vehicle-mounted camera that automatically exposes a frame of a film when the vehicle has moved 40 feet along the road. The speedometer and odometer values as well as the "sway" of the vehicle are recorded on guages at the bottom of the frame. The system provides a quick reference tool for centralized department personnel to assess road conditions. Utility poles and many of the buildings are also shown clearly on the picture. The digital positions of poles and buildings might be calculated by some means of approximating the offset distances from the road to the features and noting the respective odometer reading. The horizontal roadway alignment is also necessary if this information is to be translated into two dimensional coordinates. Digitization of this horizontal alignment from medium scale maps may be sufficient. The accuracy of the feature positioning by this method would be less than a field interpretation on a photograph or orthophoto map. Many features such as telephone terminal posts may be hidden by trees, bushes and weeds and it may be difficult to identify detail such as the secondary electric power distribution.

When the specification of the initial collection of data can be clearly written, undoubtedly several means of collecting the data can be devised. Then a comprehensive study will be required to determine the most feasible means to the desired end.

6.9 GENERAL COMMENTS ON THE REGIONAL MODEL

Throughout this report there has been considerable emphasis on the fact that infrastructure information is a system and, as such, has many components. The system must serve the needs of many users and its information up-dating must be dynamic. We have seen past system developments hampered by unforeseen pitfalls and we can be sure there will be pitfalls in new developments. Therefore, an iterative process for region infrastructure information system development is suggested as presented in Diagram 6-13. The initial five steps of the iterative sequence shown in the diagram have been touched upon in this chapter, namely:

i. define the elements needed;
ii. define an interim organization structure;
iii. devise a preliminary up-dating method;
iv. investigate the alternative methods for initial data collection;
v. estimate the hardware and software requirements and costs.

6.10 RECOMMENDATION : THE FIRST STEP

It is assumed that this report will be circulated to those agencies that may have an interest in a regional infrastructure system and that they will be invited to comment upon it. It would be presumptuous to suggest which agencies will be willing to make sufficient commitment to put further study on this concept. However at the present time New Brunswick Power and the Land Registration and Information Service appear to have sufficient commitment to start serious study of the subject. Other agencies who have an interest but perhaps have not the motivation to proceed immediately should be invited to give their concurrence to the initiative by N.B. Power and LRIS and indicate at what point they would like to phase into the investigation.

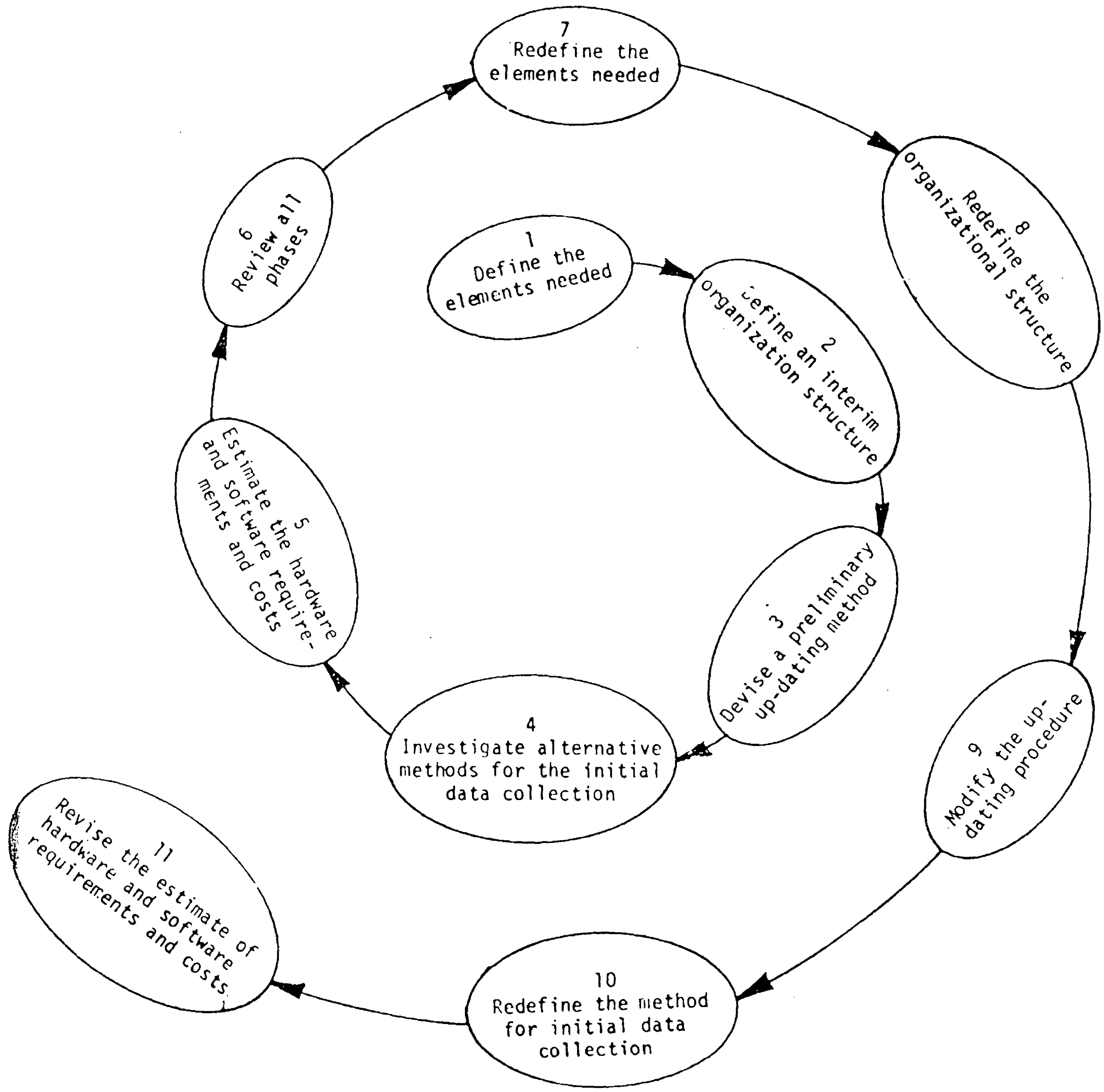


Diagram 6-13 Iterative sequence of steps recommended for the development of the regional infrastructure information data base. Note that organizational structure and up-dating are listed ahead of data collection and all of these are listed ahead of hardware and software.

7 Conclusions and Recommendations

7.1 MAIN CONCLUSIONS

A. *There are needs for both urban and regional infrastructure information systems:*

i. In the major metropolitan areas there is a need for an information system that includes all of the underground and surface utilities.

ii. Throughout the entire region there is a need for an information system that includes details of power networks, telecommunications networks, transportation networks, and those features that are normally shown on medium scale maps.

B. *Digital information systems (computer systems) are becoming progressively more competitive with graphical (manual) methods:* The major question facing graphic information managers is the timing of the switch from a manual graphic system to a digital graphic system.

7.2 RECOMMENDATIONS

7.2.1 Urban Infrastructure Recommendations

A. The main recommendation with respect to urban infrastructure information systems is that *a good graphic system is necessary before a computerized system can be considered.*

Comment: The inter-relationships of the various systems in urban situations (in particular the underground systems) are so complex that it would be virtually impossible to collect this information in digital form, and get a meaningful output from a digital data base without first having a good graphical representation of all the information. It is anticipated that up-dating a digital system will ultimately be more convenient and more effective than up-dating a graphical system. In spite of several attempts, no city has yet been able to develop a cost-effective digital infrastructure information system. The prudent approach is the development of a good graphical system with the anticipation that in time the graphical system will be converted into a digital system. Specific suggestions in this regard are included in Chapter 5 (sub-section 5.8).

B. *The Municipalities and the Land Registration and Information Service should collaborate in the production of the adequate topographic maps* that are essential to a good graphic information system.

Comment: Municipalities, as administrators of urban service, and LRIS, as a "broker" of urban information in Phase IV of its program, both have interests in large scale urban mapping. Whereas the role that LRIS should play in urban information is not yet established, the two groups should open discussions with the purpose of defining common goals. LRIS has found that urban maps at a scale of 1:1200 (or the metric equivalent at 1:1000) are adequate for property mapping, but utility mapping requires a scale of 1:500 or larger.

C. *The onus is on the municipalities to take responsibility for urban map up-dating.*

Comment: It is the city and the utility agencies (whom the city regulates in respect to positioning of utilities) that are effecting the changes in the infrastructure. As emphasized in the report, it is the changes in the infrastructure that necessitate map revision.

7.2.2 Regional Infrastructure Recommendations

A. *Steps should be taken immediately to plan for the orderly development of a regional infrastructure information system.*

B. *An area should be designated as the site for the development of a prototype system.* Specific steps for the development of a prototype are given in Section 6.9.