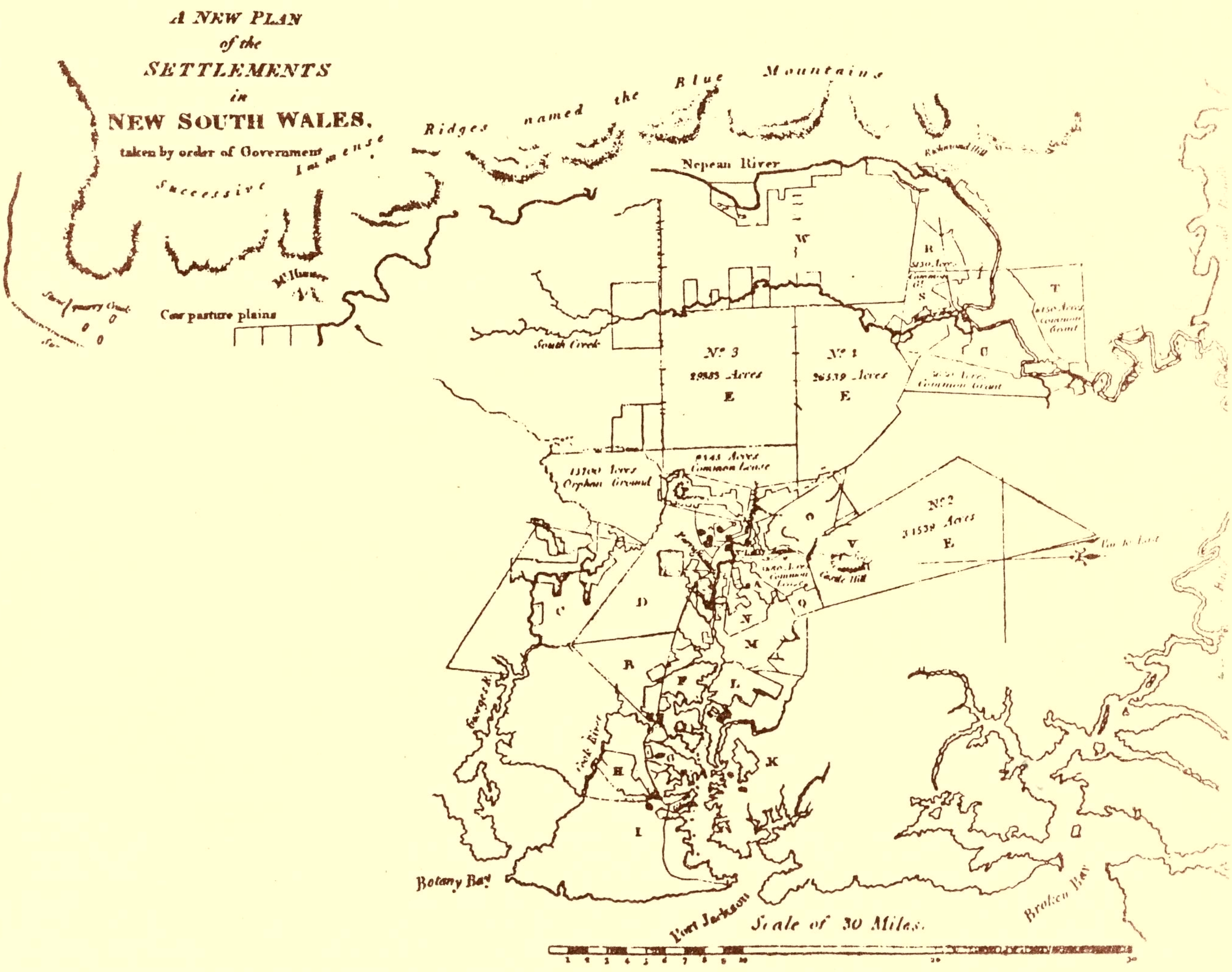
A MODEL OF COMPUTERIZED PARCEL BASED LAND INFORMATION SYSTEM FOR THE DEPARTMENT OF LANDS THAILAND

WATTANA JAROONDHAMPINIJ



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SCHOOL OF SURVEYING
UNIVERSITY OF NEW SOUTH WALES
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ABSTRACT

In Thailand, the Department of Lands (DOL) is in charge of the basic information on land parcels, records of ownership, and current value of each parcel. This makes the DOL the major body responsible for the development of a parcel-based land information system (LIS) within the country. This study is concerned with a model of computerized parcel-based LIS for the DOL. The main objective is to investigate the land administration of the DOL which provides for the LIS development and study methods which can be used to introduce a computerized LIS in the DOL. The investigation and findings will result in outlining the problems which must be solved before introducing the computerized LIS.

The study consists of four main parts. *Firstly*, the reader will be refreshed with the concept of LIS as a decision-making support system. Then the development of LIS in developing countries with emphasis on Thailand and specifically in the DOL is described in chapter 1. Strategies and methodologies in setting up the system are presented in chapters 2-3. *Secondly*, description of the parcel-based LIS in the DOL will be centred around 5 divisions: Surveying and Mapping, Urban Mapping, Central Valuation, Land Documents and Land Offices, and Computing and Data Processing Divisions. These divisions generate the basic data through their activities. The essential parts of investigation are the method of data production, data collection and coding, and data quality. The investigation of these activities with some comments are in chapters 4-6. *Thirdly*, the cadastral system is a foundation for parcel-based LIS development. The DOL has had sole responsibility for cadastral system administration since 1903. The study and findings on the cadastral system are focussed on land parcel identification. The current situation is that the land parcel is identified by various identifiers which are not unique in themselves and required more indexing which is costly in land administration. Thus, a suitable land parcel identification for computerized LIS is proposed in chapter 7. *Lastly*, the computerized LIS requires an efficient data base system and computer system. The data base structure for the textual and spatial data which is the responsibility of the DOL is discussed in chapter 8. The computer network system and data communication for future integrated LIS in the DOL is described in chapter 9. The economic evaluation of computerized LIS is also presented.

The establishment of computerized parcel-based LIS will increase the efficiency in land management of the DOL. Moreover, it will make the DOL information more accessible to the public and other government agencies. This research will be a base line for the development of computerized parcel-based LIS in the DOL.

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CONTENTS

ABBREVIATIONS

ACT	Australian Capital Territory
A.D.	Anno Domini
AIDAB	Australian International Development Assistance Bureau
Amphur	District
Baht	Unit of Thai money (1 A$ ≈ 20 Bahts)
B.E.	Buddhist Era
BMA	Bangkok Metropolitan Administration
Changwat	Province
CIM	Cadastral Index Map
CLI	Command Language Interpreter
CM	Cadastral Map
CVA	Central Valuation Authority
DBMS	Data Base Management System
DCDB	Digital Cadastral Data Base
DDL	Data Definition Language
DLD	Department of Land Development
DML	Data Manipulation Language
DOA	Department of Administration
DOL	Department of Lands
DOLA	Department of Local Administration
EDM	Electromagnetic Distance Measurement
FIG	Federation Internationale des Geometres
GDP	Gross Domestic Product
GIS	Geographic Information System
GKS	Graphical Kernel System
GPS	Global Positioning System
Khet	District (in Bangkok area)
Khweang	Locality (in Bangkok area)
Klong	Canal
LIS	Land Information System
LOTS	Land Ownership and Tenure System
LTP	Land Titling Project
Mae Narm	River

MEA	Metropolitan Electricity Authority
MOI	Ministry of Interior
Moo Ban	Commune
MPC	Multi-Purpose Cadastre
MWWA	Metropolitan Water Work Authority
NESDP	National Economic and Social Development Plan
NS2	Nor Sor Song (Bai Chong)
NS3	Nor Sor Sarm (Certificate of Utilisation)
NS3K	Nor Sor Sarm (Certificate of Utilisation)
NS4	Chanod (Title Deeds)
NSO	National Statistic Office
OSI	Open System Interconnection
PBT6	Por Bor Tor Hok
PID	Parcel Identifier
PIN	Population Identification Number
RCDP	Regional Cities Development Project
ROM	Read Only Memory
R.S.	Ratanakosin Sok
RTG	Royal Thai Government
RTSD	Royal Thai Survey Department
SK1	Sor Kor Neung
Soi	Subroad
SQL	Standard Query Language
STK	Sor Tor Kor
Tambon	Locality
Thanon	Road
TC&P	Town and Country Planning Office
TD1	Tor Dor Neung
TOT	Telephone Organization of Thailand
UTM	Universal Transverse Mercator
VDU	Visual Display Unit
Wa	Unit of distance (1 wa = 40 m.)

1 OVERVIEW OF LAND INFORMATION SYSTEM DEVELOPMENT IN DEVELOPING COUNTRIES WITH PARTICULAR REFERENCE TO THAILAND

"Land Information System : The Hidden Science"

1.1 Introduction

In the modern world, humans are involved with information about their environment in their daily lives because it conveys knowledge, or intelligence to them. The extent of relevant information received by a person depends on the level of the available communication processes by various media such as newspaper, radio, television etc. The concept of information is difficult to define independently of any communication process or context. The concept of an information system deals with interactions between the different types of information and the users of the information. In general, the principle of maximum information is a criteria in designing, developing, and implementing an information system. This means that the optimal information system must be based on easy access to the range of information which it can provide, so that the right information is available in a timely way to end users. The details of analysis and evaluation of an information system can be obtained from Demski (1980) and Feltham (1972). The contents of any information system can only be optimized once the available information and the actual user community have been considered. The communication components of the system can be optimized in terms of coding strategies for the available communication networks (Blais 1987). The optimization of coding strategies and communication aspects depend mainly on an efficient data structure and system design of the information with appropriate objectives and methodology.

Land information generally concerns all information that is related to the land and its resources. The information may be geographical, cadastral, environmental, etc. as derived from measurements, judicial decisions, scientific principles, etc. A land information system (LIS) deals with spatially referenced land-related data, procedures and techniques for the systematic collection, updating, processing, and distribution of data (Hamilton 1986). The purpose of LIS is to simplify access to land information, and to facilitate the manipulation of data held within the system in order to produce new relevant information. The information then can be used for land administration, conveyancing, land valuation, engineering and public utility services, urban and social planning for resource allocation to community services, etc.

1.2 The Definition of LIS by FIG's

The Federation Internationale des Geometres (FIG, 1982) has defined a LIS as "... *a tool for legal, administrative and economic decision-making and an aid for planning and development which consists on the one hand of a data base containing spatially referenced land-related data for a defined area, and on the other hand of procedures and techniques for the systematic collection, updating, processing, and distribution of the data. The base of a LIS is a uniform spatial referencing system for the data in the system which also facilitates the linking of data within the system with other land-related data.*"

The major components of a LIS from the FIG's definition can be categorized into 3 broad elements which are:-

- LIS is a tool for decision-making process and an aid for planning and development;
- LIS constitutes procedures and techniques for systematic collection, updating, processing, and distribution of the data; and
- LIS is based on a uniform spatial referencing system.

1.2.1 LIS as a decision-making support system

LIS as a tool in the decision-making process, helps decision-makers to recognise and define the problem or opportunity, select the criteria for choice, and choose measures for the estimated payoffs, from alternative strategies and from the actual income achieved. This requires an adequate LIS content which is able to supply land information to support decision makers with different goals over the range of decisions which they may wish to make. The following figure 1.1 illustrates the process of decision making in a simplified model and figure 1.2 is an example of the LIS as a decision support system which provides information for decision maker to reduce uncertainty and increase the expected value of decisions.

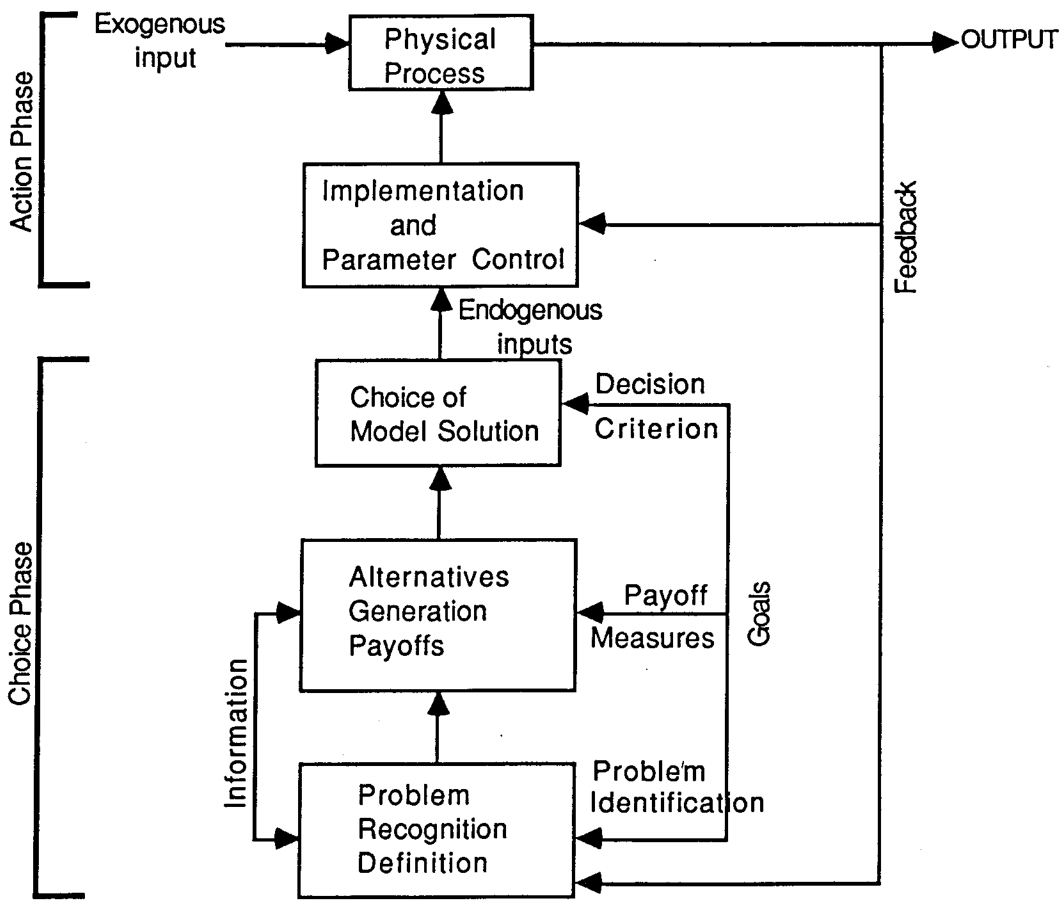


Figure 1.1 The Decision Process (Adapted from Demski 1980)

Figure 1.1 shows the sequential stages of the general decision process. The first three steps are in the choice phase whereby the decision maker chooses what action should be taken. The other two are the action phase which involve implementing the decision and measuring and providing feedback on its outcome. To undertake a rational decision, the decision maker requires two essential components; the information and knowledge to develop the decision maker's goals. The role of information in this aspect is to decrease uncertainty. The quality of the information determines how accurately the problem can be defined and the payoffs from alternative strategies can be measured. The other requirement is that the decision maker must establish the goals or objectives which he wishes to achieve. This is essential since his aims determine how he:-

- defines the problem or opportunity;
- selects the criteria for choice; and
- chooses measures for the estimated payoffs from alternative strategies and from the actual income achieved.

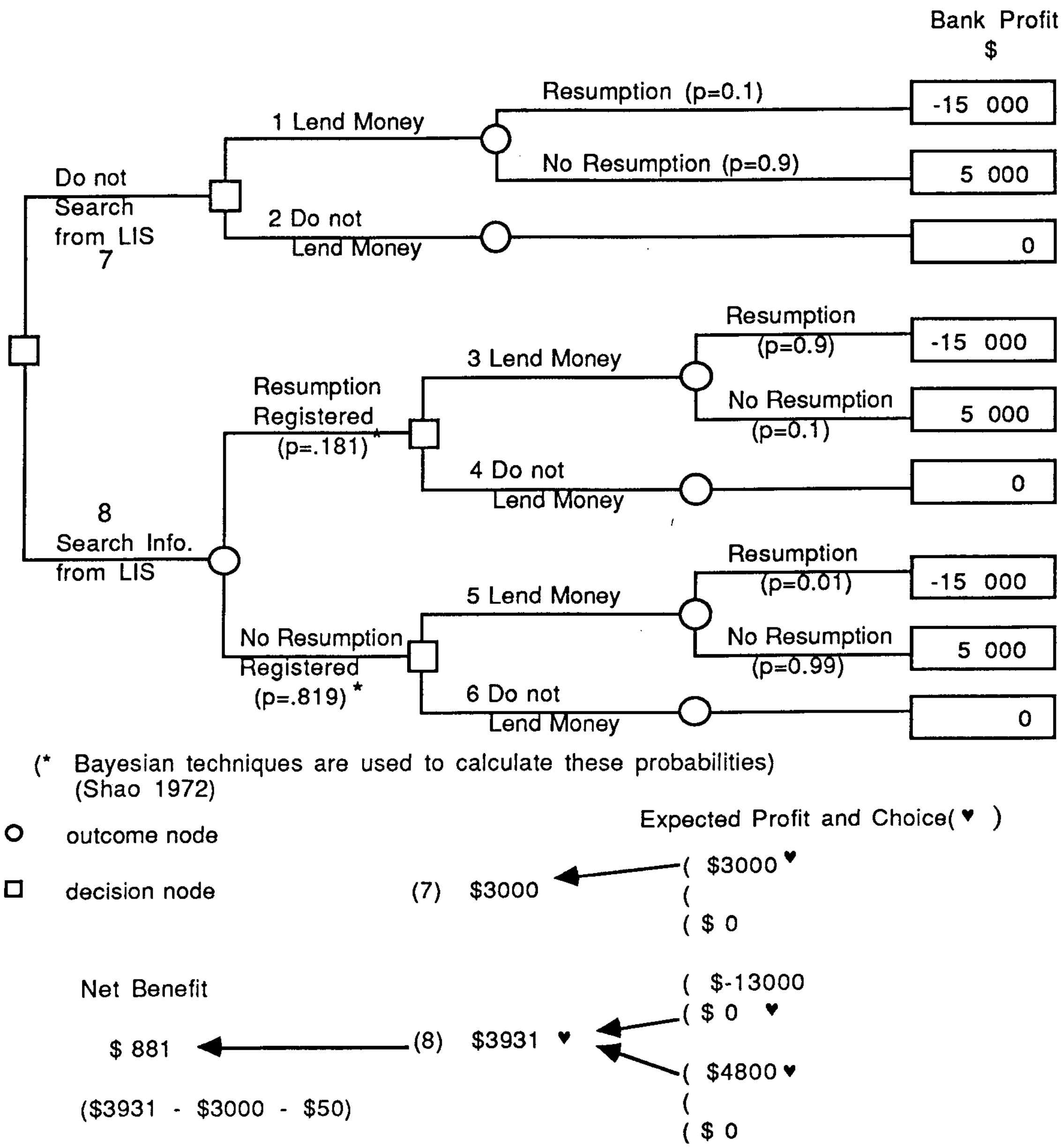


Figure 1.2 Decision Tree to Value LIS as a Decision Support System (Pamela Angus-Leppan 1983)

An example of evaluation of value of LIS for economic decision-making is illustrated in figure 1.2 which illustrates how a single user values the LIS to support decision making. Suppose a credit officer is asked by a lender for a loan of $100 000 with $5000 interest charges on the loan. The client offers, as security, the deeds to his home, currently valued at $110 000. The loan officer knows that the property can be sold for at least this amount provided that it is not resumed for road works. If, it is resumed, the compensation paid will only be $80 000. The bank officer knows that one home in ten in the district is being resumed. He can search the land information for proposed property resumptions at a total cost of $50. If no resumption is recorded, there will still be a 1% chance that resumption will occur because the notice may not have been recorded yet. On the other hand, if resumption order has been noted, there will remain a 10% chance that the property will not be taken over for road works. For simplicity, the discount on the capital and interest charged are ignored. The value of searching from a LIS can be determined as follows:-

In the figure 1.2, the problem is solved from the right hand side. Weighted average expected profits are first calculated at each outcome node. At each decision node, an action is chosen which yields the highest expected profit. The outcomes and choices made are shown under the decision tree. From the analysis, the credit institution gains a net profit of $881 by searching from the LIS and this represents its value in a single decision. Aggregation over all decisions would indicate the value of the LIS.

1.2.2 LIS as systematic procedures and techniques

LIS combines procedures and techniques for systematic collection, updating, processing, and distribution of the data. This is reflected in increasing the efficiency of management of land information. The strategic or corporate approach is an essential element for information management. The development of land information management will be on an incremental basis depending on the level of monetary, technology, and personnel available. The systematic development will provide for the integration of all individual systems and sharing data base in the future. The following figure 1.3 shows an example of the incremental stages of land information management development for the Installed Facilities Information System (IFIS) of the Sydney Water Board starting from stage of data acquisition to the stage of management of information system.

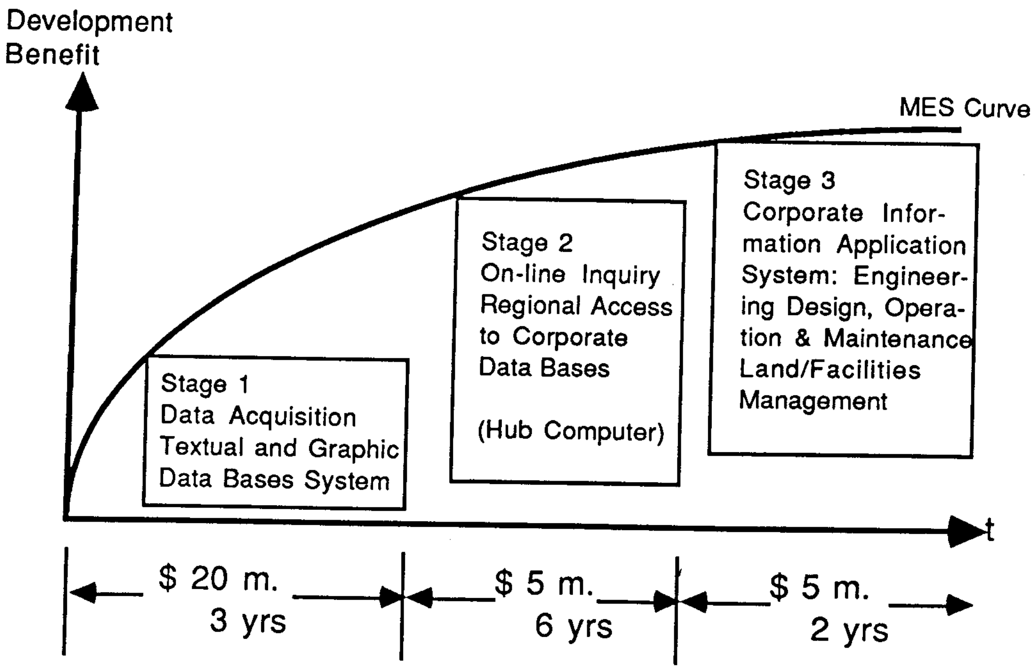


Figure 1.3 The Stages of IFIS Development by the Sydney Water Board

The first stage or non-system involves the inventories applications ,e.g. data acquisition and data base system implementation. Stage 2 concerns the analysis application of land information in form of LIS. The last stage involves the integration of land information from various sources into one corporate information application system. This stage will be the operation and maintenance of land/facilities management. The enveloping curve combines the systems which employ least time period to develop but yield the same effect or development benefit in each stage. This curve reflects the maximum efficient system (MES) from the management of information system development.

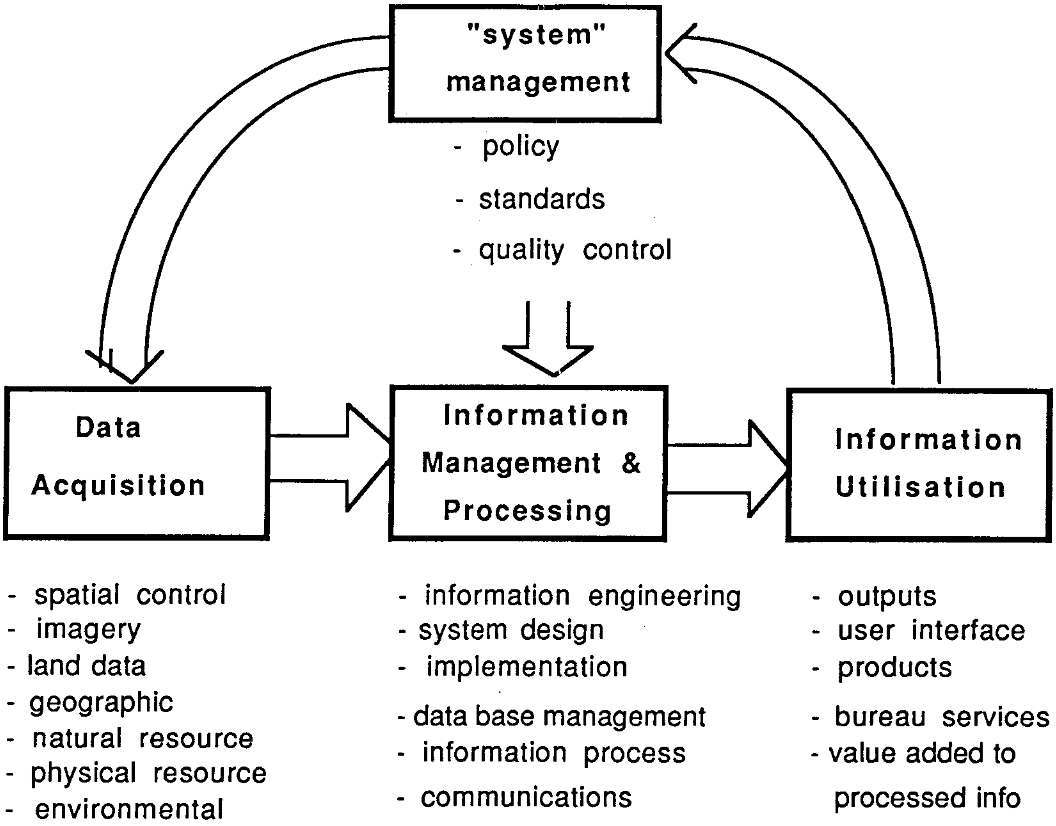


Figure 1.4 Land Information Management Process

Figure 1.4 illustrates that the development of land information management consists of the information management and system management with their elements as shown. The captured data is processed under the set criteria and output in the form of land information which suits the end user's needs. This process is one kind of production since it adds value to the raw data.

1.2.3 LIS bases on a uniform spatial referencing system

A LIS is based on a uniform spatial referencing system with a common co-ordinate system for points, lines or closed polygons. It helps facilitate the linking of data within the system with other land-related data bases. The essential requirement in LIS development is to assign a set of co-ordinates to a point, line or closed polygon of a land parcel. The establishment of interconnected points, lines and polygons together with identifiers will combine that information with other geographically displayed information in order to determine various relationships and/or a plan of action. This concept is shown in the figure 1.5.

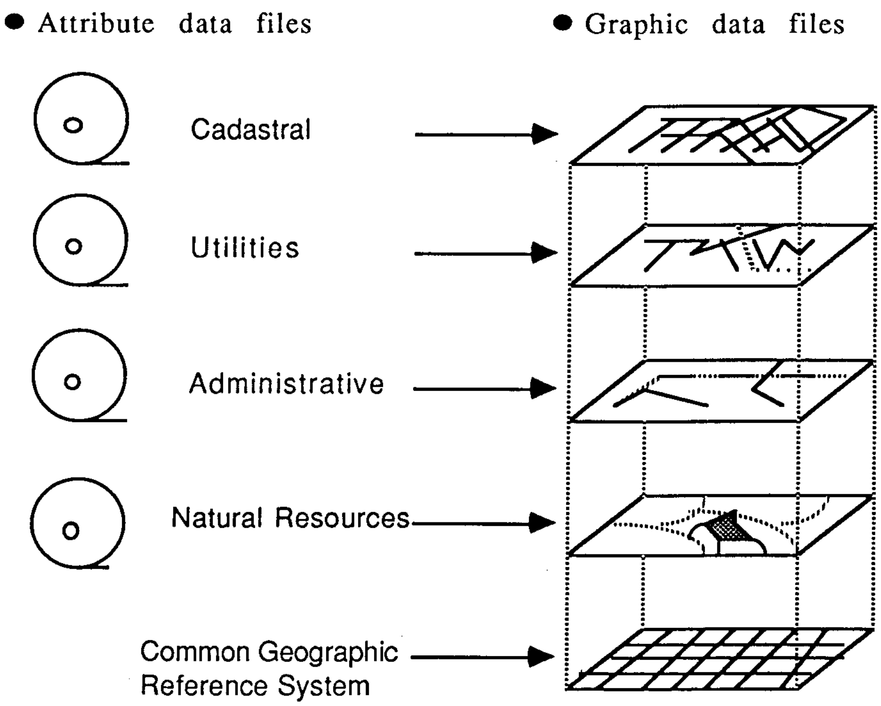


Figure 1.5 The Concept of Land-related Data Bases for LIS

The concept of LIS from the FIG's definition is applied in many developed and developing countries. The main purpose of this study is to investigate the application of LIS to developing countries with emphasis on Thailand. At present, the management of land-related information is increasingly recognised in developing countries. Many governments in these countries have considered the improvements in the land administration as a basic priority for the betterment of both rural and urban poor. This awareness is also shared by world aid organization such as World Bank. But the establishment of a LIS in those countries involves many problems which will be discussed in the following section.

1.3 Problems of Setting Up a LIS in the Developing Countries

The doubling of the population in developing countries over the last 30 years has resulted in a doubling of dwellings, units and land parcels. Furthermore, it has been estimated that between 1975 and the 2000 urban communities in the developing countries will have to absorb another 1 billion people (Williamson 1985). This growth has has long since outpaced any LIS that has been used to record and manage the effects of population increase on both rural and urban land.

Developing countries usually have abundant natural resources but they face a management crisis. Lack of information and poor resources, both financial and human, devoted to LIS makes efficient planning almost impossible. Development programs are difficult to implemented and costly to assess. Dunkerley (1986) has described that nearly half of the world's population lives in countries where the average per capita income is about 1 US$/day. This generates approximately 50 US$/person/year in tax which is to be spent on all public expenditure, including such high priority areas as health, education, and defence. There is thus considerable competition with other projects for government and aid funds. In contrast, a developed country like Canada spends approximately 50 US$/head/year on LIS alone.

The other problem is the lack of personnel who can be devoted to LIS development. The limited educational facilities eg. textbooks and journals, equipment for research, etc mean that training in LIS techniques locally is impossible. Consultants from developed countries are usually required to assess and develop LIS strategies. Staff required for the implementation of recommendations must be trained overseas, which is costly and time consuming.

The establishment of a LIS is also obstructed by the lack of necessary information which is outdated and/or contradictory. In general, detailed information in the developing countries will exist only where a particular need has arisen. Although cadastral surveys usually precede a major development project, the data is not placed in a central registry, maintained or standardised and thus becomes redundant where large projects are undertaken in a particular area at certain intervals. This leads to a waste of resources because of the need to repeatedly collect and process the same land information. Fiscal cadastre information are also not maintained so that the proportion of properties assessed is very low and values of the land parcels are outdated. Development and inflation have a significant effect on land prices and this in turn affects the amount of tax the government can impose on a land parcel.

When compared to other projects it is hard to quantify the benefits of a LIS and see a quick return on the investment made. Consequently there is a lack of ongoing commitment from governments and aid organisations to LIS's. By their nature LIS's are long term projects which can take of the order of decades to develop and become fully operational.

Inappropriate LIS's are often recommended and funded. Systems that are too complex and take too long to become operational are not beneficial to developing countries. LIS's must be able to build on existing LIS frameworks, if present, and be upgraded and improved with time. In other words there must be some near immediate benefits of establishing a LIS even if they are very rudimentary.

Lawyers, surveyors and bureaucrats may have a vested interest in maintaining existing systems. Landowners may prefer personal details about owners of land to be unknown in order to evade taxation and land laws. Consequently, this might raise the issue of the invasion of privacy by the system. Also, land information is often withheld in the interest of national security.

Thus, the factors which make the establishment of a LIS in a developing countries difficult are not so much technical as traditional, institutional, administrative, legal, educational and the lack of management expertise in government. Another main factor is that cadastral systems tend to be weakest in these countries where the rate of urbanization is rapid. Cadastral systems which will be discussed in chapter 7 are primarily concerned with land tenure, land registration, conveyancing, cadastral surveying and mapping, and related land administration tasks. The improvement of cadastral systems which provide the information for a parcel-based LIS will help improve the management of land-related information. It is expected that the efficient cadastral and land information systems will be an infrastructure for other economic and social development which in turn will help to alleviate poverty in developing countries. This hypothesis has been recognised and tested in Thailand through the implementation of the Land Titling Project which will be discussed later.

1.4 Background to Thailand

Thailand has an area of 513,115 km^2 and a population of about 55 million. The capital is Bangkok with its population of about 10 million. About half of the country is flat river delta in the central region and hilly to mountainous forest lands in the north and south. Thailand has her economy based mainly on agricultural produce and has long been the world's major rice exporter. However, Thailand is becoming an industrialised country. At present, Thailand has been recognised as the Newly Industrialised Country (Handley 1988) with a rapid economic growth among the South East Asian countries. The economic growth in the country is continually increased at a rapid rate and the Bank of Thailand forecasted the economic growth in the country to be about 7-8% this year. There are many development projects created in the country both in agriculture and industrial sectors. The Royal Thai Government (RTG) realised that to facilitate farm investment, the farmers must have the security in land as a first instance. This is because insecurity of tenure causes lower farm productivity, reduces investment incentives and accesses to credit is limited. This is also reflected in high market value of tenured land. The chain of the effect of investment in tenured land is shown in the figure 1.6.

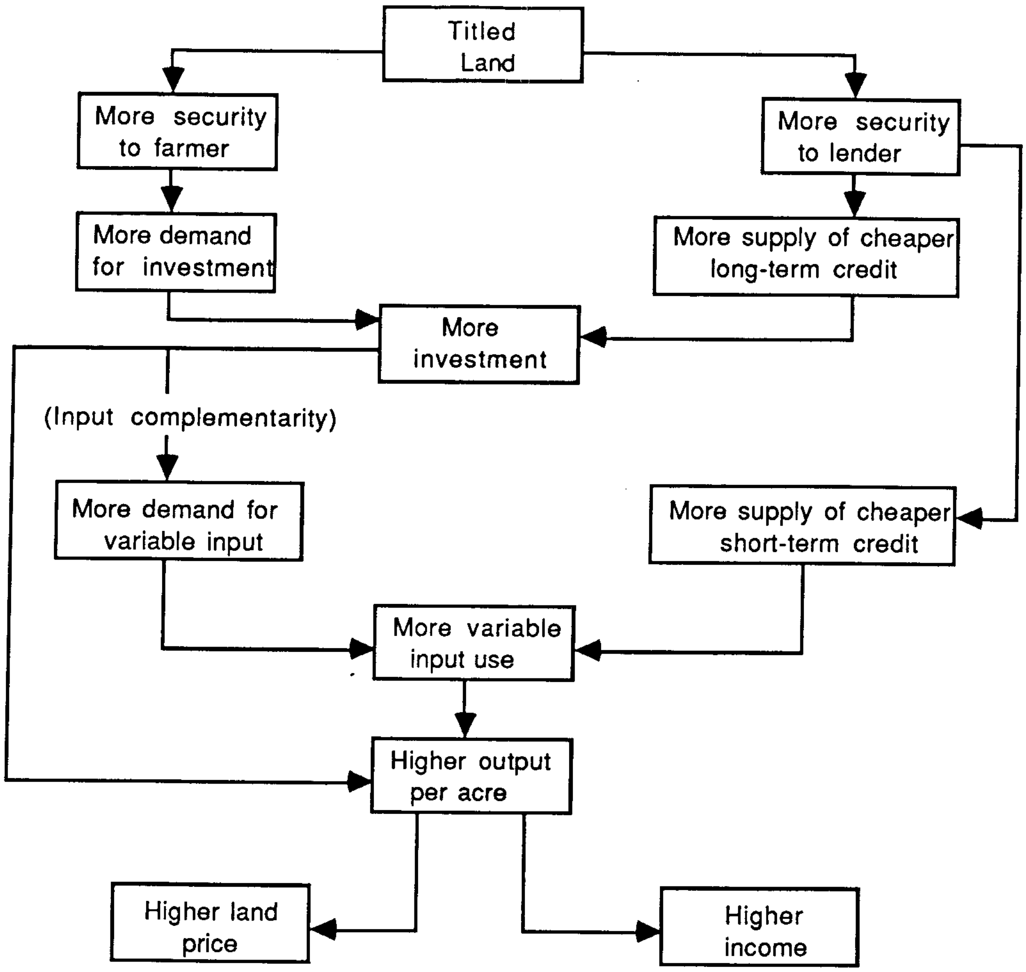


Figure 1.6 Land-Ownership Security and Farm Productivity : A Conceptual Framework (Feder 1987)

Thailand is now involved in a Land Titling Project with emphasis on improving its land administration and cadastral system. This project, which is under the responsibility of the Department of Lands (DOL), Ministry of Interior (MOI), includes the following major components:-

1) Establishment of major and minor control networks based on the geodetic UTM reference system, to supersede the existing 29 cadastral co-ordinate systems;

2) Production of cadastral maps at a scale of 1:4000 based on rectified photomaps and incorporating all land parcels. In villages or other areas where land parcels are small, the mapping will be at scales of 1:2000 or 1:1000;

3) A programme of survey, adjudication and issuing of title deeds for land held by certificates of utilization and undocumented land. The programme will cover the whole country within 20 years;

4) Development of the National Valuation Authority to undertake the task of collecting and disseminating land valuation maps and information. The aim is to provide complete and reliable information on land and building values to government agencies; and

5) A programme of technical aid and training visits to overseas countries by department staffs.

The DOL has, since its establishment, the responsibility for the overall cadastral system in Thailand which includes land tenure, all conveyancing, title registration, cadastral surveying and mapping, land administration, and land valuation functions. The DOL's activity in improving cadastral systems will lead to the development of a parcel-based LIS because it:-

- improves cadastral information;
- rationalises of co-ordinate systems for cadastral mapping; and
- generates uniform and complete property information.

1.5 The Role of DOL in LIS Development

The Department of Lands (DOL), Ministry of Interior, Thailand must act as a central agency in the future parcel-based LIS since it has statutory authority for (Department of Lands 1984):-

- the shape, size, and location of all land parcels in Thailand;
- the current owner of each parcel; and
- the current value of each parcel.

The DOL's need is mainly for a parcel-based system to support its responsibilities for:-

- land registration
- valuation
- land allocation
- land ownership control under the new Land Ownership Control Bill

Before the DOL develops the LIS, the study of user needs both internal and external to the department, a cost/benefit analysis, pilot project, and system design should all be clearly defined and undertaken. The internal DOL needs include:-

- indexes to support the daily access to parcel, title, ownership, and valuation information in all land offices;
- integration of data sources from a number of divisions and land offices;
- efficient retrieval and distribution of DOL data to users throughout DOL, other RTG agencies, private enterprise and the public; and
- synthesis of statistical information from parcel data to support DOL policy and planning.

Parcel-based LIS's have land parcels as their basic spatial unit. These land parcels have various non-spatial data attributed to them, including parcel number, area, ownership, and valuation. The ownership index card is used to store most of the basic attributes needed for a parcel-based LIS. This source of data base provides an inventory of all parcels under its title, with details of parcel location, area, land use, sale price and owner. This information is used in DOL land offices in their daily operations. It could be transformed to digital form when the manual procedures for handling the data are in place, and the users of the system identified. Computerisation will be added to speed up the processes and to enable more ways of accessing the data base. Another important source of data will be the valuation roll compiled by the Central Valuation Authority (CVA).

The DOL should be working with other RTG agencies to develop standards for data exchange, be responsible for client liaison on matters such as the use of UTM co-ordinates, common mapping standards, unique parcel identifiers, and control marks. The DOL should encourage other agencies to use the unique land parcel identifier contained in the computerised records and shown on the DOL cadastral maps.

The DOL should carry out a comprehensive LIS training programme commencing with a series of seminars for DOL senior management, followed by middle management forces. Such education is an essential element in the introduction of any new technological and administrative programme.

The development of LIS within the DOL and other agencies will:-

- reduce duplication by increasing co-operation between agencies;
- employ systematic process of data acquisition, updating, manipulation, output presentation;
- provide quick access to land information by public and another agencies;
- yield system which provides accurate, reliable, and complete information;
- create standardization of data, data structures, and formats;
- increase administrative efficiency in DOL; and
- support decision making as a major issue.

Under the Land Code, the DOL has the sole responsibility for all cadastral surveys in Thailand including those for the subdivision of land. Consequently, the DOL is the largest surveying organization in Thailand. The DOL employs over 3000 surveyors out of a staff of 10,000. The majority have either a three year full-time surveying certificate or a five year full-time diploma in surveying. There are approximately 30 survey engineering university graduates. Thus surveyors in the DOL should participate in parcel-based LIS development.

1.6 The Role of Surveyors in LIS Development

The establishment of a LIS needs the involvement of many professions- economist, accountants, statisticians, lawyers, valuers, computer engineers, surveyors, etc. All of them have the opportunity to be involved in its implementation, design, and management. However, among those professions, surveyors are in a much better position to play a role in LIS management since they are familiar with the spatial concepts involved, and they can supply survey information to the various components of the LIS, maintain and upgrade the spatial framework and data. But survey professionals are often referred to in the narrow context as their traditional role of measurement and map-making. This is because surveyors at present are trained mainly as professional technicians. The academic sector, e.g. Faculty of Surveying Engineering, Chulalongkorn University, Thailand, must redress their teaching role by adding general management principles, cadastral survey, land law, valuation, and LIS into the normal part of survey courses. All these subjects must be compulsory subjects for undergraduate students in surveying. It is strange that graduate surveyors have to register as licensed civil engineers. Surveyors cannot register in their own profession. Even though the surveying industry is small and a major function is to support other professions, surveyors must have the right to register as a licensed surveyors. At present, surveying students have to study subjects irrelevant to their field and lack some essential subjects for their profession.

The growth of urban areas and the economy is reflected in increasing demand for information on land use. Thus, surveyors must play an additional decision support role by providing information appropriately tailored to the needs of users and supporting decision-making. Surveyors should participate in the planning, development and operation of new computerised LIS since their work is concerned with providing the key elements in LIS through their mapping function which is the basis for land registration and valuation. The survey profession normally contributes to measuring, collecting, storing, manipulating, analysing and managing spatial land-related data. The above skills are applied to a range of scales from a single parcel of land to the whole country. Thus, they must find methods to integrate and co-ordinate the various data bases to provide relevant information more efficiently and effectively. Moreover, surveyors must consider the value of a LIS to the ultimate user and how the LIS assists decision makers. Thus, surveyors need to understand clearly the role of the LIS as a decision support system. They must have some knowledge of how and what information is required for the rational decision-making process. Problems facing them are, the difficulty to identify the types of decisions in which land information is used, how to establish the ways in which individual decision makers process the information, and the needs to specify the appropriate form of the information for the individual decisions made. Adams (1984) has commented in the future role of the survey profession which is quoted from The Australian Surveyor, vol 31, no.6, June 1983 as follow:

> *"... A traditional definition of surveying and mapping is 'the location and portrayal of points of the earth's surface'. A definition that might be appropriate to take to the turn of the century and beyond could be 'the planning, acquisition, measurement, analysis, portrayal and dissemination of geographically referenced data'. Acceptance of this definition would signify a change of business from locating and portraying points on the earth's surface to all aspects of geographically referenced data and information."*

If surveyors wish to optimize their profession, they must make a quick decision and contribute to the LIS area in addition to the technical aspects of measurement only. The transformation of survey professions will push the survey community to the forefront of providing service, helping the community and contributing to an improved quality of life. Surveyors must keep in mind that surveying science must serve the society directly.

1.7 Summary

This chapter presents an overview of land information systems. An investigation of the definition of LIS defined by the FIG has been concluded that a LIS consists of 3 main components. Firstly, LIS is a decision-making support system. Secondly, it combines procedures and techniques for systematic collection, updating, processing, and distribution of data. Lastly, a LIS is based on a common and uniform spatial referencing system which will allow the integration of data from various sources. It provides a framework for LIS development in especially developing countries. The impact of LIS in developing countries has been well recognised by world aid organizations such as the World Bank because a LIS is an infrastructure for other developments. But the implementing of LIS in those countries is more difficult due to the financial situation, political support, and institutional arrangements rather than technical aspects. Other primary concerns for LIS implementation in those countries depend on the status of the cadastral systems because an efficient cadastre can be expanded to a parcel-based LIS. To improve cadastral systems, the Land Titling Project (LTP) has been introduced by the World Bank in Thailand. The economic impact on farm investment from implementing LTP has been well studied by Feder (1987).

In Thailand, the DOL is responsible for the LTP. The project will generate the basic data which will be integrated into parcel-based LIS efficiently. Since the DOL is a large community for the survey profession, the role of surveyors in the DOL who will contribute to LIS development is significantly important. They can participate in LIS activity directly by investigating the land problem and designing the suitable model for the DOL etc. and indirectly by doing the cadastral surveying and mapping accurately with responsibility to make sure that the quality of data to be put in the data bases is reliable. However, at the national level, many government departments and agencies with activities involved in land administration have recognised that the system will help increase the efficiency of their land administrative activities in their organizations. Thus, the investigation of LIS implementation at the

National level is important to pave the way for systematic development of LIS to the country. This will be discussed in the following chapter.

2 LIS IMPLEMENTATION STRATEGIES AND METHODOLOGIES

"In order to become the master, the politician poses as the servant."

- *Charles de Gaulle*

2.1 Basic Problems of LIS Implementation in Thailand

In the 6th National Economic and Social Development Plan (NESDP) has emphasised the importance of natural resource and environmental development in the country. Its target is to establish plans and projects to develop methods of coordinating natural resource and environment administration. A Land/Geographic Information System which serves this land policy is mentioned in the national plan and in many government departments. In Thailand, initiatives for improving the management of land-related information are being driven by urgent social, economic, and political demands. The Royal Thai Government (RTG) recognises LIS/GIS as a general resolution to land administration problems. Setting up a country-wide LIS is a complex task because it involves various government departments, a wide range of data both spatial and textual with different levels of accuracy, resolution and format characteristics, and various technologies used in each agencies. The institutional arrangements and cooperation of activities between government agencies have to be achieved initially before the LIS can be effectively implemented technically. The obstacles to LIS development can be categorised as follow:-

1) Lack of political and administrative support is a significant factor in LIS implementation. The LIS project must be monitored to make the public realise that this system will not damage the individual's privacy. This issue plays a significant role because if the public is not satisfied with the project, political problems will arise and politicians will put pressure on the administration to modify the LIS project. Consequently the objectives may change or the project will lack political support. Thus the objectives of the proposed system must be well known and must benefit the people. The objectives should not be permanently set for all time but provide for flexibility to organisations undergoing policy changes as a result of political pressure. It is necessary to make the top administrator realize that once the LIS is implemented, it will improve the efficiency in land administration.

2) Lack of cooperative mechanisms both within agencies and between agencies is the main problem facing the LIS implementation. At present, each government agency collects its own data and manages it itself. When one department or the public wants to access basic data of another department, it involves lengthy delays to obtain even outdated data because the basic data may be missing. All these problems result in delays in the implementation of plans or projects which require some basic land information for evaluation. Even if the required information for planning is collected, the pattern of information which satisfies consumers' preferences and the composition of factors supplied might change before production and distribution plans are implemented. This institutional problem causes a time-lag between the collection of information and the formulation of development plans based upon that information. Consequently, there is a further time-lag between the implementation of production targets.

3) The duplication of work and data is a well known problem in land management especially in map making. Due to the wrong attitude of land managers and lack of efficient cooperative mechanisms, many government departments involved in mapping data do their own survey , manipulate spatial data , and produce maps to satisfy their own specific needs, e.g. DOL, DOLA, BMA, TC&P etc. There is no official central mapping authority which is responsible for map production and supplying spatial data for government departments and the public when required. This distributed production cannot take advantage of specialization and the economies of scale of production. If the resources are centred on a central mapping authority a more efficient system, with increased plant size, will benefit specialization in map making. Thus map production will be increased in both quantity and quality. The work flows continuously and fully utilises equipment etc. Most of these factors will help reduce the unit cost of map production and the nation as a whole will benefit from reduced spending on mapping.

4) Lack of knowledge by personnel on the form, content, and use of LIS leads to the misdirection of the development and

implementation of LIS. For recruitment of suitable staff, the organization requires a continuing education and training programme of staff who are involved with LIS development. Moreover, misunderstanding about the real needs of land data means that the users do not gain fully from the products of LIS.

Thus, the major limiting factors in modernising the land administration system and the major problems facing the LIS implementation are more bureaucratic, institutional than technical. The strategies to deal with those problems should be clearly defined and recognised for LIS development.

2.2 Strategies and Methodologies for LIS Implementation

1) The RTG must support LIS development by providing sufficient technology, equipment, and continuous personnel training to ensure that the project goes on smoothly and meets the target.

2) Various government agencies which are concerned with map production should use the common centralized mapping system. The RTG as a key administrator should monitor mapping and LIS proposals and use the national administrative power to ensure that the government departments concerned with map making and land information improve co-operation, approve complementary programmes and are not involved in duplication which wastes government resources.

3) The central committee should be established to co-ordinate the land administration, mapping and LIS. The committee should be composed of representatives from government departments and the private sector if possible. The tasks of the committee should include:-

- monitoring overall co-ordination of urban mapping and LIS activities of government agencies;
- meeting at specified periods to exchange the ideas and solve problems;

- encouraging the long term progressive development of urban LIS and the dissemination of information on urban mapping activities;
- encouraging and stimulating the technology transfer to the mapping/LIS development;
- organizing seminars and conferences on LIS/GIS, and issuing the mapping/LIS newsletters periodically as a medium for agencies concerned with LIS, and monitoring the advancement in LIS to keep pace with the LIS/GIS development both within the country and overseas;
- deriving specifications and standards for mapping and data exchange;
- deriving the public access policy to ensure that public spending on this project serves the benefit of the public as a tax payer;
- deriving regulations for data security to ensure that most land information are not widely accessed by public which will harm the national security.

4) A data centre should be fully established. The centre will hold key or aggregate data sets and provide the data standard code for data exchange between agencies such as land use codes, changwat (province) code, amphur (district), tambon (locality), and municipalities codes, etc. The centre should also be required to minimize duplication and ensure the data are up-to-date, correct, and compatible with other elements of LIS.

At present, specifications differ widely between data bases which make the data interchange task extremely difficult. The different and incompatible approaches to acquiring, coding, storing, and exchanging cartographic data could hinder the orderly development of digital cartography. Thus, a committee for digital cartographic data standards must be founded to develop standard for digital cartography. The committee should consist of individuals from government department and local authorities, private enterprise, and the university community as shown in the following diagram 2.1.

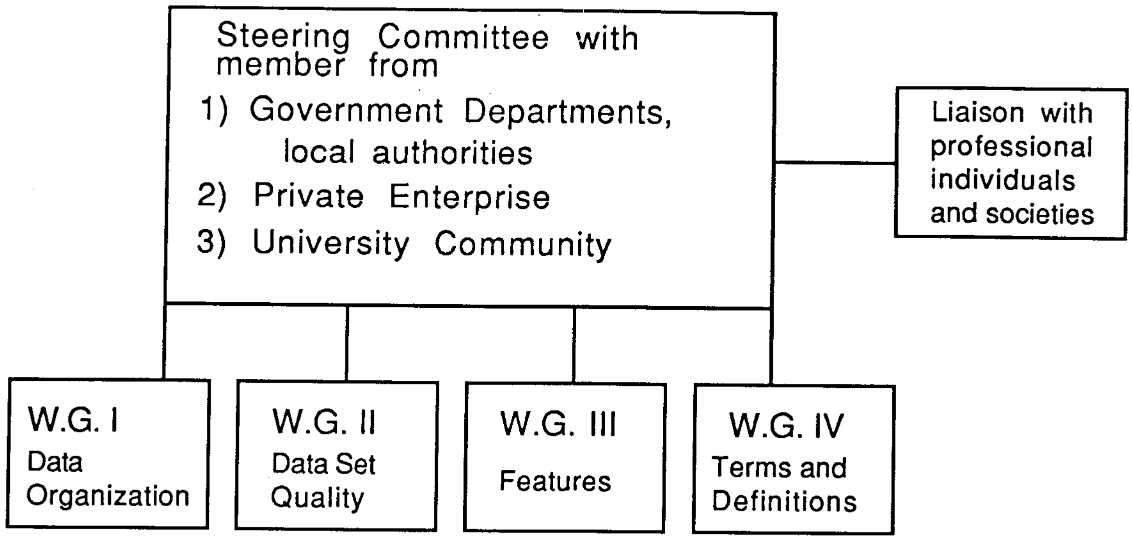


Figure 2.1 Organization of the Central Committee for Digital Cartographic Data Standards (Moellering 1980)

The working groups have to assess the state of current knowledge and understanding in the technical area, then define any gaps in such knowledge and understanding necessary to specify digital cartographic standards in that area. The investigation of gaps and findings can be collated, co-ordinated, and communicated to the profession for further research. The tasks of each working group will be concerned with:-

I Data Organization

a) To examine cartographic models
b) To examine cartographic data structure
c) To examine cartographic data interchange

II Data Set Quality

A data set should include five basic categories:-

a) Fidelity of graphical data, metric and topological
b) Coding reliability

c) Update and other temporal information
d) Lineage of a data set
e) Checking procedures used by the producer to verify quality

III Features

To specify a consistent and comprehensive set of feature classes and codes for cartographic objects and the hierarchical structure.

IV Terms and Definitions

To collect and examine the existing and new terms and definitions in numerical and analytical cartography.

The process must contain a set of review cycles to solicit direct comment from the profession at large at appropriate times. The review cycles for developing Digital Cartographic Data Standards should follow the sequence as:-

a) Define the fundamental issues involved
b) Define the alternatives to the problem
c) Formulate interim proposed standards
d) Reformulate interim proposed standards
e) Generate final proposed standards

Thus, a preparation of digital cartographic data standards is an important step to overcoming the current situation of a multitude of incompatabilities.

5) Each RTG agency manages its own land information but cooperates with the data centre to ensure that strategies for common data base and standard format are clearly defined and enforced. Individual data bases will be created, updated and controlled by various agencies having primary responsibility but the use of standard land information indexes will provide for the development to link each system. This concept is shown in figure 2.2.

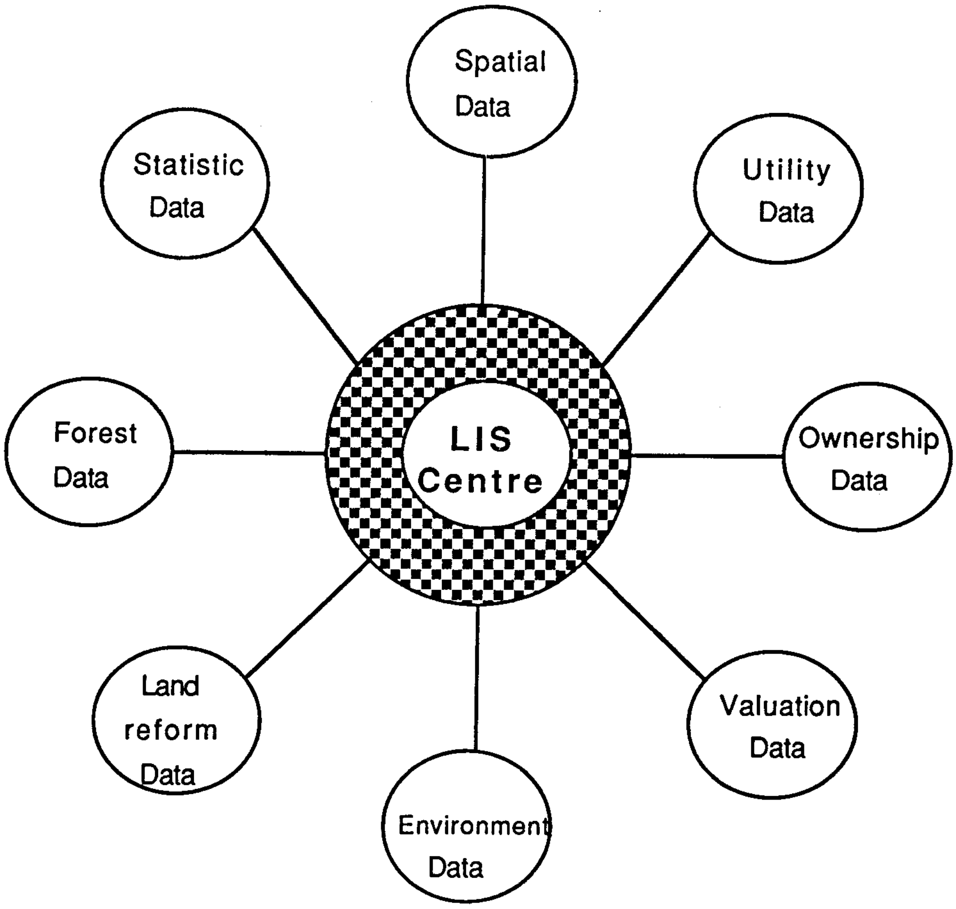


Figure 2.2 Relationship between LIS Centre and Individual Data Base

Some practical problems facing the LIS implementation involve the categories and methods of data collection, institutional arrangements to respond to the information system, and financing. Therefore, each department should continue collecting its own land data systematically. When each department is ready both technologically and monetarily, then the strategy is to develop the index system to the network. As mentioned by the expert in GIS, Dr. Duane Marble, during his seminar on the direction in establishing the LIS in Thailand to the land sub-committee on June 12, 1986. He pointed out that:-

" the feasibility of establishing the fully computerised LIS was not suitable to the technology and current monetary situation of Thailand because it is more capital intensive system and because each government department concerning with the land employs various types of computer both hardware and software which may not be linked together. Therefore the first stage of LIS in Thailand should be created in form of "index system" because it is simple and less capital investment."

2.3 Types of Important Data Bases for LIS Development

In Thailand, there should be about 5 main groups of data bases which are operated in the government authorities and private agencies. They are categorized as follow:-

1) Parcel or property based cadastral data base
2) Municipal data base
3) Utility and infrastructure data base
4) Resource and environmental data base
5) Statistical data base

1) Parcel or property based cadastral data base is run by the land office and the central valuation office in the DOL, the county land assessment offices of municipal council in the Department of Local Administration (DOLA), the Bangkok Metropolitan Administration (BMA), Town and Country Planning Authority (TC&P). They deal with legal and fiscal cadastre data held at the parcel level. Data is held usually in manual systems including land title books, title registration books, valuation rolls, property sheets, cadastral maps, and survey plans, along with taxation maps. Textual data acquisition is usually by transaction based operations. Map type data is obtained from submitted survey plans held in the divisions in the Department of Lands and provincial land office.

2) Municipal data base has the role of assisting in the efficient administration and management of the municipality in most of its functions especially with personal data, land valuation and assessment for rating purposes, building control, area cleaning, road details and footpath linking with utilities such as sewerage, water, electricity, telephone line etc. The spatial data base is usually inefficient because the maps are usually out of date as the urbanization has expanded rapidly in Thailand in the last two decades. This data base is compiled in the municipal council, district offices, and BMA.

3) Utility and infrastructure data base is mostly held by public enterprises which are responsible for the following services: electricity, water, telephone, roads, railways, sewerage, irrigation etc. Links are made to the customer billing data files for some items of information especially in the estimation of future requirements. The utility maps and plans are updated on a regular basis upon the receipt of new service or recticulation data. Records are updated at account sending time and period of new valuation. If the billing system was transaction based, then updating would be instantaneous.

4) Resource and environment data base is associated with regional and district environmental maintenance, forestry purposes, illegal occupation of land in the reserved forestry area, highway and dam location, land development suitability, and new settlement location following the building of dams. Data typically held in such files are administrative district boundaries, land use, topography (contours and slope), plans of forestry area, certificate of utilization records, mineral lease etc. Data are acquired from existing small scale topographic and thematic maps, aerial photography, LANDSAT, and special social surveys. These sorts of data are usually required for projects rather than for use in administration.

5) Statistical data base is used for regional and country planning by government departments, economists, town planners, researcher etc. This data base involves socio-economic studies,

census, usually at the regional and national level. This data base can be obtained from the National Statistic Organisation (NSO), government department, and banking institutions.

All these data bases have to be integrated into one land-related data base. The possible model in gathering these data bases is as follows.

2.4 Possible Model of LIS/GIS Development

The nodal approach which is shown in figure 2.3 is rather suitable for LIS development both technically and economically. It should consist of 5 major data bases and act as the major nodes which are legal/fiscal, municipal or administration, utility or infrastructure, and statistical and many smaller data bases. The major data bases act as communication hubs with a strong inter-relationship to smaller data bases. Inter-communication between the nodes or with peripheral systems is via either primary communications links or lesser levels of communication, depending on data loads (Sedunary 1984). This approach is helpful in achieving a balance between centralised/decentralised concepts of government. It allows an incremental implementation and development of LIS which in turn allows cost return to be gained from most of the implementation stages and special application can be undertaken as required. The success of this approach is evident in the legal/fiscal cadastre of South Australia which is Land Ownership and Tenure System (LOTS).

Figure 2.4 shows the possible National Spatial Data Bases arrangement for all surveying offices in Thailand. The model should be designed and arranged to be compatible with all spatial data to be stored in digital form in the near future in Thailand. The model is directed at the operations and functions of all surveying offices with a logical development. The spatial data base would comprise two components based on the scale of map compiled. The first component, the Cadastral Parcel Data Base, Tax/Valuation Data

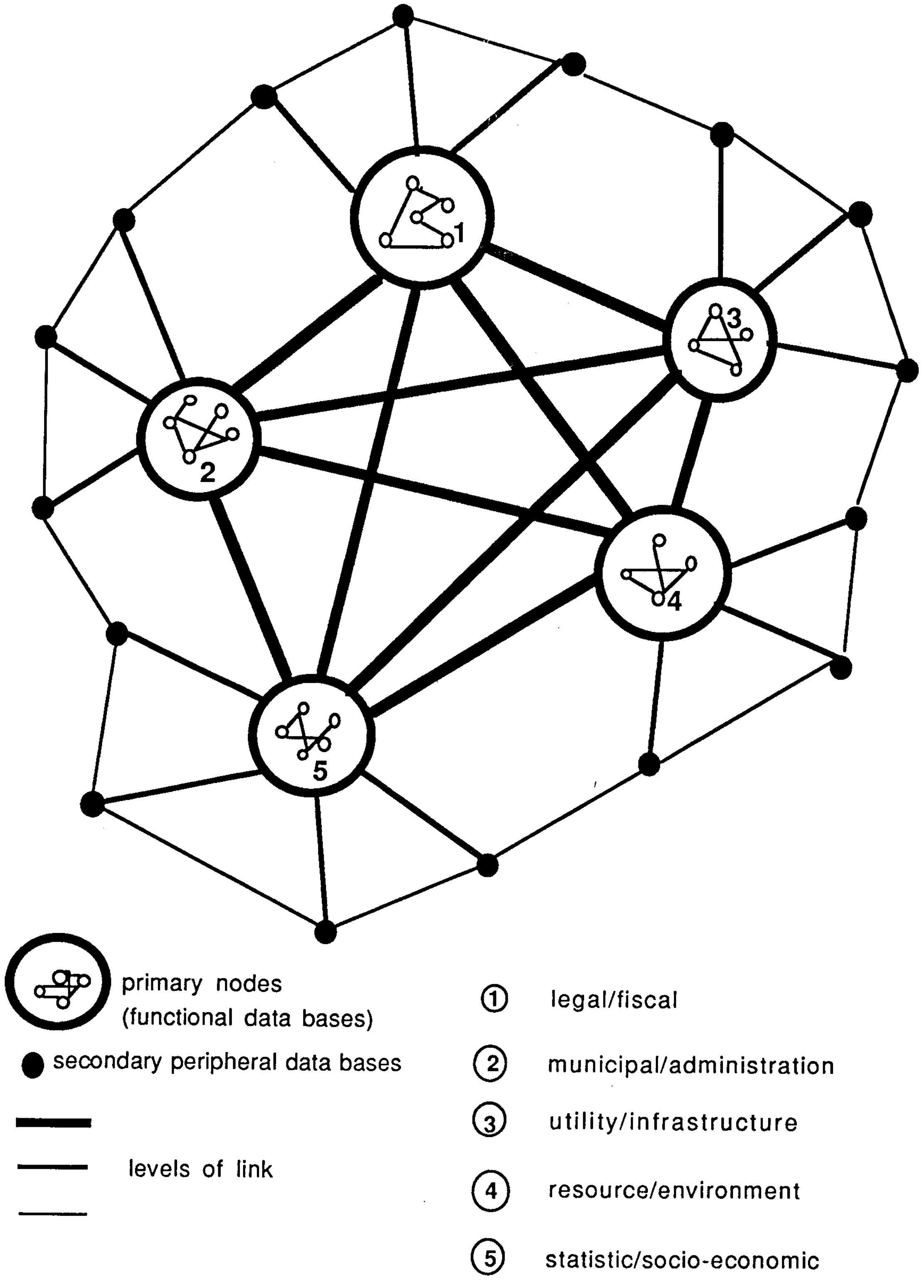


Figure 2.3 Technical Nodal Function Model to a Land Data Base Configuration (Adapted from Nodal Approach to a Land Data Base of South Australia)

bearings, control or other survey information such as owner's name etc. which can be put in the separate attribute file. Underlying this data base would be a fiscal data base which would be based on the present subdivision data base, computation sheets, or valuation/taxation map but with the common mapping co-ordinates and accuracy. The integrity of the two data bases would be the responsibility of the DOL, BMA, DOLA, TC&P. Any additions or amendments to these two data bases, whether by DOL staff or private surveyors, would have to pass through an examination process to make sure that the data is reliable. The other layer in the system would be the Utility/Infrastructure Data Base which is the responsibility of other public enterprises, e.g. MWWA, MEA, TOT, DPMW. The linkage mechanism via georeferenced mapping co-ordinates is essential to overlay all these Spatial Data Bases.

The other component in the National Spatial Data Base comprises, conceptually, three layers: Statistical/Thematic Data Base, Municipal/Administration Data Base, and Land Use/Environment Data Base. The compilation of this component is based on the small scale maps. Within the overall National Spatial Data Base it would be possible to combine data from any individual data bases and provide for the linkage mechanism to allow such data base to interact horizontally and vertically. Both components would be based on the Topographic Data Base and the Geodetic Reference Framework Data Base.

2.5 Linkage Mechanism of Various Data Bases to a LIS

In general, a LIS in Thailand would comprise two major components: a spatial data base and an attribute data base linked by some common mechanism as shown in the figure 2.5. Each component can be developed independently since the users' requirements of a graphic data base are quite different from the attribute data base (Soetandi 1988). In a computerised system environment, when land information must be converted into digital form, the full value of digitally stored land data will be evident when two or more sets of information are superimposed and

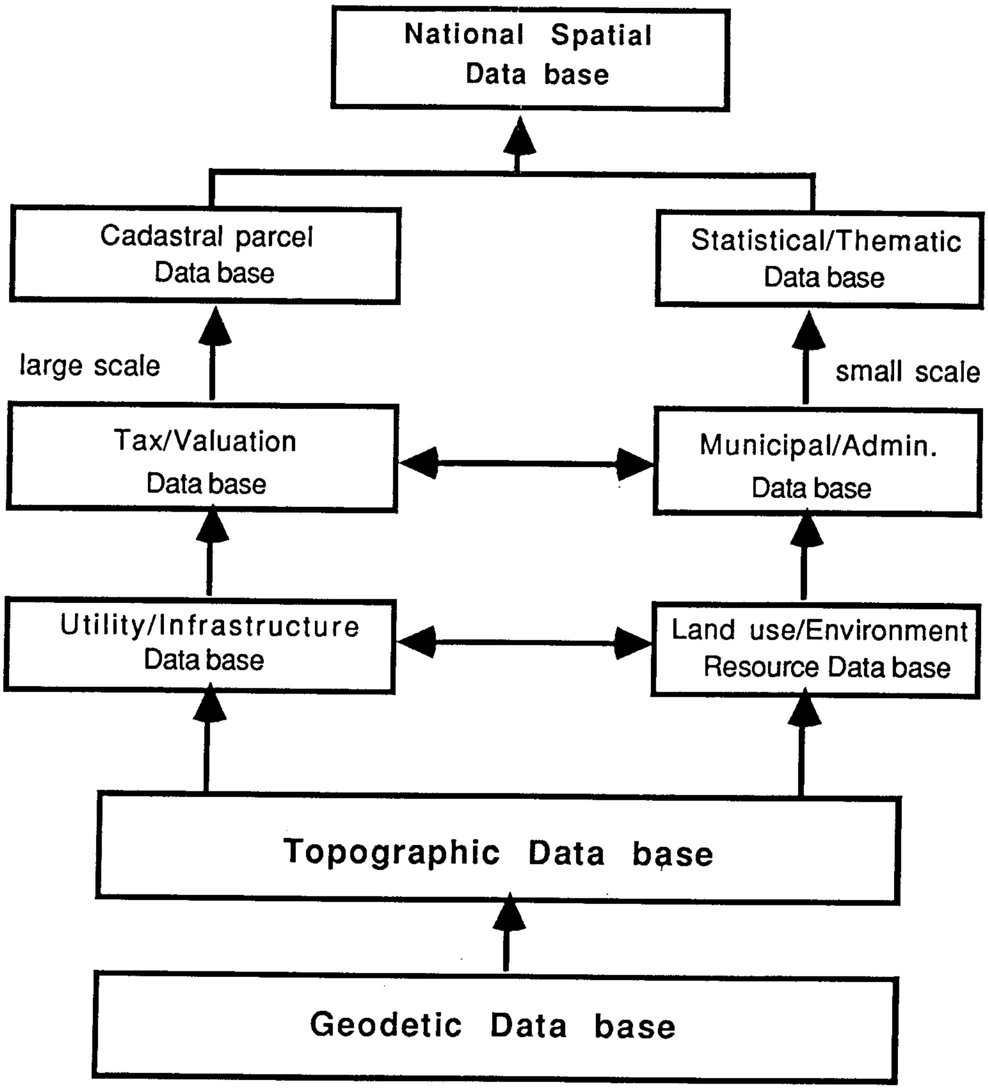


Figure 2.4 Technical Possible Structure of National Spatial Data Base based on Scale of Map
(Adapted from ACT Spatial Data Base Structure; Williamson 1987)

Base, and Utility/Infrastructure Data Base is based on the large scale map compilation process. These would all be seen conceptually as layers in the overall data base. The Cadastral Parcel Data Base as in the sense of the legal parcel data base would be a simplified continuous deposited plan. This data base would show parcels, parcel identifiers, road names, public places and possibly distances on boundaries and areas, but would not show analysed to determine the relationships (Groom 1988). Thus the linkage mechanism via unique identifiers, standard data exchange, and proper system design would be required to integrate the two components.

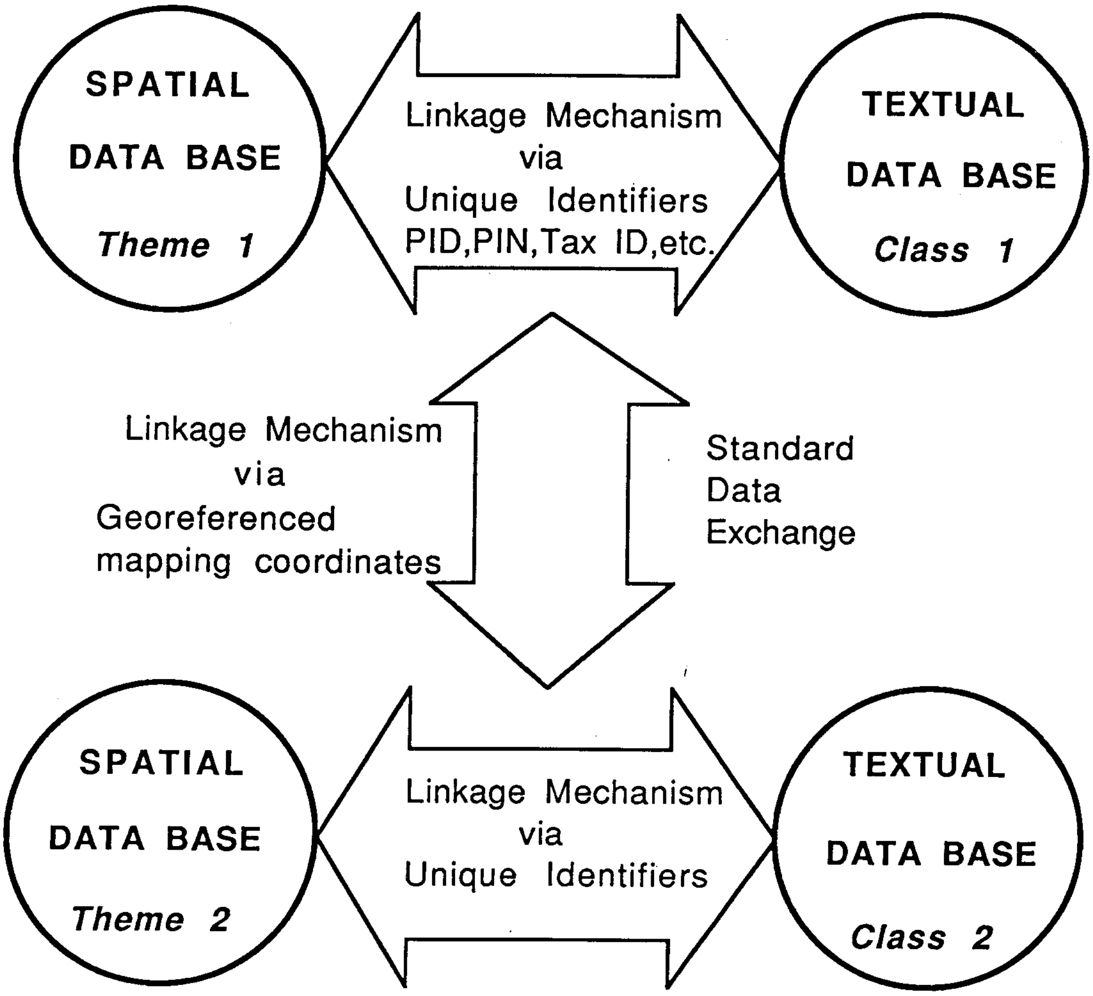


Figure 2.5 Linkage Mechanism between Each Set of Data Base

The LIS implementation should not only satisfy technical requirements but the system must also yield an economic cost return. Hence, the cost of setting up LIS involves personnel, system, and data. It is clear that the cost of gathering information is likely to be very high, as it requires many experts such as statisticians, engineers, planners, and administrators; high cost of instrument both hardware and software; and the data management cost. Since LIS is a government project and serves government and private land information, the source of financing this project comes from collected tax, but not all private individuals benefit from it. It is sufficiently justified to impose charges on the user for this service. Broadly, the term user charge refers to the price charged to an individual user of a facility provided by the public sector and has its origin in the benefit principle of taxation (Challen et al 1985). It is unfair to raise taxes to finance those social services which benefit identifiable groups. In the absence of user charges, governments are encouraged to over supply high cost services at zero prices.

2.6 Summary

This chapter is concerned with the conceptual framework for the establishment of a LIS in Thailand. The basic problems of LIS implementation in Thailand are mainly the lack of political and administrative support, lack of cooperative mechanisms between organizations which result in the duplication of effort in data collection and data maintenance. These problems must be clearly solved before a LIS can be implemented technically. The RTG which is the top administrator must stimulate each agency to increase cooperation by organizing the central committee with representatives from various agencies to work out a LIS establishment. The LIS centre should also be set up to hold the major aggregate data set, provide the data standard code for data exchange and to coordinate between government agencies. The suitable procedure for LIS development in Thailand should involve each government agency managing its own data base but cooperating with the LIS centre to ensure that strategy for common data base and standard formats are clearly defined and enforced. These distributed systems will be linked to the network when each department is ready both technologically and financially.

From the investigation on data types operating in government departments, it is concluded that there should be 5 main groups of data bases which are categorized as parcel or property based cadastral data base, municipal data base, utility and infrastructure data base, resource and environmental data base, and statistical data base. The integration of these data bases into an integrated LIS should be based on the nodal approach which has been operating in South Australia. This approach provides for the incremental development which is suitable for the technological and monetary situation of Thailand. The development within each primary node of the model will be the responsibility of agencies concerned. From this base line, the legal/fiscal primary node involved with parcel or property based cadastral data base which is in the charge of the Department of Lands will be investigated.

3 INVESTIGATION OF DOL's FUNCTIONS AND POSSIBLE STRATEGIES AND METHODOLOGIES IN IMPLEMENTATION OF LIS IN THE DOL

" I wish he would explain his explanation."

- *Lord Byron*

3.1 The DOL Activity Relating to LIS Implementation

The Department of Lands (DOL) has a major role in parcel-based systems in a future National LIS under the 6^{th} National Economic and Social Development Plan (NESDP) because the DOL is in charge of the basic information on land parcels, records of ownership, and current value of each parcel. The DOL, Ministry of Interior is a large decentralized organization which is responsible for land administration, land development, cadastral surveying and mapping, and land registration throughout Thailand. There are approximately 10,000 staff located in eight Bangkok land offices, 74 changwat (provincial) offices and 684 amphur (district) offices. The DOL not only administers the cadastre but carries out virtually all cadastral redefinition, adjudication and subdivision of non-forestry land in Thailand. There is currently no private cadastral survey in Thailand. Thus, the DOL tends to be a monopoly in this field. With the large organization and responsibilities, and being a monopoly, the DOL thus must be an efficient and effective tool for legal/fiscal cadastral administration, planning, decision making and development. The study of the DOL's function concerning LIS is:-

1) To define what are the important land data requirements (both within DOL and outside DOL), create and develop the data index and map index;

2) To investigate the LIS activity in the DOL-i.e., a pilot study of ownership card index etc.; and

3) To investigate the major programs in the Land Titling Project (LTP) which will be the basis for LIS development in DOL such as:-
   - adjudication and issuing the title deeds to all land ownersthroughout the country;
   - repair of damaged titles and security of records;
   - urban mapping programme;
   - individual massive valuation programme; and
   - automated mapping implementation.

3.2 Divisions within the DOL Involving DOL's LIS Development

3.2.1 Divisions within the DOL and their functions which relate to LIS activity are as follow.

1) Surveying and Mapping Division is responsible for densification of the control survey network throughout the country. The survey practices involve advanced technology such as Doppler positioning, EDM and the Global Positioning System (GPS) in the near future.
2) Mapping by Photogrammetry Division is responsible for the aerial triangulation adjustment , production of rectified photo maps. The maps will be used as a base map for adjudication and cadastral index map compilation, and land registration.
3) Urban Mapping Division is responsible for the compilation of cadastral index map of both urban and rural areas. The compiled cadastral index map is 50×50 cm^2 format in hard copy form. The scale of map may range from 1:250 to 1:4000.
4) Computation and Data Processing Division has carried out pilot studies of data register, owner's name reformatting, and will implement the automated mapping system soon.
5) Land Document Division has the duty to adjudicate and issue land documents to all legal land owners.
6) Land Registry Division investigates and collects the evidence on land, corrects and updates the changes in land registration.
7) Central Valuation Authority (CVA) is responsible for valuation of rateable land parcels, collects and supplies valuation to other agencies and the public.
8) Policy and Planning Division collects data for policy planning and department statistical data.
9) National Land Reform Committee collects data on land reform and land use.

The co-operation between these divisions is essential for DOL's LIS development because they generate basic data both textual and graphical through their activities.

3.2.2 Basic data which is the responsibility of DOL are:-

1) Land Parcel Identifier (PID)
2) Size and shape of land parcel
3) Owner's name
4) Owner's address
5) Land use
6) Type of land
7) Type of real property on land
8) Land value
9) Real property price
10) Legal dealing history of land parcel

The needs of DOL in LIS are mostly for parcel-related land information to support its functions in land registration, land valuation, and land allocation. The Land Titling Project (LTP) which is being undertaken in DOL, will generate basic land data to DOL's LIS. Its activities are to identify parcels, document land ownership, extend the survey control network, carry out a full coverage of cadastral mapping, and establish valuation records for all parcels. The improved data generated by the activity when combined with the already large amount of land data held by DOL, will need efficient management. From the DOL's internal needs, computerization could lead to more efficient data management. The establishment of computerized LIS will modernize existing systems and reduce the cost of operations since it provides fast access to information, reduces duplication of storage and improves maintenance of records, assists decision-making by making basic land administration and planning data available more efficiently. The management of land information in the DOL should be investigated with regards to its administrative structure, finance available, organization aspects, and personal available.

3.3 Administrative Arrangement for DOL's LIS Implementation

3.3.1 Structure of the DOL's LIS support group

This section will provide the general structure framework for the DOL. Departmental structure for implementing DOL's LIS should be based on an executive steering committee, implementation working team, and special interest groups or advisory team outside the main management set (Burrough 1986).

3.3.1.1 The executive steering committee must be headed by the Director General. The committee consists of the director of the divisions which are involved in LIS activity. The task of this committee is to propose DOL's LIS policy both organizational and at a national level, make decisions on LIS issues, and provide co-ordination between divisions. This will ensure that the LIS programme is supported continuously in terms of finance and required resource.

3.3.1.2 The implementation working team consists of a project manager, economist, accountant, survey engineer, computer engineer, technician, valuer, lawyer, and operator. All members work together, propose the LIS policy to the executive steering committee for decision-making and receive the accepted policy for application. This group is the core of LIS development. Therefore, skilled or trained personnel are required. The group should work independently from other divisions and have the ability to contact people within and outside the department. The main task is to do research in LIS and design the system for the department. The team members must have curiosity to learn and keep pace with the LIS and technology development both in the country and overseas. This will ensure that the LIS is developed continuously.

3.3.1.3 The advisory group consists of the researcher or lecturer in LIS area drawn from various professions involving in land-related information. The task of this group is to advise the executive steering committee and working group both in policy and technique. They may be a special interest group or experts employed by the department. As a result, the budget and resources can be allocated to support LIS development more logically, sufficiently, and continuously.

3.3.2 Finance available

Initial investment funding and continual financial support are major components in LIS project. In the situation that funding is limited to support well-defended and well-argued requests for a given LIS configuration, the proposed LIS must constitute clear objectives and be well-planned to serve the organization policy and benefit the needs of users. Planners should first attempt to define the requirements for the job as closely as possible. The planned LIS should not disturb the work flow in the organization and use the existing resources available as much as possible. Then it is in a state to consider possible hardware and software to meet these requirements within a broad budgetary framework.

3.3.3 Organizational aspects

A serious commitment to LIS implies a major impact on the whole of the department as conventional operations no longer need be done by hand if a computerized method is used. New staff and new organizational units need to be created. The LIS needs to be supported by staff to give technical support at least for the daily operation of the system, including local maintenance of hardware and software, data archiving and so on, due to the decentralized structure of the DOL. Other departmental aspects include reliable funding and proper legal and political support. Indeed, initially the computerized LIS solution will be more expensive than the conventional methods it has replaced, but in the long term the computerized LIS will provide cost recovery to the organization by economies of scale in the land information production. The skill in setting up computerized LIS is to choose a configuration that brings the greatest power and flexibility for the problem at hand for the minimum investment.

3.3.4 Personnel available

Computerized LIS involves complicated technology. It needs to be used and operated by trained or skilled staff. Staff need to be monitored because the new methods are quite contrary to previous manual methods. Two groups of staff in the organization can be categorized as:-

- Existing staff who have no skill in the new technology; and
- New graduate and employed staff who have gained some experience in the new technology.

The first group requires retraining by a short courses on the basics of the new technology, the concepts of LIS to enable them to operate the equipment. This group does not have to know how LIS works, but all they need to do is to maintain its operation, input the data and ensure that the products are satisfactory. The second group requires some period of time for them to learn the scope of work in the organization. The new staff have to work closely with experienced officers who are in charge of the organizational planning policy. Then the LIS is planned carefully to maximize the objective requirement of the organization and the national inventory. However, this second group often causes serious problems in government agencies at times of staff cut backs or with senior personnel. The conceptual conflict between the elder personnel and new graduate staff causes the delay in system implementation. Therefore, the conflicts between these two groups must be solved and well managed.

The highly skilled personnel falls into four groups - managerial, liaison, technical, and engineer. Good managers are necessary both for the daily running of the LIS and for the harmonious interaction between it and the rest of the organization. These people must have a good personality, good knowledge and experience about the work in the organization and outside, ability to propose the LIS concepts both in organization and at the national level, and good conceptual in decision-making. Liaison personnel are needed to establish and maintain contacts with users. Good laison personnel will find out the real needs of users. Therefore, the system configuration can be evaluated and designed to meet users' needs. Technical staff include cartographers, programmers, system developers, who know how the LIS works technically. They are necessary in the LIS operation both hardware and software, data input, data output, and data analysis. Engineers and scientific staff include LIS researchers and application developers who can solve the LIS problems both conceptual and technically and may develop new LIS methodology. If trained programmers are available, it might be cheaper and more effective to obtain a number of software libraries that can be used to build up the required packages without having to develop all the algorithms afresh.

3.4 Possible Functional Strategies and Methodologies of the DOL'LIS

As mentioned in the previous chapter, the DOL's LIS development will be focused on the legal/fiscal cadastre of the technical nodal function configuration. It should comprise a number of separate systems. Each has its own function: data input, data verification, etc. but be integrated to the extent that the systems are inter-dependent. The component systems of DOL's LIS should be:-

- Title System
- Valuation System
- Spatial System
- Land Tax System
- Sales History System
- Enquiry and Gateway System

The status of data bases contained in these systems will be classified into 2 main classes:-

a) Current or updated data base (current layers)

The data in this layer will be used for the daily management of land by the DOL, land office, and other agencies.

b) Sales history data base (historic layers)

The data stored in historic layer will be useful for analysis, planning, supporting decision-making, and research in government agencies and private enterprises.

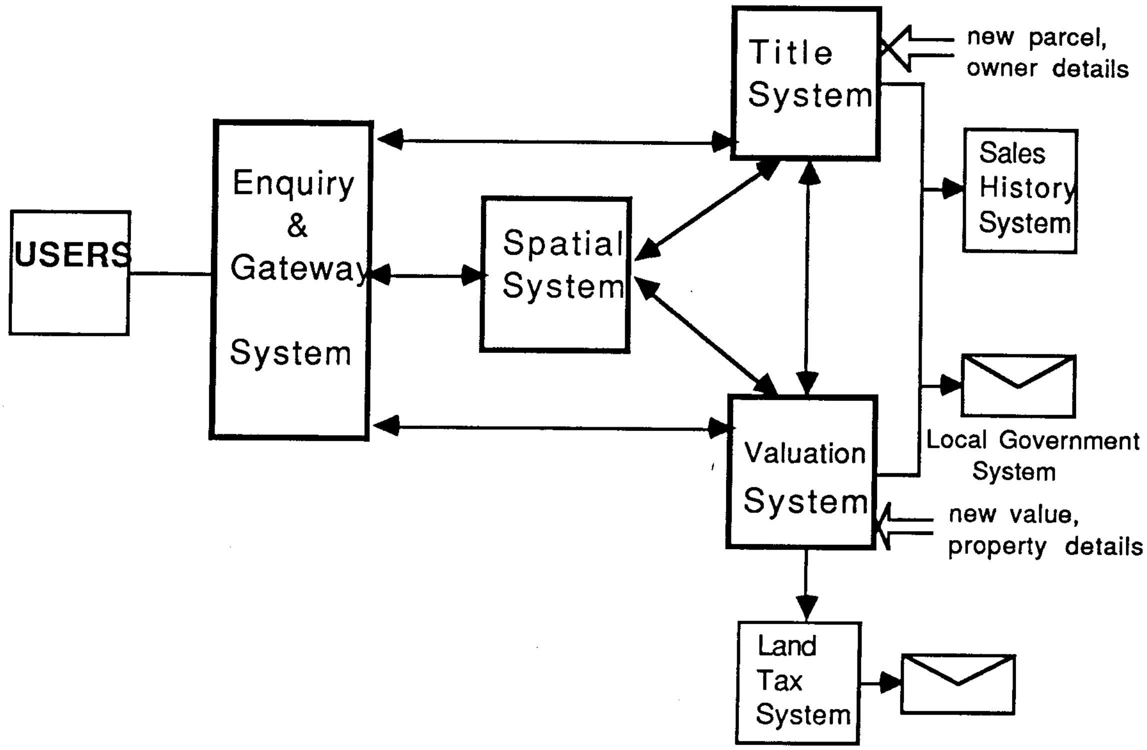


Figure 3.1 DOL's LIS Data Base and Interactions - Logical Relationship

This structure reflects logical groupings and relationships of data. The building of some of the systems can be started after the DOL administrative arrangements are in place. The functions of each system in figure 3.1 are as follows:-

3.4.1 Title System

This system should consist of a title file and ownership files. These two files contain the ownership, selected title information and other administrative data on all land parcels which is responsible by the DOL. The records include all tenure types: NS4, NS3K titles and cover all public lands. Before the existing records are computerized, the current ownership indexes held in provincial and district offices are essentially up-to-date. Then a parcel index which is a list of all recognized parcels in Thailand can be created to link all other records in any parcel-based LIS. A parcel index will contain the unique parcel numbers and other recognized coding systems. Data entry will be directly from the existing index cards by using available data base management system software. The streamlining of the data handling, alternative computing strategies to be pursued and data maintenance procedures have to be implemented. The rigorous checking of data is done by provincial offices and the spot checking of data is only done by central office staff if unsatisfactory data error levels are exceeded.

The system will cope with: changes of ownership of land; changes to title details; the creation of new land parcels; and the maintenance of current addresses on the ownership files by linking with the PIN system of MOI computer. Changes of ownership and mortgage transactions are automatically input to the system via EGS (Enquiry and Gateway System). Other transactions which emanate from various divisions of the DOL and other government authorities are input via terminals into the DOL's data bases. Files should be updated in batch mode each night.

The system then produces changes of ownership and new parcel reports which become the input to the valuation system. They then flow on to the Sales History System, Land Tax System, and Local Government Authorities. When required, the latter two systems automatically generate and post the necessary accounts (Sedunary 1984). In the longer term, the distribution of data entry and storage will be done in the regional locations.

3.4.2 Valuation System

The purpose of the system is to provide values for all rateable properties in the country and to supply valuation data to other government departments, the private sector and the general public. This system will comprise several files of valuation, property details and a street address index. Most of the information will be extracted from the valuation roll being constructed by the CVA and may be from other agencies, e.g. BMA. The valuation roll will contain attributes including parcel number, street address of the parcel, detailed land use and some measure of parcel value (Dept. of Lands 1985).

Update of the system is performed via transactions automatically generated from the Title System and manually keyed transactions from the CVA. As the files are updated, transactions are generated to the Title, Sales History, Land Tax and Local Government Systems. The computation of new property values for residential properties relies mainly on data stored on the Sales History System. Sales for an area are analysed to determine the need for revaluations.

The key attributes of this system will be street address, the parcel address captured by CVA, land use captured by CVA with a constant field checks. This valuation roll will use data contained in other systems of the DOL's LIS. The valuation mapping will be based on the maps contained in the spatial system. By computerizing and linking the valuation roll into the other systems, duplication of storage and updating would be lessened.

3.4.3 Spatial System

This system will be concerned mainly with collecting, storing and displaying the positions of land parcels contained in the cadastral map. The spatial information held in the system will also provide the link between elements held in other systems by using the same co-ordinate system such as UTM, and unique parcel identifier. At present, the spatial data base will be hard copy maps. A full coverage of up-to-date cadastral maps both urban and rural is necessary. Although the computer-assisted compilation of cadastral maps is being proposed in the DOL, the creation of a comprehensive Digital Cadastral Data Base (DCDB) is not required at this stage given the lack of experience of staff with such techniques ,e.g. the digital capture and plotting. Thus, the DCDB will be created when the objectives of developing digital cartographic data standards, training personnel, development of a computer-assisted mapping system, are in place. The DOL must undertake a pilot study in digital mapping to evaluate the value of a digital cadastral data base and gain some experience with the digital mapping. The implementation of this part of the LIS will give the DOL comprehensive map indexes to allow quick access to maps, especially when the DCDB is created. The parcel numbers on the maps will provide the link between the spatial information and the attribute data in other systems. In the future when a full DCDB is in place, it will ultimately be an essential element of a computerized LIS and a tool for many government agencies.

3.4.4 Sales History System

This system will consist of files of sets of data from Title and Valuation Systems. When there is a change of ownership, new subdivision, revaluation of property, the dated-time data will be input automatically to the Sales History System. It will be useful for data archiving, future planning, research etc.

3.4.5 Enquiry and Gateway System

LIS is concerned with the exchange of land information between organizations (public and private), and ultimately, the general public (Groom 1988). The effectiveness of this system will provide the means to achieve the above concept of LIS. The system will comprise the procedures and mechanisms for interaction of the DOL's LIS with systems in other RTG agencies. It will be made up of many individual procedures and computer programs to transfer data bilaterally, or general interfaces complying with standards set down by the inter-agency LIS co-ordination mechanism. The use of standards for data exchange are essential elements in developing this system. With the comprehensive information contained in the DOL's LIS, it will encourage other agencies to link their data directly into the system. Data flowing into the DOL's LIS may include personal statistics from the PIN system. Land data held in the DOL's LIS will flow out to agencies such as BMA, DOLA, DLD, etc. Management information derived from the LIS could also flow to the proposed MOI central computer system for use in Ministry policy and planning. During the implementation study, data flow both in and out will probably be handled manually initially. Coding sheets may be sent to DOL by other agencies for data entry while hard copy reports could be sent in answer to enquiries.

3.5 Major Subtasks to Computerize Parcel-based LIS of the DOL

The development of DOL's LIS into the computerized parcel-based LIS will require at least five subtasks. The logical relationship of these subtasks is shown in figure 3.2. The subtasks can be categorized as:-

1) Data capture and verification;
2) Data storage and data retrieval;
3) Data output and presentation;
4) Data transformation; and
5) Interaction with the user.

1) Data capture and verification

This task involves the operation of encoding the data and writing them to the data base (Burrough 1986). The DOL's data both in the form of land records and maps will be transformed into a compatible digital form. Data input to the DOL's data base would be in three types of:-

1.1 the textual, attributes data from land record, valuation, etc.;
1.2 the spatial data from the existing cadastral map and aerial photography; and
1.3 linkages between the spatial and attribute data in the form of look up table data index.

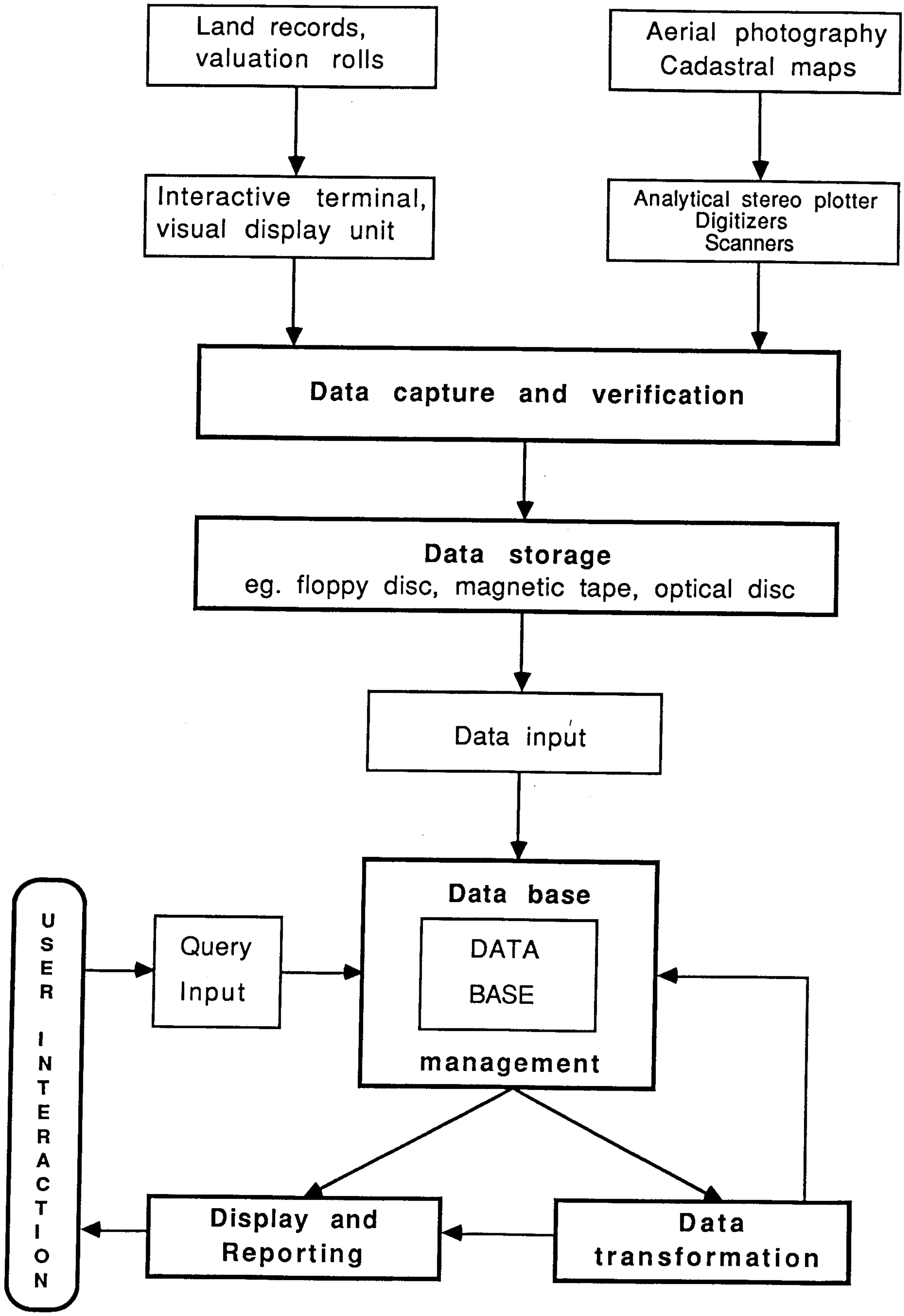


Figure 3.2 Logical Relationship of the DOL's LIS Development

The graphic and non-graphic data are stored in separate files which can be linked via various identification codes such as:-

a) cadastral parcel numbers
b) owner number
c) valuation number
d) postal address
e) code numbers of geographic, statistical, or administrative sections etc.

At the first stage, data entry would be done by the Computing and Data Processing Division in central office. When the local land office has both personnel and technology to do this, data entry will be performed locally. The master copy will be maintained in the land office and the central office will reserve the other copy.

Textual data is keyed-to-disk through interactive terminal or visual display unit (VDU) in the Computing and Data Processing Division. The devices for recording data already available would be on magnetic media such as disk, tape. Data entry can be managed by commercial data base management package such as ORACLE, DBASE III +. Since the software is used with English-liked characters it may not be suitable for data collection of Thai characters. Thus, it shoud be tailored by combining Thai word processing modules such as DJ, Rajvithi, etc. with application programs to manage the text file. This has been tested in this project with "DJ" module and program written in Fortran77 which will be presented in Chapter 8.

Spatial data in the form of existing maps and aerial photographic images are converted into digital form at an appropriate level of resolution by digitizer, analytical plotter, or scanner. The spatial data collection will be done by manual digitizing of existing cadastral map using XY table digitizers to input positional information and a keyboard/screen terminal to input commands and control information to obtain feedback from the system. With the advancement in software development, digitizing which is usually a task requiring little processing, can be done off-line using a microcomputer or personal computer for job control and data storage.

The digitizing workstation will be implemented during this year. There are initially 2 digitizer workstations implemented. Considering the number of maps to be digitized (about 10,115 map sheets for all urban areas), the system may not be sufficiently productive. Thus, the raster scanning method may replace it using a bureau service since the DOL does not have this facility.

The digitizing of existing maps will represent the transition from conventional to fully digital cartography of the DOL. Thus, the DOL must plan well and carry out a pilot study before it moves fully into the production stage. However, the digitizing of the existing maps may be the only economically acceptable means of DCDB creation but it may have some limitations. As Bullock (1984) noted:-

- digitization is only an approximation of the true digital image of the original survey plan documents. Unless all user requirements are met, time would see a number of digitized versions being created.
- digitization perpetuates all the existing errors in the manually produced sheets and contributes more of its own.
- recomputation of bearings and distances from digitized points would not bring back the values on the original survey plan.

However, the usefulness of the data base depends on the cleanness of the captured data. The data thus must pass the checking procedures and data verification before they are stored in the data base. The data verification can be done manually or by software to ensure that the resultant data base is as free as possible from error. The errors can be grouped as follow (Burrough 1986) :-

- textual data are incomplete;
- spatial data are incomplete or duplicated;
- spatial data are in the wrong place;
- spatial data are at the wrong scale;
- spatial data are distorted; and
- spatial data are linked to the wrong non-spatial data.

Before the data is keyed in or digitized, they have to be checked for content, accuracy, and reliability. After input to digital data base it should be verified again. Usually data editing is a time-consuming, interactive process that can take as long, or longer than the data input itself.

2) Data storage and data retrieval

In the decentralized administration environment of the DOL, the information will be saved in the local land office disk memory with back-up copies stored permanently in the central computer storage medium such as magnetic tape. To build a master digital data base, the local data base should be structured according to a standardized digital data base and also in a retrievable format before transmission of the data base to the central data base.

Since the cost of creating a digital data base is high and time-consuming, maintenance of the data base is most important. Digital data in all cases is stored invisibly on magnetic media such as magnetic disk or tape. Doubts are raised about the stability of the records and the best procedures for storing them. The DOL must lay down the procedure and practice of data back up and data storage to ensure that the digital data base is safely preserved. The procedure and practice for handling tapes varies greatly between organizations. For example, the back-up procedure issued by British Government Codes of Practice (Burrough 1986) involves keeping multiple copies of each plan or given tape; for data banking two copies of the tape are made. One of these tapes is then copied to produce a third, and these three first generation tapes are later supported by one still valid. After six months they are cleaned and rewound; after twelve months they are copied to produce a fresh data bank tape. However, a proper environment in both the computer and storage area for maintaining disk or tape quality is also important. The back-up systems should ensure that the operating environment is kept scrupulously clean, and storage conditions operate to prevent damage from fungus, dirt, and fire, the data base should be well maintained.

Data base management is used to manipulate a requested specific product. The data contained in the master data base (or local data base) within the specific area of interest is extracted and is used as input to the digital manipulation process. This function requires several user dependent operations (Allam 1982), and includes:-

- selection of specific feature types;
- display of land information;
- data editing and enhancement;
- data compression; and
- data updating.

3) Data output and presentation

This operation involves the presentation of the processed data in a form that is understandable to a user or a compatible form to another computer system. The output may be in form of tables, graphics, maps on VDUs or hard copies. It may be output into tape or disk that can be read into another system or some form of electronic data transmission over data communication networks. The capability of data output should include (Burrough 1986) :-

- zooming/windowing to select area for output
- scale change
- color change
- modification to text and line fonts, colors, dimensions, etc.
- selection of data using layers or overlays
- plotter commands (special plotter formats)
- dump commands to output data on magnetic media
- printing commands for text file output.

4) Data transformation

This function has the capability to merge a variety of map segments differing in size, scale, and map projections into a single continuous map of the desired area. The net result is an integrated digital mapping which incorporates information captured from different cartographic sources. Thus, maps can be extracted in a variety of commonly used projections.

5) Interaction with the user

This part is an essential component of the DOL's LIS for the acceptance and use of the information system. It involves query inputs by commands chosen from a menu (a list), or that are initiated by a response to requests in an English-like command language of verbs, nouns, and modifiers. The menu-driven operation is the simplest method for easy commmand selection. The command names are displayed on the terminal so that the user may make a choice between entering commands on the keyboard, a mouse or digitizing tablet. The program menus may be hierarchically nested so that a command sequence can be built up to allow many possible permutations. For example, options can be chosen from a main menu:-

1 MAP IDENTIFIER
2 PARCEL DETAIL
3 OWNER DETAIL
4 EXIT

Selecting item 2 from this menu, the computer could ask for user interaction by entering the parcel identification. Then the second menu shows the option for map scale selection:-

1 1 : 250
2 1 : 500
3 1 : 1000
4 1 : 2000
5 1 : 4000

Choosing item 3 might result in a menu with the following choices of parcel detail written in:-

1 THAI
2 ENGLISH

Choosing 1 would mean that user wants to know the detail of his land parcel in the Thai language presentation.

Highly skilled users of systems in which a very large range of options existed are better served by a command language interpreter or CLI (Burrough 1986). The commands can be written in high level language with strict rules of grammar and syntax. A command language consists of three components: verbs, nouns, and modifiers. The verbs refer to actions that the system must perform, such as INPUT, MOVE, ROTATE, DELETE or CHANGE. The nouns refer to the kinds of data base elements that are being acted upon, such as POINT, LINE, CIRCLE, TEXT. The modifiers are used to complement the action of the verb on the noun. The example set of commands could be entered as:-

INPUT	LINE	VERTICALLY:
verb	noun	modifier

The : tells the computer to stop accepting characters from the keyboard. The command language interpreter is much more powerful than the simple menu. It allows a user to write programs into a file that consist of a series of commands which are often called a "MACRO" or a "BATCH" file. MACRO programs can be translated into machine mode to provide "supercommands". These facilities help the user in developing specialized application software without having to write out the basic subroutines for manipulating the land data.

Thus, proper and easy interaction between user and DOL's LIS requires a well-designed menu system, a CLI, or both. Development of DOL's LIS must be user friendly as much as possible.

3.6 Comments

In summary, the expense of DOL's LIS is not only the cost of the hardware, software, and trained personnel but also the costs of data collection and data processing. It is the main purpose of the LIS that the collection and processing of land related data leads to improvements in land management and control. This can be achieved if the data that are collected, entered, stored, and processed are sufficiently reliable and error-free for the purposes for which they are required. "Error free" does not mean only the absence of factually wrong data caused by faulty survey or input of out-of-date data, but also absence of statistical errors, i.e., free from variation. The data in the study area must be perfect and completely deterministic documents with uniform level of data quality. Good data quality and as near as possible error-free will help reduce the overhead cost in the whole system.

The next two chapters will investigate the procedures in data production, data acquisition, and preparation of the suitable form of data entry for implementation of a computerized LIS. Chapter 4 will be concerned with the urban mapping functions in the DOL which will generate the basic data in the Spatial and Title Systems as mentioned in section 3.4. Chapter 5 will be involved with the individual massive valuation study which will be the framework for computerized Valuation System in the DOL's LIS.

4 URBAN MAPPING FUNCTION IN THE DOL : A SPATIAL REFERENCE FRAMEWORK FOR THE DOL's PARCEL-BASED LIS DEVELOPMENT

" Indeed, I would urgently warn against demanding extreme accuracy in cadastral surveys. This has in some cases, resulted in having no cadastral maps at all."

- F. Ackermann, 1974

4.1 The Need for a Large Scale Urban Cadastral Map

Urban mapping plays a significant role in the land surveying, registration and land administration goals of the DOL. At present, a lack of up-to-date, reliable, good quality urban cadastral maps has created problems for DOL land administration in its own and other government departments and local authorities that are involved in land management, planning and provision of services. As a result many government agencies have endeavoured to produce urban maps by using available resources to satisfy their specific needs. A general conclusion is that the existing base maps are created in response to a specific project. Each department responds to their own internal needs for additional detailed information and subsequently creates enough data to satisfy the decision makers involved in a particular project. This approach leads to duplication of effort in base map production and more importantly, to the creation of a series of base maps that lack standards or a common geographic referencing point. However, because each map user has different accuracy needs, map symbology, and different levels of detail, the establishment of a mechanism of standardization and specifications for map production is a primary requirements. The issue of specifications and standards should be addressed from a global perspective of all users rather than departmentally. The additional issue is that there should be efficient data communication between departments in relation to exchanging newly created and updated spatial information data bases. This will lead to achieving the major goal of LIS implementation, to reduce the duplication of effort in map making and increase co-ordination between the agencies involved.

4.2 Cadastral Map in General

4.2.1 Two types of cadastral map

A cadastral map shows the relative location of land parcels in an area including parcel boundaries, parcel identifiers, street names, public place names, a distinction between public and private lands, and other parcel information. A cadastral map can be broadly categorised into 2 types according to its characteristic and legal status - a cadastral survey map and a cadastral index map.

A cadastral map which is generally compiled from field survey, has some legal status as regards boundary and ownership details shown on the map. It also serves as an index map, showing the relative locations of all parcels in the area. In contrast, a cadastral index map (CIM) usually compiled over a base map at an appropriate scale to clearly show all parcels, but the information is not accorded legal status. Its primary function is to serve as a graphic index to all parcels to enable rapid entry into the land registration and administration records (Smith and Holstein 1987). The information shown on the CIM should be correct, but the boundary lines are not necessarily plotted to usual map accuracy standards because it is only a representation of relative position and shape rather than absolute position on the earth's surface.

4.2.2 Trends of cadastral map requirement

Smith and Holstein (1987) has mentioned the trends in cadastral mapping techniques which are widely adopted as follows:-

- adoption of the Cadastral Index Map (CIM) concept rather than the stricter cadastral map approach;
- inclusion of all land parcels regardless of tenure type, land document type or ownership status (public or private); boundaries; parcel identifiers, road and public place names on the maps;
- optimization and simplification of the information on the CIM such as exclusion of survey data, monuments and numbers, buildings, title references, and owners' names on maps;
- map cross-reference indexes linking parcel number, adjudication number and parcel area;
- adoption of common and simplified parcel identifiers; and
- relating cadastral maps to the national topographic map series via the national co-ordinate reference system, compatible map scales and sheet formats.

The DOL tends to adopt the CIM technique for urban mapping because it is a simplified, cost/effective approach. The accuracy of map is acceptable for a land registration index and it is a multi-purpose map. The compiled CIM is related to the national rectangular co-ordinate framework (UTM), compatible formats, and scales.

4.2.3 The urban mapping activity in the DOL

The DOL needs the cadastral map for its land registration index and also as a base plan containing survey information for parcel boundaries but the cadastral maps are in a poor state because a high proportion of cadastral maps in urban areas are out-of-date, incomplete, cluttered with detail, damage or at too small a scale to be useful as shown in figures 4.1 and 4.2. This has decreased the efficiency of the DOL's land-related responsibilities. The DOL by approval of the cabinet has set up the Urban Mapping Division in 1986 with its main responsibility to produce an accurate and complete urban cadastral map at an appropriate scale for DOL land administration purpose, for CVA valuation purposes and for planning by other government agencies, regional bodies and local authorities. The study of the urban mapping function will contribute to the DOL's LIS development because up-to-date cadastral maps with unique parcel identifiers for each parcel of land will be used to link parcels with other attribute files. The integration of the spatial and attribute data with some processing will form the parcel-based land information.

The main tasks of the urban mapping programme are to compile the cadastral map over the urban areas. The accuracy of compilation, scale of map, standard format, and availability on demand are major factors which will convince another agencies involving in land management to co-operate and use the cadastral map of the DOL as a land ownership layer. The integration of mapping and land information activities into a common reference system will encourage the long term development of an urban land information system. At the first stage it is necessary to investigate the overall map scale requirement of concerned agencies.

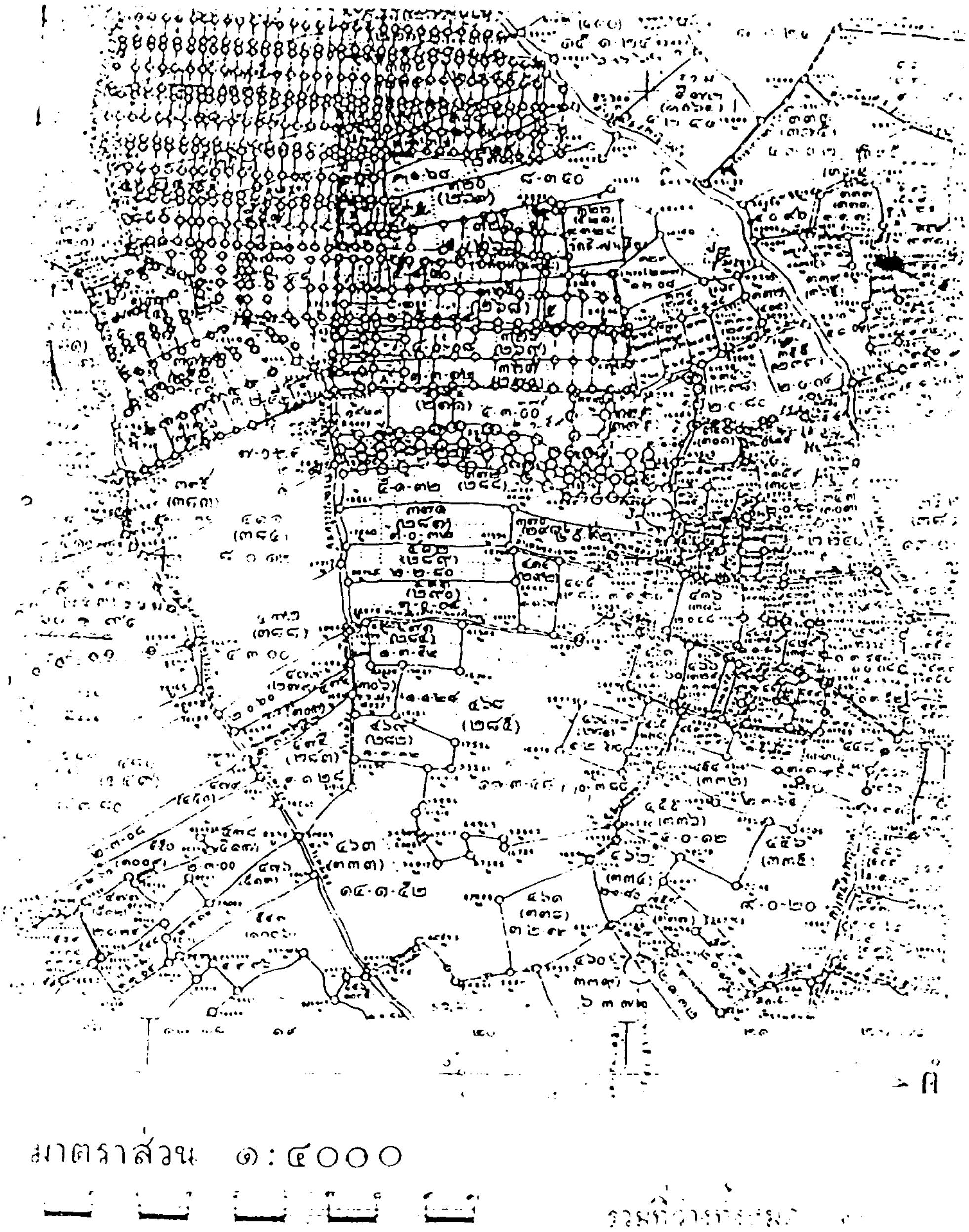


Figure 4.1 An Example of DOL Old Cadastral Map
for NS4 Scale 1:4000

Figure 4.2 DOL Old Cadastral Map for NS4 Scale 1:4000 in a Dilapidated Condition

4.3 Survey of Predominant Map Scale Requirements

The required map scale depends on a graphical presentation in which each detail is clearly depicted by a symbol. Blachut et al (1979) have classified map scales into 3 broad categories.

1. Large-scale maps or plans provide for the main features, such as streets, land parcel, buildings, to be plotted according to their dimensions. The term is applicable to scales of 1:5000, 1:2000, 1:1000, and up.
2. Medium-scale maps are at a relatively large scale in which planimetric details are generalized or presented by symbols. Typical scales in this class range from 1:7500 to 1:15 000.
3. Small-scale maps belong to the topographical maps category which range from 1:20 000 scale and smaller.

This classification of the map scale will be a framework for the in vestigation of the map scale used in Thailand.

In Thailand, there is a range of large-scale mapping products. The North West-Stewart Weir Group, Canada have undertaken a feasibility study of the Urban Land Information for the Bangkok Metropolitan Administration (BMA). The data inventory undertaken by the group provides information on the types and scales of base maps being used by different departments and gives an opportunity to evaluate the level of co-operation and information exchange between agencies. The data inventory was conducted by intensive interviews with key individuals from both central government and local state government. The observation shows the existing base scale of map and photography required by concerned agencies in response to a specific project and their own internal needs as illustrated in tables 4.1 and 4.2.

The investigations showed that urban information users are primarily concerned with large scale mapping (1:200 to 1:5000) whereas resource oriented information users have a more diverse range of base map requirements ranging from 1:10,000 to 1:250,000. The investigation also showed that the 1:50,000 series

Ministry	Department	1:200	1:250	1:500	1:1000	1:2000	1:3960	1:4000	1:5000	1:8000	1:10,000	1:12,500	1:15,000	1:20,000	1:25,000	1:50,000	1:100,000	1:250,000	1:500,000	1:1,000,000	1:1,250,000	1:2,500,000	LANDSAT 1:1000,000 enlarged to 250,000	Photos 1:6000	Photos 1:15,000	Photos 1:30,000	Photogrammetric Capability
Office of the Prime Minister	N.E.S.D.B.																										
	National Satistics Office					●					●				●	●		●									
Defense	Royal Thai Survey											●		●	●	●								●	●	●	●
Agriculture & Cooperatives	Royal Irrigation							●			●					●									●		●
	Royal Forest															●						●	●				
	Land Development								●		●					●	●	●		●					●		●
	Office of Agr'tre Land Reform	●			●											●		●			●						
Communications	Dept. of Highways				●											●				●							
Interior	Local Admin.				●																						
	Police Dept.			●	●				●							●											
	Dept. of Lands			●	●	●	●	●	●												●	●			●		●
	Town & Country Planning					●		●								●									●		●
	Expressway & Rapid Transit Auth'ty															●								●			
	Metro. Water Work Authority		●		●			●																			
	Metro. Electrical Authority				●			●																			

Table 4.1 Summary of Base Scales (Maps and Photographs) Central Government Overview (Stewart & Weir 1985)

BANGKOK METROPOLITAN ADMINISTRATION
SUMMARY OF BASE SCALES (MAPS & PHOTOGRAPHS)

Department	Division	1:200	1:500	1:1000	1:2000	1:4000	1:5000	1:8000	1:10,000	1:15,000	1:20,000	1:25,000	1:50,000
Permanent Secretary	City Planning			●	●	●	●						
Public Works	Design	●		●							●	●	●
	R.O.W. and Land Acquisition	●		●									
	Building Permit			●									
Severage & Drainage				●		●		●					

Table 4.2 Summary of Base Scales (Maps and Photographs)
Bangkok Metropolitan Administration
(Stewart & Weir 1985)

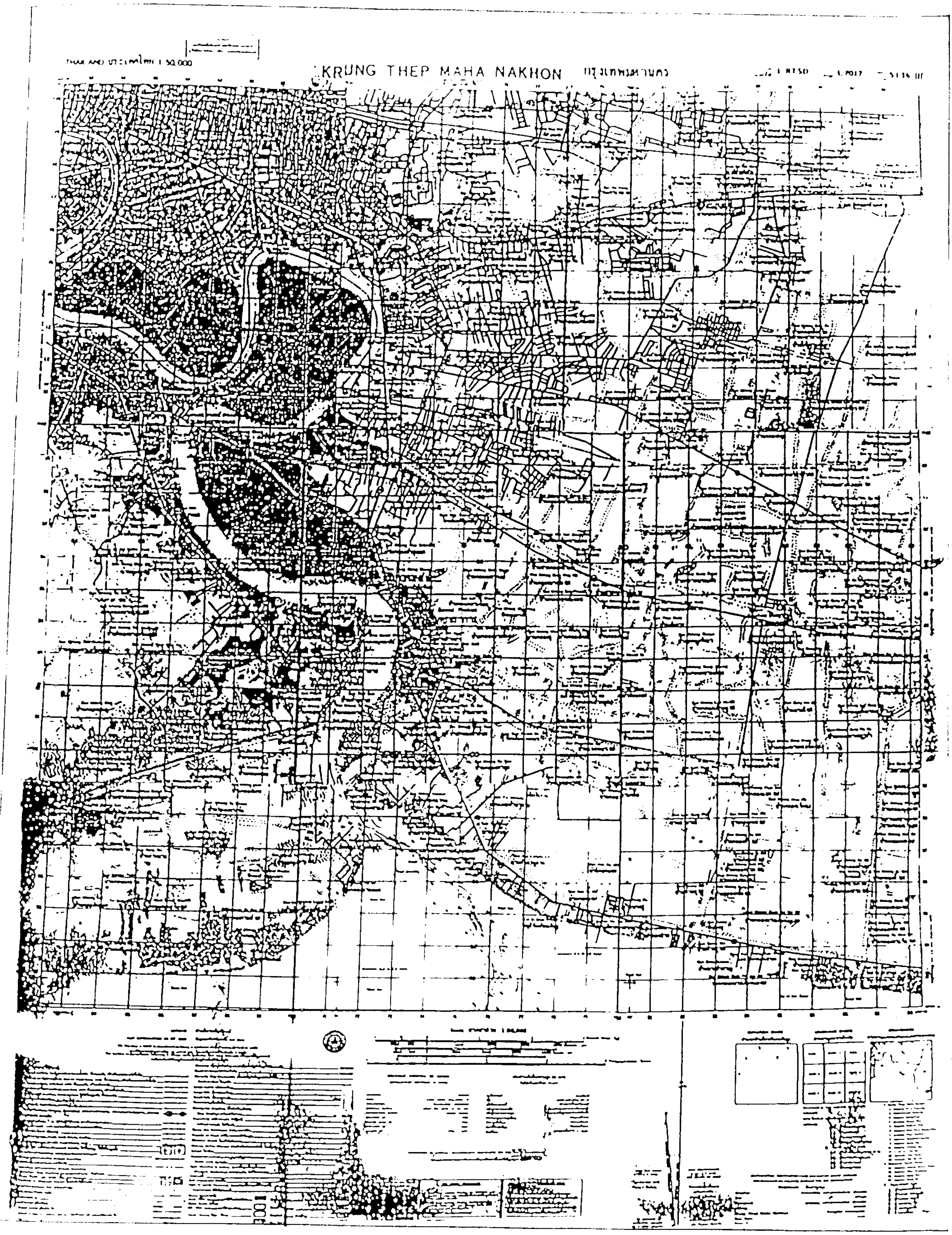


Figure 4.3 National Topographic Map Produced by RTSD
Map Series L7017 Scale 1:50 000 Format 15' × 15'
Map Sheet No. 5136 III Bangkok Area

base map known as the National Topographic Series created by the Royal Thai Survey Department (RTSD, Ministry of Defence) is used extensively by most agencies. The map series are used as a general spatial reference base for many proposed projects. This would suggest that the existing 1:50,000 topographic map essentially meets the needs of the land information community. Figure 4.3 shows a topographic map of Bangkok area at scale 1:50,000 produced by the Royal Thai Survey Department, Ministry of Defence.

MAP SCALES OBSERVED

MAP SCALES	FREQUENCY OF USE	PERCENTAGE OF TOTAL
1:200	3	34.76
1:250	1	1.59
1:500	1	1.59
1:1000	12	19.05
1:2000	4	6.36
1:3960	1	1.59
1:4000	7	11.12
1:5000	3	4.76
1:8000	1	1.59
1:10 000	3	4.76
1:12 500	1	1.59
1:20 000	2	3.17
1:25 000	3	4.76
1:50 000	10	15.87
1:100 000	2	3.17
1:250 000	3	4.76
1:1 000 000	2	3.17
1:1 250 000	2	3.17
1:2 500 000	2	3.17
19 scales	63	100.00

Table 4.3 Frequency of the Observed Map Scales
Source: (Stewart Weir & Co. 1985)

Table 4.3 gives the frequency of the map scales being used. From the table, it tends to suggest that three map scales are at present the most significant for land information users in Thailand. This can be summarized as follows:-

a) the 1:1000 base map is used by 19% of the users interviewed.
b) the 1:4000 cadastral map series is used by 11.12% of users.
c) the 1:50,000 base map is used by 16% of users.

When compared to the other existing base maps created within the government agencies together with the topographic maps at 1:250,000 scale number, there are four predominant map scales used in Thailand as shown in table 4.4.

Map Scale	% of Users
1:1000	19.0
1:4000	11.2
1:50 000	16.0
1:250 000	4.76

Table 4.4 Summary of Predominant Map Scales Used in Thailand

The map scales in table 4.3 might be grouped according to the function of the map as follows:-

Map scale	**Map Type**
1:200 - 1:1000	land reform, city public work, utility, sanitary, urban cadastral, police, city planning, administrative
1:2000 - 1:5000	utility, sanitary, irrigation, rural cadastral, police, project planning, statistic
1:8000 - 1:12500	topographic, land use, thematic
1:20000 - 1:25000	topographic, public works
1:50000 - 1:100000	topographic, provincial land use
1:250000 - 1:2500000	general purposes, road, soil, land use in reserved forest, statistic

It should be noted that the importance of a map cannot be judged solely by the number of users. The map scale 1:250,000 has a comparatively low value compared to the other map scales, but it is an important component in resource management of a land information system. Which scales the land information community should have is directly related to the types of activities that are being undertaken within the decision making process. The scale of the cadastral map is usually a function of the size of the predominant land parcel which corresponds to the level of land value or degree of urbanization. However, the large scale maps 1:1000 and 1:4000 are the major requirements of many agencies. These maps are used extensively in their daily operations.

4.4 The Background of the Base Maps

4.4.1 Base map at scale 1:1000

Urban land information users have been utilizing the 1:1000 base map extensively in their daily operations. The history behind the creation of this map base dates back to 1958. At this time the Police Department, Ministry of Interior, recognized that a large scale map was required to assist in analyzing crime patterns and for traffic control. Then, the International Co-operation Administration, U.S.A. in co-operation with the RTSD undertook the aerial photography (at an original photo scale 1:15,000) over the Bangkok and Thon Buri (Stewart & Weir 1985). Mosaics at a scale 1:4000 were prepared using ground survey for control and slotted template methods.

These mosaics were manually enlarged to produce the existing 1:1000 line maps of Bangkok. There are 371 urban maps of the city which are continually updated by the Police Department. Changes to the map base is a daily activity involving a physical reconnaisance of the city to identify changing patterns in the urban infrastructure. Tape measurements from street curb lines to the corners of new buildings are measured and recorded onto the existing 1:1000 base. Figure 4.4 shows the Police line map 1:1000 scale in Bangkok area.

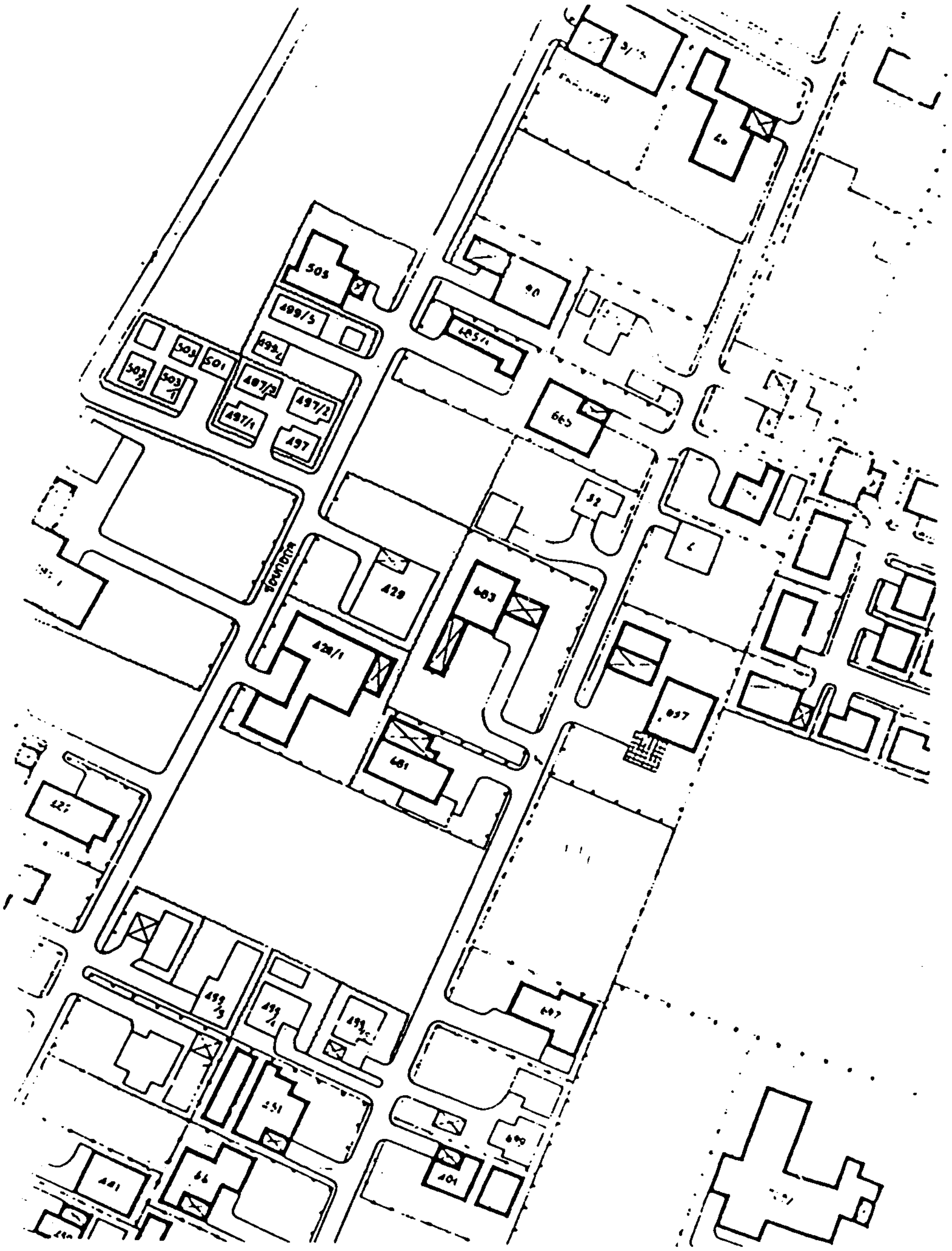


Figure 4.4 Police Department Line Map Scale 1:1000
Khet Phra Khanong, Bangkok

4.4.2 Base map at scale 1:4000

An important factor of mapping program at scale 1:4000 relates to the unit of land measurement used in Thailand. Length and area units in Thailand are as follows:-

	Thai Unit			Metric Unit	
Length	1	sen	=	40	metres
Area	1	rai	=	1600	m^2
	(4	ngan	=	1	rai)
	(100	wa^2	=	1	ngan)
at the scale 1:4000	1	sen	=	1	cm
	1	rai	=	1	cm^2

The DOL is the predominant user of this map scale for mapping cadastral parcel manuscripts since 1903.

4.4.3 The DOL's base scale cadastral map requirement

The DOL needs cadastral map scales ranging from 1:250 to 1:4000 which are compiled relative to the national topographic map scale 1:50000. In dense urban areas the cadastral map is compiled at scale 1:1000 and 1:500. For rural areas the map is at scale 1:4000. The Urban Mapping Division which is responsible for cadastral map compilation is expected to produce 10,000 photomaps and cadastral maps within 12 years (Department of Lands 1985). The number of urban cadastral maps are classified according to the areas as follows:-

	Area	Number of Maps
1	Bangkok Metropolitan area	4755
2	Main provincial cities (RCDP)	968
3	Main municipalities	3160
4	Main sanitary districts	1232
	Total mapping programme	10,115

Figure 4.5 Amount of New Urban Cadastral Maps Requirement of the DOL

4.5 Methods of Cadastral Map Compilation

There are two main methods for the cadastral map compilation process. They are the "cadastral base map option" and the "planimetric base and cadastral overlay option".

4.5.1 Cadastral base map method

This method demands a major breakdown of survey control to the suburban block level. Ground surveys are undertaken to connect the cadastral framework into the national co-ordinate system. The cadastral information collected from cadastral surveys becomes the actual base map. This method is very labour intensive, time consuming, and single purpose mapping. In terms of cost/effectiveness, this method is not satisfactory.

4.5.2 Planimetric base and cadastral overlay option

This method involves the production of a topographic base map over the area under survey and the subsequent compilation of a cadastral framework map as an overlay to this base map. The function of the base map is to be a medium for the location of land parcels on the overlay relative to the geodetic reference framework. The base map is more usually produced by photogrammetric means rather than terrestrial survey methods. The photogrammetric approaches may be the production of a line map, a rectified photomap, or an orthophotomap. The cadastral overlay is usually compiled over the base map as far as scale and position are concerned with other information (existing survey plans and title deed diagrams) being used as necessary. The function of the cadastral overlay is to represent positions of property boundaries in relation to the other features shown on the base map and to show the standard identifier of each parcel. This identifier will serve as the key to link with many other parcel ownership and valuation records. Thus, the planimetric base and cadastral overlay method allows the base map to be used for the compilation of other overlays showing other theme information each on its own map sheet. Each component can be up-dated separately and can be computerized separately in the future.

This method is a flexible approach and can be very cost/effective. It allows the base to be used for many purposes by various agencies given that the choice, accuracy, and the production capacity of the base map are agreed upon by all users. This will be part of a total multi-purpose system - a land information system. This approach is chosen for urban map compilation in the DOL because of the following reasons:-

- The method allows the task to be undertaken in a shorter period using less staff and for less cost than the "cadastral base map" method.
- It is cost/effective especially when photomaps are used as the base map.
- The approach is similar to the methods used for the NS4 second class and NS3K cadastral programs.
- The technology is available and familiar to the staff of the DOL.
- It is a systems approach allowing other agencies to use the base maps for their own map compilation process.

4.5.3 Choice for base map production

The costs of choosing line maps (graphical or digital) or photomaps as the base map are estimated to be:-

rectified photomap	100	cost units
orthophoto map	800	cost units
line map	2300	cost units

Figure 4.6 Estimated Comparative Cost of Base Map Production
Source: (Smith and Holstein 1987)

In terms of completeness of detail, speed of map production, ease of map revision, and low unit cost of production, the rectified photomap method has been chosen as a base map. Rectified photomap methods achieve the technical requirements due to the following reasons:-

- Relatively flat terrain of Thailand, especially in central region and Bangkok;
- Reasonable accuracy, scale and control for CIM production;
- Equipment costs, reliability and maintenance;
- Staff training and familiarity with rectified photomap methods and products; and
- Multi-purpose base map and suitability for LIS development.

Since the compilation of cadastral maps by "planimetric base and cadastral overlay approach" requires the base map, the method of providing for the positioning of the components is to establish a First Order Geodetic Base, densify to Second Order Accuracy and infill to Third Order Specifications. This geodetic reference frame work will then form the spatial foundation for the cadastral overlay compilation. The compilation procedure for urban map are as follows.

4.6 Procedures

The compilation of urban cadastral map involves 5 stages.

1. The survey of ground control for aerial triangulation and photomap production;
2. The production of photomaps from rectified aerial photography at scales of either 1:1000 or 1:2000;
3. The compilation of cadastral index maps (CIM) showing all parcels including state land, produced as overlays to the photomaps;
4. The cyclic revision (replacement) of the photomaps produced in stage 1 with a newly produced map based on newly flown aerial photography on a 7-10 years basis; and
5. The continuous updating of the CIM in the appropriate land offices by incorporating the latest subdivisions, consolidations and boundary changes.

Following the cadastral compilation there is an ongoing, essential need to update the cadastral maps on a continuous basis to reflect changes in land boundaries, subdivisions and urban development. There is a need for cyclic revision of photomaps from new, up-to-date photography.

4.6.1 Stage 1 Survey Control

First Order Geodetic Survey Networks

The first order geodetic network in Thailand is the responsibility of the Royal Thai Survey Department (RTSD), Ministry of Defence. The geodetic co-ordinate system is based on the Everest ellipsoid with two parameters namely:-

semi-major axis (a)	=	6377276.345	metres; and
reciprocal flattening (1/f)	=	300.8017	

The computation base of the Everest ellipsoid has been fixed to the Earth by the Indian Datum with its origin at Kalianpur in Central India. The original Indian Datum (1916) has subsequently been adjusted in 1954 and lastly in 1975. The existing First Order Control Network in Thailand as shown in figure 4.7 consists of:

7	baselines;
363	triangulation stations;
216	traverse stations;
50	Laplace stations; and
64	Doppler stations.

The DOL has the responsibility for establishing secondary survey control networks. The controls are later used for cadastral surveying and mapping. The co-ordinates are computed in UTM (former co-ordinates were based on 29 independent origins) to conform with the National Topographic Map co-ordinates. Thailand is covered by parts of the two UTM zones-i.e., 47 and 48.

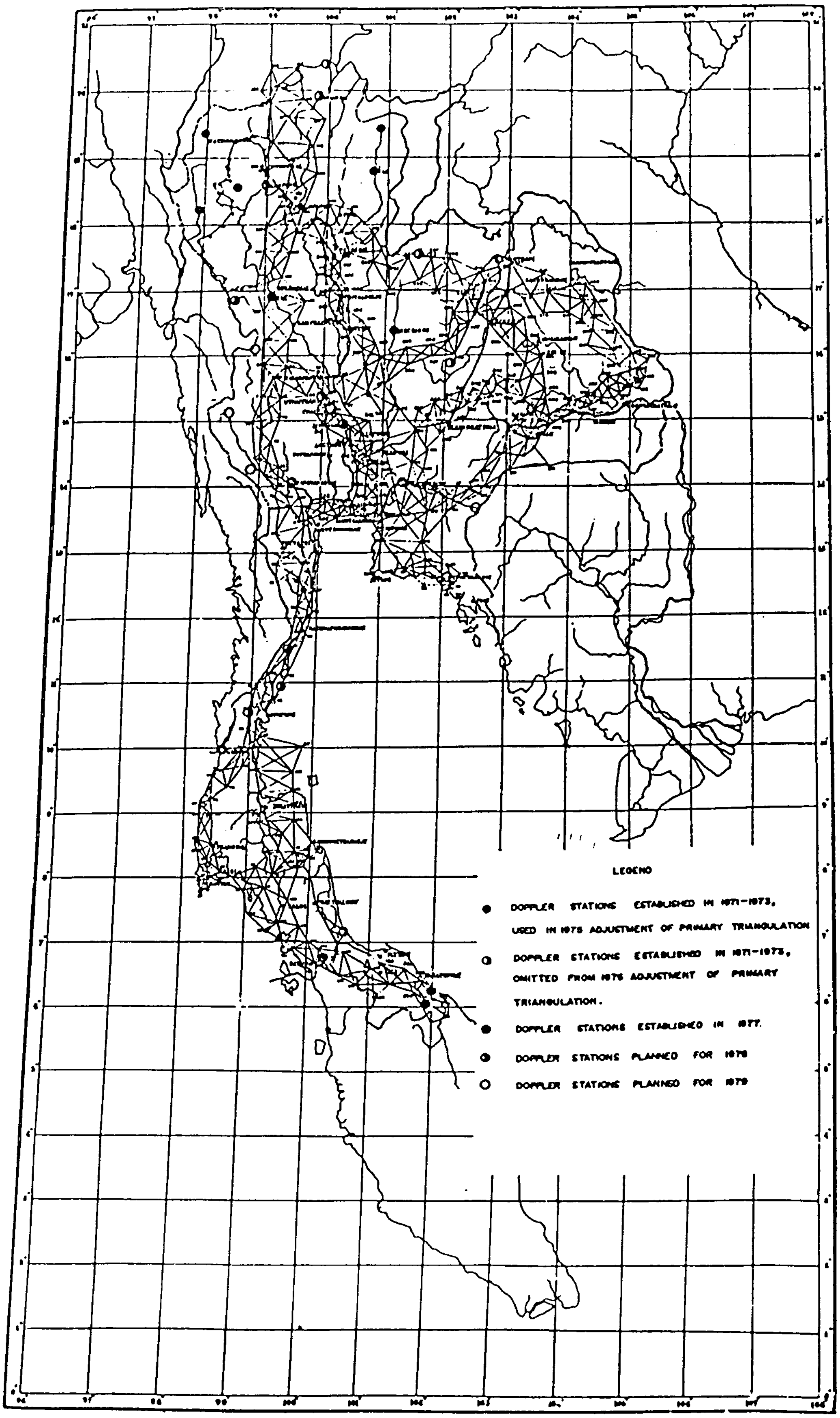


Figure 4.7 The Existing First Order Control Network in Thailand
Royal Thai Survey Department, Ministry of Defence

In the Bangkok and Thon Buri areas, geodetic control networks have been established by the Department of Surveying Engineering, Chulalongkorn University under contract with the DOL. The networks are based on 7 RTSD geodetic stations (1975 adjustment) and contain a total of 547 stations (Department of Lands 1985). The network of control stations over this area is adjusted simultaneously to propagate the positional error uniforming over the control network. Table 4.5 shows the Geographic and UTM control co-ordinates of 7 RTSD geodetic stations which are used in Chula Traversing. This table is presented to prove that the DOL's control network is tied to the National Geodetic Control Network of RTSD. Thus, other agencies will be encouraged to use the DOL's traverse stations for their surveying purposes. This will help reduce the duplication of effort in creating the new control stations.

Geodetic Survey Control UTM To Geographic Co-ordinates Used for Chulalongkorn Traverse							
Stations (Id)		Indian Datum 1975					
RTSD	Chula	Northing (m)	Easting (m)	Latitude	Longitude	Converg	Scale fac
247	A	1520708.675	663230.835	13°45'07".819	100°30'35".900	0.21325	0.999929
49	Q	1524276.528	656368.091	13°47'05".302	100°26'48".124	0.20412	0.999902
245	B.PING	1503365.570	639257.062	13°35'47".893	100°17'14".614	0.18097	0.999840
246	OMN 01	1514975.135	640606.761	13°42'05".509	100°18'01".594	0.18291	0.999882
328	P	1525755.618	651058.009	13°47'54".461	100°23'51".586	0.20003	0.999882
329	R	1518011.729	659762.181	13°43'40".750	100°28'39".864	0.21027	0.999915

Table 4.5 RTSD Geodetic Stations used for Chula Traverse in Bangkok
Source : (Stewart & Weir , Co. 1985)

In other provinces outside Bangkok and Thon Buri the control networks are done by the DOL's surveyors of the Control Survey Subdivision, Surveying and Mapping Division. The RTSD controls are densified by Doppler Positioning and by GPS in the near future. The control networks are established by traversing using one second theodolite and EDM equipments with the astronomical observation control of the direction.

4.6.2 Stage 2 Photomapping Procedure

This stage involves 3 main processes which are:-

- Aerial photography;
- Aerial Triangulation; and
- Production of rectified photomaps.

4.6.2.1 Aerial photography

The key aspects (Smith and Holstein 1987) are:-

- Normal angle (305 mm focal length) high resolution photography together with 80% forward overlap to maximise photomap image quality and to minimise the building "lean-over" effects that are particulary significant in Bangkok with its extensive but scattered, high rise buildings;
- Low-level photography for photomapping (scale 1:6000 to 1:10000);
- High level photography for the photomapping control (aerial triangulation ; scale 1:22 000); and
- Exposure specifications to optimize imagery (including the option of photography under full high level cloud cover to eliminate problems of loss of detail and adverse image effects from shadows).

4.6.2.2 Aerial triangulation

The key aspects of aerial triangulation are:-

- High level aerial photography to reduce the cost and maximize the efficiency of providing control for photomapping (rectification);
- Independent model aerial triangulation observations on Wild BC2 analytical plotters;
- Zoom transfer point equipment for aerial triangulation and control transfers from the high to low level photography;
- Pre-targeting perimeter control where possible;
- Independent model triangulation adjustment (PAT M4-3); and
- Application of techniques to improve error detection and reliability.

4.6.2.3 Production of rectified photomap

A selection of the optimum photomapping procedure depends on the nature and density of the urban area, building heights and also other production factors. Options range from standard photomapping methods that can readily provide an acceptable quality product through to innovative methods, involving the production of four photomaps from one aerial photo, which require more stringent quality controls to achieve the required result but which offer the potential of significant saving in map production.

	1:6000 Photograph 1 Photomap/Photo	1:10 000 Photograph 1 Photomap/Photo	1:10 000 Photograph 4 Photomaps/Photo
Camera(Principal Distance)	305 mm	305 mm	305 mm
Forward Overlap	90%	90%	90%
Side Overlap	60%	80%	60%
Rectification/Photomap production	One stage	Two stages	Two stages
Image Quality (Photomap)	Very high	Good/Average	Moderate/ Satisfactory
Relief Displacement (Maximum for 4 storey building)	3 mm	1.6 mm	3.7 mm
Maximum building height for 10 mm relief displacement tolerance (buildings)	50 metres (12 storeys)	90 metres (22 storeys)	40 metres (10 storeys)
Coverage	15 photos/km^2	9 photos/km^2	4.4 photos/km^2
Application	Urban areas (building heights < 12 storeys)	Urban core areas (building heights < 22 storeys)	Fringe urban areas (building heights < 10 storeys)

Figure 4.8 Summarizes the Alternatives (Department of Lands 1985)

Figure 4.8 summarizes the alternative photogrammetric procedures for production of rectified photomap at 1:1000 scale. The three photo mapping procedures are:-

1) One photomap per photo from 1:6000 scale aerial photography

This is one stage rectification process, involving high photography, control and aerial photography costs. The relief displacement effect of building on the photomap is moderate. The maximum acceptable for building heights are 12 storeys. It is appropriate to urban areas of low-medium rise buildings.

2) One photomap per photo from 1:10 000 scale aerial photography

This is a two stage process involving rectification to an intermediate scale of 1:2000 followed by photo-enlargement to a scale of 1:1000. This method reduces aerial photography and triangulation costs but it adds photo-enlargement stage. The relief displacement of buildings on the photomap is low. The maximum acceptable for building heights are 22 storeys. It is suitable for the centre of urban area where there are high-rise buildings.

3) Four photomaps per photo from 1:10 000 aerial photography

This involves a two stage process of rectification to 1:2000 followed by photo-enlargement to 1:1000. It significantly reduces photography and aerial ·triangulation costs for the rectification phase but adds an additional photo-enlargement stage. The relief displacement of buildings on the photomap is moderate. The maximum acceptable for building heights are 10 storeys. This method is appropriate for low-rise urban fringe areas. Figure 4.9 presents an example of rectified photomap produced by the DOL at scale 1:1000 in Bangkok area and figure 4.10 is at scale 1:4000 in Nakhon Ratchasima province.

4.6.3 Stage 3 Cadastral Index Map Compilation Procedures

The key aspects in this stage are:-

- Comprehensive search of DOL records - cadastral maps, detail files, titles and survey files;
- Comprehensive search of other authorities' records - tax maps, property maps;
- Photo-reduction/enlargement of survey plans and title diagrams to photomap scale;
- "Mosaicing" scaled parcel diagrams into larger units and fitting, on a street block basis, to the photomap with the aid of identified cadastral corners;
- Plotting the cadastral boundary overlay (from the "mosaic" of parcel diagrams fitted to the photomap);

- Rationalization of parcel identifier number;
- Preparation of indexes (via microcomputers) to provide cross-references between the new parcel identifier, adjudication number, old parcel number, title number and parcel area; and
- Dyeline reproduction.

Figure 4.11 is an example of new cadastral map compiled for Bangkok area at scale 1:1000 with map sheet number 5136 III - 7214 - 1:1000/4.

4.6.4 Stage 4 Photomap Updating

Since the base map is made up of details on the aerial photographs, the contents of the map are as at the date of photography. Additions and subtractions are difficult to make without completely replacing the photomap. The revision of a photomap needs new aerial photography on a cyclic basis. The periodic revision reflects new subdivisions, urban redevelopment, civil projects and major road-works. Rectification of new aerial photography, using the former control and photomap, provides a rapid and inexpensive means of updating the photomap on a cyclic basis (Smith and Holstein 1987).

4.6.5 Stage 5 Cadastral Index Mapping Up-dating

It is a major requirement for LIS development that the data has to be kept continually up-to-date. The cadastral map which is the main component of the spatial data base must be up-dated continuously from the moment of its initial compilation. This up-dating should be undertaken in the appropriate land office by specially assigned survey and drafting staff, since the cadastral framework in Thailand is dynamic with subdivisions take place at a significant rate, especially in Bangkok. Table 4.6 indicates that each year the total number of parcels is increasing by at least 4%.

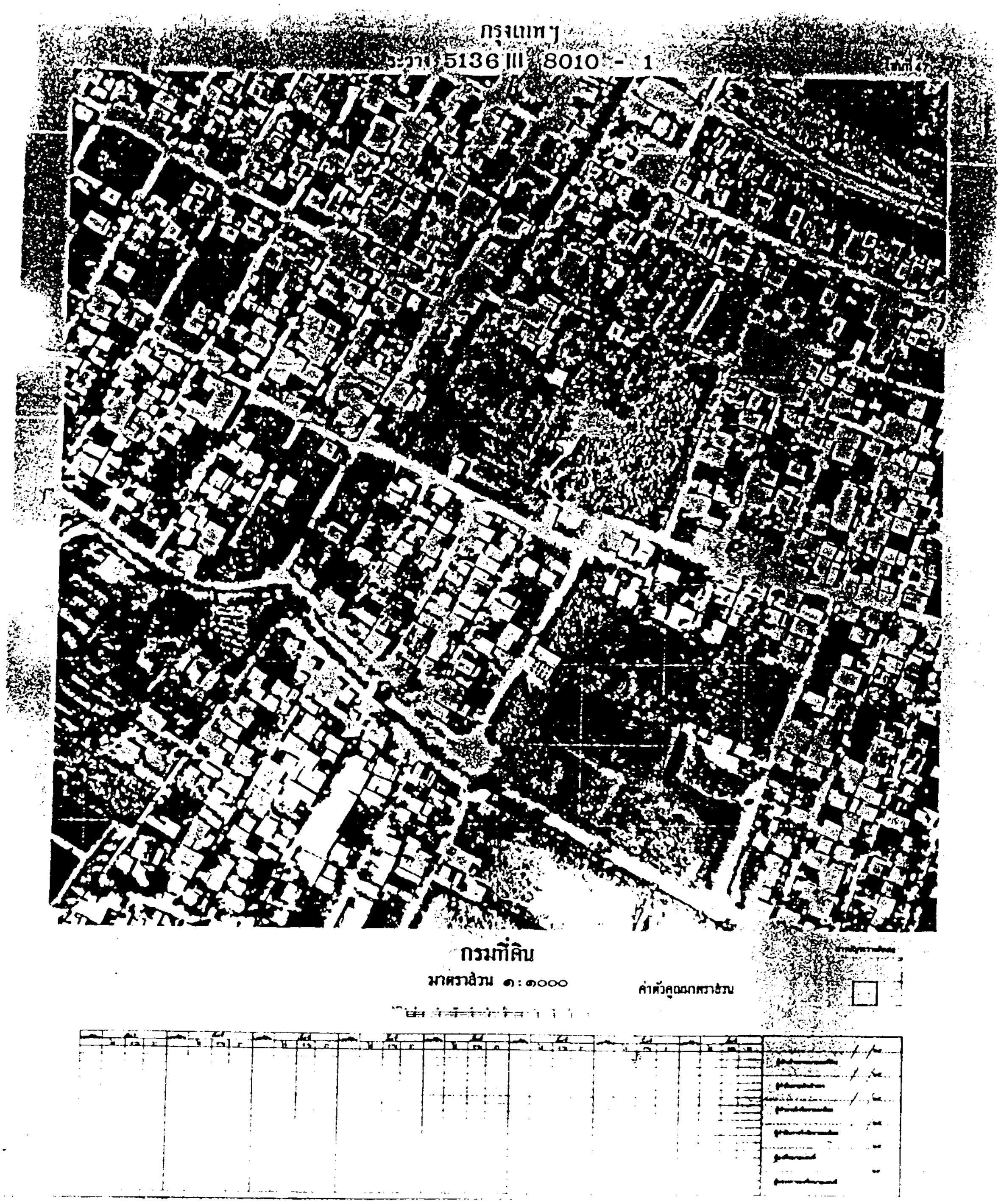


Figure 4.9 New Rectified Photomap for NS4 Cadastral Map Compilation, Map Format 500 × 500 mm^2, Scale 1:1000 Photo No. 5136 III 8010-1, UTM Zone 47, Bangkok Area

Figure 4.10 New Rectified Photomap for NS4 Cadastral Map Compilation , Map Format 500 × 500 mm^2, Scale 1:4000 Photo No. 5538 IV 3650, UTM Zone 48, Korat Area

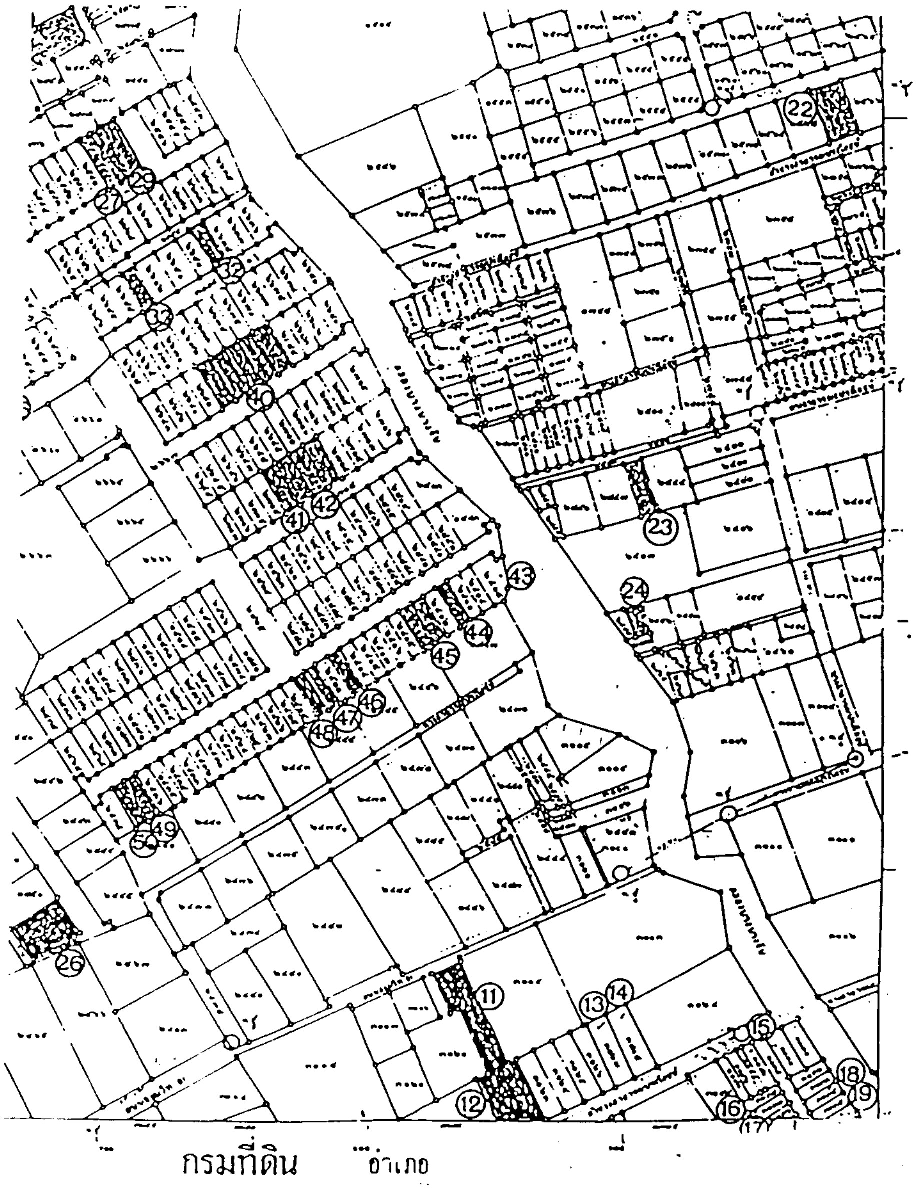


Figure 4.11 New Cadastral Map Compiled for Bangkok Area
Scale 1:1000, Map Sheet No. 5136 III-7214-1:1000/4

Year	New NS4 Records	% Change of Total NS4	End of Year Total
1981			768 346
1982	30 525	4.0	798 871
1983	31 642	4.0	830 513
1984	48 751	5.8	879 264

Table 4.6 % Changes of NS4 in Bangkok Area from 1981-1984

In terms of map up-dating for the Bangkok area this means at present about 6400 parcels per land office per year are being created (Department of Lands 1985).

The main causes of change to cadastral information of the countryside are subdivision and consolidation. DOL is responsible for receiving applications for subdivision (section 79, Land Code 1954). The DOL carry out checks to ensure that the proposal does not include state lands - road and drainage, forest etc. Surveyors in the land offices undertake the subdivision surveys for land document purposes which include verification of the external boundaries of the parcel before the establishment of the new internal boundaries. The new NS4 title deeds and NS3K land documents are prepared and the appropriate cadastral maps updated.

However, effective mapping requires the use of efficient mapping techniques and the adoption of realistic production standards. The setting of excessively high product standards will increase the complexity of techniques used, increase costs of equipment and operation, slow production, and reduce the ability to complete the mapping programme. As a result, it is significant lowers the overall quality of the mapping programme. For a LIS implementation stage, the quality of spatial data is an essential element, the DOL and other agencies have to establish a compromise in setting the standards, the techniques of production, and set the capacity of production for the base map to match the needs of the vast majority of users. This then will encourage co-operation between agencies in the mapping programme.

4.7 Production Standards

The objective in setting map production standards is to ensure rapid map production to satisfy user needs, completion of the mapping programme, and development of an effective revision programme. Adopting realistic standards is critical to the long-term success of a mapping programme and LIS development. The production standards (Department of Lands 1985) for each stage of cadastral map compilation are as follows:-

4.7.1 Survey control production standards

- To ensure the accuracy of survey control co-ordinates meets the adopted standard; RMSE (easting and northing) = ± 0.4 metres
- To include sufficient checks and redundancies to eliminate gross errors and improve co-ordinate reliability

4.7.2 Aerial Triangulation production standards

- To carry out aerial triangulation to provide control for rectification to an accuracy of; RMSE (easting and northing) = ± 0.8metres
- To utilize smaller scale aerial photography if the required rectification control accuracy can be achieved

4.7.3 Rectification and photo enlargement production standards

- To produce rectified photomaps that have a positional accuracy; RMSE (northing and easting) = ± 1.0 metres
- To produce photomaps that permit identification of the majority of boundary occupations
- To provide photomap detail in shadow areas
- To select normal angle camera, appropriate photo scale and production techniques that will keep maximum relief displacement of buildings to less than approximately = ± 10 mm in the corners of the 1:1000 photomap

4.7.4 Cadastral compilation production standards

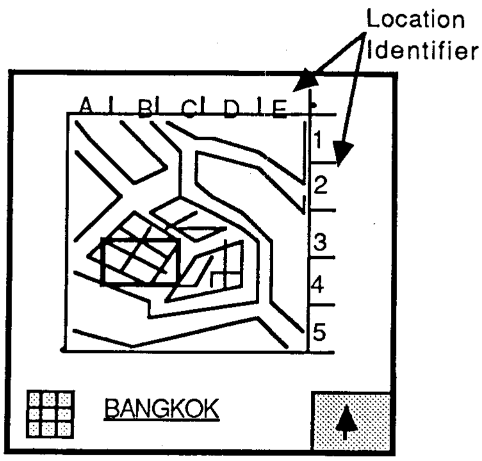
- To plot the cadastral boundaries to fit the rectified photomap to an accuracy of approximately; RMSE (easting and northing) = ± 1 mm to = ± 2 mm at map scale (excluding areas effected by relief displacement of buildings)
- To plot the cadastral boundaries so that the boundary distances on the photomap have a relative accuracy of approximately = ± 1.5 mm
- To ensure all land parcels are identified on the cadastral overlay
- To ensure that the data on the maps and the land parcel ownership indices are complete and without error

4.8 Comments

The investigation of the urban mapping activity of the DOL leads to some comments as follows.

4.8.1 Cadastral index map (CIM) must contain the updated map features because the investigation may show that a feature in the map as a canal but on the ground the same feature may be a road. This is because the feature in the survey plan in the land office is shown as a canal and the Urban Mapping Division that compiles the CIM from survey plans has to continue to show that feature as a canal on the map because this Division has no authority to change the map feature unless the survey plan in the land office is changed. Thus, the DOL should provide the Urban Mapping Division with the authority to show the current map feature to ensure that the CIM up-to-date.

4.8.2 The new cadastral index map (CIM) must add the location identifier for easy reference to the required land parcel in the map, e.g.,

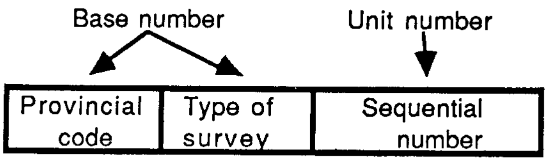


4.8.3 The Surveying and Mapping Division is responsible for the establishment, maintaining, updating, and record-keeping of the control network. To achieve the computerized LIS objective, the division must consider keeping reliable records and up-to-date co-ordinates of the control points and allowing recognized users easy access to the record which includes:-

- A large-scale map with marked control points, including the numbering and order of the network to which the points belong as well as intervisibility lines to other points;
- A file of control points which shows: the number of each point, the order of the survey, the address of its location and the file number of the topographical descriptions (based on topographic map scale 1:50 000, e.g., 5136 III), and co-ordinates updated to the dates of computations; and
- The file of standard deviation of the control in the network.

The integrated survey system in the computerized LIS can be successful if control points are readily available in all parts of the required project areas and the up-to-date information on co-ordinates and accuracy of the network is easily accessible to lawful users. The accessibility of the control records will rely mainly on the numbering system of the control monument.

The procedure for numbering monuments should consist of assigning two-part point numbers- a base number with an additional modifier and a unit number (Blachut 1979). The base number and modifier refer to coding with reference to the type of survey, the administrative boundary, e.g., provincial code. The unit number is a sequential number within the numbering province. For example, the numbering of control should consist of three parts as shown below.



The first part is the base number which refers to the provincial code, e.g., Bangkok = 12.

The second part represents the type of survey, e.g.,

Doppler	=D
GPS	=G
Aerial Triangulation	= A
EDM	=E

The last part is a unit number in a sequential order (start from 001-999 in each province). For examplé, the coding of control monuments are:-

Doppler	code	12-D-001
GPS	code	12-G-001
Aerial Triangulation	code	12-A-001

EDM monument codes must consist of four parts.

- the base number refers to provincial code, e.g., Bangkok codes 12;
- The type of survey, e.g., code E1 for major traverse and E2 for minor traverse;
- the traverse line number within that province which consists of a combination of two character codes: A-Z, e.g., traverse line code numbers AA, AB, ..., ZZ ; and
- the unit number of three digits sequentially represents a number of EDM monument in the traverse line (001-999), e.g.,
  The major traverse monument codes 12-E1-AA-001.
  The minor traverse monument codes 12-E2-AA-001.

For the corner of land parcel, the coding of corner monument consists of the base number which contains the provincial code, and the unit number which contains one character string (A-Z) and sequential numeric of 5 digits (00001-99999) within that province), e.g.,

Corner of land parcel monument codes 12-A-25386.

4.8.4 In the northern part where the area is mountainous, the base map might be produced as an orthophoto to reduce the relief displacement of topographic feature due to the hilly terrain.

4.8.5 If there is a commitment to the creation of large-scale line maps either hardcopy or in digital form as the base map, the DOL has to make a careful judgement on this decision in terms of economics, productivity, cost/effectiveness, user's need since it does not serve the DOL's internal need in its dialy operations. However, if the large-scale line map is produced either by the DOL or other agencies, there should be the common accuracy requirements. The following is an example of large-scale line map accuracy standard which is proposed by the ASP Specifications and Standard Committee to be a base line for large-scale line base maps.

This proposed specification for spatial accuracy for large-scale line maps might be the basis and provide general framework for the DOL and other map producers for producing large-scale line maps either in hard copy or in digital form. The specification has been prepared by the Committee for Specifications and Standards, the American Society of Photogrammetry (ASP 1985) and presented for discussion and comments in many public meetings of ASP/ACSM. The accuracy specification has been characterized as follows.

4.8.5.1 Horizontal accuracy specification : Class 1

This standard requires that horizontal errors must not exceed the measures of allowable horizontal co-ordinate errors defined in table 4.7. This table approximately corresponds to an accuracy statement that 90% of well-defined points be within 0.54 mm of their correct planimetric position as measured on the map at delivery scale. Test points' ground co-ordinates are derived from measurements on the delivered map.

Typical Map Sheet Delivery Scale*	Allowable Errors (metres) Standard Error (1 σ)	CMAS**	Maximum Error (3 σ)
1:100	0.025	0.054	0.075
1:200	0.050	0.107	0.15
1:500	0.125	0.268	0.375
1:1000	0.25	0.54	0.75
1:2000	0.50	1.07	1.5
1:2500	0.63	1.35	1.9
1:4000	1.0	2.1	3.0
1:8000	2.0	4.3	6.0
1:16000	4.0	8.6	12.0

Table 4.7 Class 1. Horizontal Accuracy Standard in Terms of X or Y Survey Co-ordinates (ASP 1985)

These map scales (*) are typical for the corresponding accuracy definitions. Appropriate scales for other choices of allowable errors may be obtained by linear interpolation.

The Circular Map Accuracy Standard (CMAS**) requires that 90% of well-defined points will be in error by less than the indicated full scale ground value. For the indicated map scales, the error corresponds to about 0.54 mm on the map. However, this standard is defined at full scale (ground) values in terms of either standard error (1σ), CMAS, or maximum (3σ) errors. The relationship between standard error (1σ) and CMAS is taken as CMAS = 2.1460σ for either σ_x or σ_y, assuming $\sigma_{min}/\sigma_{max} \geq 0.2$ (ACIC 1962, pp.59).

4.8.5.2 Vertical accuracy specification : Class 1

This standard requires that vertical errors must not exceed the measures of allowable vertical errors defined in table 4.8. Elevations of test points are derived from interpolation between contours on the map.

	(metres)		
Contour Interval	Standard Error (1σ)	VMAS*	Maximum Error (3σ)
0.05	0.015	0.025	0.045
0.10	0.03	0.05	0.09
0.50	0.15	0.25	0.45
1.0	0.30	0.50	0.90
2.0	0.61	1.00	1.83
2.5	0.76	1.25	2.28
5	1.52	2.50	4.56
10	3.04	5.00	9.12

Table 4.8 Class 1. Accuracy Standard in Terms of Elevation (ASP 1985)

Vertical Map Accuracy Standard (VMAS*) corresponds to the definition that 90% of well-defined points are not in error by more than one-half the contour interval.

4.8.5.3 Lower accuracy maps

The error values stated in tables 4.7 and 4.8 are increased by a factor corresponding to the accuracy class for maps of lower accuracy. The allowable error values for a Class2 and a Class3 map equal those for a Class1 map multiplied by two and three, respectively.

4.8.5.4 Testing map accuracy

The accuracy of the map at publication scale is tested by comparing ground co-ordinates (X and Y) or elevations (Z) of at least 20 well-defined and well-distributed mapped features, as determined from measurements on the map, to those for the same points, as provided by a check survey of higher accuracy. The check survey is one which can be expected to produce errors no greater than *one-third* those allowable by the accuracy requirements stated as Standard Errors in table 4.7 and 4.8. The design of the check survey is based on the standard of survey accuracy and specifications prepared by the Federal Geodetic Control Committee (FGCC) and adopted by the United States National Ocean Survey (NOS). To ensure that the check survey produces nominal positional accuracy three times better than that required of the delivered map and that the test result is representative of the entire map, the following procedures must be achieved:-

- All surveys for Class 1 maps shall be conducted in accordance with the standards of accuracy and specifications published by the NOS. Horizontal surveys by triangulation, trilateration, and traverse shall be conducted by Second-Order Class II methods, or by Second-Order Class I methods if analytical photogrammetric methods are used. Vertical surveys shall be conducted by Third-Order methods. Surveys for checking Class 2 and 3 maps shall be conducted by field procedures of proportionally lower accuracy.

Testing of the delivered map may be accomplished by standard statistical procedures to assure that it complies with the required *accuracies* both in the horizontal and in elevation. Explanations and examples of bias and precision testing of maps are provided in Appendix A of ASP (1985).

4.8.6 Another innovation are the satellite surveying systems,i.e., TRANSIT Doppler Positioning and GPS that are capable of accurate sensing of motion in three dimensional space. The DOL plans to employ GPS receivers for the second-order densification of the control networks. The Surveying and Mapping Division which is responsible for this new operation must derive standards, survey practices, and regulations in consultation with overseas experienced institutions (academic, manufacturer, mapping authorities) as a base line for undertake surveys by this satellite surveying system. The following are a guidelines for this survey practice.

4.8.6.1 Planning of GPS Surveys

The Control Section in the Surveying and Mapping Division which is responsible for GPS surveys must lay down the GPS survey standards and practices as general guidance for GPS survey practices. The following standards are extracted from GPS Workshop of School of Surveying, UNSW, which are quoted from *US Draft Standards and Specifications.* The aspects to be considered are:-

- Definition of Network: size, shape, number of stations;
- Location of existing and new stations;
- Accuracy standards in GPS surveying;
- Centring errors at stations and spacing of stations;
- Minimum length of observation session per station;
- Minimum number of satellites observed simultaneously;
- Satellite configuration and observation window;
- Selection of optimal observation period (day/night, month);
- Logistic design;
- Minimum number of common station between sessions;
- Number of sessions per day;
- Reconnaisance: point recovery, site visibility diagrams;
- List of equipment per station; and
- List of stations with an efficient numbering system and their co-ordinates.

4.8.6.2 Draft Accuracy Standards

- The draft 5.0 of the *U.S. Geometric Geodetic Accuracy Standards and Specifications* for using *GPS Relative Positioning Techniques* (May 1988) may be taken as a guide when designing and specifying GPS surveys.

Order	Min. Accuracy (95% Conf. Int.)	Applications
1 2-I 2-II 3	10 mm + 10 ppm 20 mm + 20 ppm 30 mm + 50 ppm 50 mm + 100 ppm	Control Surveys for mapping, LIS, cadastral and engineering surveys, classical first to third order control.

4.8.6.3 Centering Accuracy

- The accuracy of the antenna centring has a direct effect on the GPS positioning accuracy. Centring errors are most critical on short lines and where highest accuracy is required.
- A minimal centring error is of ±3 mm at 95% confidence level (standard deviation = ±1.5 mm) for tripod mounted antennas.
- This is easily achieved with:-
    - centering tripods (with centering rod);
    - rotatable optical plummets;
    - EDM reflector tripods (with struts); and
    - trivets, centering plates.

4.8.6.4 Length of sessions

The following advice on the length of observing sessions is:-

Description	Class 1,2,3 (min)
General Requirement (min)	30-60
Continuous and simultaneous observation between all receivers(min)	20-30
Data Sampling Rate (sec)	15-30
Maximum elevation for obstructions (deg)	20-40

4.8.6.5 Satellite Configuration

The *US Draft Standard and Specifications* states the following rules. Minimum number of quadrants from which satellite signals are observed for Class 1,2,3 are 3 or 2* (* = satellites to pass in diagonally opposite quadrants). The satellite geometry can be viewed with the aid of Sky-Plot Program.

4.8.6.6 Observation Period

The optimal observation period should be selected under consideration of:-

- One, two or three observation session per day? This depends on travel time between stations and on length of observation window providing good geometry;
- Day or night observations? For best accuracy with single frequency receivers, night time observations might be required;
- The present 7 satellite configuration provides about 5 hours of 4 satellite coverage; 6 satellite coverage for about 2.5 hours;
- Every day, satellites rise about 4 minutes 3.4 seconds earlier than on the previous day (sideral day).

4.8.6.7 Logistic design rules

The *US Draft Standards and Specifications* suggest the following design rules:-

Description	Class 1,2,3
Minimum number of continuous tracking stations	option
Minimum percentage of stations with 2 or more occupations:	
• known stations	
• horizontal	25%
• new stations	30%
Minimum percentage of lines measured twice	5
Direct connection between any adjacent station when spacing is less than	3 km

4.8.6.8 Accuracy of known stations

- The station which will have to be kept fixed in the processing of GPS data must be known in the World Geodetic System 1984 (WGS 84). *The US Draft Standards and Specifications* state the following minimum required accuracies for these known coordinates of fixed stations of Class 1,2,3 to be ± 25 m;
- These WGS 84 coordinates may be obtained from:
  - GPS Point Positioning with Doppler Smoothed Pseudorange (code phase) data;
  - GPS Point Positioning with Unsmoothed Pseudorange data;
  - TRANSIT Doppler Point Positioning with Precise Ephemerides as Transformed to WGS 84.

4.8.6.9 Accuracy of new stations

- The required accuracy of the new stations is defined by the project;
- The final coordinate accuracy depends on the precision of the transformation between the GPS derived coordinates and the coordinates in the local network. A sufficient number must be available in *both* systems; and
- The accuracy of the GPS derived coordinates and heights depend on the accuracy of the fixed WGS 84 coordinates.

4.8.7 In urban areas, the local authorities concern with the precise location of property boundaries but individual owners recognize physical monuments to define boundaries. Thus, the DOL has to maintain social order by setting up a cadastre that in a simple and clear way determines who owns the land and property. From the view point of accuracy requirements, various technical requirements and enforcement of regulations, all are of primary importance for cadastral survey. Another aspect to be considered is that the designated accuracy of cadastral surveys in urban areas should not be based on a specified quantity derived from the performance of modern surveying equipment but should reflect realistic local needs and conditions (Blachut 1979). Uniform accuracy over larger areas or absolute accuracy is of a major requirement and can be achieved only if the cadastral surveying is based on an adequate control net.

In summary, the fulfilment of operational cadastral survey functions may not be justified only on the high accuracy of boundary determination but another attributes, i.e., completeness, continuous updating, and finality of cadastral documents are also important features to be considered in setting up a parcel-based LIS.

5 INDIVIDUAL MASSIVE VALUATION : A BASIS FOR THE VALUATION SYSTEM OF THE DOL's LIS IMPLEMENTATION

A Cynic : " Someone who knows the price of everything,
and the value of nothing."

- Oscar Wilde

5.1 Trend of Land Tax Collection for Government Revenue

The source of government revenue in almost all of the countries in the world comes from tax collection. In Thailand it is the same: the major source of government revenue comes from income tax and other taxes such as house rent tax, land development tax, sign board tax, slaughter tax etc. The following diagrams show the trend of the government tax collection during the period 1980-1985.

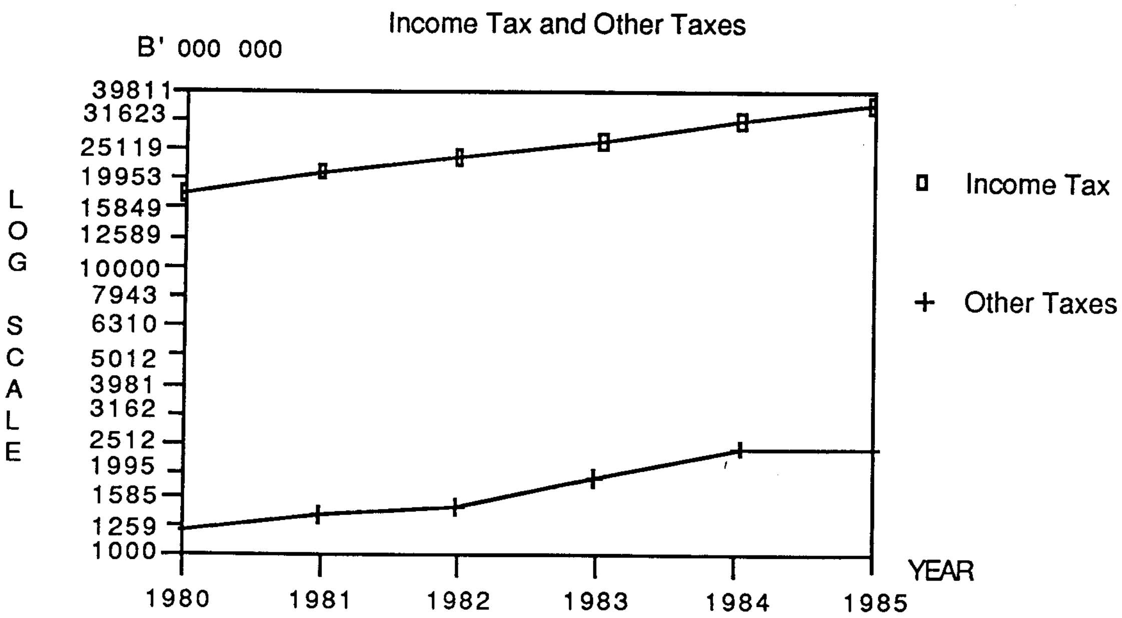


Figure 5.1 Taxes in Thailand (Hornby 1985)

Figure 5.1 shows that income taxes are the most important to government revenue in Thailand, increasing steadily with time. Other taxes are minor revenue to government but also show reasonably growth.

<u>N.B.</u> Y axis is a log scale which tends to compress the income tax curve.

Figure 5.2 shows that income tax has a good correlation with GDP over the period of 1980-1985. The rate of income tax collection increases at nearly the same rate as GDP. This means the tax collection system in Thailand progressive.

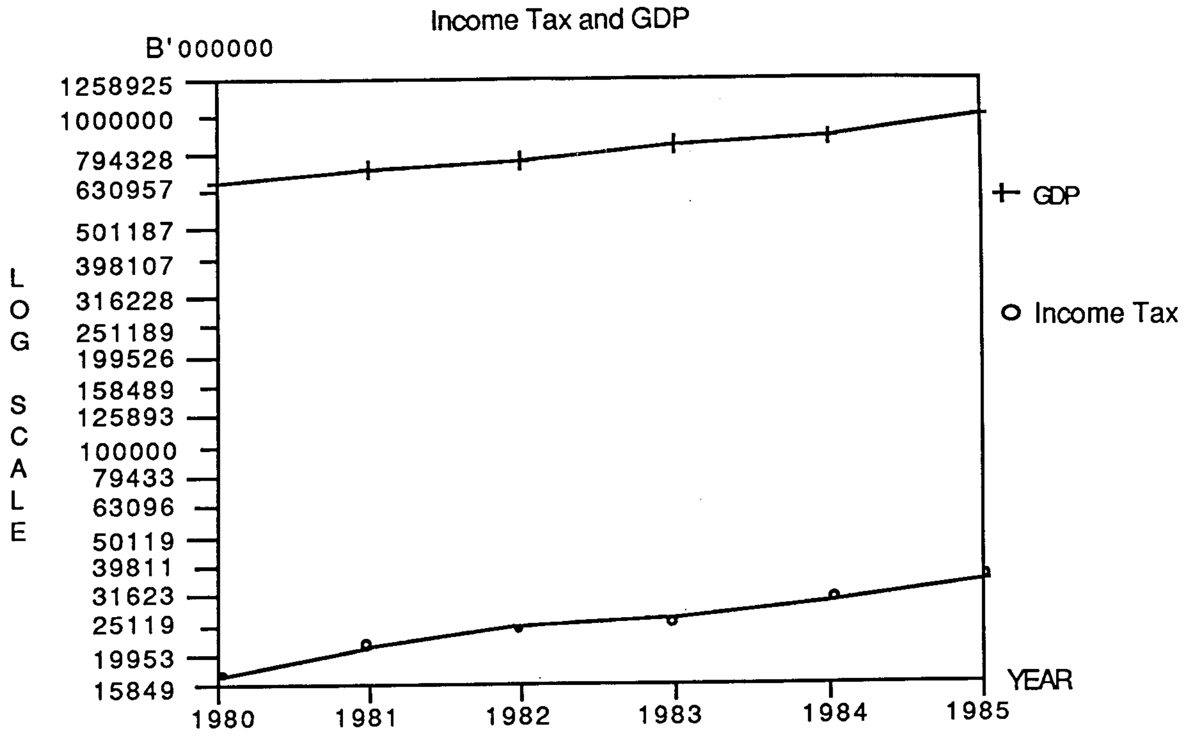


Figure 5.2 Income Tax Thailand (Hornby 1985)

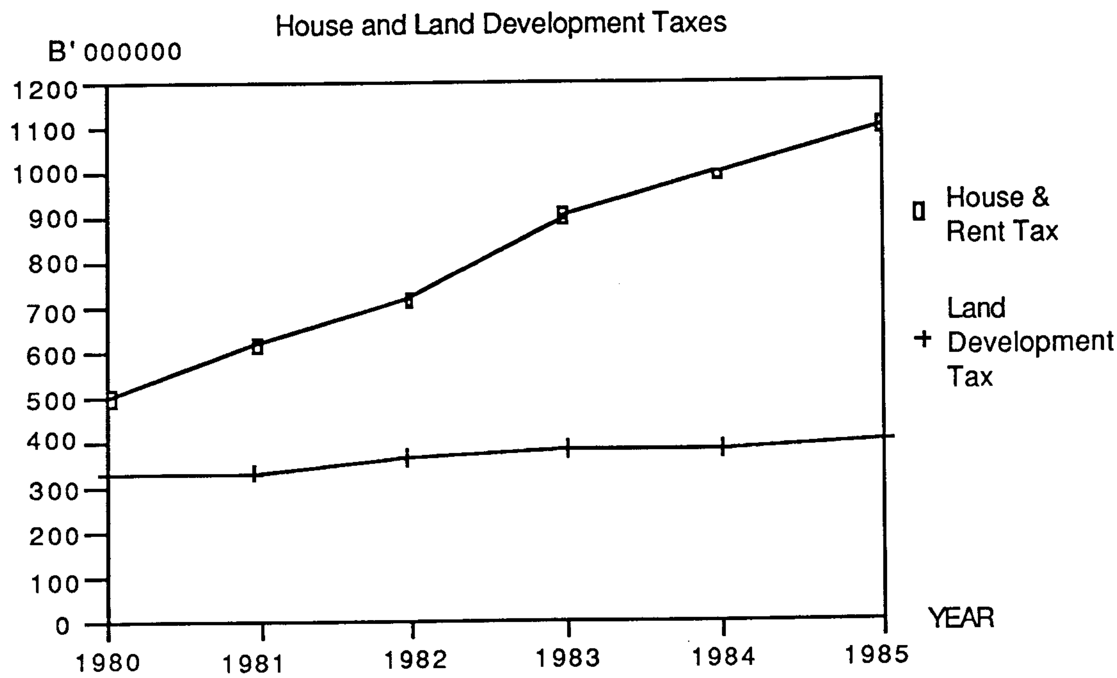


Figure 5.3 Local- Taxes- Thailand (Hornby 1985)

Figure 5.3 shows that of the local taxes, House Rent tax is the most important local tax revenue source and it increases dramatically over the year. Land development tax tends to be steady over the period of inflation. In real terms, this tax has decreased over time. This reflects the increase of urban areas especially in major cities in Thailand.

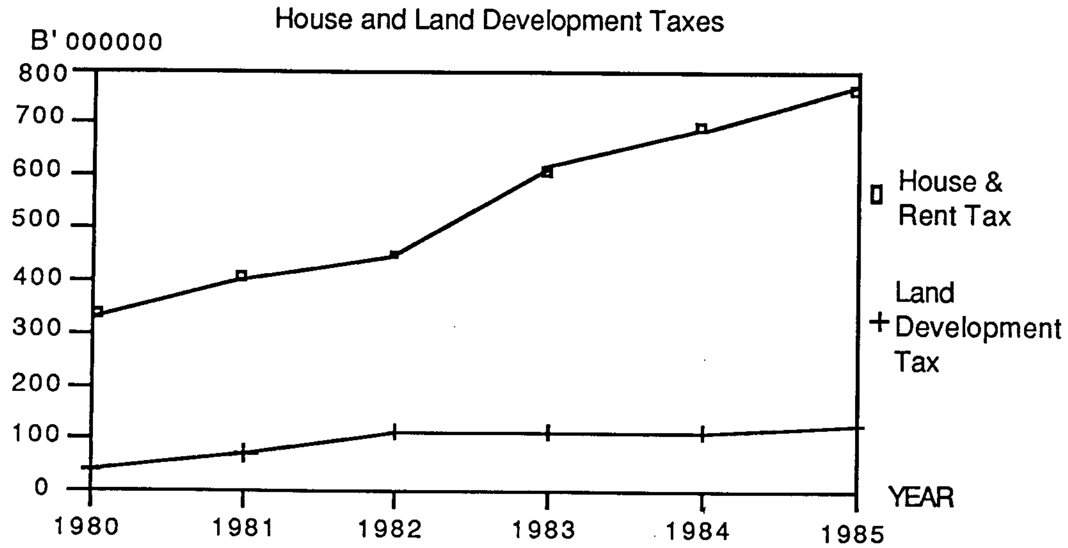


Figure 5.4 Bangkok MetropolitanAdministration (BMA) Local Taxes (Hornby 1985)

Figure 5.4 shows the same trend with the increase House Rent tax as in figure 5.3. The land development tax has shown a decrease in real terms. This must be increased to discourage land speculation and taxes must be imposed on unearned income largely caused by increasing services provided by the BMA.

From the above diagrams of tax collection in Thailand, the land and property transfer tax have tended to increase as the urbanization expanded. The collected tax has then been spent by the government to provide basic utilities back to the community as social welfare. Since land valuation plays a significant role in land tax collection for the government, the improvement of the valuation system will help government to collect land tax efficiently. The government with the approval of the cabinet has set up the Central Valuation Authority (CVA) under the DOL administration on November 17, 1981. This authority is responsible for land and real property valuation which would be used to collect land transfer tax and fee for land registration and legal dealings in land. According to the decision to introduce the LIS/GIS in the country under the 6^{th} National Development Plan, the DOL has a major role to serve this land policy. Consequently, CVA will play a significant role in the DOL's LIS since it constitutes the authority for all lands valuation in the country.

Valuation system which has been mentioned in chapter 3, section 3.4.2, is a major component of fiscal cadastre of the DOL's LIS development. The development of the valuation system for the DOL's LIS will help improve the efficiency of the administration of the CVA and government for tax collection in general. This chapter will investigate the pilot study of the individual massive valuation programme which was undertaken by the CVA. The purpose of investigation of the valuation system of the DOL's LIS development is not only the procedure for collection of data but to ensure the quality of collected data. Thus, the techniques of how to obtain the updated, accurate, and reliable valuation information is investigated.

5.2 Investigation of Individual Massive Valuation

The purpose of this valuation is to value land parcels individually in addition to present practice of valuation on the zone/block basis. The valuation data collected from this programme will be used as the tax base in tax collection. There are 2 property value tax bases used in the CVA:-

1) Land value used as a base line for property tax collection; and
2) Real property value used as a base line to collect income tax outof capital gain from transactions of real property.

The land valuation undertaken by the CVA is based on the market value of the property. From an economic point of view, the market price is the price that the buyer is willing to pay and seller is willing to accept for the property, according to the demand-supply theory. The willing buyer and willing seller theory defines that both the buyer and seller place no constraints on the transaction at market value. Both know the factors which affect the proper value on the day of valuation. These factors exclude the instability factors such as government's development projects, town planning legislation or draft zoning which may occur in the future. The indicators of the trend of changes in land prices and land use in each area can be observed from:-

- statistics of land registration in the land office;
- amount of land transfer tax and fee collected from land registration and legal dealings in land;
- number of deposited plans for land subdivisions and land allocations;
- statistics of building construction;
- amount of migration of people in the area;
- average income of people in the area;
- number of banks, credit institutions and interest rates;
- level of urban development;
- utility network in the area; and
- number of laws and acts which are used in the area.

5.3 Sources for Determining Market Price for Land Valuation

1) The DOL's record of transaction data which contains name, address of seller and buyer, number of contract, the date of transaction which has the price shown in the record. The price obtained from this record is not reliable but will provide an indication of the market price.

2) The data from the land allotor is not directly reliable but can be used to determine the maximum value of property.

3) The usual way for a valuer to obtain data is by interviewing the seller and buyer. The quality of data depends on the technique of the individual valuer because the owner is concerned about the tax that he/she will incur if he/she answers directy. Therefore, the reliable data from interviewing depends mostly on the psychology the valuer uses in interviewing

4) The valuation data from banks or credit institutions is more reliable because each land parcel is valued individually. But this data is usually kept confidential by the institutions so it is difficult for valuers to access this data for reference.

The data which is not suitable for valuation is the data which is not based on the willing buyer and willing seller theory. Such data is characterized as:-

- The date of transaction is far beyond the date of valuation;
- The land lord sells to tenant;
- Transaction contract involves obligation;
- The data is the offered transaction price;
- The seller is forced or does not wish to sell;
- The buyer has the adjoining land parcels to the purchased land parcel;
- The transaction price is based on time payment not cash; and
- The transaction occurs between relatives or joint-companies.

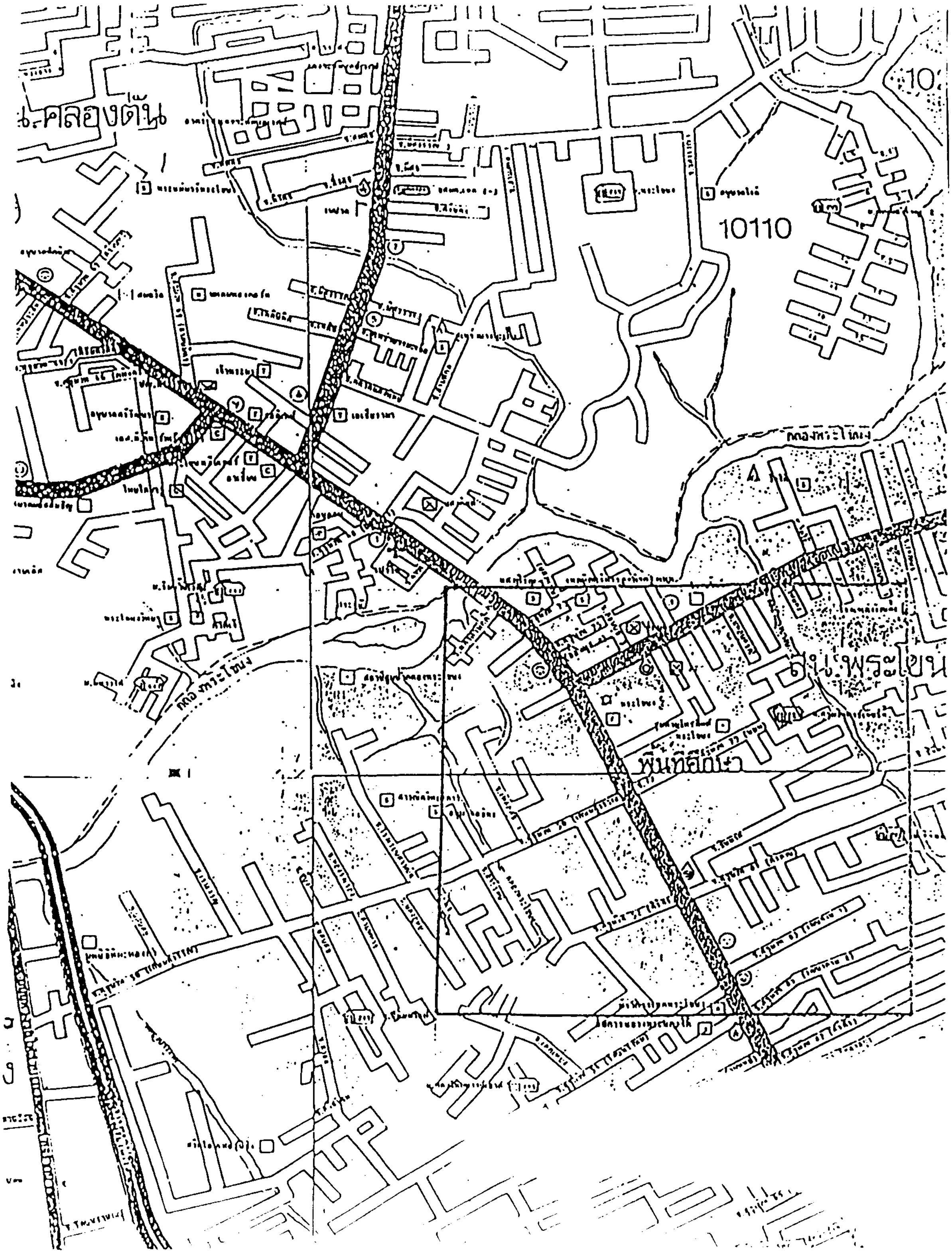
Thus, the quality of data depends mainly on those factors. After the valuer has obtained the market price, the procedure is to find the relationship between the land value and various factors such as the size of land parcel, shape, physical characteristics, the distance from market place, the soil improvement, traffic, utility and environment etc.. The valuer has to find the future depreciation which will be used for finding improved value. From the investigation, it is found that the quality of valuation data depends mostly on the ability of the valuer to value the land accurately. The pilot study of individual massive valuation will be the best trial in valuation data collection for DOL's LIS development because it values the land individually.

The pilot study of individual massive valution was undertaken by the CVA during 11 February - 16 March 1987. The study has yielded the summary of:-

- method and procedure of valuation of land;
- method and procedure of valuation of buildings;
- method of capital valuation;
- field book questionnaire;
- the form of sale analysis;
- table of sale price comparison;
- the rate of work progress; and
- property valuation roll form which will be a basis for a valuation data acquisition for valuation system of the DOL's LIS.

5.4 The Area of Study

The area of study is in Khet (district) Phrakanong, Bangkok as shown in figure 5.5 covering the area of 1 square kilometre on Sukumvith Road between Soi (subroad) Sukumvith 77 and Soi Sukumvith 89. It is the joint border of two locality administrations - Phrakanong and Bangjak. The main soi is Onnuj (Sukumvith 77) between Khet Phrakanong and Lard Krabang. There is a major canal called Klong (canal) Phrakanong. Another canal is Bang Nang Jin which lies parallel to the northern part of Sukumvith Road. The expressway passes through the area of study. There is a mass transit project to link the area of study with inner and northern Bangkok. Therefore, the area of study will be developed rapidly in the future. The housing development project for high income earner has been started in the area of study-Sukumvith Garden City. The following second phrase of the project will be in the Soi Sukumvith 50. The land use in this area is zoned as commercial along Sukumvith Road and Soi Onnuj and housing areas for high, medium, and low income earners respectively. Most of the types of final registration of title of land parcels in this area are inherited.



Fgure 5.5 The Study of Individual Massive Valuation is in the Block Area in the Map

5.5 Procedure of Individual Massive Valuation

This practice consists of many stages starting from preparation of the necessary forms and maps from various offices to obtain the necessary information used in valuation field work.

5.5.1 Preparation of necessary forms

The following documents which are shown in appendix 1 are needed for field work data collection.

- Transaction list is used for collecting transaction data from TD1 (Tor Dor 1) form in the Land Office.
- N1 form is used to record the field data of individual properties.
- N2 form is used for sale analysis - one page for each parcel.
- N3 form is used for transaction price comparison and is grouped according to the type of property.

5.5.2 Preparation of maps

The following maps are collected to locate the study area and used in land valuation.

- Topographic map at scale 1:20,000 is used for locating the study area and comparison of physical relationships with local community and the transport network;
- Rectified photomaps at scale 1:1000 from Urban Mapping Division;
- Cadastral index map in UTM system from Urban Mapping Division; and
- Real property tax map from BMA.

5.5.3 Field work

The following procedures are undertaken for valuation data collection.

- Prepare the tambon (locality) number for accessing the transaction data that occurs in the area of study;
- Find supplementary transaction data from daily work book and parcel-index book from land office;
- Mark the parcels that have the transaction data on the cadastral map;
- In the field, interview the owner of property to find the correct transaction price and write down the other data in the sale analysis form (N2);
- Analyse and reduce the sale price to be land value only;
- Classify the land value according to the type of property in N3 form;
- Find the relationship between price and location of land parcel with the market price and put in cadastral map (Bench Mark Price);
- Determine primary value of every land parcel (Baht/wa^2) in cadastral map by direct comparison method;
- Create field book file by using N1 form of each parcel - 1 page/parcel. The file is classified by road (thanon) or subroad (soi);
- Adjudicate individual land parcels by recording the characteristic of land and building and then make the final land valuation by direct comparison method;
- Compute the property value in field book. The land valuation is done by the use of land value/wa^2 multiplied with the total area. The same practice is used for the improvements value by using the value of property/m^2 multiplied by the total occupied area; and
- Add the land value with the property value to find the land value plus the real property value. The method of valuation is called summation method.

5.6 Problems with Data Collection and Data Quality

1) The distribution of essential data used for valuation field work and non systematic indexing creates problems for the valuer. The valuer obtains the cadastral index map from the Urban Mapping

Division showing the land parcel numbered in a new system. But in the transaction data of the same area obtained from the daily work book in the land office the land parcel is indexed by tambon (locality) number in the old system. The valuer obtains the size of the land parcel from the survey plan in the land office because the new cadastral map does not provide the details about the size of the land parcel. When there is a change in registration, the owner's address is obtained from ownership index card in the land office. These distributed data sources and the inefficient index system retard the valuation programme. Thus, the integration of data sources into the Title System and Spatial System as mentioned in chapter 3, section 3.4 and the provision of the linkage mechanism with the new Valuation System will effectively provide necessary information to valuer and public.

2) The property identifier will be the key to access the Valuation System of DOL's LIS. In Thailand, property is identified by the house number issued by the Department of Administration. But in slum areas, the house is not registered and has no number. However, the other alternative may be to use the pipe water meter number of the Metropolitan Water Work Authority (MWWA). This alternative must be investigated further to determine which one should be used for the property identifier.

The way the CVA operates now is by identifying the property according to road or soi. The property in each road or soi is numbered from the left side of the road to the end of the block and then back along the right hand side. This may be the better way of property identifying but the CVA must create the cross-indexing to the house number or the water meter number. Thus, it creates duplication of property indexing which causes confusion.

3) Transaction data is unreliable because the source of this data comes from interviews. There should be a real property market information centre in the CVA by combining all transaction data from the land offices, land developer, creditial institution etc. Thus, the registered-transaction data can be continually updated every month and adjusted to keep pace with the real property market

values. This information will be reliable and useful. Fast access to this information will stimulate the valuation process in itself and be useful for the public. The CVA will also receive returns from providing these data to public.

4) Due to the lack of effective town planning control, there are many subroads or soi in urban areas. This creates confusion in assigning the property number using the CVA identifier because the number relates to the road. Moreover, there are many land parcels which are not close to roads or soi. Therefore, it is very hard to determine how to assign property numbers.

5) There are many private roads or soi. The problem is to judge whether this road or soi should be valued as a land parcel or left as public land. This has to be solved before the valuation data base of the Valuation System is created to ensure that data integrity can be obtained from this system.

5.7 Valuation Rolls Created by the CVA

The Valuation System data base of the DOL's LIS will extract data from the valuation roll. There are many types of property valuation rolls compiled by the CVA which are shown in appendix 1.

5.7.1 Property roll is the property index which consists of the important details about property in each administration area such as Bangkok. It contains the details of:-

- Parcel identification which is defined by chanod number (title deeds number), old parcel number (local origin system), new parcel number in new cadastral map (UTM system), or zone/block/lot (used in CVA nowadays).

For the DOL's LIS implementation, this problem of numerous identifications of land parcel in various offices must be solved in the first instance. The parcel identifying system should be unique and systematic. The proposed parcel identification which is described in chapter 7 should be considered.

- The location of parcels is referenced to road or soi. In cases where a parcel does not face a road, the location is defined by other identifiers such as Moothee (village number), tambon (locality), amphur (district), and changwat (province) as suitable;
- The area of land parcel defined in chanod (title deed) is only estimated in rai-ngan-tarangwa. But for valuation, the size should be identified much more accurately by adding details about the frontage and depth;
- The owner's name and address in this roll should be obtained from the population information centre of the DOA or postal address. However, the postal address is more up-to-date;
- Transaction date and price (market price);
- The name of tenant;
- The land use;
- The style of building; and
- Soil property (detail about improvement in land).

5.7.2 Valuation roll is the property roll but with more details added about values of property such as land value, capital value, or improved value and annual value.

5.7.3 Tax roll is the property roll which adds more details about tax collection, e.g., tax rate, date of tax collection, and added tax after due date.

5.7.4 The field book which is the survey data form is used for field work before the roll is created. It is similar to the roll but has more details. The data recorded in the field book form are:-

- Property number which is ordered consecutively along the road or soi;
- Registration data eg. chanod (title deed) number, changwat (province), amphur or khet (district), tambon (locality), area, and shape of land parcel;
- Data about changes in registration, e.g., owner name and address, date of transaction;
- The essential data for the valuer such as land use, type of soil and location of land parcel;

- Improvement data; and
- Property value data, date of inspection of property, valuer name, lease price, land value/tarangwa, land value plus building value.

5.7.5 Valuation list gives the items copied from the valuation roll. The details in this list are the essential ones for tax collection office in the period of valuation.

5.7.6 Supplementary list shows the change of property value during the valuation period such as new subdivisions. This list has to be sent to the tax collection office.

From the investigation of this programme, there is duplication of effort in work and data storage among various offices in the DOL. The CVA compiles and collects its own data which is already available through the Urban Mapping Division. The system should be based on the same cadastral map compiled by the Urban Mapping Division. On the other hand, the Urban Mapping Division should produce cadastral maps in areas required by the CVA as a first priority. The same parcel identifier should be used to eliminate the use of cross index to chanod and DOL parcel number and CVA parcel identifier should be discontinued. The transaction records in land registry office must be indexed by the new proposed parcel identification and the street name and address should be standard.

All the valuation rolls created by CVA contain most of the valuation information for all parcels in Thailand. They will be valuation data base for Valuation System of DOL's LIS. Two data bases should be created from these rolls which are the valuation file and land tax file. The valuation file should contain data extracted from valuation roll and field book. The land tax file should contain data from the tax roll and field book. However, the basic information from valuation system should consist of:-

- parcel number (the same with the number in land registry office);

- title reference;
- street address with reference to the land parcel;
- land parcel area;
- last owner name;
- transaction price (not less than the mean value from the CVA)
- land use details;
- current land value;
- legal obligation with land;
- property identifier;
- type of property and use;
- area of the property used
- shape and style of construction;
- construction materials and quality;
- property value (valued by the municipality officer);
- date of property construction;
- property improvements;
- age and extent of depreciation; and
- date of last registration.

The individual massive valuation programme is the best procedure in land and property valuation because it attaches the land and property value to each individual land parcel which is closest to the market value and more justifiable to the owner. Moreover, it will be the best source of valuation information to the Valuation System of the computerized DOL's LIS. Thus, the DOL must consider for continually undertaking this programme. However, the CVA has a limited number of officers and funds to do the individual massive valuation of all land parcels in the country. The valuation practice now therefore is done on a block basis. This practice involves dividing the valuation area on the CVA map into Zone, Block, and Lot as discussed in the following section.

5.8 Present Valuation Practice in the CVA

In this valuation practice the administrative boundary map is first divided into zones as shown in figure 5.6. Each zone is defined according to the Town & Country Planning and Municipality Acts as the area which constitutes the same land use. It can be classified as:-

- Residential;
- Commercial;
- Industrial;
- Agricultural;
- Public Building; and
- Vacant Land.

Then each zone is further divided into a number of block areas usually not more than 26 blocks for each zone (CVA 1987). Each block is surrounded by the road (thanon), subroad (soi), river (mae-narm), canal (klong) or another public land. It covers an area of about 0.25 km^2 (156.25 rai) and contains a number of land parcels which are called lots as shown in figure 5.7. The procedure in assigning the zone, block, and lot is as follow.

1) Zone number consists of 2 digit number starting from 01-99. The zone number starts from the top left corner of the map and runs across to the right side of the map. Then it starts again below the first strip and works back across the sheet in the same manner to the lowest right corner of the map.

2) Block identifier consists of 1 character starting from A-Z. The assigning procedure is the same as the zone numbering.

3) Then in each block, consisting of a group of land parcels, the land parcel is identified by Lot number which is a 3 digit number starting from 001-999.

For example, the land parcel No. 04 F 010 is the lot number 010 , block F, and zone 04.

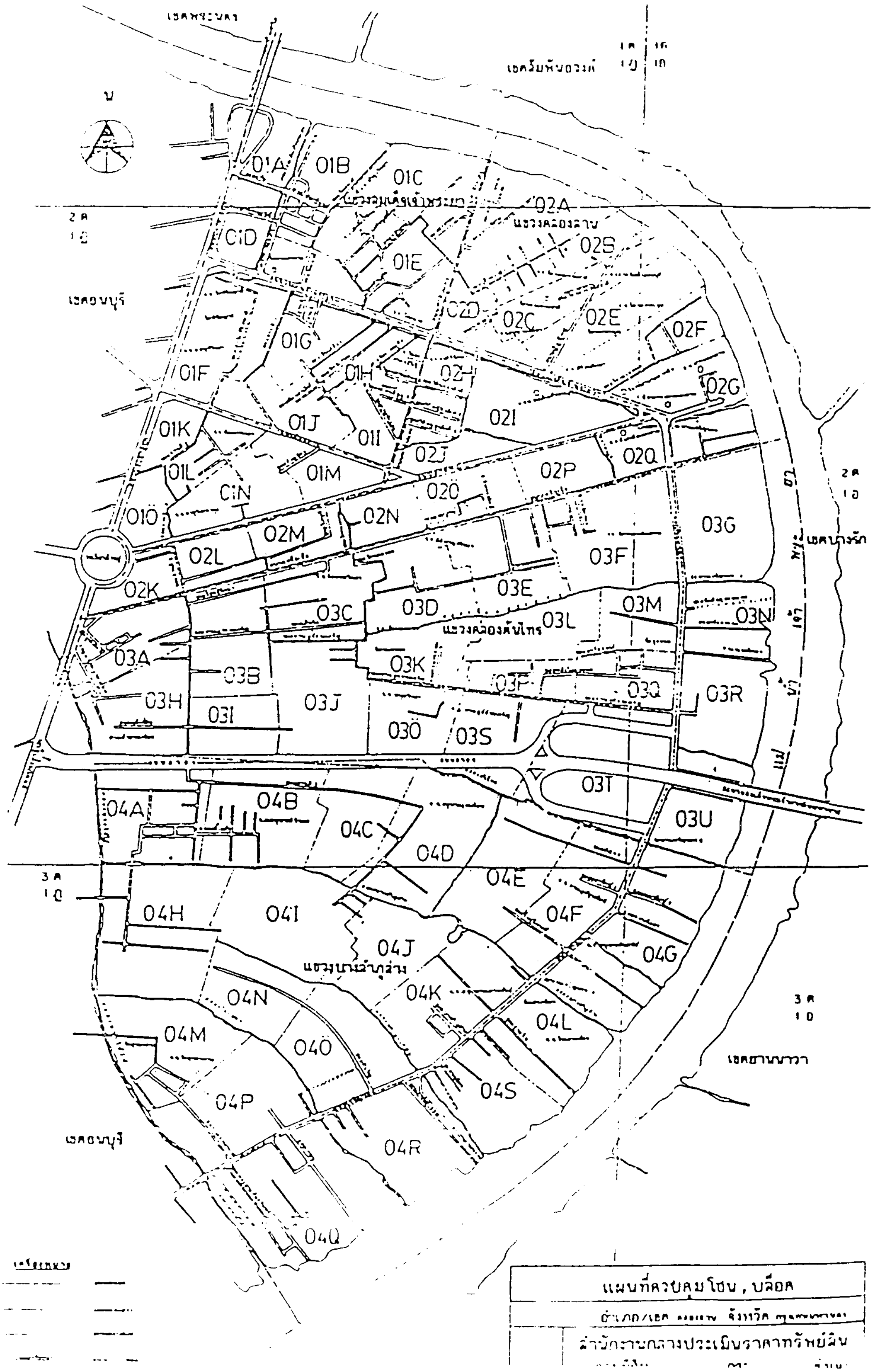
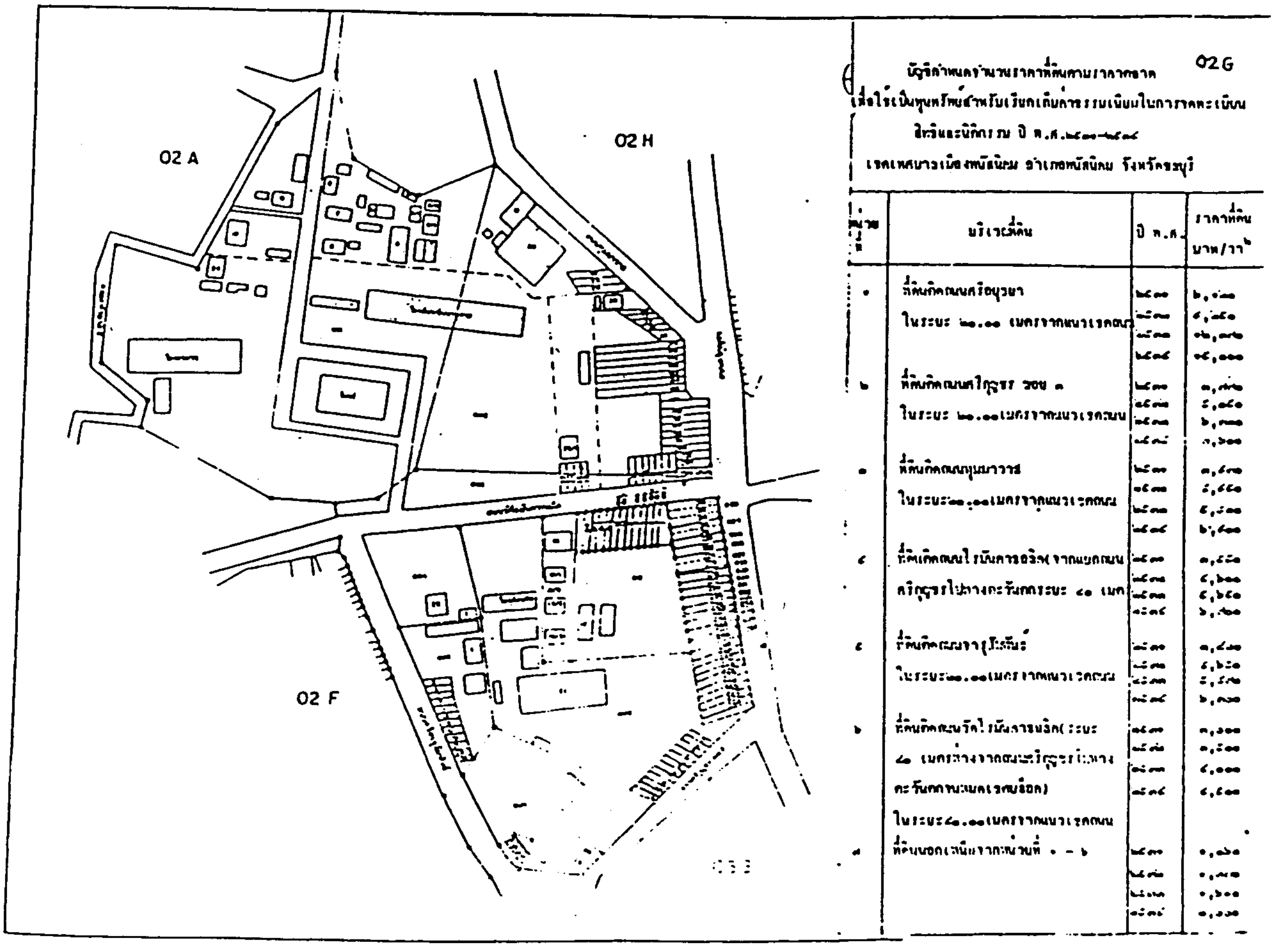


Figure 5.6 Zone/Block Control Map Produced by CVA



แผนที่บัญชีราคาประเมินที่ดิน

Figure 5.7 Valuation Map Produced by the CVA

This CVA identification from the above procedure is still ambiguous because it is not referred to the cadastral map number. It should include the map number even though it is compiled by CVA itself. Thus, it can be linked with the map and other attributes in the Title System and Spatial System of the DOL's LIS more effectively. However, the major issue of DOL's LIS should not be developed to serve the departmental use only but it must provide for the link of the system with outside departmental agencies too. Thus, the CVA identification requires much investigation before the valuation data base of the valuation system is fully created.

5.9 Conclusion

The co-operation between CVA and other government departments involved in tax collection will achieve the objective in LIS implementation. This relies mainly on the use of common procedures for describing and coding property characteristics. It also requires the common tax base system and common unified taxation laws and acts. At present, there are many acts relevant to valuation which are used in various agencies. These acts should be investigated to find the unified one which would be the basis for the valuation system implementation. The following is the list of acts relevant to valuation in Thailand (Hornby 1985).

Local Administration Act 1914
Provincial Administration Act 1955
Municipality Act 1953
Municipal Revenue Act 1954
Sanitation District Revenue Act 1955
Law on Tambon Administration
Act for the Organization of Local Government 1933
Bangkok Metropolitan Administrative Act
Local Development Tax Act 1965
Buildings and Land Rates Act 1932
House and Land Rent Control Act 1961
The Land Code of Thailand and amendments
Town Planning Act 1975

Regulations under Town Planning Act 1975
Control of the Construction of Buildings
By Laws of Bangkok Municipality Rebuilding Construction
The Civil and Commercial Code
Acts Promulgating Revisions in Book V of C&C Code
Sign Tax Act 1967
Act for the Expropriation of Immovable Properties
Land Tariff Act (no 2) 1979
City Planning Act (2) 1982
Regulations under City Planning Act
Agricultural Land Reform Act 1975
Land Development Act 1983
Civil and Commercial Code (A) Act 1976
Agriculture Land Consolidation Act 1974
The Revenue Code of Thailand and Amendment
Acts for Re examination of Land Title Deeds Issuance
Proclamations of Revolutionary Group 1-57
Land Allocation for Livelihood Act 1968
National Forest Reserves Act 1964
National Parks Act 1961
Private Commonly Owned Housing (Condominium) Act 1979

Another aspect is the designing of valuation data collection forms. The appropriate forms will serve as either a temporary or semi permanent repository for valuation information collected in the field. For computerized valuation system, it will facilitate field operations and data entry to computer data base. The design of the form must consider for encouraging accurate, complete, and consistent data by; having variable labels that are clear; having coding categories; providing sufficient space for recording; and maximizing the use of ticks or circles to ease and speed the recording of data (National Research Council 1983).

6 COMPUTER MAPPING SYSTEM : A BASIS FOR AUTOMATING PARCEL-BASED LIS IN THE DOL

" **BIT : Buy It Today** "

" **BYTE : Bring Your Time Easy** "

6.1 The Selection Procedure of Computer Mapping System

6.1.1 Purpose of selection procedure

In a modern national mapping organization, a computer-assisted mapping system is employed because the system is more suitable for very large map production than manual operations. The system usually performs the map production from the field survey data collection to outputting the map product in various forms with the minimum involvement of the operator. The DOL which is a large organization involved in map production will also implement this system to increase its capability in map making. This system will also be a basis for the computerized parcel-based LIS in the DOL. Since the system is equipped with expensive computer technology both in hardware and software, careful selection of the system is essential before purchasing. It is necessary to have knowledge of selection procedures and performance evaluation for the computer-assisted cartography system in order to achieve the maximum performance within the broad budgetary framework of the organization. The selected system will be a basis for developing the DOL's computerized parcel-based LIS to meet the required system capability.

6.1.2 System objectives

A systematic selection procedure incorporates some type of performance test based on the ability of the system. The capability of the selected system must meet specifications derived from the system production requirements of the organization. First of all, the organization has to establish the overall objectives of the production system at an early stage because they represent the basis for the later development of system specifications. The system objectives may include one or more of the following (Stefanovic 1987):-

- to improve the existing production
- to produce specific products
- to acquire a reliable system
- to acquire a cost-effective system

- to acquire a modular system
- to acquire a system which is expandable
- to acquire a system which can be upgraded
- to acquire "state-of-the-art" hardware
- to acquire a maintainable system
- to acquire a system which is compatible with others

When more than one objective is accepted, priorities must be established. Then it comes to the stage of finding the system which will meet the specified set of objectives.

6.2 Mechanism in Setting Up a System

The selection procedure should combine these major stages to meet the system requirement objectives.

6.2.1 Stage1: Define the work situation in the department

The first essential element is to make a detailed inventory of the existing work situation in order to define a clear starting point. From this base line one needs to be able to anticipate how future data handling needs are likely to develop in order to assess not only current requirements for computerization but also how the system is likely to expand. This is important because many years are required to complete the system acquisition and implementation and new needs may arise in the meantime since there is a high rate of development in the computer industry and especially in computer graphics. The details required are the number of jobs in terms of computing time to be handled in a year, the size and extent of the data base to be handled, the accuracy and the quality of the output, and the staff required. Figures 6.1, 6.2, and 6.3 present the amount of computing work in 1985 and major resource requirements of the Computing and Data Processing Division.

Types of Work	Duration Time		I/O		Cards	
	Hours	%	Item	%	Item	%
1 Computation for mapping	396	55	3,201,192	66	1,478,904	32
2 Land owner's name index	136.8	19	1,140,000	23	276,000	6
3 Salary account	79.2	11	180,000	4	2,280,000	49
4 Surveying data processing	79.2	11	251,147	5	113,932	2
5 Others jobs	28.8	4	93,600	2	508,800	11
Total	720	100	4,865,939	100	4,657,636	100

N.B. The source of computing time of the DOL's job was obtained from the annual report of job accounting of the National Statistic Office (NSO).

Figure 6.1 Statistical Amount of Work in 1985 Defined in term of Computing Times

Types of Work	Item	Characters/Item	Total (character)
1 Computation for mapping	1,168,637	80	93,490,960
2 Land owner's name index	308,353	80	24,668,240
3 Salary account	6,159	80	492,720
4 Surveying data processing	5,545	80	443,600
5 Processing programming	80,376	65	5,224,440
Total	1,569,070	-	124,319,960

Source : Computing and Data Processing Division, DOL

Figure 6.2 Amount of Data Entry in 1985 in term of Amount of Input Characters

6.2.2 Stage2: Define the software and hardware required to meet the defined work situation

The next stage is to identify and specify the kinds of hardware and software that will be implemented to serve the expected requirements. The organization should have an estimation of the order of magnitude of the funding that can be expected, so that distinctions can be made between components that are absolutely essential from the beginning, those that should be acquired over a phased period, those that would be helpful but not essential (they may be hired or bought depending on which is less), and those that are essentially experimental. The information about the "state-of-the-art" of the market can be acquired in-house or from consultants. The information can also be obtained from specialist journals which provide regular surveys of particular components such as workstations.

System/Subsystem	Data Processing Volumes	On-line Disk Requirement	Other Requirements
1 Automated Mapping			
1.1 Plotting	50 Mb/week 1.8 plotters	120 Mb	• 2 plotting systems • plotting software
1.2 Map Transformation	30 new maps /week	470 Mb	• 6 digitizing stations • 2 development and administration terminals • digitizing and interactive graphic software for automated mapping
1.3 Area Computation	7500 parcel areas/week	10 Mb	• as for 1.2
2 Parcel Indexing	7500 parcels /week	40 Mb	• 2 standalone microcomputers MS-DOS Operating System with DBASE III software
3 Data Entry	14 stations	120 Mb	• 1 standalone data entry system supporting 14 key -to-disk workstations
4 Co-ordinate Computation			
4.1 Survey Traverse	2700 km / month	25 Mb	• 3 terminals • character printer • in-house application software
4.2 Co-ordinate Transformation	200 points/ month	5 Mb	• as for 4.1
4.3 Star Azimuth	390 azimuths / month	5 Mb	• as for 4.1
5 Map Data Processing			
5.1 Base Sheets	130 maps/ month	15 Mb	• 1 terminal • in-house application software
5.2 Survey Station Data Base	3600 survey control stations month	10 Mb	• terminal at 4.1 • data base software package with in-house configuration
6 NS 4 first class Processing	1600 parcels /month	20 Mb	• 1 terminal • in-house application software
7 System Development	-	100 Mb	• 4 terminals • 1 character printer
8 Computer Operations	-	160 Mb	• 1 system console • 1 line printer • 1 magnetic tape
9 New Applications and Expansion	-	60 Mb	• 1 VDU
Total	-	1000 Mb	-

Source : Computing and Data Processing Division, DOL

Figure 6.3 Major resource requirements of application computer systems

Next, it is necessary to look for suppliers of the required software. Not all software can be obtained off-the-shelf, but there are a growing number of software houses that can provide systems that go a long way to meeting many requirements. A computer system for LIS is considered to consist of both hardware and software. There are three alternatives for obtaining a system which are:- the turnkey approach, the hybrid approach, and the tailor-made approach.

The *turnkey* approach which is characterized as a complete system, is purchased from the one company including computer hardware, data acquisition devices, screen terminal, plotters, and the vital software. The system of this type is specific to a particular design and might not satisfy the department's work because the purchased software may not match the department's requirements. As Bennet (1982) mentioned the development of a digital cadastral mapping involves the careful selection of the system. He noted that:-

> ***"Turnkey systems whilst highly functional, do not necessarily integrate easily with the administrative and procedural demands of a particular cadastral system. "***

Software in this category is ARC/INFO which is run on PRIME, DEC-VAX, DATA GENERAL, and IBM (ARC Manual 1985). This system is installed in the University of New South Wales computer for educational purposes. INTERGRAPH with standalone software such as TIGRIS is run on DEC-VAX, UNIX and graphic workstations such as Interpro 32, Inter Act 32, Inter View 32. This system is in operation at the Public Work Department of New South Wales. GENASYS software consists of two main software packages which are GENAMAP and GENACELL (GENASYS SOFTWARE MANUAL). GENAMAP is the core of a comprehensive Geographic Information System (GIS) with an internal DBMS. GENACELL is the raster and DEM processing. These two packages are run on Hewlett Packard 9000 series 300 and 800 (UNIX), IBM PC-RT (UNIX), DEC-VAX (VMS), and SUN (UNIX). The system is installed at the State Land Information Council (SLIC) of New South Wales.

The *hybrid* approach comprises of the purchase of general software packages and adapting them to run on existing or specially purchased computers and peripherals. There are several software developments which have been undertaken for a hybrid system but this approach demands good design and it will take skill to connect the components together. Another alternative is to buy the items in a modular manner and patch them together with high level language routines. The modules are obviously a DBMS, e.g., ORACLE, DBASE III+ , etc ; a spatial data acquisition system, e.g., pcARC/INFO; a statistics package, and a graphics and information display package. The hybrid approach can be undertaken either by a contractor, by an appropriate staff of the department to implement the system or by a combination of both, thereby embodying a large knowledge transfer component from the contractor to the department. This approach is suitable in that it provides flexibility to the department in choosing the suitable package to meet the requirements. The system in this type is more advanced because it requires many man-years to develop. This approach is tested in this project work in chapter 8. It deals with acquiring the suitable Thai Word Processing software and patching it with pcARC software using utility software and additional program written in Fortran 77.

Lastly, the *tailor-made* approach requires the department to design the system and implement the hardware/software on an existing or a specially acquired computer using specially written software to suit the department's work. The department must design and program the software with its own staff or under contract using the most suitable staff and available tools. The system may require many years to be developed. At present, the department's staffs have enough potential in software development, so this approach is also appropriate technically but it may take too long to develop, which may not be a cost/effective approach.

It is important to know if a given package has been designed to run on a specific machine and whether it can only be run on other computers with difficulty or with a serious loss of performance. The cheap, unsupported packages that look attractive may cost the department many man-months to make them operational, for they may in the long run cost more than an expensive, high quality product. When a range of software has been found that meets the major requirements, the next step is to determine the computer hardware necessary to support it. The evaluation of computer hardware must be concentrated on such factors as storage capacity, processing speed, reliability, availability of service, and expandability or upgradability (National Research Council 1983).

6.2.3 Stage3: Document detailing the requirements of the system

The next stage is to prepare a document detailing the requirements in such a way that the suppliers can respond with serious proposals. The purpose of the specification is to define the scope of work, the standards of performance, and the responsibilities of the department and the contractor (National Research Council 1983). The example of detailed system specifications for a computer mapping system required by the Computing and Data Processing Division, Department of Lands, Thailand is described in appendix 2.1. This specification will be a guideline for other government departments in selecting the computer mapping system and to ensure that they are compatible with the DOL's system.

It can be seen from the specification that it defines the performance characteristics of the system to be purchased while the analysis of the map production procedures is used to define the function of the system. It should be remembered that the detailed system specifications should not serve the supplier but be of benefit to the department. This depends mainly on showing no bias to any tenders of the officers and the maximum information of the system available from the market. The tenders should be matched with the system requirements as much as possible. Those clearly not meeting them should be rejected. The tenders remaining need to be treated very seriously, and the usual way of doing this is by the benchmark test.

6.2.4 Stage4: Benchmark test to evaluate the proposed system

The benchmark test (Burrough 1986) is a model of the kind of work that the department assigns to potential suppliers. The suppliers have to test the specified work to provide information about the time taken for certain operations, the ease of use (user friendliness) and positional accuracy. The department's staff must be present at the manufacturing site when the tests are carried out. Benchmark tests should be very thorough, examining every part of the work procedure in detail or concentrating on certain aspects of the requirements that are critical to ensure that certain minimum standards are met. The test has to be evaluated both technically and economically. The example of a model of a benchmark test to determine the technical suitability of the computer mapping system is described in appendix 2.2.

The benchmark test model is involved with detailing the data capture, processing, transforming, and plotting of cartographic data from a particular map sheet. The system hardware response time must be also tested. This task will be assigned to the potential vendor to perform. The quality of the output and the time taken to complete the task would be used in an attempt to rank the vendors.

6.2.5 Stage5: Decision on the final system and preparation for the system implementation

The final step is to choose a system on its price, performance and finance available. Just as with all the complex tools, skills need to be developed to use them properly. Staff and staff training must be planned so that when the system is finally delivered, it can be used to its potential as soon as possible. It might take some period of time before the system is in full operation. One of the best ways is to conduct a number of computer mapping pilot projects to train staff and to demonstrate to the manager what the system can do. The achievements of the system then, depends on good management and continual financial support.

Therefore, it is necessary to consider many aspects before choosing a computer mapping system. The system to be set up or purchased must really match technical requirements of the department. It requires specialized staff, administrator's support and financial support continuously to achieve the target. The following checklists for the contents of hardware and software will provide the basis for checking those vendors who are able to meet all, or most, requirements (Stefanovic 1987).

6.3 Checklist for the contents of a hardware contract

Hardware components

(1) Hardware component specifications
(2) Hardware configuration
(3) System performance
(4) Inclusion of the vendor's original proposal
(5) Inclusion of hardware manuals
(6) Guarantees of compatability
(7) Guarantees of interface
(8) Ability to modify equipment in the field

Service and Supplies

(9) Supply requirements
(10) Supply specification
(11) Acceptable supply vendors
(12) Guaranteed supply availability
(13) Power requirements and specifications
(14) Specifications of the ambient environment
(15) Cabling requirements
(16) Support to be supplied
(17) Staff calibre
(18) Training program
(19) Availability of training
(20) Continued availability of training
(21) Availability of instructors
(22) Availability of educational materials
(23) Rights to future courses
(24) Rights to teach courses internally

(25) Test time availability

(26) Availability of documentation

(27) Rights to future documentation

(28) Rights to reproduce documentation

Costs and Charges

(29) Terms of agreement

(30) Payment

(31) Hold-backs of payment

(33) Tax applicability

(34) Investment tax credits

(35) Methods of charging and charging types

(36) Credits for malfunctions and other features

(37) Price protection prior to delivery

(38) Price protection during the contract term

(39) Price protection for expansion equipment

(40) Price protection for supplies and services

(41) Price protection for maintenance services

Reliability and Acceptance

(42) Reliability parameters

(43) Guarantees of performance

(44) Warranty

(45) Right to replace components

(46) Backup availability

(48) Acceptance testing

Maintenance

(49) Available maintenance types

(50) On-site maintenance

(51) Response time for off-site maintenance

(52) Access requirements

(53) Space and facilities

(54) Spare parts

(55) Continuity and maintenance renewal rights

(56) Reconditioning on resale

(57) Rights to training of own maintenance staff

(58) Rights to purchase spare parts

(59) Rebates for failures not corrected promptly

(60) Malfunction and correction reporting

(61) Subcontract restriction

(62) Engineering changes

(63) Rights to schedule preventive maintenance

(64) User right to perform maintenance functions on rental contracts

Delivery

(65) Delivery dates, by component or group

(66) Option for early delivery

(67) Right to delay or postpone delivery

(68) Notice of pending deliverly

(69) Irreparable delays

(70) Site preparation responsibility

(71) Installation responsibility

(72) Risk of loss prior to installation

(73) Right to cancel components prior to delivery

(74) Substitution of components prior to delivery

Rights and Options

(75) Unrestricted use and function

(76) Unrestricted location

(77) Right to make changes and attachments

(78) Interface with equipment of other manufacturers

(79) Right to upgrade hardware

(80) Right to upgrade software

(81) Hardware trade-in

(82) Title transfer

(83) Purchase option

(84) Rental credit

(85) Protection of purchase price under purchase offer

(86) Availability of expansion units

(87) Alternative sources of supply

Damages

(88) Damages incurred if contract terminated prior to delivery

(89) Failure to deliver

(90) Liquidation of damages

(91) User costs

6.4 Checklist for the contents of a software contract

Performance

(1) Specifications
(2) Definition of documentation
(3) Availability of future documentation
(4) Right to reproduce documentation
(5) Rights to future options
(6) Run time
(7) Facility requirements
(8) Error detection
(9) Upgrades
(10) Source availability and access
(11) Right to modify programs
(12) Compliance with standards

Financial

(13) Charges by type
(14) Payment terms
(15) Terms of licence
(16) Tax status of software
(17) Rights upon business termination
(18) Price protection on other charges
(19) Price protection on licence fee
(20) Availability of financial statements

Installation and support

(21) Delivery
(22) Delivery failure
(23) Installation and modification assistance
(24) Support requirements
(25) Acceptance
(26) Destruction on termination

Warranties

(27) Guarantee of ownership
(28) Copyright, patent, or proprietary right infringement
(29) Guarantee of operation
(30) Free maintenance
(31) Freedom of use

6.5 Conclusion

The computerized LIS consists of two main components: the reliable data and the system hardware. This chapter concerns the investigation of the selection procedure for the computer mapping system step-by-step. To acquire computing capabilities, a general strategy must be developed with software needs being evaluated first. Then, hardware needs are evaluated in terms of requirements imposed by the software and the amount of data to be manipulated. The DOL has recently implemented computer mapping system which consists of:-

Hardware

- A PRIME 4050 Central Host Processor with 24 Mb base memory
- 32 Terminals
- 1 Ethernet network including 14 additional terminal lines
- 3 Disk drives each with 496 Mb
- 1 Magnetic tape unit 9 track with densities 1600 and 6250 CPI and speed of 125 IPS
- 1 Printronix P6280 line printer and 3 character printers
- 8 VDU's
- 2 Calcomp 1077 plotters with drawing speed of 52 inches and accuracy of 0.01 inch
- Sun 360C digitizing workstations each with
    - a 19" screen of displying 256 colors and resolution of 1152 × 900 pixels
    - 4 Mb of base memory
    - 2 disk drives each with 141 Mb
    - A Calcomp digitizer 36 × 48 $inch^2$
- 1 Color graphic terminal
- 4 Cubic XT personal computers

Software

* ARC/INFO

The system costs approximately A$ 1.4 million and is being installed at the Computing and Data Processing Division.

7 CADASTRAL SYSTEM UNDER THE ADMINISTRATION OF THE DOL AND PROPOSED UNIQUE LAND PARCEL IDENTIFICATION AS A BASIS FOR INTRODUCING COMPUTERIZED PARCEL-BASED LIS

"... Siam has given another proof of her determination to grasp and adapt to her own uses what is best in the laws of other nations. In this particular case her action places her in the forefront as regards land registration."

- R.W. Giblin, 1902

7.1 Cadastre Evolution in the European Countries

Since the cadastral systems are foundations of a parcel-based LIS, the establishment and improvement of cadastral systems will be an efficient cadastral base for LIS development. This chapter will examine the cadastral system development in the European countries with emphasis on the major important points to be considered for the cadastral system. More details about cadastre and land registration can be obtained from Dale (1976), Simpson (1976), and Soetandi (1988). The cadastre development in Thailand will be investigated later. Finally, the unique land parcel identifiers which are essential elements of a modern cadastre are proposed for the development of cadastre in a computerized parcel-based LIS in the DOL.

7.1.1 The cadastre in general

The cadastre is thought to come from a Greek word "KATASTIKHON" which refers to a tax registre. The origin of the word refers to the fiscal or financial side of land management. Current use of the word in most English speaking countries refers to a legal aspect of land management specifically related to land ownership. Dale (1976) has defined the cadastre as a general systematic and up-to-date register containing information about land parcels including details of their area, ownership, and interest in the land parcels.

7.1.2 Points to note on European cadastres

- Maps (large-scale) are the central component of land registration.
- Updating cadastral maps is an integral part of the legal subdivision process.
- The cadastre is first developed for fiscal purposes and subsequently to be the judical cadastre.
- The development of cadastres in 20th century has tended to be the multi-purpose cadastre (MPC). The MPC is that form of LIS concerning with parcel-based data. The MPC may

be referred as a public system, operationally and administratively integrated, that supports timely, readily available, and comprehensive land-related information at the parcel level.

- The evolution to legal cadastre is parallelled by an increase in accuracy and precision of the cadastral survey.
- Title registration is developed as a closely linked system to fiscal registers.

The modern cadastre concept requires the following essential elements (National Research Council 1983):-

- large-scale maps;
- registers;
- complete and up-to-date cadastre; and
- unique land parcel identifiers.

A cadastre consists of two main components: land registration, and cadastral survey and cadastral mapping. Land registration (Soetandi 1988) broadly means a system of documenting complete and valid records of information concerning land, whether for legal, fiscal or other purposes. Land registration has been concentrated mainly on the compilation of a registered of records containing such information about each parcel as the name of the owner, area, value, etc. It can be classified as either registration of deeds or registration of titles. The characteristics of these two types of registrations are as follows:-

7.1.3 Registration of deeds

The important points to be noted for this type of registration are that:-

- Maintenance of a public register in which documents affecting land are copied or abstracted.
- Deeds do not themselves prove title. They are merely records of isolated transactions and do not prove the transaction valid.
- Documents that are not registered have no effect.
- Investigation of validity is required. Thus, the service of a skilled conveyancer is required.

- It depends on the indexing system of the deeds register.
- Succession on death gives title by operation of law not the acts of the parties.

7.1.4 Registration of title

The main points of this registration are that:-

- It is set to remedy the deficiencies of registration by deeds.
- Title registration is based on the parcel not the persons.
- Registered title needs no investigation as does the deeds registration. The interest in land depends on what is shown in the register.
- An authoritative record is kept in a public office.
- It clearly defines a record of the rights in terms of units of land (parcels) as vested for the time being in some particular person or body. It also expresses limitations to these rights.

The other component of the cadastre is the cadastral survey and cadastral mapping. The objective of the cadastral surveying and mapping is to determine the location of each parcel, the extent of its boundaries and surface area.

7.1.5 Cadastral surveying and mapping

The essential elements required for cadastral surveying and mapping are:-

- Land law;
- Land tenure;
- Land registration systems;
- Institutional involvement;
- Parcel boundary system-delimitation methods;
- Parcel boundary marking demarcation;
- Parcel boundary description methods;
- Cadastral surveying methods; and
- Cadastral mapping.

The details of function of each element can be obtained from Simpson (1976).

7.1.6 Boundary systems

The concept of a boundary as defined by Dale (1976) is that:-

> *"A boundary is a surface that divides one property from another, which in the case of land parcels theoretically extends from the centre of the earth vertically upwards to the infinite in the sky."*

Two distinct types of boundaries used in cadastral surveying and mapping can be categorized as: general boundary and fixed boundary concepts.

7.1.6.1 General boundaries

The important points of this boundary system are that:-

- The boundary relies on developed and occupied physical boundary features.
- They are long standing; the community accepts fences.
- The owner of the boundary feature is not determined at the time of adjudication of the parcel as a whole.
- Exact determination of boundaries requires full enquiries of proprietors of parcels.
- They rely on linear monuments, e.g., hedges, walls, greek.
- Parcel limits are evident on inspection.
- Artificial parcel marking is not used.
- Topographical mapping is used for parcel description.
- Graphical descriptions are laid down on title documents.
- Photogrammetric methods of survey can be used to define the boundary.
- Systematic surveys, area by area, can be used since the boundaries are visible.

7.1.6.2 Fixed boundaries

The essential elements are that:-

- Monuments are placed on the vertices of parcel corners, or linear monument being defined as a boundary.

- Boundaries are fixed at a point in time by a point mark or mark on a fence on the boundary.
- Registered or licensed surveyors are required to determine the definition of boundaries.
- Isolated surveys are undertaken parcel by parcel.
- The techniques of survey are usually based upon traversing with theodolites and steel tapes.
- Numerical boundary description by rectangular co-ordinates and graphical portrayal of descriptions is used.

7.1.6.3 Parcel boundary marking

Parcel boundary marking can be categorized into two aspects: point marking and linear marking.

1) Point marking
   - Pegs or stakes, placed in concrete, walls
   - Engraved marks, on posts, trees, concrete, or walls
2) Linear marking
   - Natural boundaries:- cliff edges, littorial boundaries
   - Boundaries as walls, hedges etc.
     - marks are not always permanent
     - solid marks are expensive

The knowledge of the cadastre development in European countries will provide the background for understanding cadastre development in Thailand which is based on the simplified Torrens System.

7.2 Cadastre Development in Thailand

7.2.1 Historic background

Historically, all lands in Thailand belonged to the King. Traditionally, when land was readily available and agricultural activity was directed toward subsistence, any Thai person could claim up to 24 rai (4 ha) to provide for his family; rights to use the land were by custom rather than formally recorded. Dating back to the Sukhothai Period (A.D. 1283) when King Ramkamhaeng ruled the kingdom as father governs his son, he gave ownership of land to the individuals who undertook land clearance and cultivate agriculture. Land transfer at that time was by succession. In the Ayutthaya Period (A.D. 1360), the king who was absolute monarch, issued a decree that all lands belonged to him, allowing the citizens to live and earn their living on his land. At that time, there was no issuance of documents showing rights in land.

7.2.2 Development of the cadastre

During the reign of King Chulachomklao (King Rama V) period, around the turn of this century, a modified Torrens System was introduced into Thailand ("Siam" at that time). It is worth notifying that Australia has had contacts with Thailand in the cadastral area since the beginning of the century, as evidenced in a number of early editions of The Surveyor (Williamson 1983). Specifically, Mr. R.W. Giblin, a licenced surveyor from New South Wales, Australia, was the Director of the Royal Thai Survey Department in Thailand from 1901 to 1910. He helped establish the land title registration system based on a simplified version of the Australian Torrens System and the cadastral survey system based on a trigonometric network.

Thailand has continually re-assessed the performance of its cadastral survey system over the years. The DOL which plays a significant role in this area had its 88th anniversary on February 17,1989. Several important laws and by-laws were developed and issued from time to time such as:-

- The Land Title Deed Issuance Act. R.S. 127
- Act on Reservation of Waste Land which are in the Public Domain B.E. 2478
- The Land with respect to Aliens Act B.E. 2486

It can be seen that three eras are referenced in the context namely:-

- Buddhist Era (B.E.)
- Christian Calendar (A.D.)
- Ratanakosin Sok (R.S.)

The knowledge of the relationships between these eras is important to determine the age of plans and documents. These 3 eras are defined as:-

- Buddhist Era (B.E.) refers to the period of time since the Lord Buddha died.
- Christian Calendar (A.D.) is in the year since the birth of Jesus Christ.
- Ratanakosin Sok (R.S.) dates from the foundation of Krung Thep Maha Nakorn (Bangkok) as capital in B.E. 2325.

The relationships between these three eras are as follows:-

B.E. = A.D. + 543
R.S. = A.D. - 1782

Considerable changes occurred to the land laws in 1954 A.D. at which time the Land Code B.E. 2497 (A.D. 1954) was enacted. The main legal provisions governing tenure and administration of land are contained in the Land Code 1954 and subsequently amended. The code consolidated and replaced 14 earlier Acts and other pertinent laws, rules and regulations in force at that time (Stewart &Weir 1985).

7.2.3 The Land Code B.E. 2497

The code recognizes four forms of private ownership documents confirming rights to land. An additional document, known as a "Document for State Land", is issued to government agencies in the case of land used for public purposes.

The Land Code 1954 provides the basis for legislation affecting land ownership and administration throughout Thailand. It describes the powers and duties of the Minister of Interior and of the Director

General of the Department of Lands to administer the Act. It has provisions for the allocation of state land and land acquisition and contains procedures for the issue of documents evidencing rights in land, cadastral surveys and the operation of the title register. In principle, the title registration system in Thailand is based on the Torrens System.

The Torrens system is a registration of title fully based on parcels. The Torrens system of registration guarantees title to land which was pegged at the time of alienation or subsequently, at the time of subdivision (Dale 1976). The system was first introduced in South Australia in 1858 by Sir Robert Torrens. He was born in 1814 at Cork, Ireland and came to Adelaide as a customs officer. He was appointed Registrar-General of Deeds in 1853. He stood for election and became the first premier of S.A.. He introduced the private bill ("System of Conveyancing by Registration of Title"; Dale 1976) which was commenced on 2nd July 1858. He later abandoned his political career to resume duties of Registrar-General. Torrens died in 1884 in U.K.. The features of the Torrens system are as follows:-

- Compulsion and initial registration of title
- Registration of Crown land
    - Ungranted land is not registered.
    - Land reverts back to the Crown is registered in the name of the Crown.
- Boundaries marked by official marks
- Torrens' form of register based on a bound version where the history of the land is available
- Public access
- Caveats stop transactions.

Land in Thailand may be classified generally into two types: land with some document evidencing ownership or an interest in the land, and land without any documented title due to either legal or illegal occupancy. Illegal occupation of land is usually in the reserved forest areas or in the other Government land. Under the Land Code 1954, there are two major forms of documents evidencing rights in land in Thailand.

7.2.3.1 Title deeds (Chanod-NS4)

Physically, a title deed is a certificate of ownership supported by a deed plan. Legally, this document evidences full ownership and enables the owner to sell, transfer and legally mortgage the land. It is issued on the basis of a precise survey with clear identification of the property marked by boundary stones and is registered in the provincial or Bangkok land register office. Two copies of title are prepared for each piece of land, the original being kept in the land office and the duplicate being given to the owner. Figure 7.1 shows the office copy of title deed with its identifiers.

7.2.3.2 Certificates of utilization or "Exploitation Testimonial" (Nor Sor Sarm-NS3, and Nor Sor Sarm Kor-NS3K)

This document certifies that the occupant has made use of the land for a prescribed period of time. Once certain conditions are satisfied, the existing legislation provides for the conversion of this document (NS3 or NS3K) to a full title deed (NS4). The law allows sale, mortgage and other transfers utilizing these documents to record the transaction.

While the above documents (NS4, NS3, and NS3K) are the only documents which allow the owner to freely and legally transact a given tract of land, there are several other documents which provide evidence supporting a farmer's ownership claim. These documents, NS2 (Bai Chong) and SK1 (Sor Kor Neung), do not certify secure legal ownership. The four forms of private ownership documents confirming rights to land recognized by the Land Code 1954 can be summarized as follows:-

Type of documents	Procedure coincidance with the issue
Title deed (Chanod or NS4)	Boundaries are surveyed by conventional ground methods
Certificate of Utilization (Nor Sor Sarm or NS3)	Boundaries are measured in isolation by triangle method (chain survey method)

(Nor Sor Sarm Kor or NS3K)	Boundaries are taken from maps prepared from unrectified photography
Pre-emptive Certificates (Bai Chong or NS2)	A certificate authorizes temporary occupation of land, by metes&bounds
Claim Certificate (Sor Kor Neung or SK1)	A claim is made by a person in possession prior to Land Code 1954

Documents Contained in Land Code

Documents issued by other government departments which certify the use of land are as follows:-

Departments	Documents
Public Welfare Department &	NK1
Co-operative Promotion Department	NK2
Amphur (District) Land Office	PBT6 (Por Bor Tor Hok) - use of land on payment of tax
Royal Forest Department	STK (Sor Tor Kor)

Document not Contained in Land Code

Approximate number of parcels in Thailand under the types of title are as follows:-

Title deed - NS4	3.7	million
Certificate of Utilization	8.3	,,
Government Land (approximate)	0.5	,,
Undocumented Lands (approximate)	2.7	,,
Illegally occupied lands within foerest reserves (approximate)	1.0	,,
	16.2	,,

Source: (Williamson 1983)

At present, the DOL administers the cadastral systems in Thailand through five major functions of its responsibilities:-

1 Registration of rights in lands and the maintenance of an efficient recording and conveyancing system;
2 Cadastral surveying and mapping of all land parcels in Thailand;

3 The issue of land related documents - title deeds, certificate of utilization;
4 Land valuation and land taxation; and
5 Land administration.

All these functions generate the basic data which are the key elements in parcel-based LIS development.

7.3 Sources of Land Information

The major sources of land information in the DOL come from:-

1) The cadastral maps;
2) The survey files;
3) The dealing files;
4) The registers, containing the office copies of title deeds and certificates; and
5) The valuation and tax roll (ch.5).

These existing records have their characteristics and essential indices as follows:-

7.3.1 The cadastral maps

They are produced at scale 1:4000 as a base map for rural area and scale 1:2000, 1:1000, or 1:500 in urban area, the scale depends on the density of land parcels in that area. Parcel numbers are shown on the face of the map. A table at the bottom shows parcel number and area. This table links the parcel number to the parcel file. Each cadastral map sheet has an index book associated with it which contains the original parcel number reference to the survey file for that parcel. The parcel number is issued relative to the cadastral map based on map scale 1:4000 covering the area of the parcel. Upon new compilation of the map, they consist of 4 digit numbers and are numbered consecutively from the top left corner working across the sheet from left to right, in bands of definable width, and working down the sheet. Upon subdivision, one parcel retains the old number while others are given the next consecutive number available for the map. Upon enlargement of part of the map, the parcels are renumbered starting though with the next available number from the old map. A new index book is started. A separate index book for each map sheet shows:-

Transaction No.	Parcel No.		No. of Parcels	Person Making Entry
	From	To		
N346/84	7708	7711	4	
N698/84	7712			

The transactions are numbered in order of receipt on an annual basis.

7.3.2 Survey files

Survey files contain survey and subdivision information for each parcel and a survey plan. The survey file is filed under map sheet number and parcel number. An index book is used for cross reference from parcel number to survey file number.

7.3.3 Parcel files

Parcel files are held for each parcel and contain a record of all transactions in chronological order and the chanod (title deed) number. They are filed in order under district and locality name. The title deed may be accessed by the chanod number.

7.3.4 The registers

These contain the office copies of title deeds and certificates of utilization which were mentioned above. The following describes the parcel identification (PID) of the title deeds and the searching procedure in the land office.

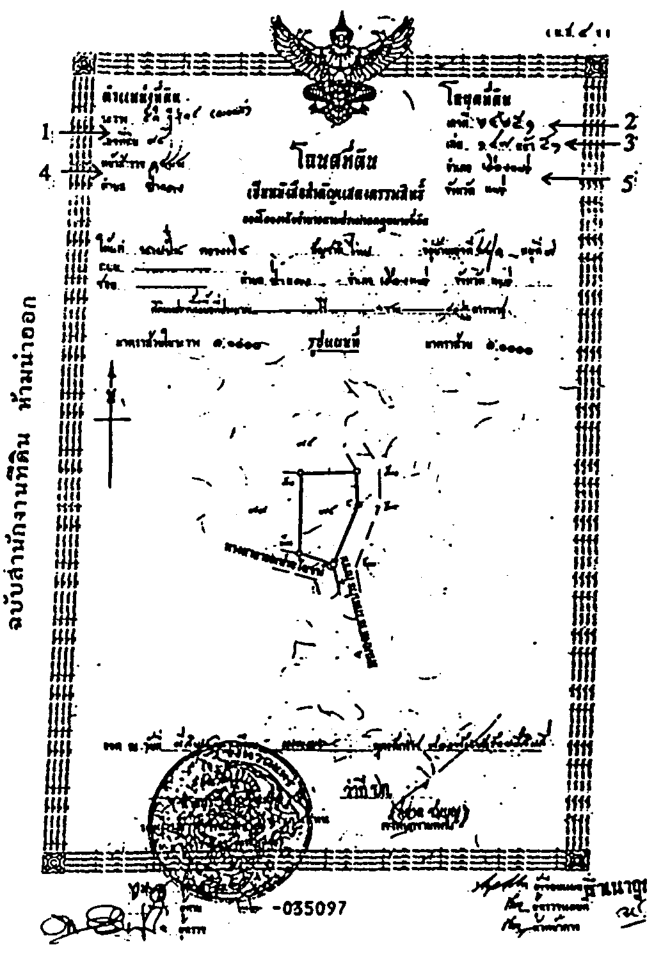
The title deeds (NS4) have their PID as follows (refer to figure 7.1):-

1 Map sheet number and parcel number on map;
2 The chanod number issued consecutively on a amphur (district) basis;

3 The title's book and page number related to the changwat (provincial) land office where the title is held;

4 The parcel's tambon (locality) number and tambon name (title deeds) are adjudicated consecutively from number one in each tambon. Upon new compilation of the cadastral map, the tambon number is not used anymore; and

5 District name and provincial name.



1 = Map number in the old system and parcel number within map
2 = Title number
3 = Book/page number
4 = Parcel number within tambon (locality) and tambon name
5 = District name and provincial name

Figure 7.1 Office Copy of Title Deed with its Identifiers

7.4 Title Deeds Searching at the Land Office

The manual search procedure for information in the land office depends on the cadastral map condition to start with. It could be one of the following procedures:-

1) Cadastral maps are not up-to-date, the procedure is to use the most recent cadastral plan available to obtain the original parcel number. The survey file index book is used to cross reference from the parcel number to the survey file number. The survey file is then used to obtain the tambon number from where the dealing file can be accessed. The procedure finishes with finding the chanod number.

2) Where up-to-date cadastral maps are available, the procedure starts with the parcel number and tambon number from the map. The tambon number is then used to access the parcel file to find the chanod number. Alternatively, after obtaining the dealing number, the parcel number index can be used to find the book and page number of the title.

Since the title deeds are referred to the cadastral map for searching, the following figure 7.2 shows how map sheets are referenced. This map sheet is in the old system based on the 29 independent origins. The origin of this map is the point at the golden pagoda in Bangkok. The base map sheet is at the scale of 1:4000 covering the area of 2×2 km^2. The identification 1S and 1E means this map is on the south and the east of the origin by one map sheet at scale 1:4000. Then this base map is further rescaled for larger scales of 1:2000, 1:1000, and 1:500 as required.

Upon new compilation of the cadastral map, the map is computed in the UTM co-ordinate system. The base map scale is still at 1:4000 covering the area of 2×2 km^2, but the map sheet is referenced with UTM grid co-ordinates of the National Topographic map scale 1:50,000 of the RTSD as shown in the figure 7.3. Figure 7.3 shows the portion of the topographic map scale 1:50,000 in Bangkok area. Each map sheet has 15' $\times$ 15' format and UTM co-ordinates. The shading area is identified as 5136 III.

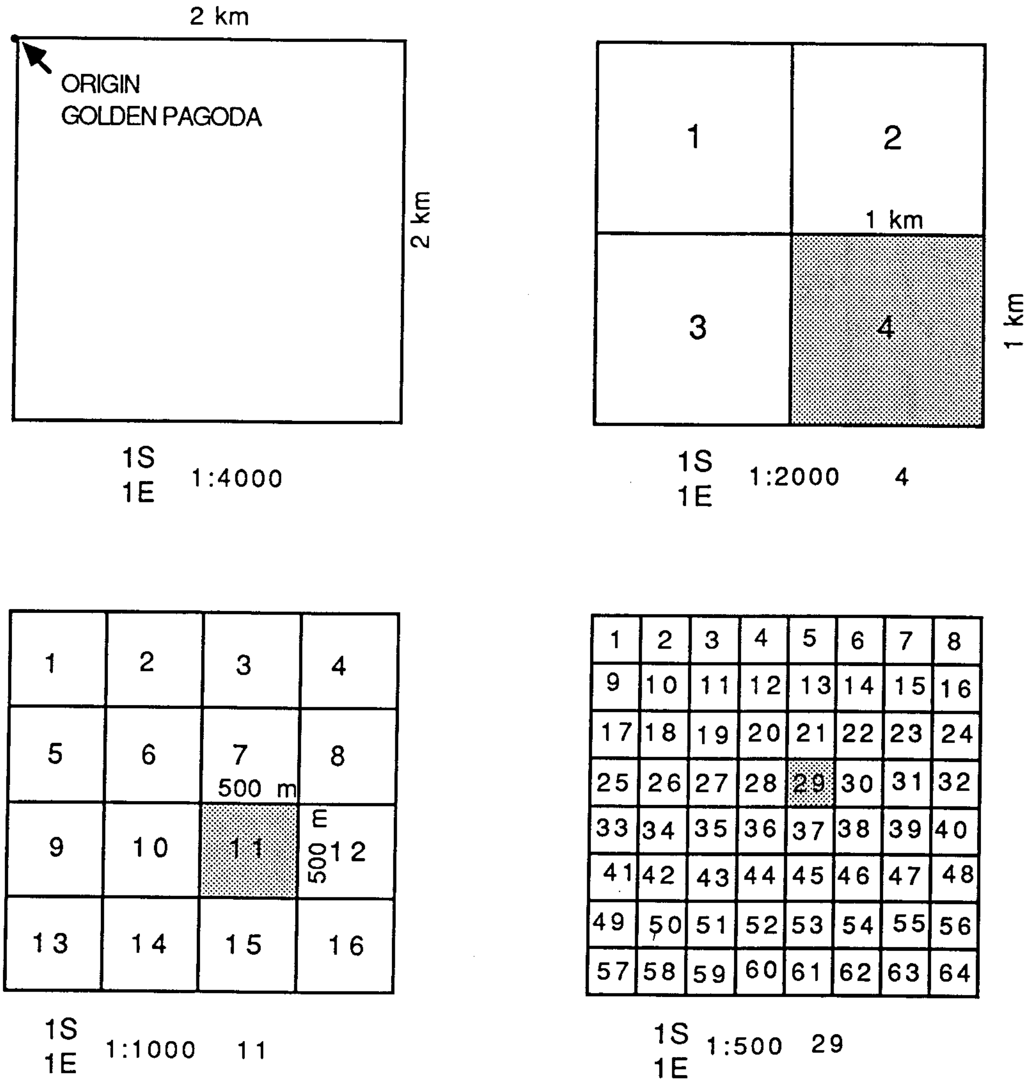


Figure 7.2 The Old Numbering System for Survey and Land Records

Figure 7.4 shows the base map scale 1:4000 which is compiled with reference to topographic grid map scale 1:50,000. The map format is 500 × 500 mm^2 and covers the area of 2 × 2 km^2. Each map is a multiple of 2 km from origin both in easting and northing. The base map is defined by the topographic map scale 1:50,000 in which the cadastral map is located and the tenth of km of easting and northing UTM co-ordinates. As shown in the figure 7.5, the base map 1:4000 is defined as 5136 III - 7214.

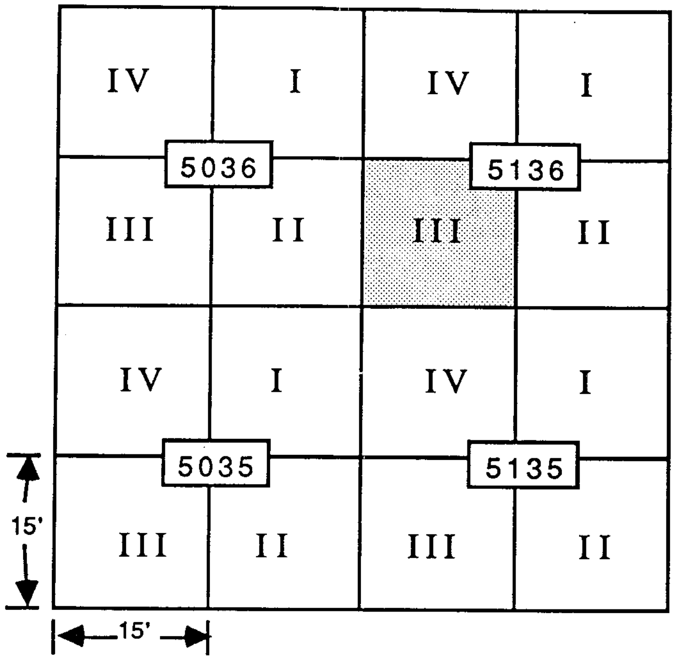


Figure 7.3 National Topographic Map Series L-7017, Scale 1:50,000
Royal Thai Survey Department, Ministry of Defence

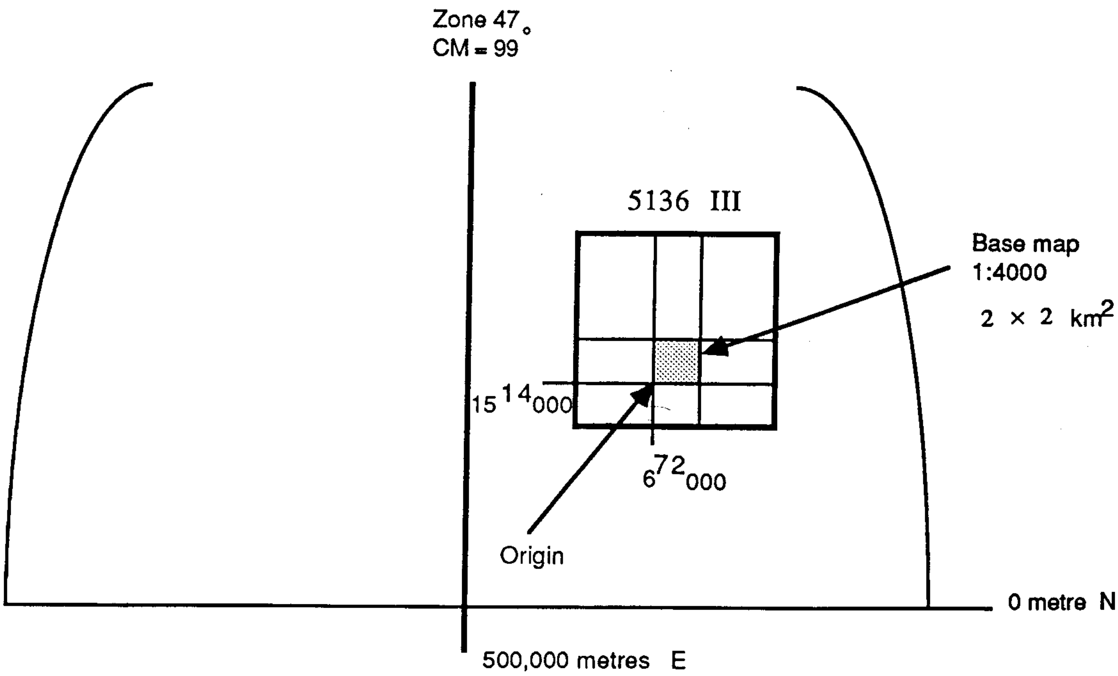


Figure 7.4 Cadastral Base Map Scale 1:4000 with Reference
to the Topographic Map Scale 1:50,000

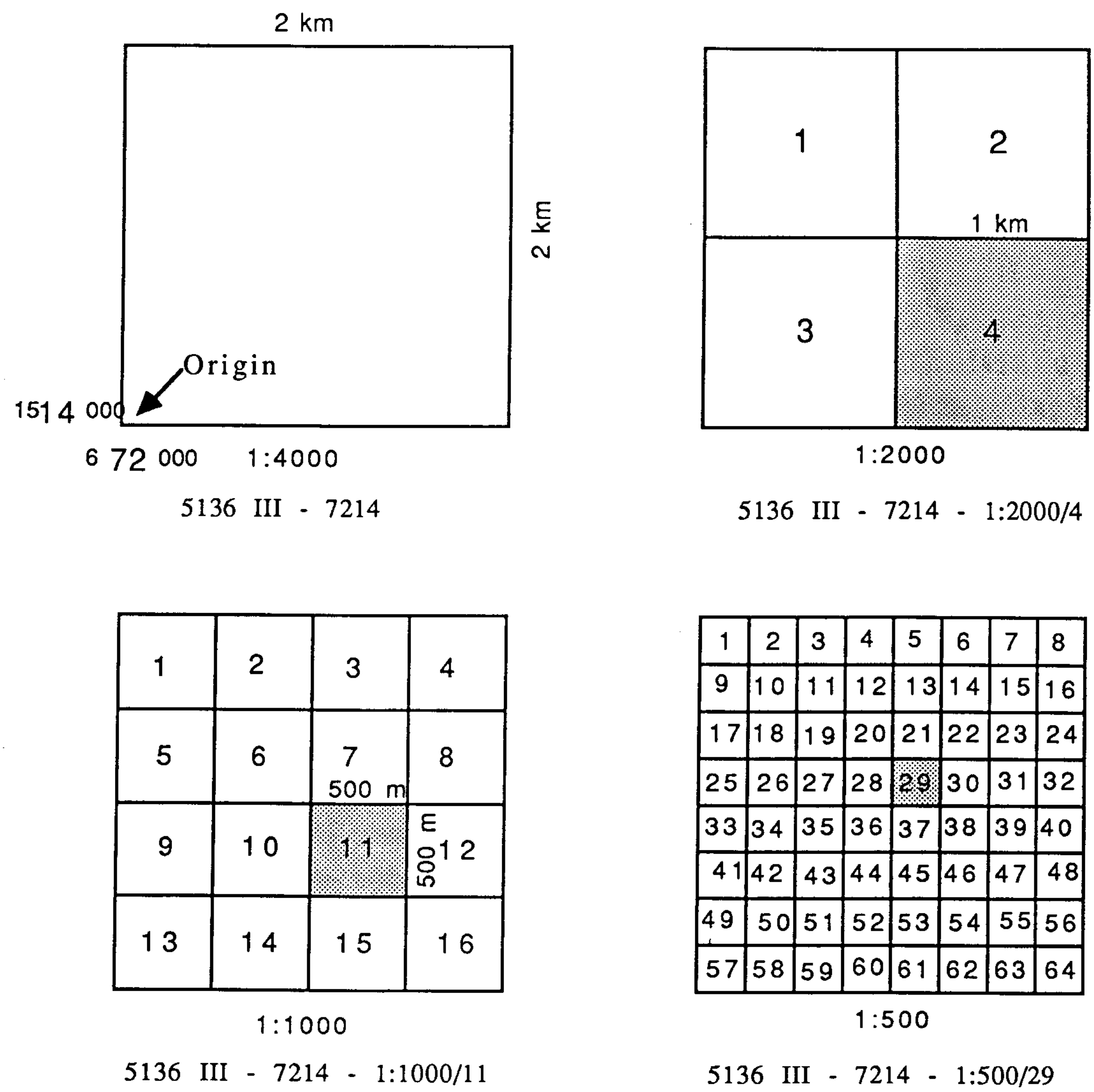


Figure 7.5 The Numbering System of New Cadastral Maps in UTM Co-ordinate with Map Sheet Identifiers

A cadastral map of scale 1:4000 is produced for rural areas where a land parcel is large enough to be plotted on the map. In urban areas where land parcels are small and dense, larger scale maps are produced at different map scales. For scale larger than 1:4000, the map sheets are identified by their scale and their quadrant based on the standard 1:4000 square map grid.

Scale	Quadrant
1:4000	-
1:2000	1 - 4
1:1000	1 - 16
1:500	1 - 64

All land parcels will be referred to the map sheet identifier in the UTM system. An investigation of a parcel numbering will be a basis for proposing unique land parcel identifier.

7.5 Current Parcel Numbering

The DOL must aware that the land parcel identifier (PID) is important for parcel-based LIS development. The PID must be unique in itself. The unique characteristic of PID means no other land parcels should be capable of having the same identity, and the PID should not be subject to change. These characteristics are important not only for the internal needs of the DOL but for the linkages between the DOL and external agencies' land information.

The parcel number presently used is not unique in itself but only becomes unique when relating to the relevant map. For example, the land parcel number 3442 has to be related to the map number and scale such as 5136 III - 7214 - 1:1000/4. Thus, the PID is 5136 III - 7214 - 1:1000/4 - 3442. In my opinion, this PID still has the disadvantage of being subject to change, when the map is rescaled the land parcel is renumbered again. Thus, the parcel numbers should be independent of the map number.

Another alternative is to use the chanod (title deed) number. The chanod number is issued on the amphur (district) basis starting from number one in each amphur. But it still involves problems with the administrative boundary, since there are about 10 changes in amphur boundaries each year (Department of Lands 1984). This change involves the movement of a tambon (locality) from one amphur to another.

When there is such a change, the method used is to divide up and re-allocate records in amphur land offices as they are filed and indexed on a tambon basis. Records in changwat (province) land offices are not changed initially. If a subdivision or dealing occurs with the land in a tambon that has been the subject of change, the new amphur name is added to the existing titles. New titles are allocated a chanod (title deed) number in the new amphur. Old titles are not renumbered in the new amphur. It is therefore possible in the existing system for two titles to have the same chanod number within the one amphur. Therefore, this creates the problem of the uniqueness being dependent on a numbering system based on amphur. For this reason, the use of chanod number as the sole parcel identifier is not suitable.

The next alternative is the use of a parcel number that is area based, rather than map based. The number is allocated within a 2×2 km^2 map grid square. But this is still not appropriate because the town planning in urban areas is very poor. There are many sub-road or soi with no names and areas are not in block shape. This procedure is suitable only for the areas which are formally zoning.

From the above investigation, the existing parcel referencing system is unwieldy because of the number of different identifiers and indexes used and their non-uniqueness.

7.6 Proposed Unique Land Parcel Identifier

The objective of the proposed PID is to simplify the system and provide an identifier which will not be the subject of change even if the administrative boundary changes or the cadastral map is rescaled. This will be the basis for computerized parcel-based LIS development of the DOL and provide for the link with outside departmental LIS.

The purpose of the proposal and view expressed in this section is to provide an alternative assignment of the PID to the land parcel. The DOL may or may not accept this proposal but it should be investigated Moreover, the programmes of issuing personal identification by the Department of Administration and personal income tax identification by the Department of Revenue should be closely investigated to take the advantage of the methods used.

7.6.1 Land parcel identifier (PID) characteristics

A land parcel identifier can be defined as a code that is assigned to each parcel for which the DOL is responsible. It is regarded as uniquely distinguishing them for the purposes of record keeping and providing for the key access to land information. It might be referred to an abstract of a full legal description of spatial referenced information. The design of PID must meet some of the following criteria both in initial selection and subsequent control.

1 They should be unique to the jurisdiction and to all land parcels in the country.
2 They should not change when administrative or cadastral map boundaries change.
3 They should be chosen with regard to possible future subdivision.
4 Upon subdivision, the old PID should be dropped from use and a new PID used for new parcels. This will ensure that the PID is unique at all times.
5 They should be simple, logical, and useful for users.
6 They should be flexible allowing other agencies to use them, and as well be useful for both manually and computer processing.
7 They should be memorable by human beings.
8 They should provide direct access to parcel files and require no other reference index.
9 They should not vary according to the type of land certificate.
10 They may contain a direct/indirect reference to the parcel location.

PID may be classified as either non-locational or locational. Non-locational identifiers may be characterized as name-related identifiers or alphanumeric identifiers (National Research Council 1983). In a name-related code, parcel records are filed according to individuals and legal entities claiming an interest to a land parcel such as the grantor-grantee index. These non-locational identifiers are not suitable in that the name of a person is subject to change and multiples of the same name often occur. This creates problems about uniqueness of the land parcel identifiers for data index, data updating, data retrieval etc. The alphanumeric identifiers, on the other hand are random numbers assigned to a parcel. This identifier is also not suitable because it is quite ambiguous in that it is not fixed with respect to definable objects such as person or cadastral map etc.

Locational identifiers, on the other hand, give the location explicitly or implicitly and serve as a record index. They can be categorized into 3 main types: hierarchical identifiers, co-ordinate identifiers, and a combination of the first two identifiers (National Research Council 1983). Firstly, the hierarchical identifier is based on a graded series of political units. For example, administrative boundary can be divided into: country, region, province, district, locality, etc. respectively. Mapping boundaries can be sub-divided as a cadastral map sheets at different scales from small to large scale. Within the smallest territorial unit, random parcel codes may be assigned. Identifiers of this type may be:-

- region code, provincial code, district code, locality code and parcel number issued within the locality;
- district code, street code, house number;
- sequential parcel number relative to an administrative district (political);
- a sequential parcel number issued on a jurisdiction basis;
- title number (issued on the district basis);
- valuation number issued on a property number and local government number;
- a sequential number relative to a cadastral index map;
- a sequential parcel number relative to a survey block

district (non-political); and

- parcel number and survey plan number.

Secondly, the co-ordinate identifier relates a parcel to a reference ellipsoid either through the use of geodetic co-ordinates or state plane co-ordinates, e.g., UTM. Any point within the parcel, usually the centroid of the land parcel, is chosen for the assignment of the co-ordinate identifier. The co-ordinate identifier is quite suitable for record index because it is one value that can serve to indicate the parcel's standing both on ground and on map. It is unique for each land parcel and suitable for computerized LIS. Some argue that the co-ordinate identifier may not be easy to use for the people who do not understand the mapping system. This argument is not significant because the identifier would be just a number identifying the location of the land parcel. There is no need for people who own the land parcels to understand the mapping system because from this PID the computer, or DOL's staff if operated manually, can access the relevant map sheet and land information as required.

Lastly, the identifier may consist of a combination of hierarchical and co-ordinate coding to form a hybrid idex. Point accuracy determination is a main requirement of this identifier. This approach will be chosen for the proposed identifier of the land parcel in Thailand. First of all, the institutional structure of the DOL and the DOA should be mentioned.

7.6.2 Institutional structure background

The structure of government administration consists of the central government, ministries, departments, divisions and sections in a hierarchical order. The DOL and the DOA are under the administration of the Ministry of Interior with the structure as shown in figure 7.6.

The administration of land office in the DOL relies on the administrative boundary of the DOA as shown in the figure 7.7.

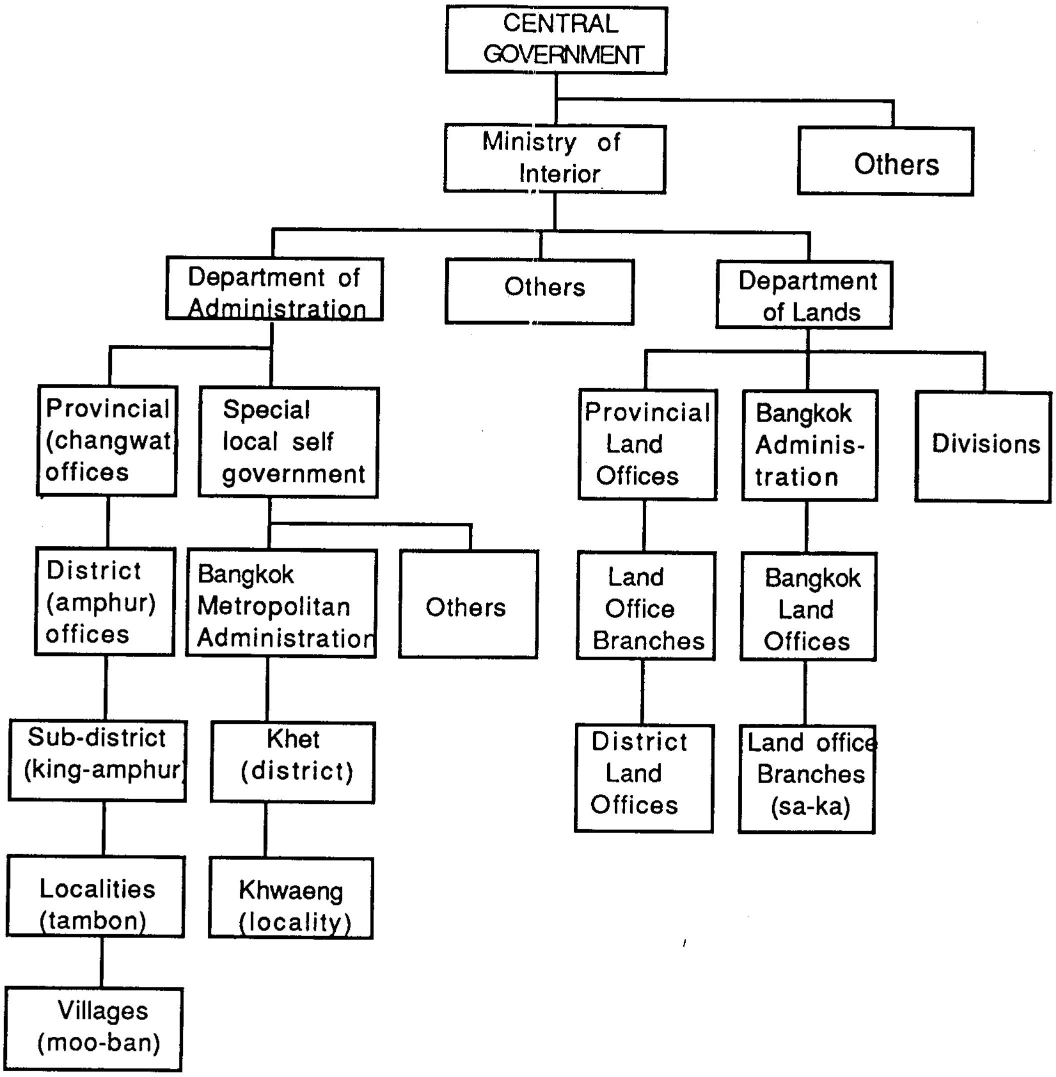


Figure 7.6 Administrative Structure of the DOL and DOA Comparison

The DOL administers two independent cadastres. Provincial land offices administer the land "title deed" system and the district land offices administer the certificate of utilization. The two systems are generally not compatible and no single system portrays the overall cadastral framework. In the future, after the conversion of certificates of utilizations to land title deeds is completed, the district land offices will administer the land title deeds in the same way as the provincial land offices. All these administrative structures are the basis for the proposed PID.

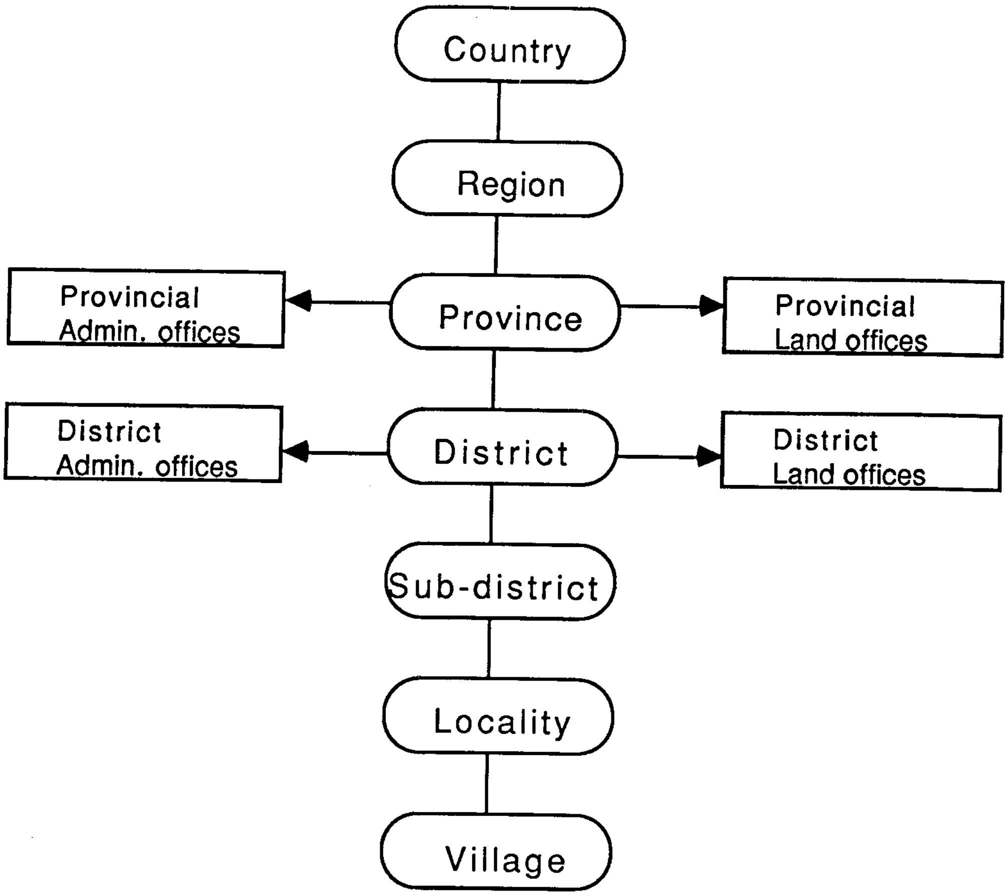


Figure 7.7 Hierarchical Order Administration of Land Offices According to the Administrative Boundary in Thailand

7.6.3 Components in determining the PID

1) There are about 13 million land parcels throughout the country which will be issued with the title deeds by the Land Titling Project.
2) Thailand is generally divided into 5 regions which are northern, northeastern, central, eastern, and southern.
3) There are 73 provinces and 73 provincial land offices which administer the land title deed system.
4) There are 684 districts and 684 district land offices which administer the certificate of utilization system.
5) As reorganization will be imposed after the completion of issuing title deeds throughout the country, the district land offices will administer the title deed system as the provincial land offices do now.

6) When there is a change of administrative boundaries of the DOA, the administrative boundary of the DOL also changes. The land title deeds are then moved from one land office to another.

7) The provincial boundary change seldom occurs, but there are about 10 district boundary changes every year. Thus, the provincial boundaries are more stable than the district boundary.

8) The PID in each province should be fixed by the region code and the provincial code. The region code and the provincial code if possible should be the same in either the one issued by the DOA or Postal Authority.

9) The PID for each province should be allocated based on the district. This means that the set of PID is allocated to land parcels in each district separately and reserved for any future subdivision. The number of PID numbers reserved in each district depends on:-
   - the area of that district
   - the number of land parcels in that district
   - the rate of subdivisions occur in that district per year
   - the urban growth in that district
   - the land use and land development in that district

10) As mentioned in section 7.6.1 the proposed land parcel identification is based on the hybrid index. Thus, the proposed identifier will consist of hierarchical and co-ordinate coding. The PID# which is the hierarchical part should be based on the fixed regional and provincial codes tagged with a sequential unit number. Also the co-ordinate identifier based on the land parcel centroid co-ordinates in National Map Grid Co-ordinate (UTM) is used to define the location of land parcel in the cadastral index map. Both identifiers are assigned to every land parcel regardless of the type of land tenure.

PID# is a primary key but the centroid co-ordinates also can be a primary key. Both are candidate keys in data base systems. These two keys uniquely identify the land parcel. But, PID# is used as a primary key because it is suitable for land record filing and compactness. On the other hand, the centroid co-ordinates are recognized as an alternative key even though it can also be used to access land records in a relational data base. The function of the primary PID and alternate PID will be discussed later.

Thus, the designed land parcel identifier for every land parcel throughout the country which is in responsibility of the DOL should be:-

PID# = R-PP-NNNNNNN

where

R is regional code starting from 1 to 5.

PP are provincial codes starting from 10 to 82.

NNNNNNN are parcel numbers starting from number 1 in each province. The set of parcel numbers in each province is allocated to the district land offices in that province. The total numbers must be more than enough for use solely in each district.

The primary parcel identifier consists of a number of 10 digits where the first digit is the regional code which may be one of the following:-

Region	Decimal code	Character code
Central	1	C
Northern	2	N
Northeastern	3	D
Eastern	4	E
Southern	5	S

The next two digits define the provincial code. They are ordered alphabetically in English starting from number 10 to 82. The province names and codes are shown in appendix 3.

The rest of seven digits represent the parcel number. They are consecutive numbering in each district based on the cadastral index map in that district. The allocation of PID# for land office should be the responsibility of the Land Document or Computing and Data Processing Division. The characteristics of this PID# are that:-

1 This PID# is unique for each land parcel. When a parcel is subdivided, the parcel number would be cancelled and the next available consecutive parcel number in the district adopted. This is part of the control of new parcel numbers. This would ensure that a parcel number is unique, and would avoid the present problem that a number could refer either to the remainder of a subdivided parcel or to the original parcel prior to subdivision as used in the old numbering system.

2 When there are administrative boundary changes the titles are moved from one land office to the other. But the PID# of the moved title is still the same because it is fixed by the regional code and provincial code of which the boundaries are seldom changed. The practice is to keep the old PID# initially from the former land office as long as no legal dealing with the moved parcel number occurs in the new land office. But the parcel file will have added to it the new provincial code, the new district code, and the new locality code. The input of PID# into the computer for searching land information will make the computer check for new codes in the parcel file against the PID#. If it is the old PID# from the former land office, the new code will virtually be used to link with other attributes within the data base. When the land parcel which has been moved due to the boundary changes is further subdivided, the new PIDs from the new land office are issued for new subdivided land parcels.

3 This PID# coincides with the centroid co-ordinates in UTM system, to define the location of land parcel on the relevant cadastral map.

4 This PID# provides direct access to the provincial land office which holds the land parcel.

5 All the dealing files involved with the land parcel must be filed according to the PID# because they are ordered chonologically and uniquely.

6 This PID# is simple, logical, and unique to all land parcels throughout the country. It is flexible allowing other agencies to link the data base by cross referencing to the PIN system of the DOA to access the personal details of the owner. It will be useful for the individual massive valuation of the CVA.

7.7 Comparison Between the Present PID and the Proposed One

The PID used now is referenced to the map sheet number and the map scale. To find the location of the land parcel from this PID, it is necessary to find the relevant map sheet first. Then the land parcel number in that map defines the location of land parcel. For example, the PID

"5136 III - 7214 - 1:1000/4 - 3442"

refers to the cadastral map no. 5136 III - 7214 - 1:1000/4 and parcel number 3442. There are 21 alphanumeric characters with this PID. The first part "5136 III" refers to the topographic map scale 1:50,000 no. 5136 III in which the cadastral map is located. The second part "7214" means the origin of the base map 1:4000 as shown in figure 7.4. The third part "1:1000/4" means the cadastral map scale 1:1000 and map sheet no.4 as shown in figure 7.5. The last one "3442" is the parcel number within that cadastral map.

The proposed one consists of two parts which are:-

PID# = "1120303591"

and Centroid co-ordinate of land parcel = "673157 - 1515919"

The function of this proposed identifier is shown in the figure 7.8.

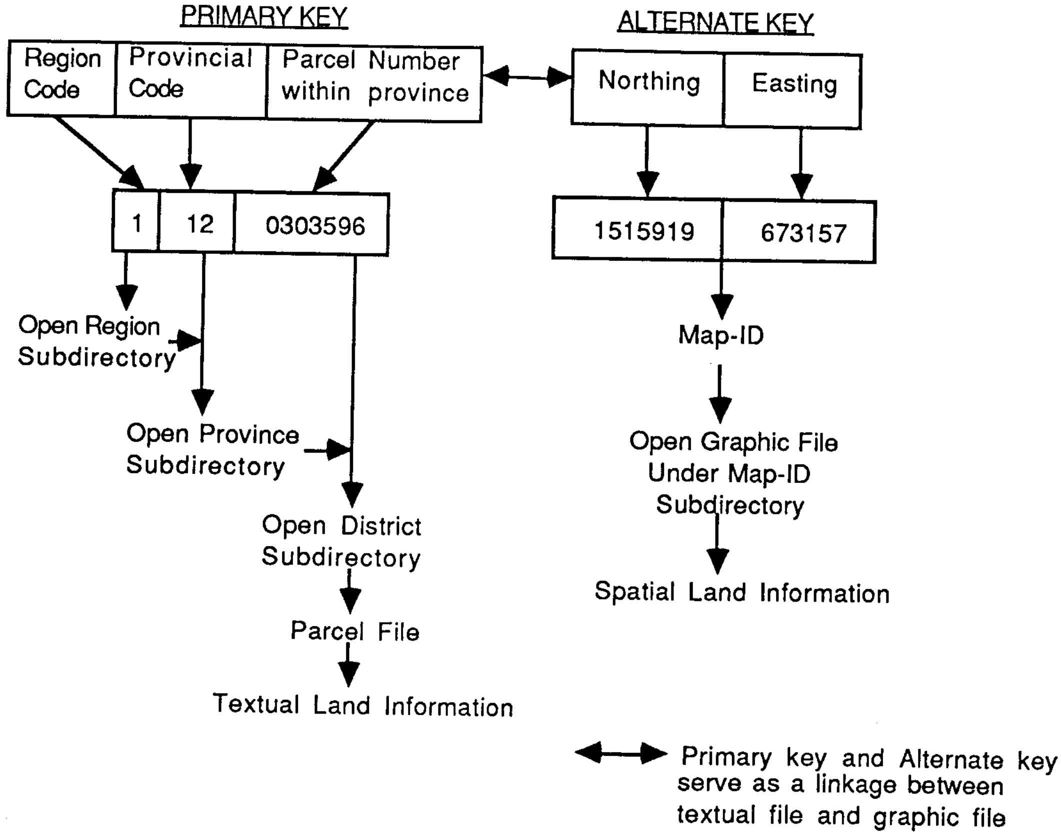


Figure 7.8 Function of PID# and Centroid Co-ordinate of Parcel

7.8 Conclusion

In the computerized parcel-based LIS environment, the uniqueness of the PID is important in data management. The PID must not depend on the map sheet number and map scale because the map sheet number will be changed when the map is rescaled. The new cadastral index map will be expressed as rectangular co-ordinates (UTM) with standard format and numbering with respect to the National Topographic map as mentioned before. Thus, the map sheet number is the only attribute which can be computed from the centroid co-ordinates of the land parcel and the co-ordinates of each map sheet extent using boolean logic test. By using the proposed parcel identifier, the PID will be independent from the map sheet number and map scale and unique for each land parcel. The introduction of this PID will be in the form of parcel identification card as shown in appendix 3. The purpose of introducing this card is to ensure that it does not disturb and change the existing title identification but provides for the cross-reference to the relevant title.

However, the allocation and subsequent control of the identifiers are as important as choosing the parcel identification system. The control of the new parcel number is involved with the subsequent allocation, re-allocation, and withdrawal of parcel identifiers due to the change in the configuration of the land parcel (e.g., subdivision, consolidation), since the original parcel remains as an historic entity, and the descriptions of it that were entered in the various registers and files. Thus, the identify of such "retired" parcels must be tagged in the record systems in the form of a redundant check digit. The practice is by adding a check digit at the end of an identifier.

In summary, for the whole system the proposed PID has far more advantages than the current PID which is dependent on map sheet number and map scale. This unique PID will be a basis for introducing computerized parcel-based LIS which will be described in the last two chapters.

8 DATA BASE SYSTEM FOR THE DOL's PARCEL-BASED LIS AND PRACTICAL WORK ON DIGITAL MAPPING AND PROGRAM DEVELOPMENT

" Once you have been to market, you have told the world. "

- *Russian Proverb*

8.1 Introduction

The essential part of the computerized parcel-based LIS for the DOL is the creation of an efficient data storage system which involves the creation of data base system to ease the manipulation and access strategy of the data. A data base system as defined by Date (1982) is basically a computerized record-keeping system; that is a system whose overall purpose is to maintain information and to make that information available on demand. The creation of efficient data base system will provide the DOL with the centralized control of its operational data (data for use in the DOL's daily operation, i.e., land parcel data, owner data, valuation data, surveying data, cadastral map data, and other administrative data) both textual data and spatial data. The benefits which will be gained from centralized data base and control are:-

- The distinct data files from various divisions in the DOL can be integrated to a unified DOL's data base. From this centralized data base, the same piece of land information can be shared by different users both within the DOL and other public and private sectors at the same time. This helps reduce the redundancy of data to be collected, stored and avoids data inconsistency.

- The centralized data base provides for the department to enforce all applicable standards, e.g., departmental, national, and international standards in the representation of the data. These standardized formatted data can then be interchanged between different systems.

- The centralized control will secure the DOL data base by providing the proper channel for user's access to operational data. The department can define authorization checks through each type of access (retrieve, modify, delete, etc.) to the DOL's land information. Thus, the application of security restrictions can be enforced.

In setting up the data base system, the DOL's data base must be independent of applications for two reasons.

1) Different applications will need different combination of the same data. Thus, the stored data must be in a standardized format or the DBMS must be able to perform all necessary conversions between the different stored representations chosen.
2) It will provide freedom to change the data structure or access strategy to satisfy user's special needs without having to modify existing applications.

The data base for the DOL's LIS would be categorized into 2 types- textual data and spatial data. The textual data base structure will be investigated first and then the spatial data base structure will be describeded later.

8.2 Textual Data Base

8.2.1 Data base structure

A data base is a collection of related data stored together for use by a number of users. It limits duplication of data items. The stored data can be used by various application programs in their operations for retrieval, updating, transforming and presentation. The updating and modification of data in the data base is common, controlled and undertaken once only. Data bases consist of files of data. The files can be of any structure made up of records either fixed length or variable length; records are made up of data items (fields). Data base structure generally can be divided into 3 main types which are relational, hierarchical, and network data structures. These three data structures will be investigated to find the suitable one for the DOL's LIS.

8.2.1.1 Relational data base structure

This section investigates the data base involving parcel details, owner details, and transaction details. Figure 8.1 illustrates the sample data in relational form where the data (details) are organized into three tables as shown in figures 8.1a, 8.1b, and 8.1c.

PARCEL Table (PARCEL RELATION)

PARCEL_ IDENTIFICATION	UTM_CENTROID CO-ORDINATES		UTM_ZONE	AREA	SALE _PRICE	← Domains
PID#	NORTHING	EASTING	ZONE	AREA	PRICE	← Attributes (Items)
PID1	N1	E1	1	A1	P1	← Tuples (Records)
PID2	N2	E2	1	A2	P2	
PID3	N3	E3	1	A3	P3	
PID4	N4	E4	2	A4	P4	

8.1a.

OWNER Table (OWNER RELATION)

OWNER-ID	OWNER_NAME	STATUS	DATE OF BIRTH
OWNER#	NAME	STATUS	BIRTH
OWNER1	J. WATTANA	1 (Single)	310762
OWNER2	T. VICHAI	3 (Divorce)	050158
OWNER3	T. ATHIKHOM	2 (Marry)	021056

8.1b.

TRANSACTION Table (PARCEL OWNER RELATION)

PID#	OWNER#	TRANSACTION DATE
PID1	OWNER1	230382
PID2	OWNER2	050183
PID3	OWNER3	310884
PID4	OWNER1	121085
PID1	OWNER2	230382
PID2	OWNER1	050183

8.1c.

Figure 8.1 Table of Sample Data in Relational Form

A relation or a table as defined by Date (1982) is that:-

"Given a collection of sets $D_1, D_2, ..., D_n$ (not necessarily distinct), R is a relation on those n sets if it is a set of ordered n- tuples $< d_1, d_2, ..., d_n>$ such that d_1 belongs to $D_1, ..., d_n$ belongs to D_n. Sets $D_1, D_2, ..., D_n$ are the *domains* of R. The value n is the *degree* of R."

Table or relation is usually a separate file. The basis for these tables are that there is a data type in the form of identification codes that are used as unique keys to identify the records in each file. The user has to define the relation by the methods of relational algebra that is appropriate for the query to extract data from a relational data base as mentioned in section 8.2.4.

For example, each land parcel has unique PID as proposed in previous chapter and each owner has a unique personal identification number issued by the DOA. All data in the tables are attribute values for a given land parcel/owner combination which provides consistency of data.

Figure 8.1a illustrates a relation called PARCEL. To familiarize the reader with this relational form, the following elements can be drawn from this table:-

1) Table in figure 8.1a is referred to as relation. It closely resembles a conventional sequential file.

2) Rows of this table which correspond to records of the file are referred to tuples. In the relational data structure, associations between tuples are represented solely by data values in columns drawn from a common domain as shown in figure 8.1a.

3) Columns of such tables which correspond to fields of the records are usually referred to as attributes. This term is ambiguous with the concept of the domain in relational theory. Attribute is usually a subset of domain. Thus, it is worth appreciating the difference between a domain and an attribute.

(i) A domain is a set of values from which the actual values appearing in a given column are drawn. It is defined in the appropriate schema and will have a name of its own. Domains drawn from PARCEL relation in figure 8.1a are:-

DOMAIN	PARCEL_IDENTIFICATION	CHARACTER (10)
DOMAIN	UTM_CENTROID_CO-ORDINATES	NUMERIC (13)
DOMAIN	UTM_ZONE	NUMERIC (1)
DOMAIN	AREA	NUMERIC (5)
DOMAIN	SALE_PRICE	NUMERIC (8)

These domains themselves are not explicitly recorded in the data base as actual set of values. The number of domains in the relation represent the degree of the relation, e.g., the domain of PARCEL relation represents a degree of 5.

(ii) An attribute on the other hand represents the use of a domain within a relation. Each attribute value in each tuple is non-decomposable. Attributes which are drawn from the domain may or may not have the same name. The distinction between names of attribute and domains in figure 8.1a is shown in figure 8.2.

DOMAINS	ATTRIBUTES
PARCEL_IDENTIFICATION	PID#
UTM_CENTROID_CO-ORDINATES	NORTHING/EASTING
UTM_ZONE	ZONE
AREA	AREA
SALE_PRICE	PRICE

Figure 8.2 Domains and Attributes Names within the Relation

4) Key, in relational data base, is one attribute with values that is unique within the relation. It is used to identify the tuples of that relation, and to distinguish that tuple from all others in the relation. A relation which constitutes one attribute

combination possessing the unique identification property is said to contain more than one candidate key. Figure 8.1a illustrates this situation where each land parcel has a unique parcel number and unique parcel centroid co-ordinates.
In such a case, if one of the candidates, i.e., PID#, is the key access to the relational data base, this candidate will be referred to as the primary key for the relation. A candidate key that is not the primary key, such as UTM_CENTROID_CO-ORDINATES represents alternate keys as mentioned in previous chapter of proposed unique land parcel identifier.

8.2.1.2 Hierarchical data base structure

The data in table form of figure 8.1 can be structured in the heirarchical form as shown in figure 8.3. This data structure is suitable for one-to-many relation.

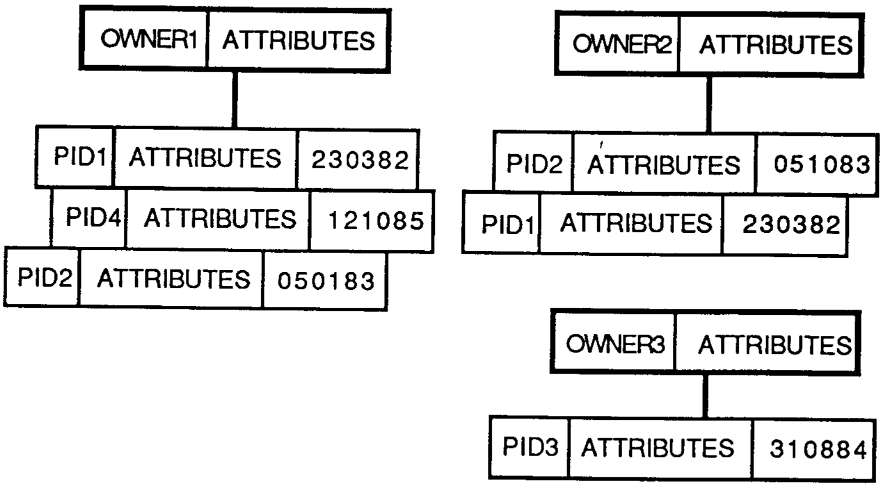


Figure 8.3 Sample Data in Hierarchical Form

Figure 8.3 illustrates a hierarchical owner and parcel data structure in a tree diagram, with owners superior to parcels. Each tree consists of one owner record occurrence (the parcel record in this type is known as the root), together with a set of subordinate parcel record occurrences (the owner record is called a dependent record type). The owner and parcel records are connected by a relevant transaction record which is called a link. This structure represents a one way relation descending from root to dependent records hierarchically. It represents asymmetry in data retrieval which can be viewed from the following query as an example, "Find the owners of land parcel#2". Since the land parcel#2 is dependent record on owner record, therefore this query requires the computer to search all owner record occurrences in the data base to find the owners of land parcel#2. This is a time-consuming process and will become more complex in program writing, debugging, and maintenance as more types of records are encountered.

8.2.1.3 Network data base structure

Figure 8.4 illustrates the parcels and owners data base (the same data in table form of figure 8.1) in the network model. This model consists of records and links. The records are categorized as the parcel, owner, and associate connector (transaction date) record type occurrences. The links or chains of pointers in this figure are placed on two sides, one parcel chain and one owner chain, and connected to relevant connector occurrences. Parcel chain starts at parcel occurrence, it is linked to corresponding connector occurrences and is returned to that parçel. A similar procedure applies to owner chain. The following examples discuss the work flow of the chain to link the parcel record occurrence with the owner record occurrences and vice versa.

Q.1: Find the owners of land parcel#1
Searching procedures for this question start at PID1 and work along the chains#1, #3, #15, #19, the process ends at owner1. Second search starts at PID1 again and work along the chains#1, #4, #16, and ends at owner#2. Therefore, the answer for Q.1 is that land parcel#1 is co-owned by owner1 and owner2.

Q.2: Find land parcels which are owned by owner1
Searching procedures start at owner1 and work along the chains#2, #4, #17, and the PID1 is found. Second search starts at owner1 and works along the chains#2, #3, #15, #18, and the PID2 is found. Third round starts at owner1 and works along the chains#2, #3, #14, and ends at PID4. Thus, the answer for Q.2 is that owner1 owns land parcels#1, #2, and #4.

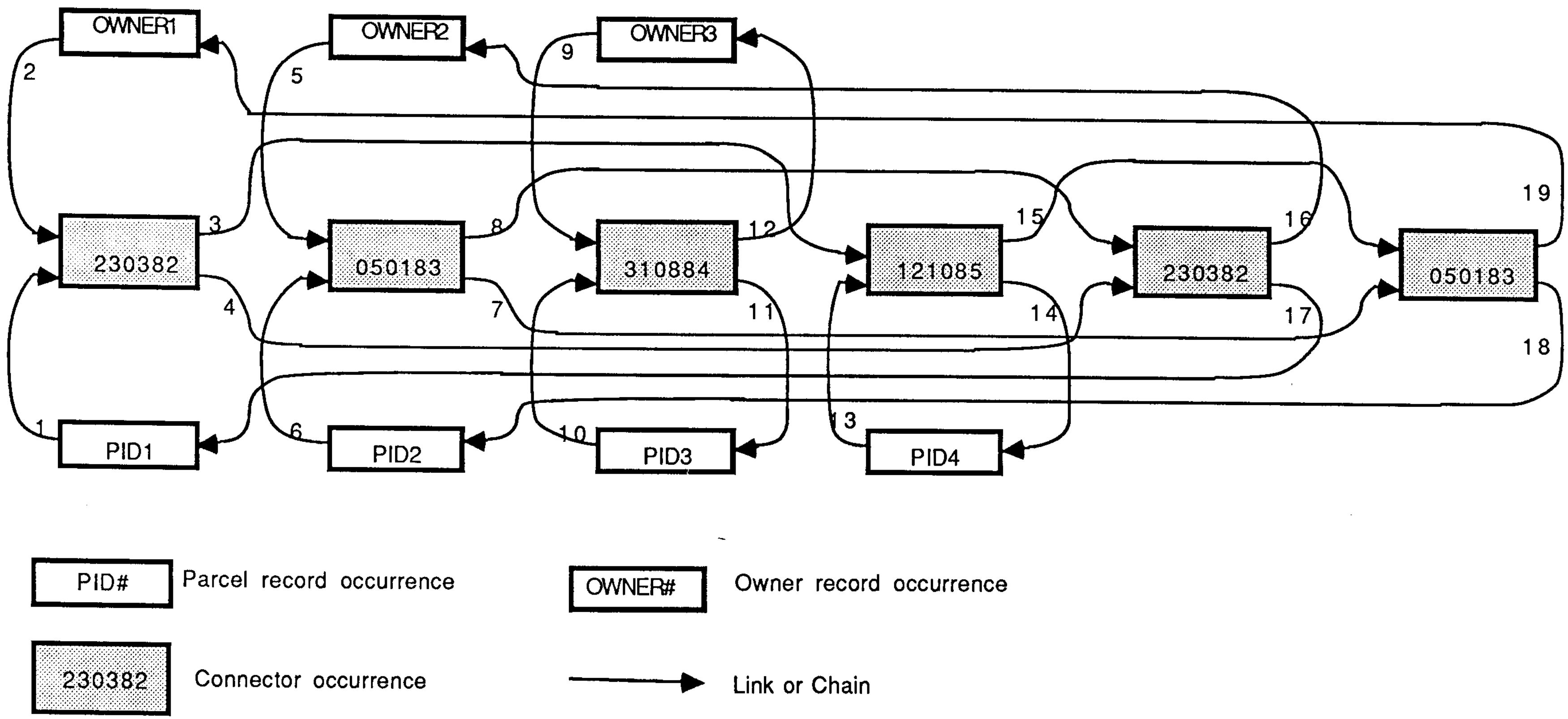


Figure 8.4 Sample Data in Network Form

Q.3:Find the owner# and parcel# that are registered in the land office on the date of 12/10/85

There are two strategies to deal with this query. First strategy starts at the owner#, i.e., #1 and scans its chain looking for a connector occurrence of 121085. From this connector occurrence, the software looks for the chain which links to the relevant PID#.

Second strategy starts at the PID#, i.e., #1, #2, #3, #4 respectively and scans its chain looking for a connector occurrence of 121085 and from this connector occurrence, looks for the chain which links to the relevant owner#. Both strategies require significant scan time through owner record occurrences, parcel record occurrences, and their corresponding chains. This involves a number of choices to be selected. The problem facing the user is which strategy should be adopted in searching the required data.

From these examples it can be concluded that the network approach can be used to model a many-to-many correspondence more directly than the hierarchical approach. But, this model is significantly more complicated than both the relational and hierarchical approaches when there are many data types involved. The following section will compare the update operations of the three data structures.

8.2.1.4 Update operation

Comparison of the update operations for the above three data structures is applied to figures 8.1, 8.3, and 8.4. The basic update operation involves functions INSERT, DELETE, and UPDATE respectively. The problems are simulated and the update functions are applied for each data structure.

Function : INSERT

Problem : From the systematic adjudication program in locality A by the DOL's staffs, the data of a new land parcel#5 is created and processed. If there is nobody claiming ownership of this new land parcel, how will this new land data is inserted into the data base.

Relational: The tuple from A is inserted into PARCEL relation under the parcel identification, PID5.

Hierarchical: This new land data cannot be inserted into the data base unless there is a person who can prove that he owns this new land parcel because the parcel record is dependent on the owner record. On the other hand, it is possible by introducing a special dummy owner to insert this land information.

Network: To insert this new land data, a new parcel record occurrence is created. Initially there will be no connector records for the new land parcel, its chain will consist of a single pointer from the land parcel record to itself.

Function : DELETE

Problem : Delete the transaction date connecting OWNER1 and PID1 because the ownership of this land parcel is changed.

Relational: The tuple is deleted from PARCEL_OWNER relation where PID# = PID4 and OWNER# = OWNER1.

Hierarchical: Delete transaction connecting OWNER1 and PARCEL4 involves with deleting the occurrence for PID4 under OWNER1. Since there is only one PID4 occurrence, the deletion of transaction date which is incorporated into parcel record type will cause all information on PID4 to be lost.

Network: The connector record occurrence linking OWNER1 and PID4 is deleted and the concerned owner chain and parcel chain will need to be adjusted. This will be a complicated task for a large data base which contains many types of data.

Function : UPDATE

Problem: The sale price of PID1 has changed from P1 to P1'.

Relational: The parcel tuple is updated where PID# = PID1 setting PRICE to P1'.

Hierarchical: Update process will encounter either the problem of searching the entire data base to find every occurrence of PID1, or the possibility of introducing an inconsistency where PID1 might have price, P1', at one record and P1 at another.

Network: Update process for price change of PID1 can be performed without problem because the price for PID1 locates at precisely one place in the structure.

The discussion of the advantages and disadvantages of these three data structures are as follows.

The advantages of relational data bases are that:-

- Their structure is flexible and can meet the demands of all queries that can be formulated using the rules of Boolean logic and of mathematical operations.
- They allow diferent kinds of data to be searched, combined, and compared.
- Update of data is easy.

The disadvantage of this data structure is that:-

- Many operations involve sequential searches through the files to find the right data to satisfy the specified relations; this is a time consuming operation. Thus, the structure must be rigorous.

The advantages of hierarchical data structure is that it is easy to understand, and expand.

The disadvantages of this data structure is that:-

- The structure is rigid, inflexible.
- Data retrieval can be done if the structure of all possible queries can be known beforehand.
- Large index files have to be maintained, and certain attribute values may have to be repeated many times, leading to data redundancy, which increases storage and access costs.

The advantage of the network model is that it avoids data redundancy and makes good use of available data. The disadvantages is that the pointers must be updated/maintained every time a change is made to the data base and the building and maintenance of pointer structures can be a considerable overhead for the data base system.

From the discussions of update operation for the three data base structures, it is concluded that the hierarchical structure is not practical itself especially for data retrieval and data update when compared to relational and network approaches. However, the network approach is complicate both in the data structure itself when many record types are encountered, and in the associated data manipulation language. In terms of simplicity of data structure and data manipulation language, consistency of data, the relational approach would be suitable for DOL's data base. The discussion following this section will be concerned the relational data structure.

8.2.2 Record structure

The data files are structured in the form of tables of records. The simplest type of record is a one-dimensional array of fixed length, divided into a number of equal partitions called fields or items as shown in the figure 8.5a. The fixed length record represents the one-to-one function because each land parcel carries its attributes which are unique in themselves. However, in the large data base environment, the searching capability is essential. The data record of the DOL's data base will contain mainly parcel, owner, and valuation attributes. An investigation of the DOL data record found that the DOL data records can be one of:-

- One person may own many land parcels.
- One land parcel may be owned by many people:- co- owners.
- one property (building) may occupy many land parcels.
- One land parcel may be occupied by many properties.
- One person may own more than one property.
- One property may be owned by many persons.

This forms a one-to-many function. Thus, fixed length records are inconvenient, when the attributes are of variable length, and when the set of attributes recorded is not common to all items. In these situations, the relationship of data in the form of data index with variable length records should be created for efficient data retrieval. Each record has a "header" which is an extra attribute that contains information about the type of information in the sub-record, the amount of space it takes up, and the data contained in the record. This variable length record is shown in figure 8.5b.

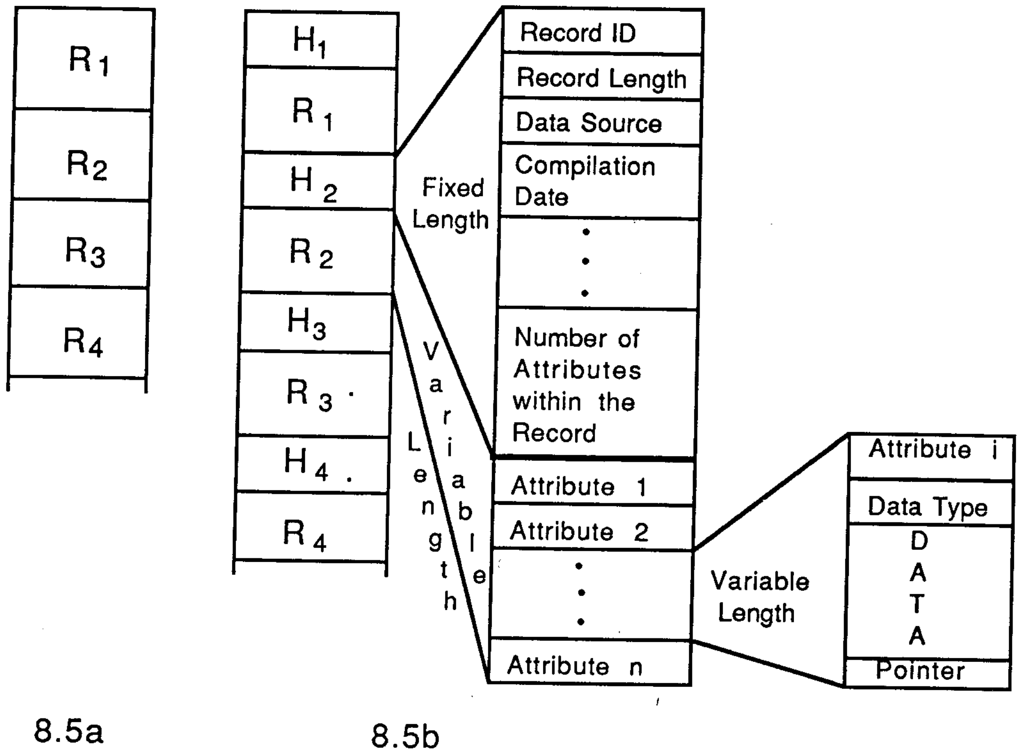


Figure 8.5 Fixed Length Records and Variable Length Records Including a "Header" H to Record Data about the Record itself

8.2.3 The DOL's data base system design concept

8.2.3.1 Data base configuration design

The design of the DOL's data base system should be based on three levels: internal, conceptual, and external as shown in figure 8.6. The internal level concerns the way in which the data is actually stored. The external level, on the other hand, involves with the way in which the data is viewed by individual users whereas the conceptual level refers to the data definition between the two. To familiarize the reader with these three levels of viewing the data base design, a simple land parcel data base structure is used to be illustrated in figure 8.7.

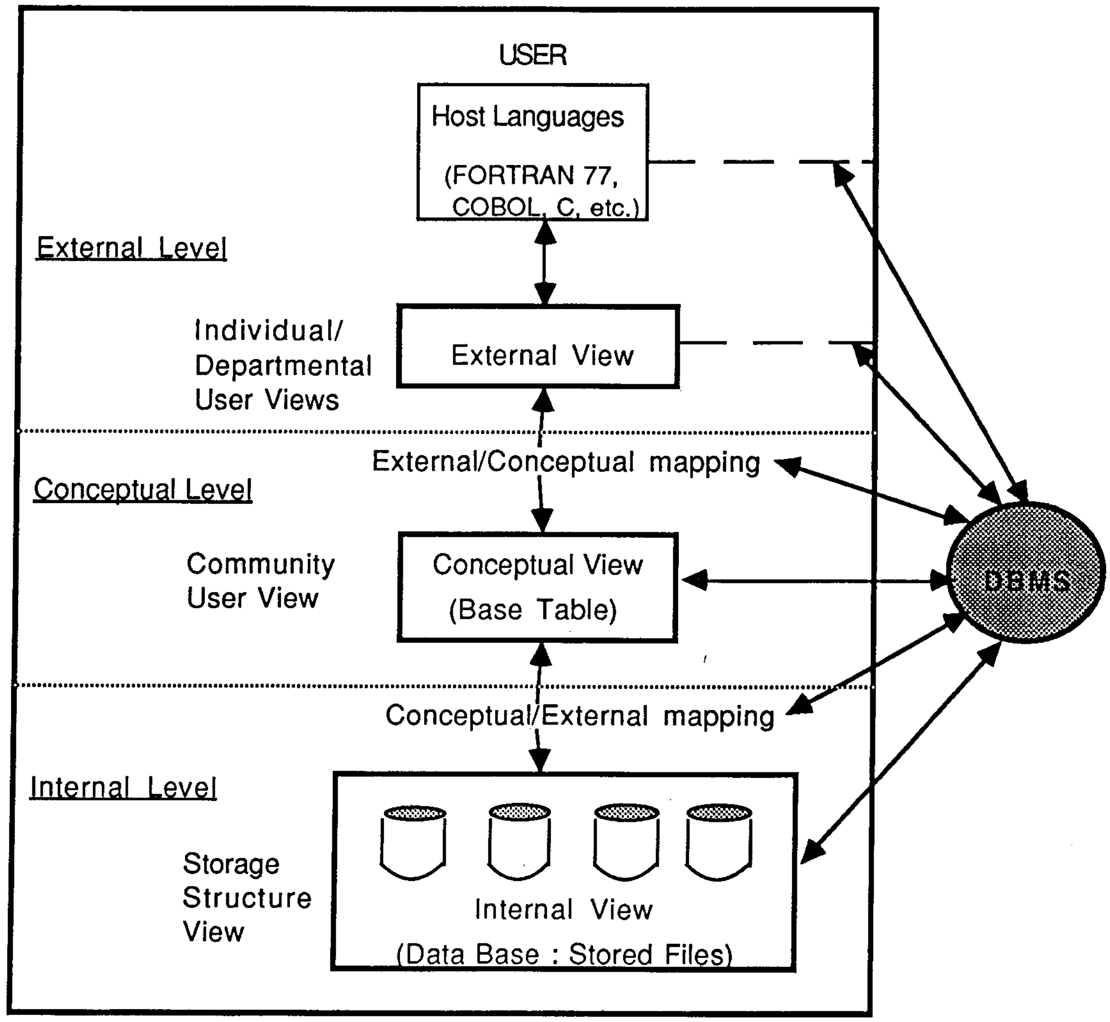


Figure 8.6 Data Base System Configuration Concept for the DOL's LIS (Adapted from Date 1982)

Figure 8.7 can be interpreted as follows:-

- At the conceptual level, an entity type called PARCEL consists of definitions of attributes called PARCEL_IDENTIFICATION (ten characters), an AREA (five digits), and a SALE_PRICE (eight digits). This is part of data dictionary for the data base.

- At the internal level, parcels are represented by a stored record type called STORED_PCL, twenty five bytes long. STORED_PCL consists of four stored field types: a ten-byte header (containing information about stored record such as flags or pointers) and three data fields correponding to the three attributes of PARCEL. STORED_PCL records are indexed on the PCL# field by an index called DISTRICT. This is part of stored data files or data base within the computer.

- The FORTRAN user has an external view in which each parcel is represented by a FORTRAN record type containing the three corresponding data fields as in conceptual level with the normal FORTRAN rules. The different names of the same objects at the three levels are commoned together via the mapping between levels, i.e., conceptual/internal mapping and external/conceptual mapping. This is part of data manipulation language concerning the set of commands as a means of data manipulation of the data base and the data dictionary.

External	$ DECLARE CHARACTER PID*10 REAL AREA, PRICE
Conceptual	PARCEL PARCEL_IDENTIFICATION CHARACTER (10) AREA NUMERIC (5) SALE_PRICE NUMERIC (8)
Internal	STORED_PCL LENGTH = 25 HEADER TYPE = BYTE (10), OFFSET = 0 PCL# TYPE = BYTE (10), OFFSET = 10, INDEX = DISTRICT AREA TYPE = BYTE (2), OFFSET = 20 PRICE TYPE = FULLWORD, OFFSET =22

Figure 8.7 Data Base System in Three Levels

8.2.3.2 Possible relational data structure for the DOL's LIS

Since many operations in the relational structure involve sequential searches through the files to find the right data to satisfy the specified relations, searches may take a considerable time with large data bases even on fast computers. Thus, the design of data bases for DOL's LIS is very important. The DOL must investigate the one which supports the search capabilities with reasonable speed. Figure 8.8 illustrates the concept of a proposed relational data base structure. The parcel-owner, parcel-valuation, and owner-valuation are the variable length records as illustrated in figure 8.5b which serve the one-to-many functions of the above assumptions in section 8.2.2. These files act as the index files in the defined level. The key access to the DOL's LIS then can be by the PID, PIN or Personal Income Tax-ID, Property-ID (House Number, Pipe Water Metre Number etc). On the other hand, the parcel, owner, and valuation attribute files are fixed length records which serve the one-to-one function of the primary key and associated attribute. For example, the parcel file contains PID as the primary key with associate attribute about the parcel address, area, type of tenure, current land value, date of last registration, type of last registration etc.

These relational structures are flexible so that they can meet the demands of all queries that can be formulated using the rules of boolean logic and mathematical operations. This allows different kinds of data to be searched, combined, and compared. The additional or deletion of data items in the record can be performed on an individual tuple. The key access to the attribute file should be by key in the PID, Owner-ID, or Property-ID. The relation files which serve as a one-to-many function will be used to cross reference to each other comprehensively to meet the end user's land information requirements. This is part of a data base management system which will be discussed later.

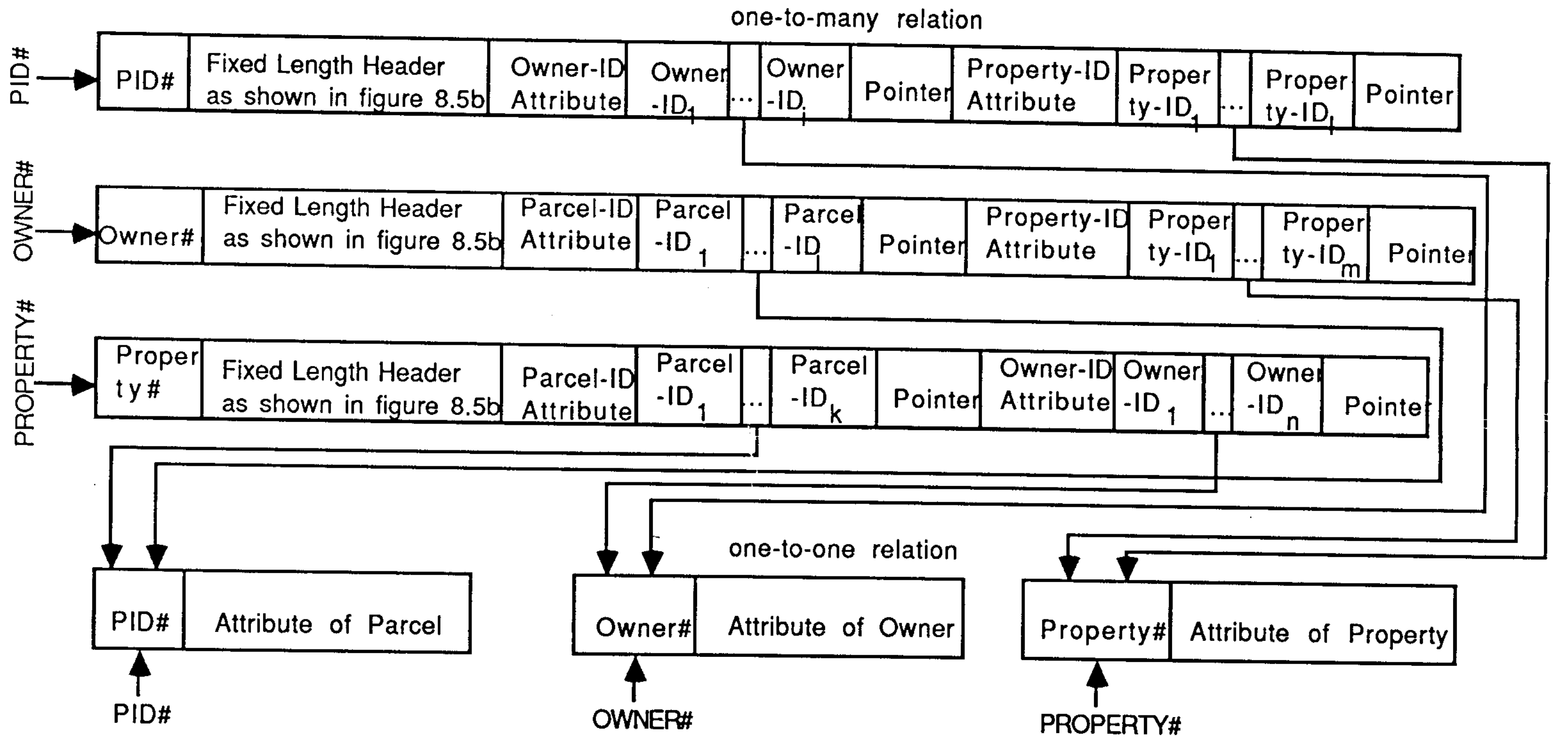


Figure 8.8 Possible Relational Data Base Structure

8.2.4 Data base management system

A data base needs a management system which can be used by all users to do the required operations: data entry, data processing, data retrieval, and information reporting. This is part of the massive investment in creating the data base management system (DBMS). A data base management system usually is the computer software that control data input, output, storage, and retrieval from a digital data base. The essential features of DBMS is that they should be able to allow data to be accessed and cross-referenced quickly. DBMS generally consists of 2 major components which are:-

- Data Definition Language (DDL); and
- Data Manipulation Language (DML).

1) Data definition language function is to define the structure of the relations (DEFINE command) and define logical views of the data (REDEFINE command).
2) Data manipulation language function is to perform data entry, deletion, update, manipulation, and display. The relational operators for this type of language are as follows.
    - SELECT (RESELECT) command extracts a subset of tuples.
    - PROJECT (LIST) command extracts a subset of attributes.
    - JOIN (RELATE) command combines the tuples from two relations on a common item.

The micro SQL module is an example of DBMS which will be mentioned. The operation is by firstly loading the data base into the SQL module, then, using the commands for data manipulation. The first command to be introduced is the SELECT command. This command is used to retrieve data from the tables of a data base. The standard queries from this command are as follows.

```
SELECT      select-list
FROM        table name (s)
WHERE       search condition (s)
GROUP BY    column name (s)
HAVING      search condition (s)
ORDER BY    column-specification (s)
```

SELECT select-list:-where the select-list contains a number of items separated by commas, an item is a column name. In case all items in the relation are selected, the character "*" which is called a wildcard will be used as a select-list.

FROM table name(s):-identifies the table(s) from which the data is to be selected.

WHERE search condition(s):-specifies the conditional retrieval of rows from a table.

GROUP BY column name (s):-rows of a table can be grouped into categories by matching values in one or more columns.

HAVING search condition(s):-contains one or more conditions to apply to groups. These group conditions cause SQL to return a result only for those groups that satisfy the condition.

ORDER BY column-specifications:-identifies the column(s) on which to order the rows of the result table. The column(s) are specified by using the relevant column name or column number.

SEARCH CONDITIONS:-the conditional selection of the data with the SELECT command may be achieved by using a search condition in the WHERE clause and/or the HAVING clause. This is done by specifying one or more conditions to be satisfied for the data to be retrieved.

Considering OWNER table 8.1b, the query command in SQL module for the following query is as follows:-

"Get the owner name and owner status from the owner who has the identification, owner1."

```
SELECT   owner-ID, owner_name, status
FROM     owner
WHERE    owner# = owner1
```

Several SELECT commands may be connected together by using the UNION operator to form a single result table where each separate query is merged and duplicate rows eliminated. For example, refer to tables 8.1b and 8.1c,
"Get PID# for parcel that was either owned by 'J.WATTANA' or was registered by transaction in the land office on the date 05/01/83."

```
    SELECT   owner_name
    FROM     owner
    WHERE    name = 'J.WATTANA'
UNION
    SELECT   transaction_date
    FROM     transaction
    WHERE    date = '050183'
```

Updating operations in the SQL module involve the use of these commands: UPDATE, INSERT INTO, and DELETE. These commands has the following syntax:-

```
UPDATE   table-name
SET      update-list
WHERE    search-conditions
```

For example, update the table "OWNER" by changing owner_name owner1's name from "J.WATTANA" to "J.SURACHAI" is:-

```
UPDATE   owner
SET      name = 'J.SURACHAI'
WHERE    name = 'J.WATTANA'
```

More details about SQL module can be obtained from SQL manual and Date (1982). In using an efficient DBMS, the DOL will achieve the following objectives:-
(1) Standardization of data
(2) Data sharing between divisions
(3) Data independence from applications
(4) Data base change or growth potential recovery

(5) User access to data base control
(6) More reliable back up and recovery
(7) faster data base programming for applications by programmers

The best known of the microcomputer commercial DBMS is ORACLE, dBASE III+. The dBASE III+ is available for about $ 845 and suitable for educational purposes. A high language program (e.g., Fortran) can be used to enter data into a data structure created by one of the micro DBMS used for up-date and query etc. The following sections will investigate the spatial data base model and structure for the DOL's LIS. The spatial data base management software, ARC, which is used for digital mapping in this project work will be discussed later.

8.3 Spatial Data Base

8.3.1 Basic concept

The other data type which is in responsible by the DOL is the graphic data in the form of cadastral map. The data in cadastral map can in principle be represented by points, lines, or areas plus appropriate label. The land parcels which are the major components in cadastral map are represented by a label point entity consisting of single XY co-ordinate pairs in the UTM co-ordinate system. Each label point is at the estimated centroid of the land parcel with the addition of the land parcel number. This PID can be cross-referenced to attribute data to provide details about the land parcel. Graphic entities can be categorized as:-

1) Point data is defined by a single location in space in terms of the acceptable co-ordinate system. It represents the label point of land parcel, corner of land parcel etc.
2) Line data is described in terms of string of graphic co-ordinates. It represents a centre line of a road, river etc.
3) Polygon data or areas over a defined space is associated with a closed string of spatial co-ordinates. It represents the boundary of land parcels and area of land parcel.

The rigorous modelling of these three types of graphic entities to represent the spatial land information is an essential part of the creation of spatial data base for the DOL's LIS. The concept design must determine how a collection of data is to be optimally represented in digital form and rigorously structured to be viewed at a number of levels by users, and to be efficiently stored in the computer. Various spatial data models have been investigated by Peuquet (1984). This study will emphasis the topological model which is suitable for handling the DOL's spatial data because it serves the DOL's need in application for:-

- Neighbour of land parcel relations;
- Overlay processing;
- Network analysis; and
- Update of data base capability.

8.3.2 Topologic model

Topological model conceptually consists of basic logical entity of a straight line segment, recorded with the co-ordinates of its two end points. A line segment begins or ends at the intersection with another line or a bend in the line. The polygons on either side of the line are identified and named to provide the elementary spatial relationships which is termed topology. This provides the definitions and adjacency information for individual polygons to be searched in an efficient way. This model allows the spatial definitions of point, line, and polygon type entities to be stored in a nonredundant way. The illustration of this model is shown in figure 8.9.

Figure 8.9 is an example of part of cadastral map encoded in the topological model. It consists of spatial entities (points, lines, areas) structured topologically as shown in figure 8.10. This topological structure describes the relationship between graphic entities in the form of linking entries of one table to another. This model stores each type of spatial data entity in a hierarchical data structure separately. The line entity is illustrated as a boundary segment or traverse segment. It consists of straight line segments which begin and end at a node. A node represents a corner of a land parcel or

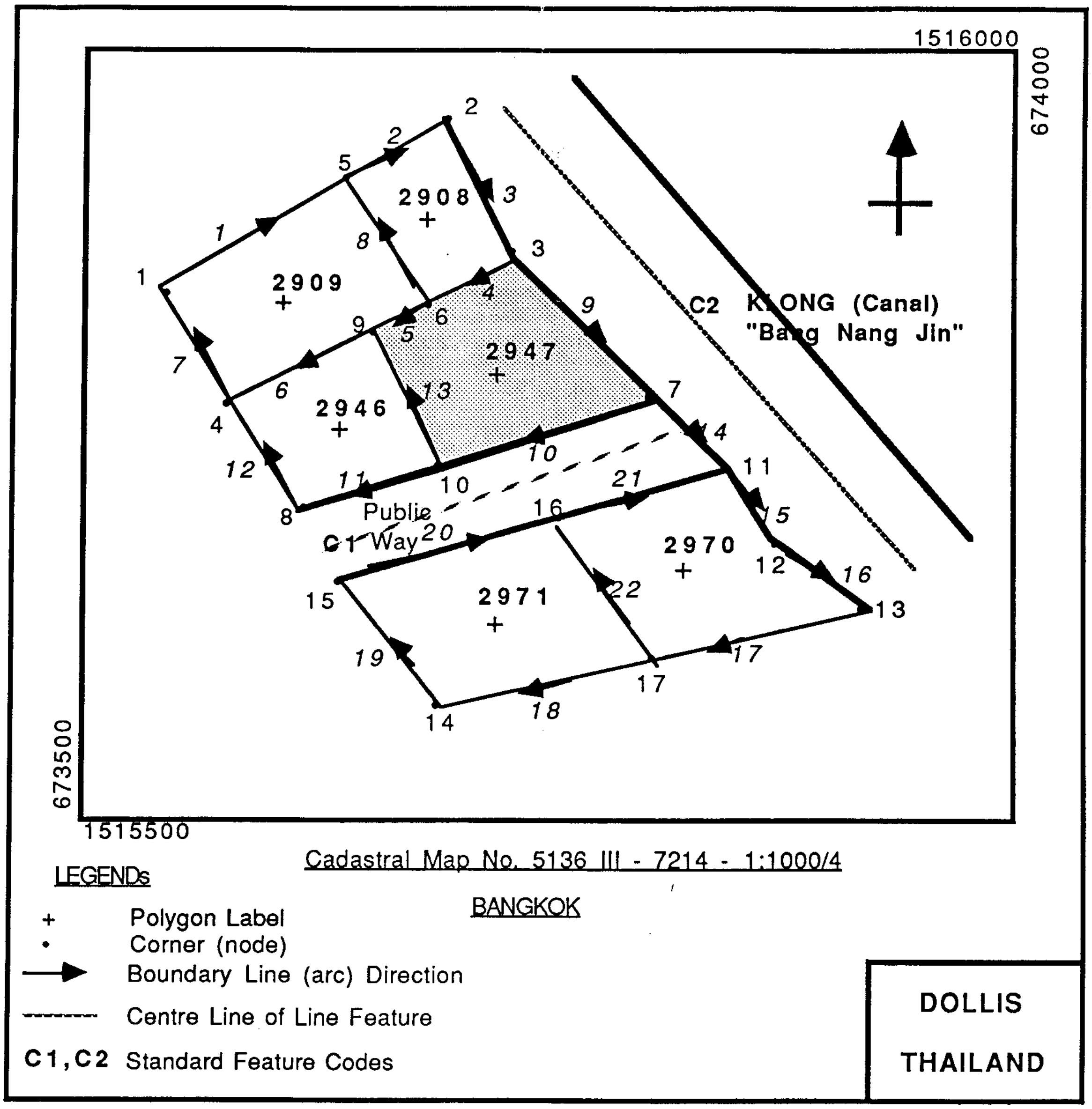


Figure 8.9 Example of Part of Cadastral Map Encoded in Topologic Model

intersection of line features. Its co-ordinates are stored in a separate node file. On the other hand, the point co-ordinate strings of boundary segments are recorded in a chain table. The From-and To-nodes in the boundary segment table are used to define the direction of line feature. The line direction is then used to define the left and right adjacent polygons as shown in the boundary segment table of figure 8.10. In case there is no adjacent polygon to line segment, the left or right polygon is denoted as '0'.

In addition to the spatial entity relationships, the linking between spatial data files to the textual data files is also shown in figure 8.10. The proposed design concept of the data base storage for the DOL's LIS is that the textual files are stored under the regional, provincial, and implicit district codes subdirectory which can be extracted from the proposed unique identifier of land parcel. The spatial data files, however, are stored under the cadastral map identifier subdirectory which can be computed from the proposed centroid co-ordinates of land parcel. Linking between textual data base and spatial data base is at the polygon level as shown.

The topological structure provides efficient spatial data retrieval and manipulation. It allows selective retrieval of any specific classes of data, i.e., points, lines, polygons at any time as shown in figure 8.11. The queries concerning the adjacency of polygons which is the major need for DOL's land registration, need only deal with the polygon and chain portion of the data. Only the boundary segment of polygons of interest are retrieved. The actual co-ordinate strings can be explicitly retrieved either for passing to graphic routines such as GKS, Autocad etc. for graphic presentation or to a distance calculations function.

The important point to note on this spatial data handling is that the topographic features such as river, road etc. as shown in figure 8.9 must be coded in a standard format for the interchange of digital mapping between different organizations involving in LIS. In this study, the Australian Standards will be used as an example of coding the topographic features.

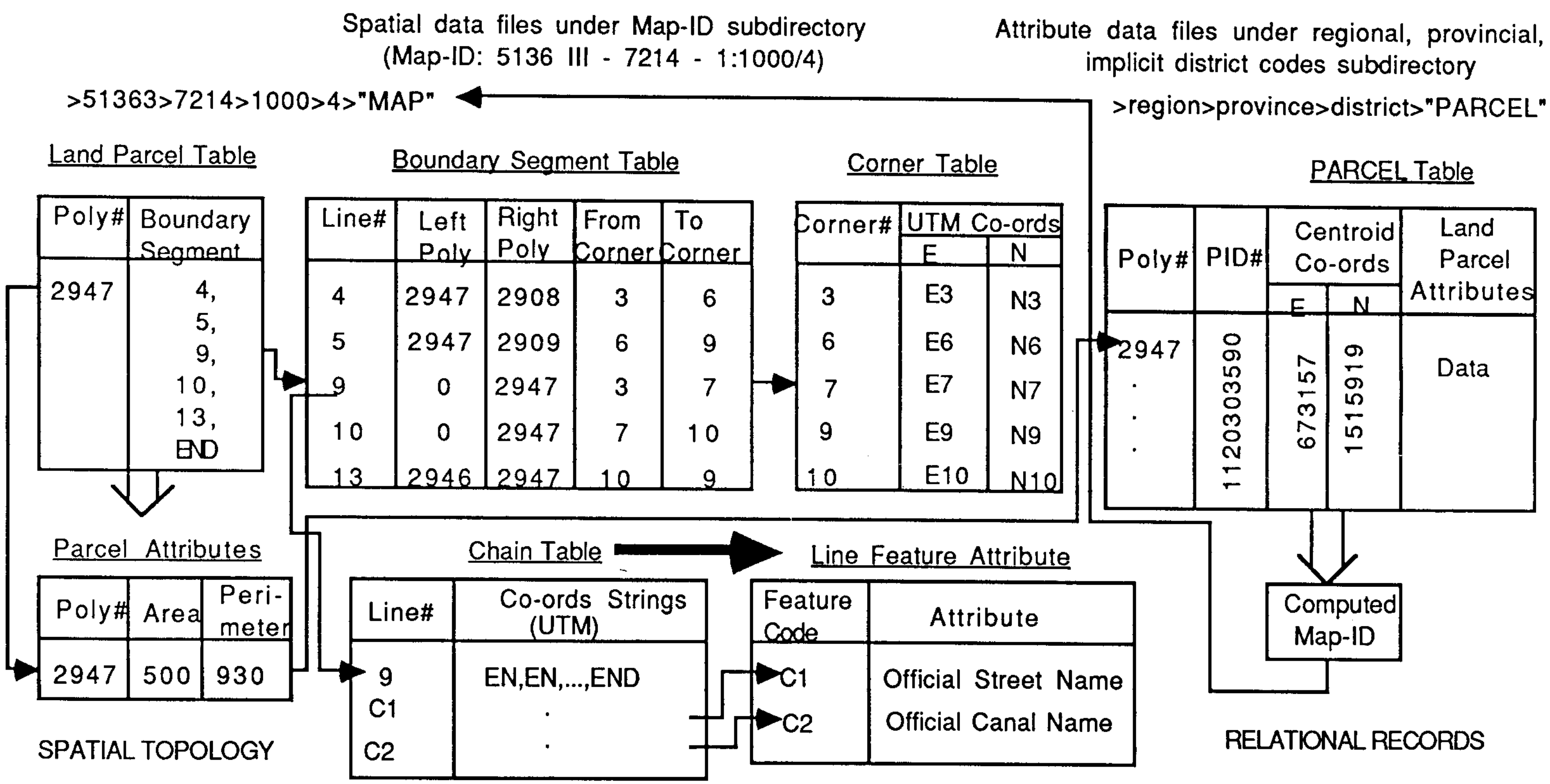


Figure 8.10 Topologic Model for Spatial Data Handling and Linking between Spatial Data Base and Textual Data Base

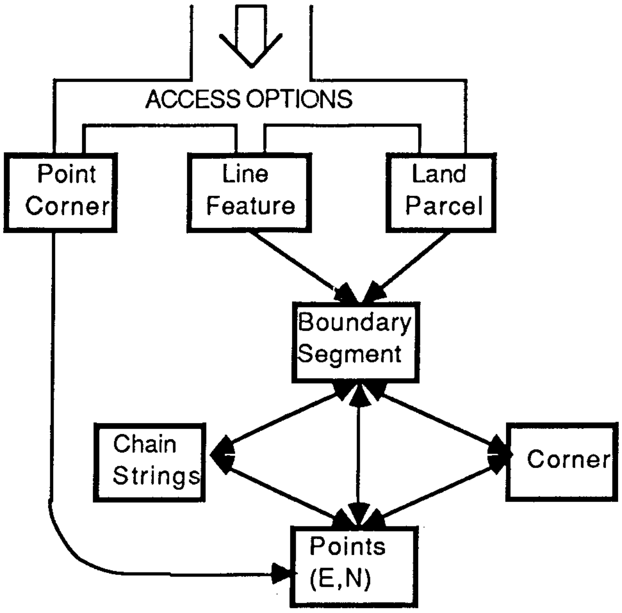


Figure 8.11 Spatial Data Access Options

8.3.3 Feature codes for interchange of digital mapping data

This section is based on the Australian Standards, AS2482-1984 . This interchange standard is based on individual records of each feature involved without any attempt to define structures or relationships within the data (Standards Association of Australia 1984). AS2482-1984 identifies the features by an 8-digit feature header code and followed by a string of co-ordinate values. The feature header is composed of the first four digits as a feature code and a second four as a feature modifier to define a feature more clearly. Where a feature modifier is not required, the last four digits will be four zeros. Figure 8.12 illustrates the AS2482-1984 feature code format.

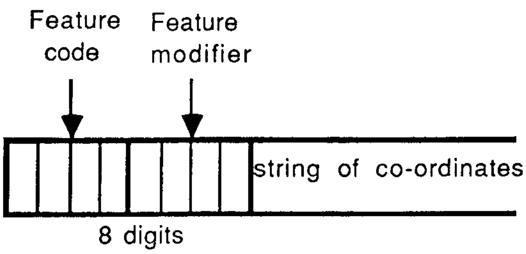


Figure 8.12 AS 2482-1984, Feature Code Format

For example, the Klong (Canal) "Bang Nang Jin" in figure 8.9 can be coded as follows:-

Feature code: 4810 for channel, drain, canal, ditch, waterway, aqueduct;
Feature modifier : assume 0005 for official standard coding for canal name "Bang Nang Jin".
Thus, the feature code for Klong (Canal) "Bang Nang Jin" is 4810-0005 and co-ordinate strings.

The public way with no name in the same figure can be coded as follows:-
Feature code :8054 for seal minor road with un restricted public use;
Feature modifier : 0000 for unnamed feature.
Thus, the feture code for public way with no name is 8054-0000 and co-ordinate strings.

To set up the suitable standard in Thailand, the AS2482-1984 should be investigated. It should be adapted by adding the provincial code of 2 digits in front of the feature header to facilitate the data retrieval. The adapted feature header is shown in figure 8.13.

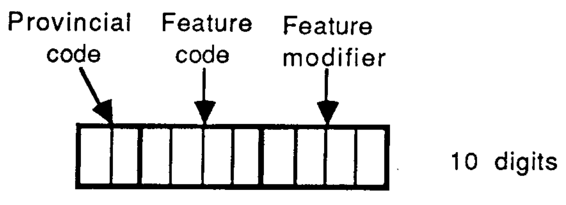


Figure 8.13 Adapted Feature Header of AS 2482-1984

The following sections presents the practical work on this project concerning the digital mapping and program development.

8.4 Practical Work On Digital Mapping and Program Development

8.4.1 Purpose

This section presents practical work in this project which concerns the acquisition of spatial data by manual digitizing of the existing cadastral index map (CIM) by pcARC software. The development of program "WATTANA" to manipulate the attribute data file is also a part of this project work. The workstation for this practical work consists of:-

- the microcomputer NEC APC IV (IBM compatible) with 640 Kbyte base memory, 20 Mb hard disk, 1.2 Mb floppy disk drive, and operating system MS-DOS Version 3.10;
- the digitizing table DIGI-PAD Type 5A linked with the pc;
- the digital mapping software pcARC/INFO for spatial data acquisition and the complete ARC/INFO software stored on the university minicomputer VAX-11/875;
- Tektronix 4957 the digitizing pad and graphic terminal 4107 linked with the university computer VAX-VMS;
- the communication software KERMIT for data transfer between the pc and VAX; and
- communication line: serial TTL, RS232C, GPIB (IEEE-488).

The map sheet to be digitized is the cadastral index map (CIM) number "5136 III - 7214 - 1:1000/4" in Khet (District) Phrakanong, Bangkok. The map is on UTM co-ordinate system with a map format of 500 $\times$ 500 mm^2, covering the area on the ground of 500 $\times$ 500 m^2. There are about 600 land parcels in this map sheet.

The INFO software associated with the ARC software has not been thoroughly investigated because it can be operated according to the user manual step by step. The purpose of this part is to develop a user designed INFO program, "WATTANA" to manage the Thai character type file under the ARC software environment. The essential modules used for this program development consists of:-

- Word Star Release 4.0
- Thai Word Processing module (DJ)
- Fortran-77 compiler stored on pc and VAX
- Utility software

8.4.2 Procedures

The operation in this practical work can be summarized roughly into 20 steps. Steps 1-5 deal with the attribute program development using Fortran 77 language in pc and VAX-VMS. Steps 6-18 concern the digital mapping using the pcARC, VAX-ARC, and "KERMIT" communication softwares to collect cadastral spatial data. Steps 19-20 deal with the linking between the attribute software and the ARC software. The details of each step is as follows:-

1) Create the data file in a table form
2) Design the program structure and write the program "WATTANA" in VAX Fortran-77
3) Develop program "WATTANA" on pc using Fortran-77 and utility software
4) Patch the written program with the Thai word processing module "DJ" and utility software
5) Test and editing
6) Digitize the map sheet by using pcARC software
7) Clean the data in the coverage
8) Transform coverage from digitizing table co-ordinates to real world co-ordinates (UTM) using TIC co-ordinates as a control point
9) Change coverage to interchangeable file by using the module EXPORT in pcARC
10) Run KERMIT software to link the pc with the VAX computer
11) Send interchangeable file to VAX for editing using the communication software KERMIT
12) Run IMPORT module in VAX-ARC software to convert the interchangeable file back to coverage type that ARC software can recognise
13) Use ARCEDITOR module to edit feature in coverage ,i.e.,node, arc, polygon, annotation

14) Change the edited coverage to be map type data
15) Convert the edited map to an interchangeable file using EXPORT module
16) Run KERMIT on VAX and send interchangeable file back to pc
17) Run IMPORT module in pcARC to convert the interchangeable file back to coverage type again
18) Save this complete map in the file named "MAP" in the subdirectory under the MAP-ID ,e.g., MAP-ID "5136 III - 7214 - 1:1000/4" would be:-

> 51363
> 51363 > 7214
> 51363 > 7214 > 1000
> 51363 > 7214 > 1000 > 4>"MAP"

19) Link the developed software "WATTANA" with the "MAP" file by using the proposed PID and MAP-ID and utility module
20) Demonstrate the program to test the concept of linking spatial data with the attribute data. The source program can be obtained from the programmer separately.

The previous procedure of digital mapping can be logically illustrated in the figure 8.14. The details of the spatial data file created by the ARC software in the figure such as .TIC, .BND, .ARC, .LOG, etc. can be found in the ARC software (1985) manual.

The essential features of any data storage system are that they should be able to allow data to be accessed and cross-referenced quickly. Thus, the spatial data files are stored in a small block of cadastral map under the Map-ID subdirectory to facilitate the data access capability. This requires the efficient procedure to search the Map-ID.

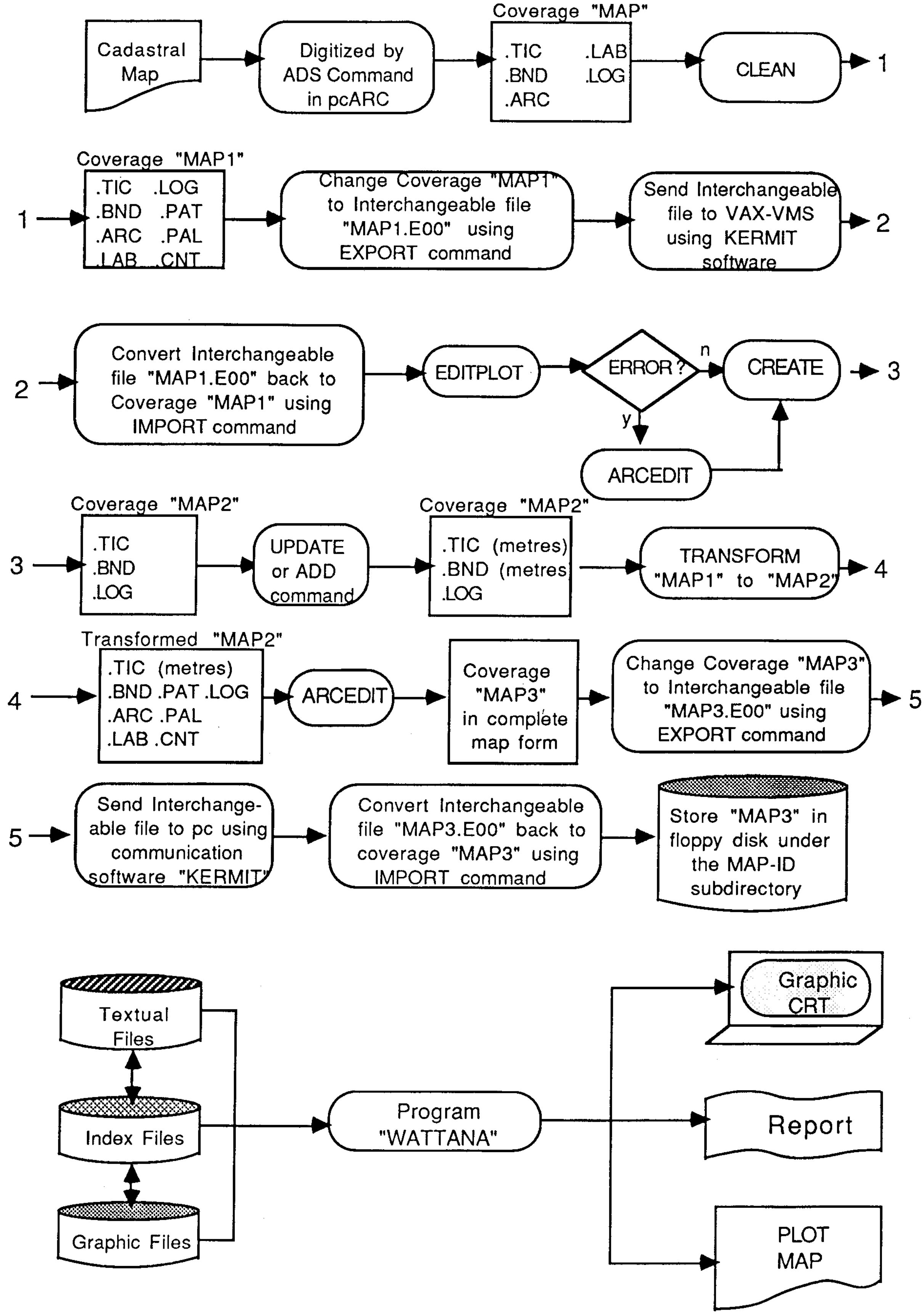


Figure 8.14 Computer Mapping Procedure

8.4.3 Cadastral map sheet searching in program "WATTANA"

8.4.3.1 Procedure in brief

In program "WATTANA", searching for cadastral map sheet uses the quadtree search and bit interchanging to find the desired map sheet number. The procedure is that the map sheet number is computed from the centroid co-ordinates of land parcel described in the previous chapter. The land parcel is first located in the cadastral base scale map 1:4000. From this base scale, the operation of quadtree search will be on the recursive decomposition of a grid into the desired multiple map scale based on powers of 2. To understand the Map-ID search procedure, it is essential to be familiarized with algorithms used in Map-ID search based on quadtree search and bit interchanging.

8.4.3.2 Quadtree search algorithm

The quadtree search method is chosen to find Map-ID because it matches the cadastral map sheet identification of the DOL. This algorithm has been well studied by Peuquet (1984), Samet and Webber(1985). The term quadtree is used to describe a class of hierarchical data structures which is based on the principle of recursive decomposition (Samet and Webber 1985). Recursive subdivision of map grid in this manner results in a regular, balanced tree structure of degree 4. Each subdivided area will generate hierarchical 4 equal sub-areas for the land parcels. The sub-areas are assigned with a numeric locational key as a numeric index for quadrants formed by a quadtree decomposion of a region. The first level of the decomposition the region (square with side length unity) consists of four quadrants encoded with the quadrant number 0, 1, 2, and 3 as shown in figure 8.15 and side length 2^{-1}. This process may be continued to an arbitrary level m.

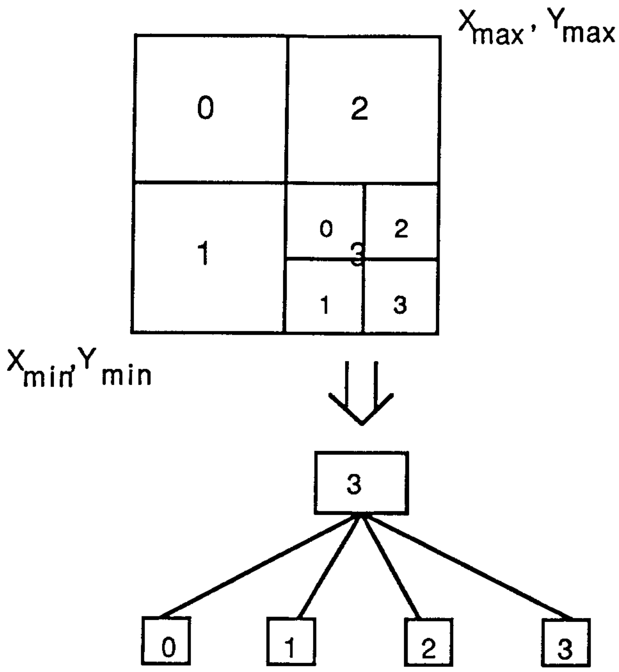


Figure 8.15 The Quadtree Algorithm Used for Map-ID Search

The quadtree search for Map-ID involves a point location problem to determine the map region which covers the target land parcel represented by unique centroid co-ordinates. The boundary of the map region is defined by co-ordinates of its lower left-hand corner (X_{min}, Y_{min}) and upper right-hand corner (X_{max}, Y_{max}). The algorithm to search the covering map sheet for the desired land parcel is a top-down tree traversal of the region by quadrant. If the area does not cover the land parcel (centroid co-ordinates), the quadrant next to it in the traversal is determined and examined by using function NEXT and boolean logic test. The procedure continues until a suitable quadrant is found or the end of the region is reached. The encoded quadrant surrounding the land parcel is then passed to the method of interchanging quadrant number to matrix form for processing which will be described below.

8.4.3.3 Method of interchanging quadrant number to matrix form

Basic elements

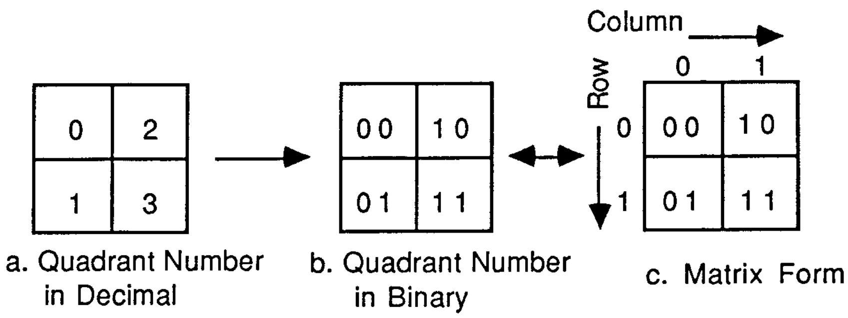


Figure 8.16 Basic Elements of Quadrant Number in Decimal and Binary Form with the Corresponding Numbering in Matrix Form

The basic elements of this method are the quadrant numbers 0, 1, 2, and 3. The ordering of these numbers are shown in figure 8.16a. The interchanging between quadrant number in decimal form (8.16a) to matrix form (8.16c) is via 8.16b which represents the quadrant numbering in binary form. From the relationship found between 8.16b and 8.16c gives:-

Quadrant Number (decimal)	Column	Row
0	0	0
1	0	1
2	1	0
3	1	1

Figure 8.17 Basic Relationship between Quadrant (decimal) and Matrix forms (Column, Row)

The relationship in figure 8.17 is used for further development.

Recursive decomposition of basic elements (2nd subdivision)

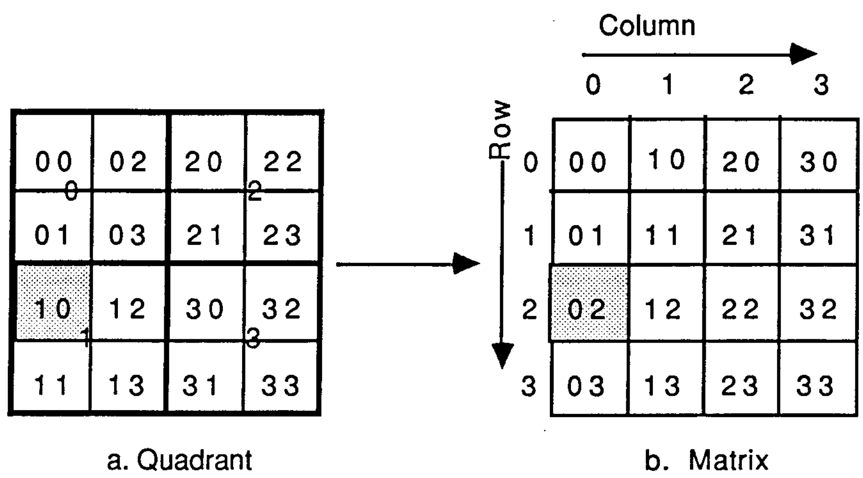
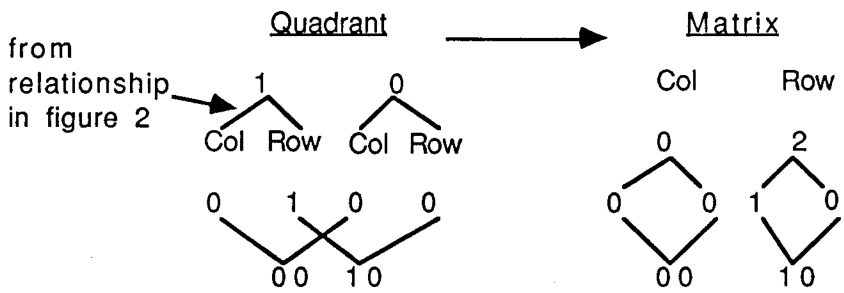


Figure 8.18 2nd Degree of Subdivision

The shaded elements are selected from figure 8.18 to test the relationship for interchanging from quadrant to matrix forms.

The selected element is the quadrant number 10 with the corresponding element in matrix form (Col, Row) of 02.



Other examples can be proved likewise.

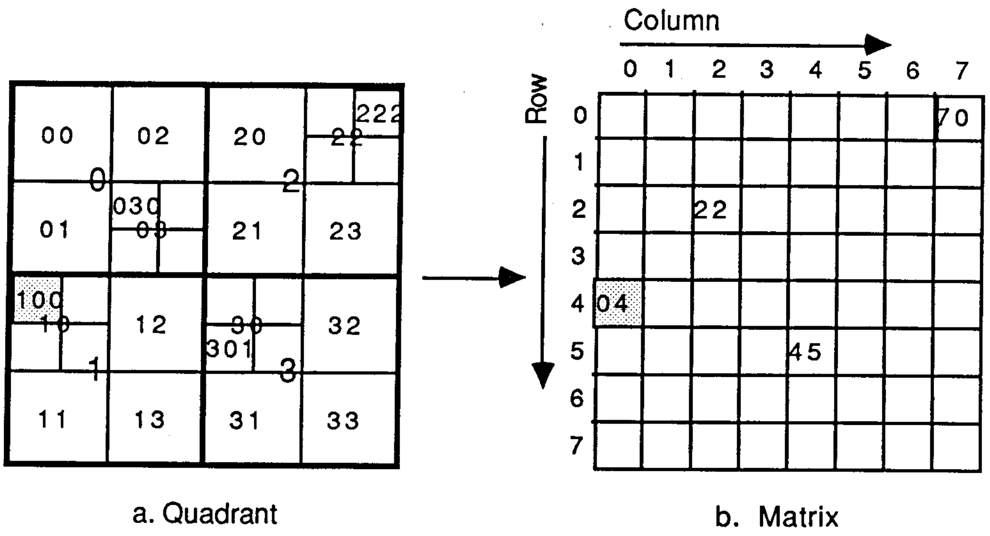
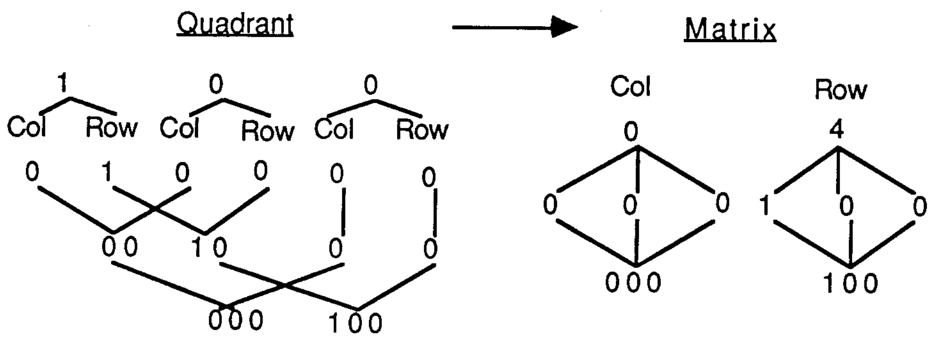


Figure 8.19 3rd Degree of Subdivision

The shaded elements are chosen from figure 8.19 to test the interchanging from quadrant to matrix forms of 3rd degree subdivision of basic elements in figure 8.16.



For the higher degree of subdivision of power 2, this method is performed in the same manner. Therefore, this method can be used to change the quadrant number from quadtree search to matrix form of column and row. From the matrix form, it can be converted to sequential numbering of elements as illustrated below.

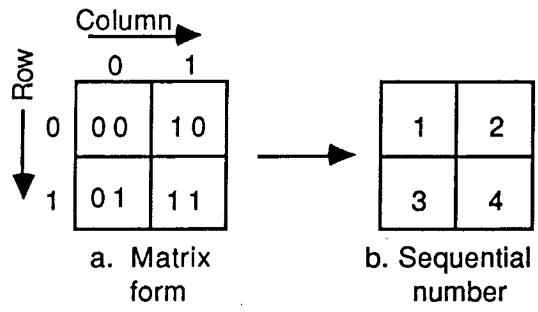


Figure 8.20 Conversion of Matrix form to Sequential Form of 1^{st} Degree of Subdivision

The number of subdivision (NSUBDI) in figure 8.20 is 1. The relationship to convert 8.20a to 8.20b is:-

$$\text{Sequential number} = \text{Col} + 1 + (\text{Row} \times 2^{\text{NSUBDI}})$$

For example, element 00 in 8.20a is the Col = 0 and Row = 0
Sequential number = $0 + 1 + (0 \times 2^1) = 1$

element 10 in 8.20a	=	sequential	number	$= 1 + 1 + (0 \times 2^1) = 2$
„ 01 „	=	„		$= 0 + 1 + (1 \times 2^1) = 3$
„ 11 „	=	„		$= 1 + 1 + (1 \times 2^1) = 4$

From figure 8.18b, the shaded elements are tested where NSUBDI = 2.
element 02 in 8.18b = sequential number $= 0 + 1 + (2 \times 2^2) = 9$

From figure 8.19b, the shaded elements are tested where NSUBDI = 3.
element 04 in 8.19b = sequential number $= 0 + 1 + (4 \times 2^3) = 33$

The method of interchanging quadrant number to matrix form and further conversion of matrix to sequential form from this method is then applied to cadastral map identifier searching.

8.4.3.4 Cadastral Map-ID search procedure

The Map-ID search is based on the recursive decomposition of map grid. The potential base scale of CIM produced by the Urban

Mapping Division are at a scale 1:4000 for mapping rural areas and at scale 1:1000 for mapping urban areas. However, the map scales produced by DOL can range from 1:250 to 1:4000. Thus, the program "WATTANA" is based on the assumption that the map scales are 1:250, 1:500, 1:1000, 1:2000, and 1:4000. The menu provides for these map scales to be selected. If the selected map scale does not exist, the program will ask for another map scale to be input. The procedure to find Map-ID is illustrated below.

The cadastral index map (CIM) scale 1:1000 with its identifier "5136 III - 7214 - 1:1000/4" is used as an example. This Map ID consists of 3 parts which are:-

- topographic map scale 1: 50000 number-i.e., 5136 III ;
- the origin of the CIM base scale 1:4000 in UTM co-ordinate system-i.e., 7214 ; and
- the scale of desired CIM with the map sheet no. based on CIM scale 1:4000-i.e., 1:1000/4.

These three parts are derived from the proposed land parcel identifier which is mentioned in the previous chapter. Two strategies can be used either input primary key of PID# and cross reference to relevant centroid co-ordinates in the parcel file, or alternately, input the alternate key of centroid-co-ordinates directly as shown in figure 8.21.

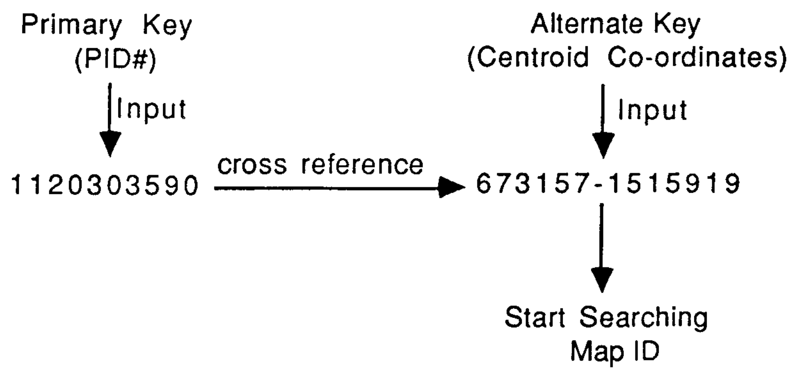


Figure 8.21 Relationship Between PID# and Centroid Co-ordinates in Map-ID Search

From centroid co-ordinates:-

1. Find the map sheet number of topographic map scale 1:50000 by:-
   - using the routine to convert centroid co-ordinate from UTM to longitude and latitude;
   - run the routine to find the topographic map which shows the map sheet no. and map extent;
   - compare the centroid co-ordinate in latitude & longtitude with the map extent of the topographic map in the same co-ordinate system until the relevant map sheet no. in which the centroid co-ordinate of land parcel is found using boolean logic test. Then, the topographic map sheet no. is found - i.e., 5136 III.
2. From centroid co-ordinates in UTM, find the boundary of the cadastral map base scale 1:4000 which contains this land parcel:

   Easting 6<u>72</u>000 < 673157 < 674000

   Northing 15<u>14</u>000 < 1515919 <1516000

   Thus, the boundaries of the cadastral map base scale 1:4000 which contain this land parcel is:-

   E_{min} = 6<u>72</u>000 ; E_{max} = 674000

   N_{min} = 15<u>14</u>000 ; N_{max} = 1516000
3. Find the origin of the cadastral map base scale 1:4000 by extracting the tenth of kilometre both easting and northing. In this case, the origin is identified as 7214.
4. Find the scale of the desired cadastral map by choosing from the menu selection-i.e., 1:1000.
5. Find the map sheet number by using the quadtree search algorithm and boolean logic test. Then using the method of interchanging quadrant in matrix form and in sequential number as illustrated in figures 8.22, 8.23, and 8.24. Referring to figure 8.23, the map sheet no.4 at scale 1:1000 based on 1:4000 is found.
6. Combine each part from 1, 3, 4, and 5 together and the Map-ID is obtained as "5136 III - 7214 - 1:1000/4". From this computed Map-ID, the spatial data files can be accessed under Map-ID subdirectory.

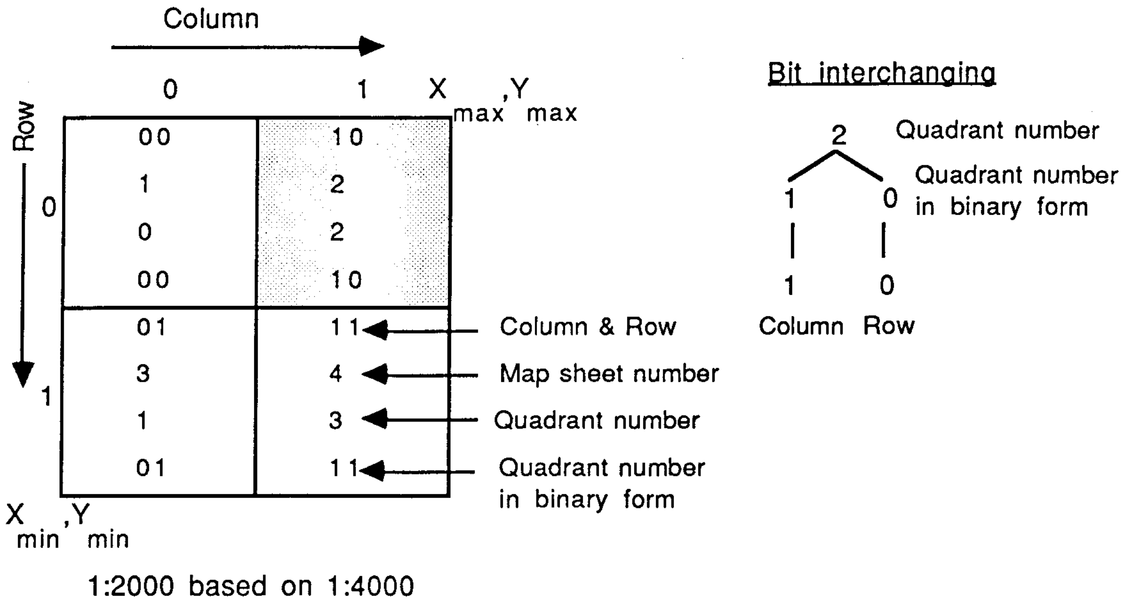


Figure 8.22 The Quadtree Search and Bit Interchanging Algorithm for Map-ID Search

The quadtree search algorithm used in finding the map sheet number is as follows:- given XY co-ordinates of the land parcel - compute the quadrant it falls in using the boolean test between the centroid co-ordinates of the land parcel and the map extent co-ordinates. For example, if X and Y are co-ordinates of the label point of the centroid of the land parcel and X_{min}, Y_{min}, X_{max}, Y_{max} are the map extent, the problem is solved by:-

If $Y_{min} \leq Y \leq Y_{max}$ and $X_{min} \leq X \leq X_{max}$ is .TRUE. then the X,Y is inside the rectangle. In Fortran this amounts to:-

IF [(Y_{max} - Y) .LE. (Y_{max} - Y_{min}) .AND. (X_{max} - X) .LE. (X_{max} - X_{min})]

INOUT = .TRUE. then test INOUT

The computed quadrant is then converted to matrix form (col, row) by using bit interchanging. The matrix form is further converted to map sheet number by the following relationship:-

$$\text{Map Number} = (\text{Col}) + 1 + (\text{Row}) \times 2^{NSUBDI}$$

where

NSUBDI	= Number of map subdivision from base map scale 1:4000
	= (LOG10(FSC/DSC))/LOG10(2.) ; where
FSC	= Base map scale number (1:4000)
DSC	= Desired map scale number (1:2000)

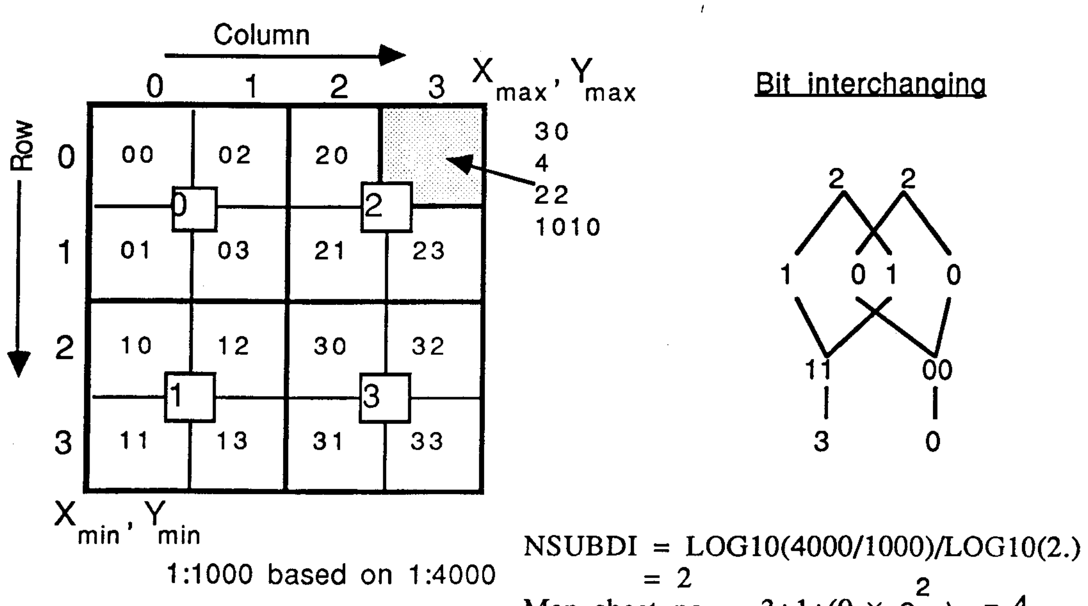
For example, the map sheet no. for the shading area of figure 8.22 is computed by:

$$NSUBDI = LOG10(4000/2000)/LOG10(2.) = 1$$

using the quadtree search and bit interchanging method, the mapsheet no. in matrix form is:-

$$Col = 1 , Row = 0$$

Thus, the map sheet no. = $1+1+(0 \times 2^1) = 2$ at scale 1:2000.



NSUBDI = LOG10(4000/1000)/LOG10(2.)
= 2
Map sheet no. = $3+1+(0 \times 2^2) = 4$

Figure 8.23 Searching Map Sheet Scale 1:1000

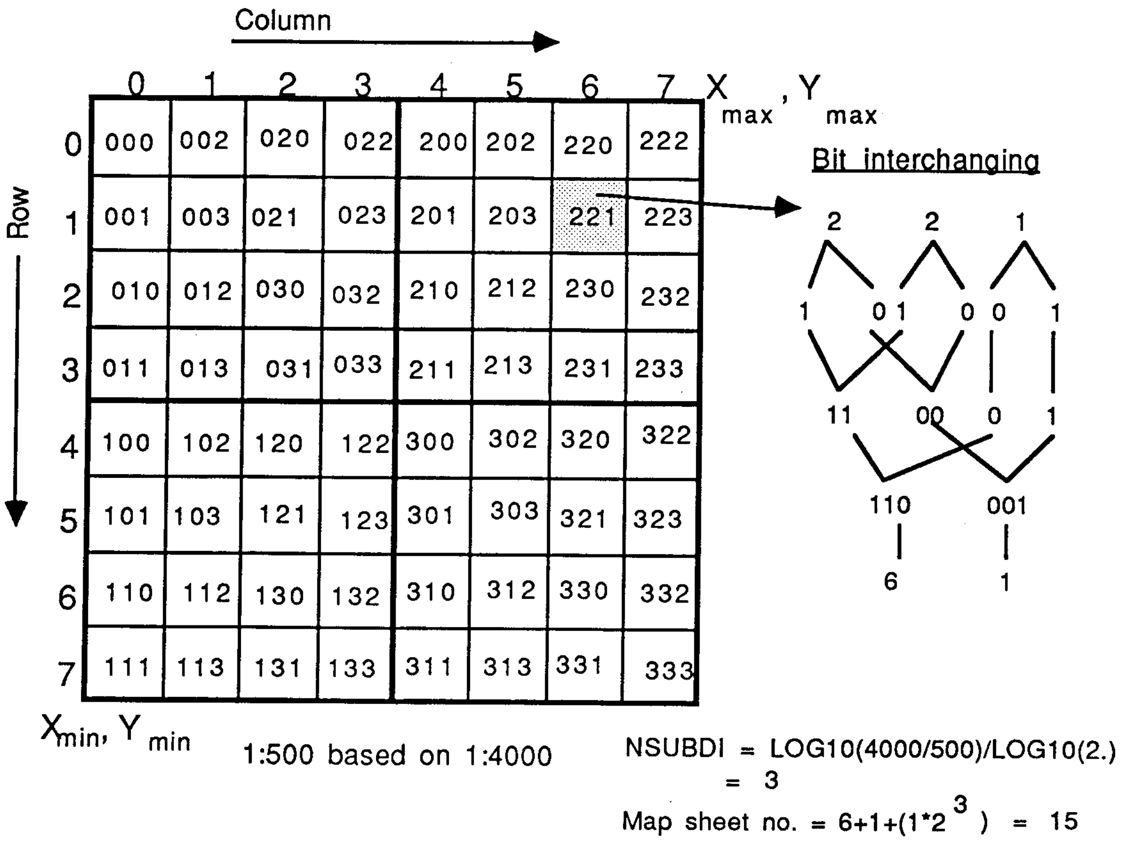


Figure 8.24 Searching Map Sheet Scale 1:500

8.4.4 ARC software

8.4.4.1 ARC software characteristics

ARC is a graphic data base management system. It combines the capability of computer-aided design (CAD) functions and a geographic data base. The spatial data in this software is topologically structured where topology refers to the relationships between graphic entities (e.g., points, lines, areas). The ARC system stores nodes, arcs and their relationships. The features in ARC system can be classified as follows:-

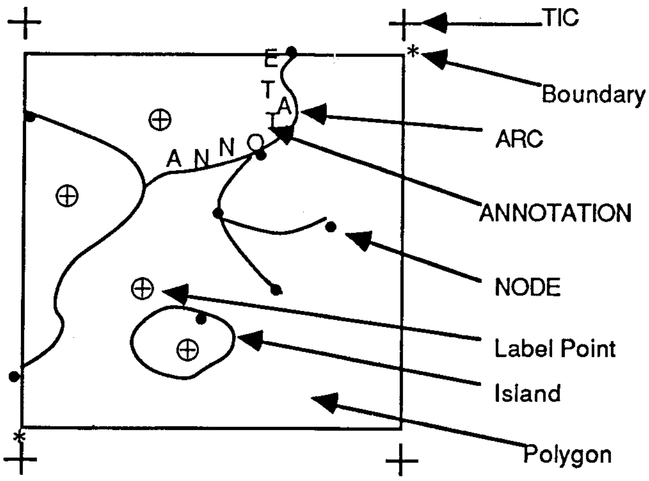


Figure 8.25 Shows Coverage Features - point, line, label

- Nodes represent arc end points and intersections of line features.
- Arcs represent line features and borders of areas.
- Polygons represent area features defined by a series of arcs.
- Label points represent point features. They are used to associate attributes to polygons.
- Islands are polygons within polygons.

8.4.4.2 Digitizing operation

The "ADS" module (detail of this module is in ARC manual 1985) is used for spatial data acquisition. Commands can be selected from nested menu on screen or menu sheet. Commands can also be input via keyboard. The key aspect is that the explicit breaks must be made at line intersections during digitizing.

8.4.43 Data structure for ARC software

ARC software structures data by topological relationships as mentioned in section 8.3.2. The procedure for structuring data in ARC software is by polygonization which involves 3 operations.

1) Identify Nodes
   - Process arc by arc
   - Search node table
   - Enter values in node and arc tables
2) Form Polygons
   - Traverse polygons in a clockwise direction
   - At each node look for the arc which makes the largest clockwise angle
   - Mark arcs and update polygon table
   - Traverse all arcs twice
3) Associate Labels
   - Form polygons
   - Compute point in polygon for label points
   - Update polygon table, user-id and arc table, polygon left, polygon right

After digitizing, the latter operation is data verification and editing. This operation can be categorized as follows:-

8.4.4.4 Digitizing checks

1) Dangle is a node with only one arc. It can be detected by software. There are many types of errors occurring during digitization as shown in figure 8.26.

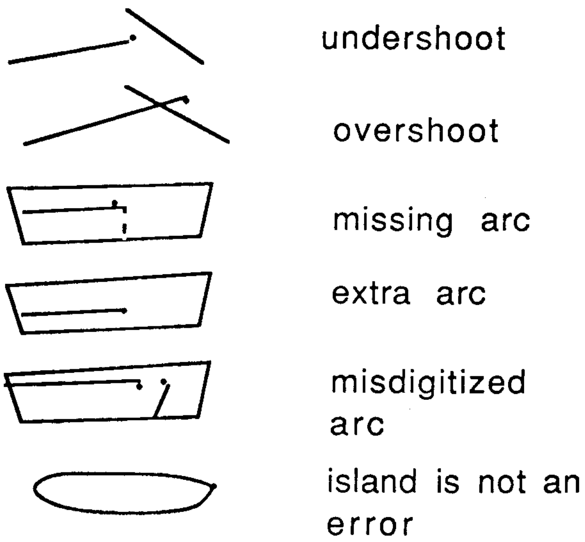
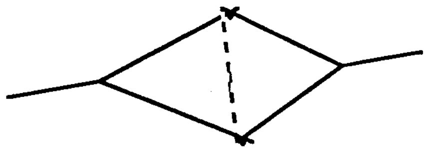
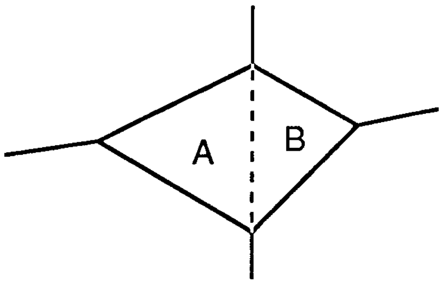


Figure 8.26 Dangle Errors from Digitization

2) Pseudo node is a node created by only two arcs.

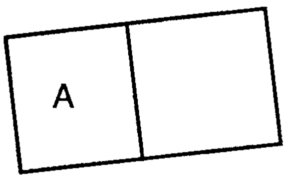


missing arc

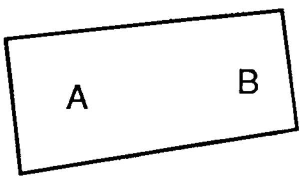


missing arc
is not detected
(should get 2 labels
in 1 polygon)

3) Labels



missing label



duplicate < missing arc / double digitizing

4) Area checks

4.1 The sum of areas of each polygon must be equal to total area. The problems occur with islands because duplication of areas will occur.

4.2 If the polygon has a small area (narrow shape polygon), the area per perimetre must be more than the tolerance. This criteria is set to detect double digitized lines.

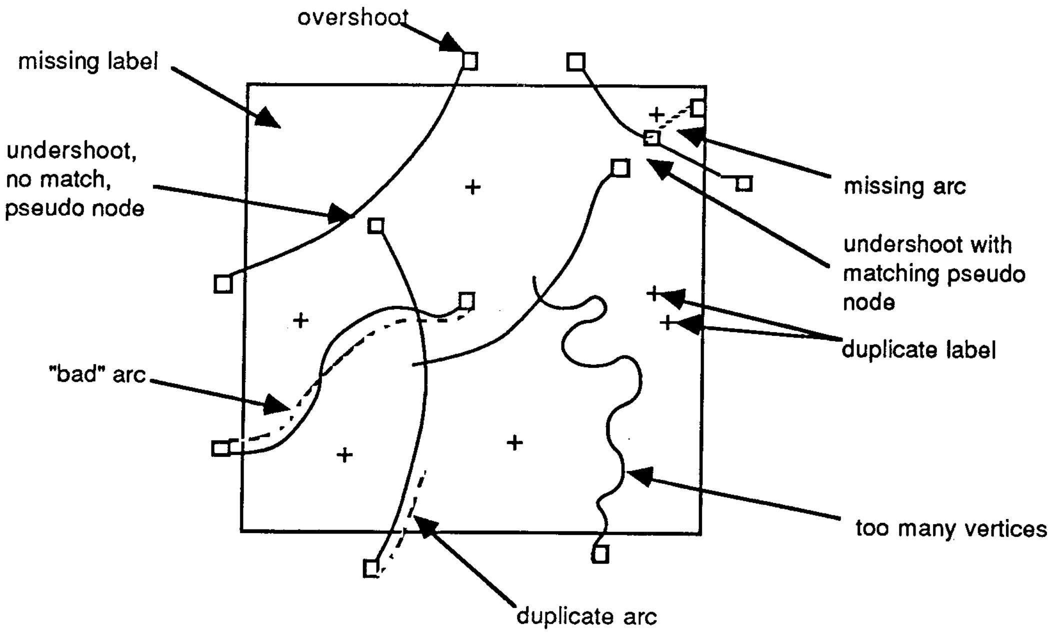


Figure 8.27 Coverage Conditions

Figure 8.27 illustrates the coverage conditions after digitizing. It demonstrates errors mentioned in section 8.4.4.4.

Refining a coverage can be performed automatic by software or manually. The steps are as follows:-

- Automatic
  - co-ordinate edit
  - Topology creation
    - polygon
    - line
    - point

- Manual
  - co-ordinate verification
  - co-ordinate edit

This has been summarized in figure 8.9.

Automatic Refining

Problem	Correction
Overshoot	CLEAN
Undershoot with matching pseudo	MNODE
Duplicate arc	CLEAN
Too many vertices	MNODE or ARCEDIT with SPLINE

Manual Refining

Problem	Correction
Missing arc, duplicate labels	ARCEDIT
Missing label	ARCEDIT
"Bad" arc	ARCEDIT
Undershoot, no match	ARCEDIT

Figure 8.9 Summary of Refining Procedures by ARC Software

More details about ARC software can be obtained from ARC, ARCEDIT, ARCPLOT, NETWORK, LIBRARIAN, COGO, TIN, AML manuals, and Mullin(1988).

8.5 Summary

The computerized parcel-based LIS for the DOL depends mainly on the data base system design for both the textual and spatial data base. From the investigation, the suitable textual data base structure for the DOL's LIS should be a relational data base structure because it provides efficiency in data structure, retrieval, and data manipulation. The query language design for data retrieval should be based on the SQL module concept and land information must be presented in Thai scripts as tested in program "WATTANA". On the other hand, the spatial data model and structure should be based on the topological model because it provides an efficiency in data manipulation and analysis. The data are stored explicitly for each type of entity (point, line, polygon) and in a non-redundant manner.

The design concept of the data base storage system for the DOL's LIS presented in this chapter is that the textual files are stored under the regional, provincial, and implicit district codes subdirectory which can be extracted from the proposed unique identifier of land parcel. The spatial data base, however, is stored under the cadastral map identifier subdirectory which can be computed from the centroid co-ordinates of the land parcel using quadtree search, boolean logic test, and bit interchanging algorithms. The linkage mechanism for the textual and spatial data bases is via the proposed PID# and the centroid co-ordinates as mentioned in sections 8.3.2 and 8.4.3.4.

For the practical work on program development, the results are shown in appendix 4.1. The program is run on microcomputer under the pcARC environment. It took about 3 months to investigate, design, and develop the program.

The result of cadastral map digitization is shown in appendix 4.2. The map sheet is in UTM system, 1:1000, scale, number 5136 III - 7214 - 1:1000/4, and in Khet Phrakanong, Bangkok. It took about 2 days to digitize the 600 land parcels in this map sheet. The digitized coverage was sent to VAX-VMS for editing which took about 2 days. The computer memory required for one complete digital map is about 180,000 bytes/map sheet. Thus, one map sheet takes about 4 days to be converted to digital form. However, a skilled person can operate at about 2-3 days/map sheet. The key element is that when the computer mapping is in full operation, the "MACROS" or "BATCH" processing module must be written and used because it is easy to operate and reduces tedious iterative command input selection.

Regarding the Thai word module, the essential points to be noted are that:-

- The standard for Thai character code used in the computer like ASCII code must be set up and monitored by the users especially governments agencies.
- Individual computer-houses in Thailand should develop the

software on its own design to provide for various software developments, but it should provide for the conversion to the standard code if required.

- The Thai module must be independent from DOS and needs no additional character ROM card in the hardware component after purchasing computer.
- The character font and number of lines per each page must be at least 12 lines and a maximum 24 lines if possible.
- The DOL must investigate the various Thai software before using it in data base creation.

The next chapter for this research will deal with the integration of the essential components which had been investigated in each chapter as a model of a network of computerized parcel-based LIS for the DOL.

9 COMPUTERIZED PARCEL-BASED LIS IN THE DOL

" The purpose of studying economics is to learn not to be deceived by economists. "

- Joan Robinson

9.1 Basic Concept

The objective of the computerized parcel-based LIS for the DOL presented in this research is that it should provide the authorized user from single inquiry land office, access to parcel-based land information regardless of which divisions in the DOL or land offices manage each piece of data. This concept reflects a network of interlinked computerized data bases of the DOL, and also the link of DOL's operational data base with outside departmental data bases such as personal data bases of the DOA, utility data bases, taxation data bases etc. The computerized parcel-based LIS is a large project and long term by nature because it requires large capital investment from the limited budget of the DOL. Thus, it is impossible to forecast future major developments. However, in the first stage of implementation the main concern must be the organization of the data in terms of data collection, data quality, data definition and identification, data models, data structures, and the flexibility of the existing computer systems to manage those data described in the former chapters. The strategy for development of the organization of the data collection and processing must be on an incremental basis. The readiness of the data preparation and system design will lead to the stage of integrated parcel-based LIS in the DOL. This chapter will describe the conceptual framework for the computerized parcel-based LIS based on the decentralized administrative structure of the DOL. First of all, the feasible model of computer system configuration will be discussed.

9.2 Model of Computer System Configuration

9.2.1 Existing computer system

The computer system recently installed in the Computing and Data Processing Division is a PRIME minicomputer with its peripherals as have been described in chapter 6, section 6.5. This computer mapping system when combined with the photogrammetric stereoplotter of the Mapping by Aerial Photography Division should be configured as shown in figure 9.1.

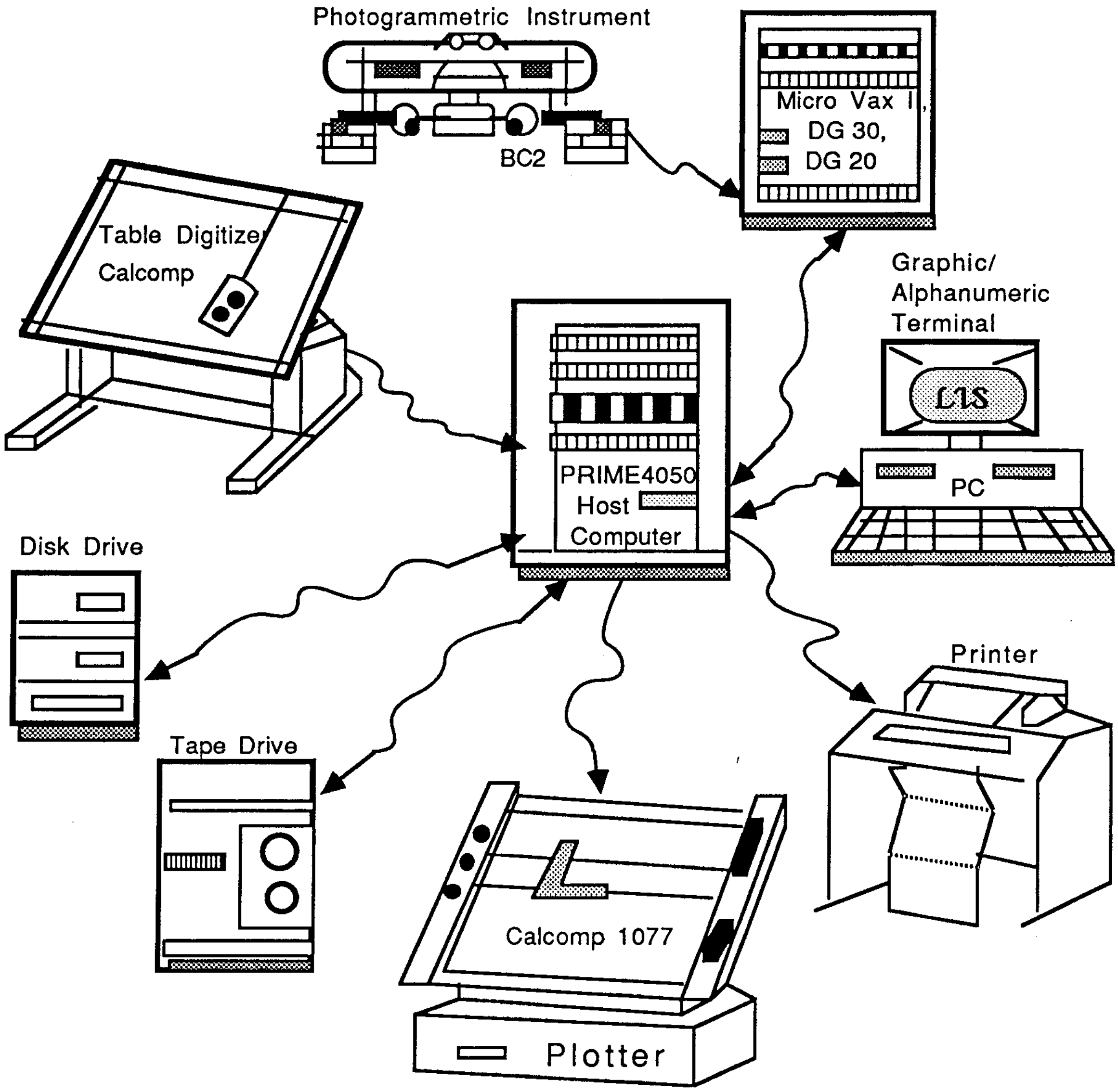


Figure 9.1 Central Computer-mapping Hardware Configuration for the DOL's Parcel-Based LIS

This system will mainly support the functional requirements for:-

1) Data acquisition
   1.1) Key in textual data (alphanumeric terminal and key board)

1.2) Digitization from analog aerial photographs (photogrammetric stereoplotter)

1.3 Manual digitization of existing graphic maps (table digitizer)

2) Data storage (disk and disk-drive, tape and tape-drive)
3) Data manipulation (host computer, softwares)
4) Textual /Graphic data presentation (graphic terminal, printer, plotter)
5) Communication link (telecommunication line)

To achieve the computerized parcel-based LIS environment, the proposed system development (hardware, software, and operation) is direct towards the configuration of a distributed computer network to suit the decentralized structure of the DOL. The main characteristic of a distributed data processing system is that the processor and storage facilities are physically dispersed and interconnected by communications facilities of some type. The users can do processing locally on their personal computer. The first stage of computer network implementation will be centred on the central computer (host) and linked with the microcomputers located in the Bangkok land offices and divisions within the DOL, in the form of local area network system (LAN).

9.2.2 Computer network

Brumm (1986) has characterized computer networks where major computing systems, called hosts, communicate with each other, with users, and with peripherals. Networks may be viewed as composed of nodes, with links connecting them. A node may be a device used to support network connections, or attachment points for major computers and users. The size and extent of a network is specified by the area of the user's need. The purpose of the computer network is to make possible the vertical integration of distributed network resources from standalone microcomputer workstations to the central computer. This will increase the computer power in the network, and the application programs can be uploaded and run on a large host computer.

9.2.2.1 Local area network system

The local area network system (LAN) can be interpreted as telecommunications exchanges of data by the computers within the network over a limited distance such as within the building or the province. The design of the LAN systems are centred in 3 strategies which are the star, the ring, and the bus networks as shown in figure 9.2.

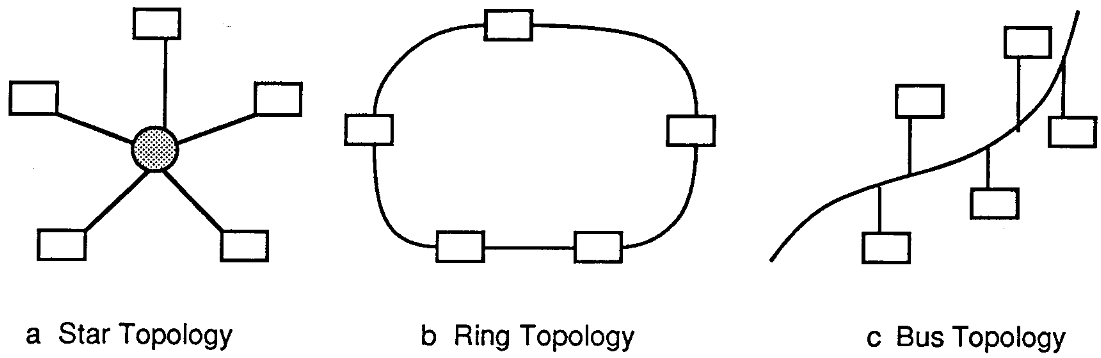


Figure 9.2 Local Area Network Topologies
(McRae and Svrcek 1986)

A star network (figure 9.2a) performs all communications through a central unit/node which is responsible for establishing, maintaining, and controlling the communications to the outlying nodes. The central unit of the star takes care of routing messages to the correct recipients.

A ring network (figure 9.2b) is in the form of a loop. Messages originate at a source node attached to the loop and then flow through intermediate nodes on the way to the destination node. The intermediate nodes function as relays. Each node removes only the messages sent to it.

In a bus network (figure 9.2c), messages are broadcasted onto a shared communications channel. All nodes attached to the communications path "hear" all the messages sent onto the loop, and ignore any message not sent to them.

The advantages of both the star and ring configurations are that they eliminate contention problems, when more than one network device attempts to send data at the same time (McRae and Svrcek 1986). But both have the difficulty of reconfiguring disadvantages. If the device acting as the active core of the star, or any device in the ring should fail, the entire network will fail. On the other hand, the bus network is easy to reconfigure, but needs a complex access control method to resolve contention problems. The access control method is that part of the protocol (the rules and standards that govern data interchange between sending and receiving computers, typically, the methods of packing, unpacking and routing the data) that allocates the band width of the broadcast medium to accommodate all network users and it ensures that only one device on the bus transmits at a given time, or alternatively itinstitutes a schema if more than one transmission. The main considerations in choosing the suitable topology are that:-

- how well a topology performs basic network functions;
- does it provide network management, data switching, and transmission?;
- is it reliable and maintainable?;
- can it provide protocol conversion within the network?;
- does it provide gateways to the networks?

The LAN system should be first implemented within the DOL and land offices in the Bangkok area. In the second stage, the LAN system should be set up in regional areas where a user's need is clearly defined. The feasible LAN system in regional areas will be in the form of microcomputer workstations at each provincial land office configured to the available regional university computer. The provincial land office will be the microunit of the DOL's LIS responsible for the land information of the district land offices within that province. The feasible computer hardware for the provincial land office will be a standalone microcomputer with printer and plotter configured as shown in figure 9.3.

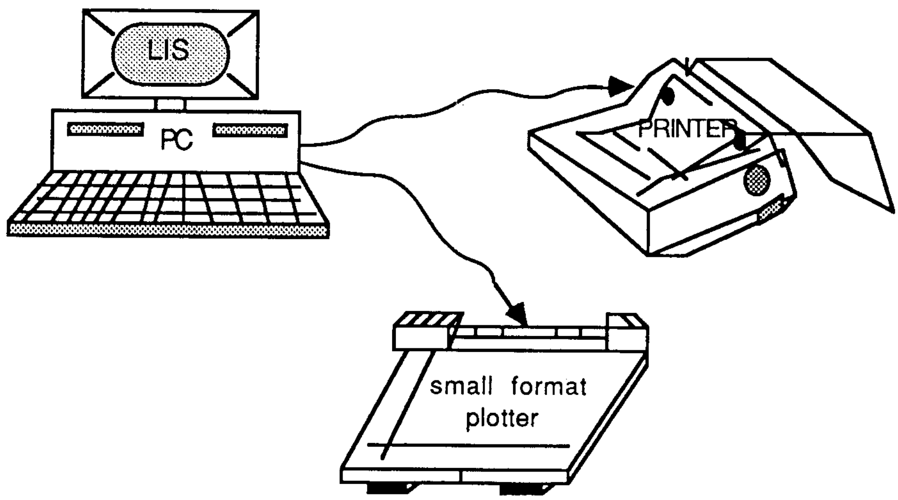


Figure 9.3 Feasible Provincial Land Office Computer Workstation

The hardware capability (based on IBM/AT compatible) of the pc depends on the amount of data in that land office. This standalone pc will employ the available pc-based DBMS and graphic management software. The integration of each LAN system and creation of the communication network management will form the wide area network (WAN) for the DOL's LIS as shown in the conceptual model of figure 9.4. This network model consists of host (central) computer, nodes (regional computers), pc, and transmission links between nodes.

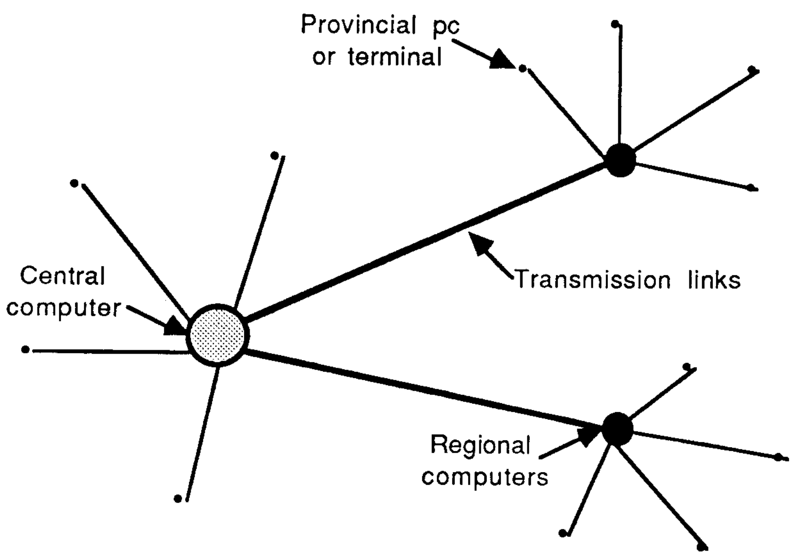


Figure 9.4 Model of Wide Area Network of DOL's LIS
(Adapted from Allam 1984)

To make the land office micros-to-central computer link feasible, there are two technical issues to be concerned. The first is making the physical connection: how the micros will link with the central minicomputer without spending extra money for additional hardware. The second is making the data connection: how the data transfers between micro and central computer will be achieved without extra money in programming. This second issue is concerned with the incompatability between the formats of data, and the differences in the way data itself is internally represented. These two problems are obviously solved by introducing the standards for linking heterogeneous computers called the Open System Interconnection model (OSI). This model is referred to as the network manager with its functions to provide the practical solution to interlinking heterogeneous computers within the network.

9.2.2.2 The Open System Interconnection Model

The OSI is based on the layer structuring technique. Each of the OSI layers performs a related subset of the functions required to communicate with another system. A brief summary of the OSI layers are as follows (Brumm 1986):-

Layer 1 called the Physical Layer, provides mechanical and electrical specifications and procedures to establish, maintain, and end physical connections.
Layer 2 called the Data Link Layer, ensures that the data passes without error from one computer to another.
Layer 3 called the Network Layer, lets two system exchange data. It defines packet addressing and data routing to its final destination.
Layer 4 called the Transport Layer, handles end-to-end error and flow control to ensure that communications exchange is orderly and reliable.
Layer 5 called the Session Layer, provides the structure for data exchange by managing connections between applications processes, and establishing and terminating connections. It also sends end-to-end messages and controller dialogues.

Layer 6 called the Presentation Layer, provides common communications services such as text compression and reformatting for heterogeneous computer systems if the same set of communications functions are implemented and organized into the same set of layers, and the same protocol for the various layers are used.
Layer 7 called the Application Layer, supports user and application tasks. It provides the communications services available for specific computer applications.

More details about each layer in the OSI model can be obtained from Brumm (1986). Another requirement in the link is to ensure that data transfer is efficiently accomplished. The need for efficient data transfers depends on choosing the telecommunication link and communicating software. To choose the communication link depends on the volume of data traffic between two points. If it is light, existing telephone lines may be used. If traffic is much heavier and the end points geographically close such as in the same building, a local area network line may be desirable. If the end points are distant, it is better to lease high-speed lines from the TOT. It should be recognized that the cost of telecommunications link can amount to a third or more of the total data processing budget (Brumm 1986). Another requirement is to choose the communicating software. The best known one is Kermit software. The functions of this software are as follows.

9.2.2.3 Kermit communication software

Kermit is a protocol based on the concept of co-operating Kermit programs resident on both the local microcomputer and the remote host computer, running simultaneously. To transfer files between a microcomputer, all the users have to invoke Kermit on the local microcomputer and connect to the remote host computer, login, invoke Kermit on the remote computer, then transfer back to the local Kermit to send or receive the desired files from the remote Kermit. Kermit performs receive file and send-file tasks as shown in figure 9.5.

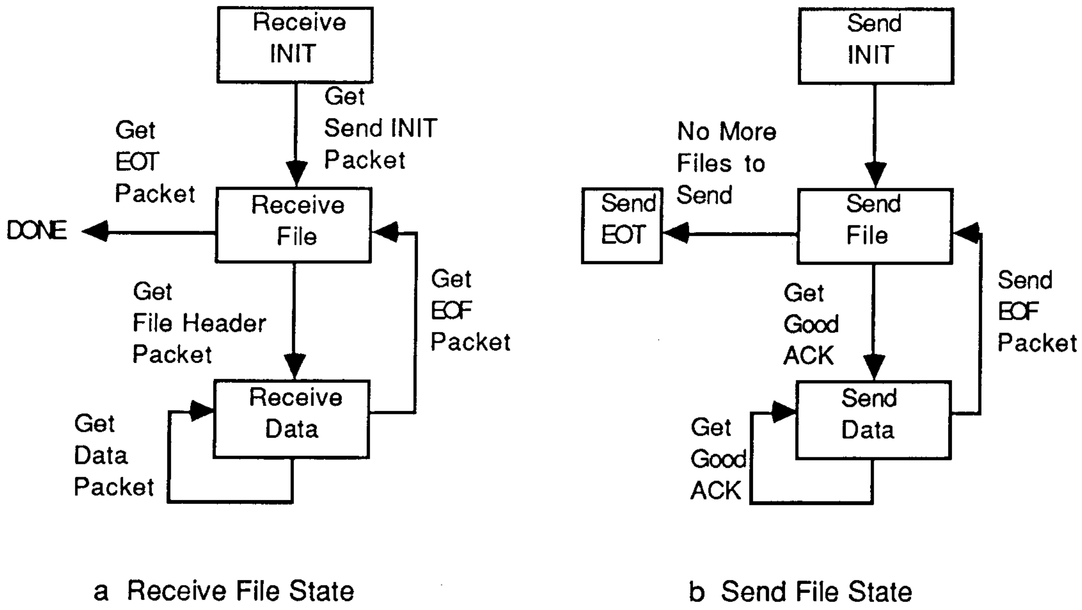


Figure 9.5 Kermit State Diagram (McRae and Svrcek 1986)

In figure 9.5a, the receiver starts receiving state and waits for the remote site to send a "Send INIT" packet. After the "Send INIT" arrives, the state becomes the "Receive File". Kermit waits for a "File Header" packet containing the name of the file that is to come. When the "File Header" arrives, Kermit opens a new file using the name provided, and switches to the "Receive Data" state. Kermit then receives the contents of the file until an EOF (end of file) packet arrives. At this point, Kermit switches back to the "Receive File" state. If another file is sent, another "File Header" packet will follow, otherwise an EOT (end of transmission) will terminate the transfer.

In the sending state (figure 9.5b), instead of waiting for a particular packet type, Kermit sends the appropriate packet and waits for ACK. If ACK does not arrive within the specified time, or another packet type arrives, the same packet ACK is retransmitted. A send operation begins with a "Send INIT" packet, includes one or more files, starting with a "File Header", followed by one or more data packets and then an EOF. When all the specified files have been sent, an EOT packet closes the connection and terminates the operation.

The study of the computer network provides a framework for introducing wide area network of computerized parcel-based LIS for the DOL as shown in figure 9.6.

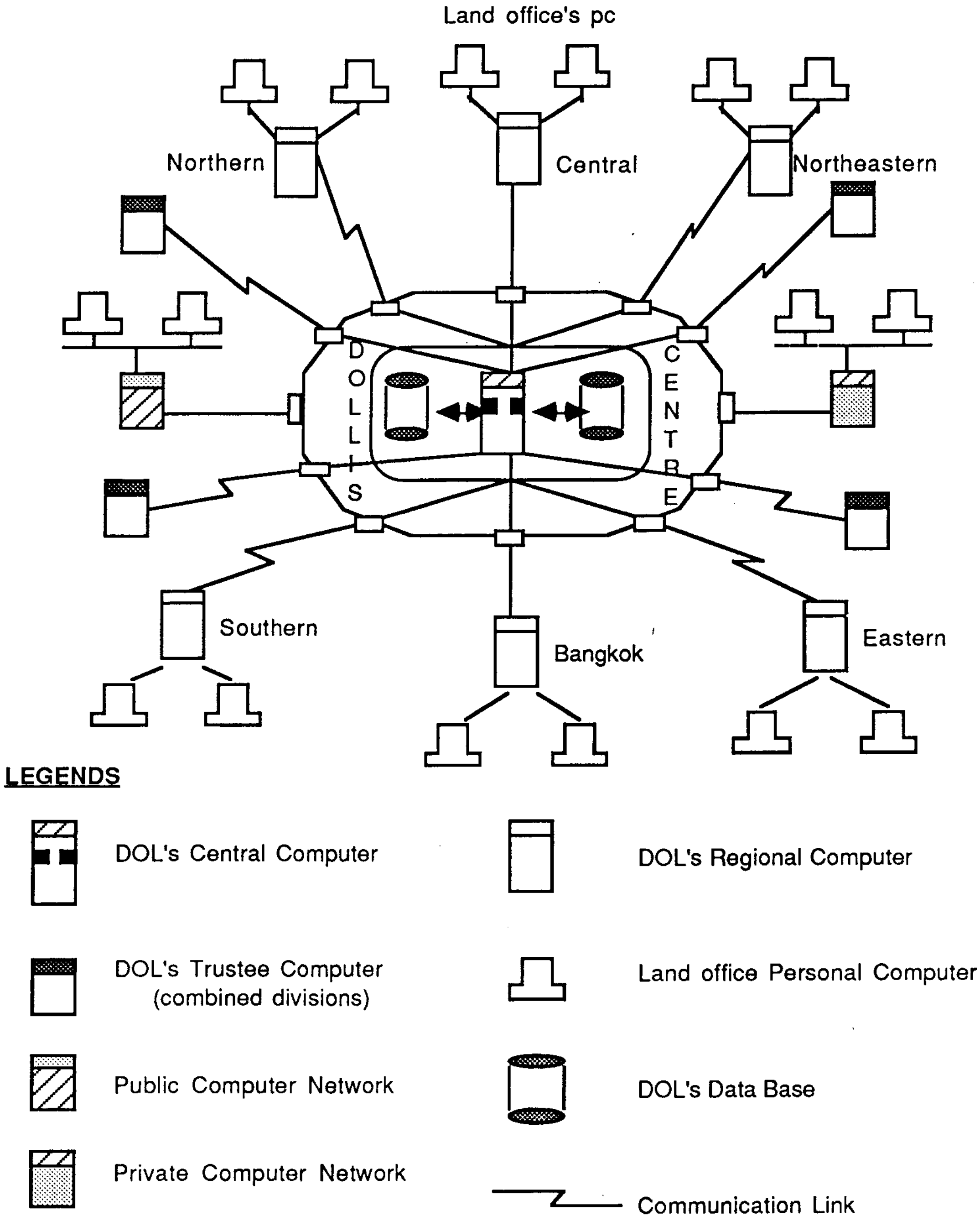


Figure 9.6 The Proposed Conceptual Wide Area Network Model of the DOL's Computerized Parcel-Based LIS (Adapted from SLIC, NSW)

This configuration is based on the assumptions that:-

1. The DOL implements the central computer or uses MOI central computer (already exist).
2. The provincial land office employs the pc.
3. The communication line is perfect.
4. The co-operation between the DOL and Ministry of University Affairs is accomplished.
5. There are trained officers in the computer area in the land office and the senior officer that have knowledge of computing.
6. The user needs are well investigated because it is a major factor in investing this capital intensive system.

From the figure 9.6, the DOL must nominate the responsible divisions within the DOL to act as trustee organizations to be responsible for the regular data acquisition, maintenance and storage of specific items of data within their own divisions. For example, the Urban Mapping Division is responsible for cadastral mapping, the Surveying and Mapping Division for control survey data, CVA for valuation roll, Land Document Division for ownership record etc. The trustees have to provide the data to the computerized LIS as required to meet the demands of timeliness and accuracy and control for the outside departmental system network which is linked to the DOL's LIS.

9.3 The Concept for the System Network of the DOL's LIS

The system network configuration in the figure 9.6 is based on the decentralized administrative structure of the DOL. The background to this is that the area is divided into 5 regions-i.e , North, Northeast, Central, East, South and Bangkok-Thon Buri as a separate administrative area. Each region covers the provinces under that administrative boundary. To achieve the system network, the DOL should have the co-operation of the Ministry of

University Affairs to use the university computer centres which are located in the regional universities. This also requires telecommunication lines to link the regional computer centres with the DOL's central computer. Thus, the co-operation with the TOT is also important.

The concept for this network is that the provincial land office will be the microunit of the DOL's LIS by gathering and manipulating data from the district land offices and linking with the regional computer. To achieve the decentralized structure, the data acquisition (textual file), updating, editing etc. will be performed in the provincial land office while the central computer acts as the storage of master copy files. The quality control should be the responsibility of senior officer in that land office and the trained staff. This is feasible because the software development in LIS area tends to be pc-based and the power of the computer both hardware and software increases rapidly while prices are decreasing. This allows the land office to afford the powerful pc and relevant pc-based LIS software.

This distributed network systems relies mainly on processor and data communications technology. A distributed communication mechanism created for this configuration will provide multiple processors with the objective of sharing local data bases and the central data bases. The collection of the local data in a central data base will require translation programs to reformat files according to a standardized data base structure. The updates must be done in a way that preserves the consistency of the data base. The central computer is also required to provide indexes and bibliographies to the data bases. Facilities at the regional computer also control communications paths between the distributed systems as a switch. The important point to be noted in figure 9.6 is in the central computer and data bases which form the LIS centre for the DOL. The LIS centre will integrate all components which have been investigated from chapters 3-9 into one logical relationship as shown in figure 9.7.

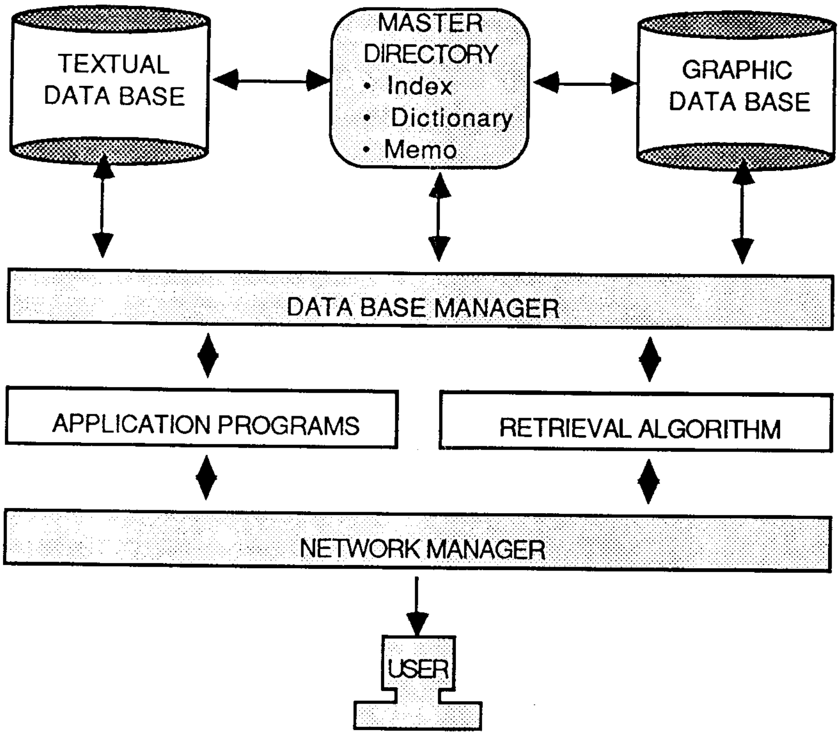


Figure 9.7 The DOL's LIS Centre

This DOL's LIS will allow all users access to data bases as soon as the update is made. However, to keep the DOL's data base up-to-date in the distributed systems is a quite complicate task. The DOL has to assign documentation duties to one person and make it a major responsibility. That person is referred to a data base manager and is a central point for controlling change flow. Periodically the documentation will be updated and the data base manager will forward (or enter on-line) corrected copies to all concerned parties.

The last issue of concern is the security and protection of the system from unauthorized access and accident. Data base security problems can occur in the storage devices on the central computer, land office micros, as well as at each of the access points to the central computer. To maintain internal security and protection while allowing people to access and use the system is difficult. Thus, planning for security and protection such as password assignment etc will help protect data base from data integrity violation.

The study of model of computerized parcel-based LIS in this research is mainly concentrated on the institutional arrangements and the technical aspects in setting up the system. In addition to achieving those aspects, the system must satisfy economic aspects. The following will discuss the economic aspects in implementing the system.

9.4 Economic Point of View in Implementing Computerized LIS

LIS is implicitly a type of land information production since the system puts added-value to the raw data during data processing. The processed data is then used in a decision-making support role. In economic terms, the first stage of implementation of computerized LIS may involve a large amount of investment in capital cost such as computer systems, softwares etc and the operational cost such as data acquisition, software design etc. But in the long term, the cost will be reduced to only operational costs and maintenance of the system while the system improves the efficiency in land management of the DOL. Costs arising from implementing the system are generally identified as tangible and intangible costs. Tangible costs which can be valued in monetary terms involve:-

- documentation detailing system requirements
- software purchasing and development
- hardware purchasing
- system testing
- initial data base creation
- materials (tapes, disks, pens, paper etc)
- retraining of staff who interface with the system
- existing internal staff and additional external staff salaries
- equipment maintenance and depreciation
- on-site vendor support (first year)
- electricity charges (hardware, airconditioning)

Intangible costs, on the other hand, cannot be valued in terms of a monetary unit. It includes the opportunity cost which is the value of the highest foregone alternative invested in other projects due to implementing computerized LIS. These costs involve:-

- impact of implementation delays
- disruption of current operations during implementation
- staff attitudes due to changes

To evaluate the economics of implementing the system using cost/benefit analysis is not practical for many reasons:-

1. This project is undertaken by the government sector.
2. The objective of a government project is to supply services to public not to maximize profits as in private projects.
3. The cost and benefit incurred from implementing the system are difficult to value in monetary terms.
4. The demand and supply of land information is difficult to quantify in unit terms like commodity goods. Therefore, the analysis of implementing the system using the production-consumption theory in terms of demand-supply constraint is not feasible.

In this study, the system will be evaluated in terms of economies of scale brought about by implementing the computerized LIS. The economies of scale are well studied by Silberston (1972). It refers to the behavior of average costs of producing a given product at different rates of output per unit of time. The characteristic of economies of scale can be illustrated in figure 9.8.

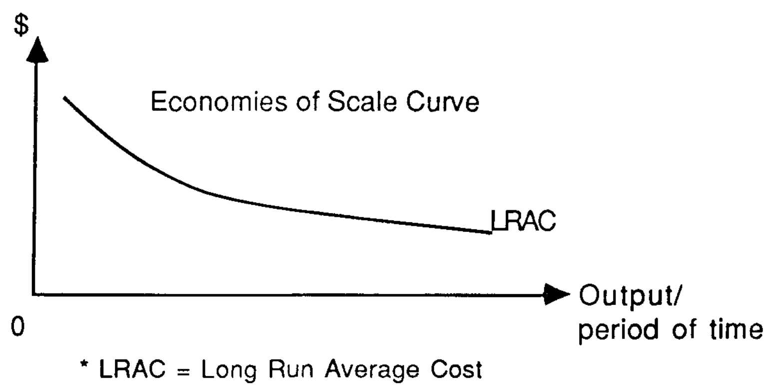


Figure 9.8 Economies of Scale from Land Information Production

The horizontal axis is the output/period of time. The rate of output increases while the cost of producing the output represented by long run average cost, LRAC decreases. The higher the rate of output (land information), the more the automation process of land information production. This represents the transition of manual to computerized LIS. The decrease in long run average cost of land information by implementing the computerized LIS is determined by reference to the economies of land information production. The economies may arise from cost reduction or savings. The source of cost reduction can be classified as:-

- Those that affect capital costs (per unit). Some costs may be constant whatever the scale of the system is, e.g., system design costs, or research and development costs. The larger the total land information output supplied over time once the computerized LIS is in full operation, the lower will be in these costs per unit.

- Those that affect operating costs (per unit). This can be categorized as:-
  - Specialization of staff and organizations will increase scale of land information output per unit of time (related to user demand or user need). For example, agencies which have the capability to produce standard maps with its specialized techniques, can supply the products to another agency as required in a timely way.
  - Vertical linking of economies in the case where a computerized LIS network is implemented. Large scale land information production and massive organizational resources will be used. It is possible to link successive stages of land information production without sacrificing economies at each stage. Thus, a large scale of output per unit of time can be achieved and economies may arise as a result of the linkage, e.g, reduction of transport costs when the information can be on-line to local land offices.

On the other side, savings may come from cost reduction in operation of computerized LIS in comparison to previous non-integrated manual system. For the DOL, savings may be some form of opportunity benefits due to service improvements which cannot be translated into monetary terms and increasing efficiency in land tax collection. The economies arising from implementing the system can be regarded as a function of: time periods, land information products, and units which generate the land information.

1. Time periods refer to the life of the computer system and peripherals which can supply land information, and the life of land information itself (can be used without change over time). Other things being equal, longer the life-span of the system and land information will reduce costs per unit of output.

2. Land information products refer to:-
   2.1 Total land information products generated from the system over time will indicate savings by spreading initial costs over the period.
   2.2 Standardization between land information products is relevant to savings in design and from reducing duplication of effort in data collection, processing, and maintaining.

3. Units refer to:-
   3.1 Participation of several organizations results in savings that may arise from co-operation, specialization in map making, data collection, and land administration. The savings depend on the degree of co-operation or horizontal integration, since it affects the possibilities of data sharing between the organizations.
   3.2 One agency may create savings that arise from specialization in various stages of the process of map making. It relates to the degree of depth or vertical integration, since it affects the possibilities for technical linkage within the organization.

However, since the land information product is the output of the LIS project, the product must serve the potential user's needs as much as possible. In order to understand how a product benefits users, it is essential to understand the features of that product which are relevant to the users. The following is a checklist of LIS product features which should be considered and be a guide when defining the LIS products.

9.4.1 Information characteristics

- Contents
  - How accurate is the land-related information which would be produced?
  - Have accuracy standards for the data been established?
  - How would the accuracy of the information differ, if at all, from current available information of this type?
  - Would accuracy standards be evident to users?

9.4.2 Temporal characteristics

  - Would time series data be available?
  - How often would the information be updated?
- Compatability
  - What other types of information can the LIS product be related to or interact with?
  - What are the major types of cross referencing with other data bases which are foreseen?
- Legal status
  - What would be the legal status of the LIS product?

9.4.3 Spatial referencing characteristics

- Mode of spatial referencing
  - How would the LIS product be referenced spatially, e.g., survey co-ordinates, administrative boundaries, etc ?
- Resolution
  - At what degree of resolution is the system by which the LIS product would be referenced?
  - How broad an area of the country would be covered by the LIS product?

9.4.4 Mode of access and output

- Graphic characteristics
  - What form of graphic output would be available?
- Report format
  - In what format would reports be available?
  - Would there be a standard format for reports?
- Communications
  - Could the LIS product be accessed by remote users?
  - If so, how would the information be transmitted?
- Security and privacy
  - What protection would there be against unauthorized modification or destruction of data?
  - What protection would there be against accidental or intentional disclosure of the LIS product to unauthorized users?
- User data analysis characteristics
  - To what degree will the user be able to undertake basic data analysis functions such as distance and area calculations, polygon overlay, boolean logic analysis, point in polygon analysis, basic statistical analysis, boundary determination etc ?
- Response time
  - What are the average and maximum times it will take users to access the information?

10 FINAL CONCLUSION

" In the '*Long Run*', we are all dead."

- J.M. Keynes

This research investigates and specifies the essential components for the development of computerized parcel-based LIS for the DOL. The investigations are in both macroview and microview.

In macroview, it provides the base line for the implementation of the system at the national level and departmental level with correlation with each other. The discussions are centred around chapters 1-3. The main points are to define the problems which obstruct the LIS development in Thailand. The problem are mainly institutional problems. The lack of co-operative mechanisms between organizations involved in LIS is a main problem. This leads to duplication of effort in data production, data collection. Consequently, the data collected by various organizations lack standards and therefore are incompatible with other agencies favours. The strategies and methodologies imposed are to increase co-operation by setting up a committee for land resource management and a data centre within the country. The committee consists of key representatives from the concerned organizations. The committee should organize meetings at, specified periods to discussed the problems and issues concerning the LIS development. The data centre is also important for co-ordinating LIS developments between organizations and compiling data standards.

The major data bases in Thailand can be categorized into parcel-based, utility, municipal, resource and environment, and statistical data bases. The function of each type of data base is described in chapter 2, section 2.3. The integration of these data sources to one logical LIS should be based on nodal approach as presented in chapter 2, section 2.4. This model allows each node of the data base to be developed independently but provides for the communication between each node. It also allows the development of the system incrementally.

In microview, the DOL which is responsible for the parcel-based data base is then thoroughly investigated departmentally, in regard to each of the essential components for the parcel-based LIS development. The investigation is centred around the urban mapping activity, individual massive valuation, computer mapping system, and cadastral system of the DOL. The study is focussed on the method of data production, data collection and coding, and data quality. To computerize parcel-based LIS within the DOL, the parcel identification is investigated and a suitable identifier is proposed. Another essential component is the creation of the efficient data base system. The data base system for the textual and spatial data of the DOL is discussed to determine the suitable data structure for the DOL's data base. The suitable data structure for the textual data is the relational data structure, while the topological data structure should be selected for spatial data. Finally, the computer network system and data communication for future integrated parcel-based LIS in the DOL is discussed. The integration of each component will form the model of the computerized parcel-based LIS for the DOL.

In final summary, the DOL must lead in LIS development by encouraging inter-agency conferences on LIS in the manner of creating awareness of each other's needs and activities. A seminar environment should be created by a non-biased body (such as Chulalongkorn University) to find the solution to the needs, the purposes, the goals, and liaison required for LIS. The aim is to increase the awareness of LIS and create conditions for better communication between agencies. A seminar may be necessary on an annual basis to resolve the continuing issues. Such a seminar will lead to the creation of inter-agency committees able to commission state-of-the-art papers, investigate the needs, to act as a co-ordination agency, to promote interchange codes and standards, to address the problems such as land parcel identifiers, the links between data sets manually and computerized, to raise the whole land information management area in importance politically.

The model of computerized parcel-based LIS for the DOL in this research will provide the basis for DOL in LIS development. However, the research in the LIS area must be continually undertaken in the DOL to solve the particular problems which obstruct the LIS development. This relies mainly on the administrative support and co-operation between the divisions within the DOL. The transition from manual system to the computerized parcel-based LIS for the DOL will help increase the efficiency of the DOL in its land administration and serve the potential users as tax payers with the land information as the main objective.

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APPENDIX 1

แบบฟอร์ม ฆ1 ทรัพย์สิน ลำดับที่ ๒๐

จังหวัด กรุงเทพมหานคร	ที่ตั้งแปลงที่ดิน ๑๑๔/๑,๑๑๔/๒ ซอยสุขุมวิท ๔๑
อำเภอ/เขต พระโขนง	โซน/บล็อก/ล็อต ๗๐๑๔-๔/๓๖๔๖
ตำบล พระโขนง	พื้นที่ ไร่ ๑ งาน ๖๒ ตารางวา
โฉนด เลขที่ ๑๓๔๔๒	ขนาด (กว้าง ยาว)
หน้าสำรวจ	

ชื่อเจ้าของ	ที่อยู่	การซื้อขาย	
		วันที่	ราคา
นางปราณี จันทรศร	๑๑๔/๑ ซอยสุขุมวิท ๔๑		

การใช้ประโยชน์ ที่อยู่อาศัย [/] พาณิชยกรรม [ ] อุตสาหกรรม [ ] อื่นๆ [ ]

ลักษณะที่ดิน มีการระบายน้ำเป็นอย่างดี [ ] มีน้ำท่วมขัง [/] ถมเรียบร้อยแล้ว [ ]

ทำเลที่ตั้งของที่ดิน ติดถนนใหญ่ [ ] ติดถนนซอย [/] ไม่ติดซอยและถนนใหญ่ [ ]

ประเภทของสิ่งปลูกสร้าง	อายุ	วัสดุที่ใช้	วัสดุหลังคา	ขนาด($ม^2$)	มูลค่าต่อ $ม^2$	มูลค่าประเมิน
บ้านตึกสองชั้น	๒๕๒๘	คอนกรีต	ถอนก	๑๔๔	๔,๐๐๐	๕๗๖,๐๐๐
บ้านไม้สองชั้น	๒๕๐๐	ไม้	ถอนก	๙๖	๗๐๐	๖๗,๒๐๐
ชั้นเดียว	๒๕๐๐	ไม้	ถอนก	๓๒	๖๐๐	๑๙,๒๐๐
มูลค่าทั้งหมดของสิ่งปลูกสร้าง						

วันที่สำรวจ	ชื่อเจ้าหน้าที่ผู้สำรวจ	ค่าเช่า	หมายเหตุ	ต่อ วา^2	มูลค่าที่ดิน	มูลค่าที่ดินรวมสิ่งปลูกสร้าง
๔ เม.ย. ๓๐	แกลว			๑๒,๐๐๐	๑,๙๔๔,๐๐๐	๒,๖๐๖,๔๐๐

N1 Form Used to Record Data of Individual Properties

สำนักงานกลางประเมินราคาทรัพย์สิน

แบบฟอร์ม N2

การซื้อขายรายที่ ๓๘

แบบฟอร์มวิเคราะห์การซื้อขาย

การซื้อขายรายที่

จังหวัด กรุงเทพมหานคร อำเภอ/เขต พระโขนง ตำบล แขวง พระโขนง โฉนด เลขที่ ๑๙๓๙๑๒ หน้าสำรวจ –	ที่ตั้งแปลงที่ดิน ซอยสุขุมวิท ๗๙ โซน/บล็อก/ล็อต ๗๒๑๙ – ๙/๒๖๒๓ เนื้อที่ – ไร่ – งาน ๓๐.๙ ตารางวา ขนาด (กว้าง ยาว)

ชื่อเจ้าของ นางวนิกา จินารักษ์พงษ์

ที่อยู่

ชื่อผู้เช่า (ถ้าให้เช่า)

รายละเอียดเกี่ยวกับการเช่า ระยะเวลา ค่าเช่า

วันที่ทำการซื้อขาย ๘ พ.ค. ๒๘	จากสำนักงานที่ดิน	จากการสัมภาษณ์	เจ้าหน้าที่
ราคาตามสัญญา	๕๐๐,๐๐๐	๒,๕๐๐,๐๐๐	
หัก ค่าเฟอร์นิเจอร์ อุปกรณ์ต่างๆ		–	
= ราคาอสังหาริมทรัพย์		๒,๕๐๐,๐๐๐	
หัก มูลค่าของสิ่งปลูกสร้าง		๑,๕๖๕,๗๐๐	
= ราคาสุทธิของที่ดิน		๙๓๔,๓๐๐	
ราคาสุทธิต่อตารางวา		๓๐,๒๓๖	๓๐,๐๐๐

การใช้ประโยชน์ ที่อยู่อาศัย [/] พาณิชยกรรม [ ] อุตสาหกรรม [ ] อื่นๆ [ ]

ลักษณะที่ดิน มีการระบายน้ำเป็นอย่างดี [/] มีน้ำท่วมขัง [ ] ถมเรียบร้อยแล้ว [ ]

ทำเลที่ตั้งของที่ดิน ติดถนนใหญ่ [ ] ติดถนนซอย [/] ไม่ติดซอยและถนนใหญ่ [ ]

ประเภทของสิ่งปลูกสร้าง	อายุ	วัสดุที่ใช้	วัสดุหลังคา	ขนาด ($ม^2$)	มูลค่าต่อ $ม^2$	มูลค่าประเมิน
ทาวน์เฮาส์ ๓ ชั้น	๒๕๒๙	คอนกรีต	ซีเมนต์	๒๒๙.๓	๖,๐๐๐	๑,๓๗๕,๘๐๐
๖.๙๐ + ๑๒			เคลือบ	๖๓.๓	๓,๐๐๐	๑๘๙,๙๐๐
			สี			๑,๕๖๕,๗๐๐
มูลค่าประเมินทั้งหมดของสิ่งปลูกสร้าง						[illegible]

ผู้สำรวจ

วันที่

N2 Form (Sale Analysis Form)

แบบฟอร์ม N3

ตารางเปรียบเทียบการซื้อขาย

วิเคราะห์ราคาซื้อขายตามที่กำนวณไว้ในแบบฟอร์ม N2

จังหวัด กรุงเทพมหานคร อำเภอ/เขต พระโขนง			ตำบล พระโขนง ช่วงเวลาที่ศึกษา ๑ - ๓๐ มีนาคม ๒๕๓๐				การใช้ประโยชน์ทรัพย์สิน ตึกแถว ที่ตั้งของแปลงที่ดิน ติดซอย		
รายที่	วันที่ขาย	ราคาขาย	หักค่าสิ่งของเครื่องใช้	= ราคาอสังหาริมทรัพย์	หัก มูลค่าสิ่งปลูกสร้าง	= มูลค่าที่ดิน	พื้นที่ที่ดิน	มูลค่าต่อ วา^2	ข้อสังเกตในการเปรียบเทียบ
๔	๓/๘/๒๘	๗๕๐,๐๐๐	๑๐๐,๐๐๐	๖๕๐,๐๐๐	๓๘๐,๐๐๐	๒๗๐,๐๐๐	๐-๐-๑๔	๑๙,๐๐๐	ทำเลค้าขายได้
๔	๒๓/๑๒/๒๙	๕๐๐,๐๐๐	–	๕๐๐,๐๐๐	๓๐๔,๐๐๐	๑๙๖,๐๐๐	๐-๐-๑๔	๑๔,๐๐๐	เป็นที่อยู่อาศัย
๔	๑๗/๐๔/๒๘	๙๕๐,๐๐๐	–	๙๕๐,๐๐๐	๔๔๘,๐๐๐	๕๐๒,๐๐๐	๐-๐-๑๑.๒	๔๔,๘๐๐	อยู่ในตลาดอ่อนนุช

ผู้ตรวจ ... ผู้ควบคุม

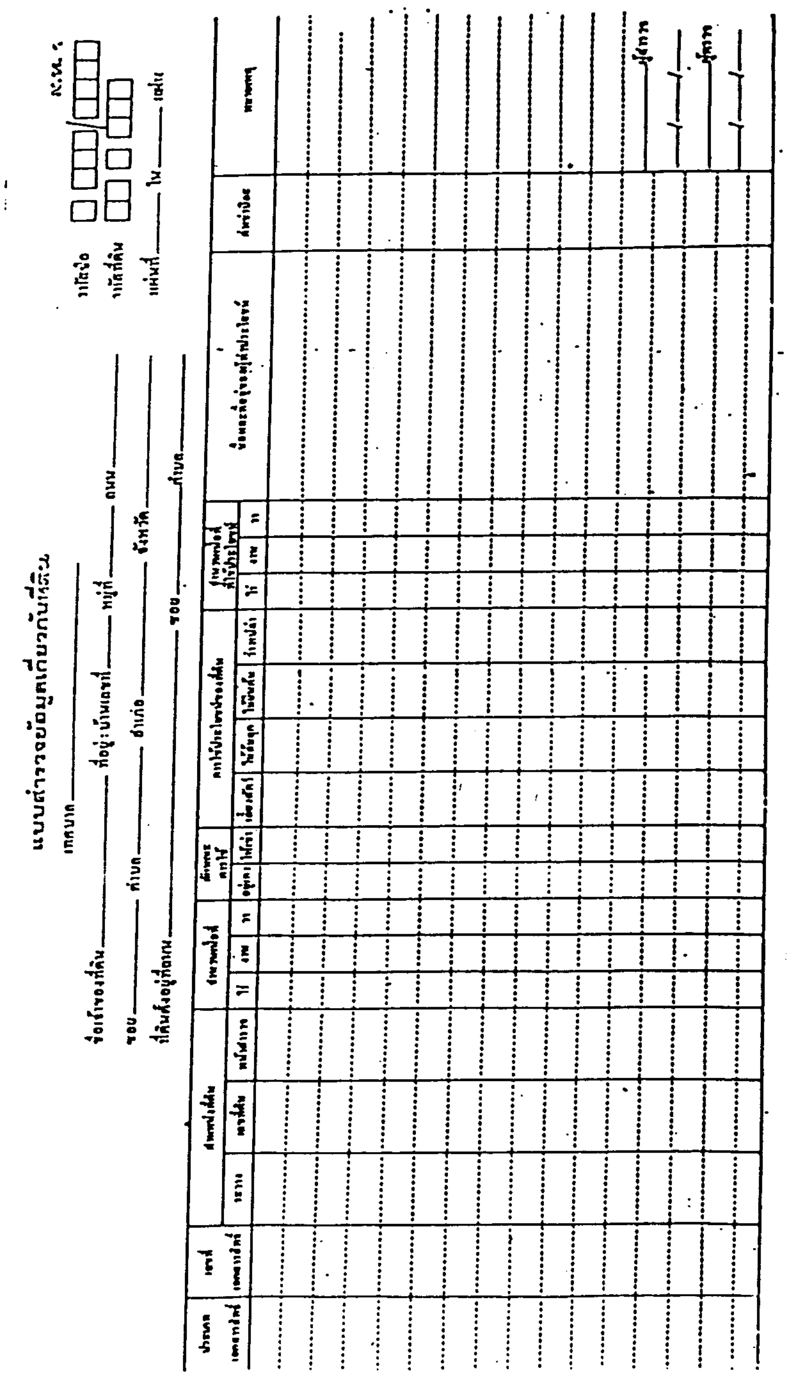
วันที่

N3 Form (Transaction Price Comparison Form)

ทะเบียนที่ดินและโรงเรือน บล็อคที่ ..๗.๑......

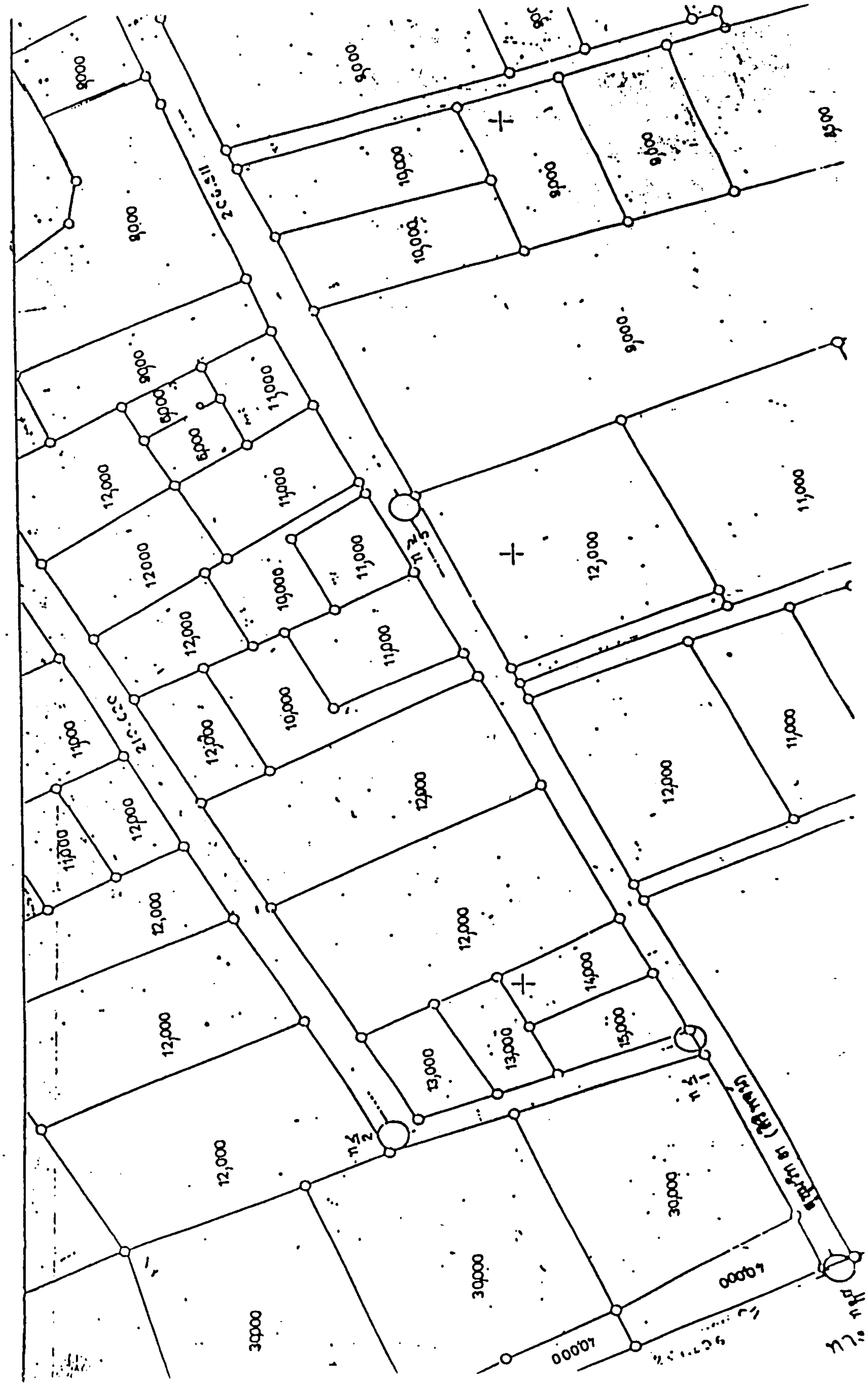
รหัส	เลขที่ดิน	หน้าสำรวจ	โฉนดที่	เนื้อที่			ชื่อผู้ถือกรรมสิทธิ์	สิ่งปลูกสร้างบนพื้นดิน							หักค่าเสื่อม	ราคาโรงเรือน	หมาเ
				ไร่	งาน	วา		ที่	บ้านเลขที่	แบบบ้าน	การใช้ประโยชน์	ปีที่ก่อสร้าง	เนื้อที่อาคาร	การครอบครอง			
๒๖	๘๗๘	๖๙	๘๑๖๙	–	๑	๕๐	นางบุษฐ เผ่าธัญญลักษณ์	๑	๑๘๒/๑	๑.๓	อยู่อาศัย	๒๕๐๐	๔๖	เช่า	๑๐๐	๑๓๕,๗๐๐	
								๒	๑๘๒/๒	๑.๓	"	"	๔๖	"	๑๐๐	"	
								๓	๑๘๒/๓	๑.๓	"	"	"	"	๑๐๐	"	
๒๗			๓๓๕๔								ว่าง						
๒๘	๖๖	๒๖๘๘	๒๒๒๓๘	–	–	๘๐	นายผล นาวีสิทธิ์	๑	๒๓๑/๖	๒.๓	อยู่อาศัย	๒๕๑๗	๑๔๔		๒๒	๔๓๖,๓๒๐	๓๔๐
								๒	–	๒.๓	"	๒๕๒๕	"		–	"	๔๓๖
๒๙	๓๗						นางทัศนา นาวีสิทธิ์	๑	๒๓๑	๑.๓	"	๒๕๑๐	๔๔		๖๕	๑๔๔,๓๐๐	๔๔
๓๐	๗๑	๓๓๐๗	๒๓๗๗๘	–	๑	๒๕	นางประจง สัจจะเวช	๑	๒๓๑/๕	๑.๓	"	๒๕๑๕	๑๒๙		๔๐	๓๘๐,๕๕๐	๒๒๘

Property Roll



Field Book Form

แผนที่แสดงการประเมินมูลค่าที่ดินรายแปลง (บาทต่อตารางวา)



Massive Individual Valuation Map (Baht/wa^2)

APPENDIX 2.1

Specification for computer mapping system

1) Central computer

Processor(s) and Online Disk Storage

- Central computer processors must employ 32 bit architecture with integral hardware for virtual memory management of at least 512 Mbyte, and provide fast floating point process or for single and double precision accuracy, and must handle re-entrant code.

- Control computer must support 16 and 32 bit integers, and 32 and 64 bit floating point numbers, and 8 bit characters.

- Where a single central processor is proposed, it must have a minimum 8 Mbyte main memory and where more than one cantral processor is proposed, the memory must be at least the equivalent and sufficient to avoid excessive disk I/O.

- Capable of multi-level interupt; the number of interupt levels, or equivalent, must be stated.

- On-line disk storage of at least 900 Mb formatted capacity distributed over at least two drivers is required for a single processor configuration and greater amount of disk for multi-central processor. The disk units and controller must be of high performance to allow efficient I/O for automated mapping applications; peak transfer rate must be at least 1.2 Mb/second or better.

- The disk controller must be capable of handling at least 2 future drives

- Each processor in a multi-processor configuration must have at least one on-line disk unit.

- A suitable system console incorporating detachable keyboard, visual display of 80 characters by 24 lines at least, and 80 columns character printer with suitable printing speed unit be provided.

2) Magnetic Tape Unit

9 track magnetic tape system employing vacuum pump not streaming tape technology, is required for daily incremental and weekly back up, data archiving and data transfer to other computers. The system must provide high speed and interactive data transfer facility.

As a minimum the unit must process 0.5 inch tape of 2400 feet length and 1600 / 6250 BPI at 75 IPS.

The system must provide error detection by read after write check and write - or - erase lock out mechanism.

(i) back up / archive / retrieve of binary data

(ii) data transfer of ASCII and EBCDIC data on tape with user defined parameters (eg blocking factor, label)

3) Network Software (in the case of multi-processors)

(i) terminals connected to one processor may communicate with others as if connected directly (eg to ' log-on ' directly)

(ii) users may read and write files on any network processor so that file transfer is transparent across the network

(iii) Files accessed locally or across the network have the same file security mechanism

Software for communication with the existing and new 'IBM PC compatible' terminal
(i) text data transfer from the PC/VDU to a file on the central processor via serial asynchonous communications
(ii) terminal emulation, to allow the PC/VDU to operate on the system

Serial asynchonous communication software on the central processor must allow for the software selection of duplex type, number of bits, parity type, baud rate, stop bits etc.

Multi-user re-entrant software capability to enable concurrent use of programs by a number of batch and interactive users
re-entrant interactive screen editor
program linker, using object module libraries

4) Data Capture

At least two maps to be registered on the digitizer simultaneously and able to be digitized during the one session.

Transformation of digitized table co-ordinates to real world co-ordinates must be performed using up to 10 input control units. Both the transformations should be performed interactively ' on the fly ' rather than post processing.

The fixed co-ordinate values of the control points will themselves be obtained by digitizing maps rather than from keyboard entry of survey co-ordinate values. It is therefore highly desirable that these co-ordinates can be retained for later use during the registration process of the cadastral map. The activity flow is expected to be;
Firstly, register and then digitize several control points from each of 2 or 3 detail maps and;
Secondly, register the cadastral map using control point co-ordinates obtained at the first step.

The transformation parameters must be saved between closed sessions (where the maps are not moved)

It is desirable that the transformation residuals be displayed.

Digitized line strings must be allowed to start and close exactly onto existing points and lines.

Entry of co-ordinate and line vector information from the keyboard must be available.

5) Editing

The hitting or ' log-on ' of existing entities must result in a clear response on the graphic screen.

Effective use of color and local intelligence in the graphic workstations must facilitate editing. Hardware generated line styles and character styles.

An easy to use map sheet edge matching facility must be provided.

Editing by post-process clean-up routine to snap open lines onto nearby points and lines is desirable.

6) Data Base and Windowing

It must allow at least 255 different features to be feature coded or labelled. Entities must be interactively made, viewable/not viewable, editable/not editable, plotable/not plotable, user definable pen numbers for plotting. Both software windowing and local terminal pan and zoom in virtual address space must be supported. The virtual address space should be at least 4000 by 4000.

7) General Features

User Interface

The user must be able to create menus for use on the graphic screen data tablet and cursor buttons.

Data Transfer

The system must allow a selected window of the data base to be output to an ASCII file for data transfer to an outside computer.

Graphics Library Tools

(i) user defineable character fonts to provide additional fonts to the standard character sets and to allow in particular the department to define Thai Script numeric characters.

Polygonisation

The precise need of the department is defined below. Parcels which are fully contained within a map sheet window or the greater part of their area falls within the map sheet window from a group and each parcel within the group is assigned a unique parcel number. The group is identified by the map sheet number. The boundaries of parcels not in the group (ie those near the sheet edge) are shown on the map sheet but these parcels do not show a parcel number on this sheet. The parcels are numbered starting with number one in the top left corner of the window and moving left to right across the window, in a horizontal band of say 40 mm wide, and down the window. A group listing showing all the parcels by parcel number and area must be produced.

Graphic Workstation provide ergonomic environment for graphic digitizing and editing. Screen size at least 19 inch diagonal, pixel resolution of 1024 by 768 or better.
A minimum of at least 8 simultaneously viewable colors for graphic data.

At least 770 Kbytes RAM for local picture storage.
Screen cursor control via data tablet with multi button puck (not pen)

The digitizing table must be supported by an adjustable pedestal and conform to the following specifications.

- active digitizing area of at least 36 inches by 48 inches with hard and lightly colored surface
- resolution of at least 25 microns and high accuracy of ± 0.15 mm in X and Y over the active are of the table
- repeatabilty of at least 0.1 mm

- freely moving cursor with at least 12 buttons, preferably 16
- operate in point, run and increment modes
- adjustable tilt and height control

The keyboard must be detachable and provide alternative command input to that from the tablet menu.

Automated Plotter with Terminal

- low speed liquid ink and high speed ball point plotting on both paper and drafting film material
- minimum plot area must be A0 size (1189 mm by 841 mm)
- dual mode cut-sheet and continuous roll work
- static positional accuracy for both axes on cut-sheet of ±0.25 mm or better and repeatabilty of 0.15 mm or better
- maximum speed of at least 35 IPS axially and 4G acceleration, and user selectable to slower than 10 IPS and 2G for wet ink plots
  at least 2 pen holder and automatic pen capping with fast pen cycle time (no more than 25 milliseconds per cycle)

Operator Control for

(i) return to origin

(ii) pen type and force

(iii) scale change

Thai modification is required under MS-DOS and it must displayed at least 20 lines of clear Thai script characters.

APPENDIX 2.2

Benchmark Test Model

For this test, two map copies are provided to be digitized. The maps show land parcels of what is known as NS3K tenure (which is a right to put the land to productive use but is not a full ownership). The original maps are transparent overlays at approximately 1:5000 scale and have been compiled from photo enlargement of aerial photography. Hence, the NS3K maps have metric errors due to unknown scale and photo tilt effects. For the maps and control point co-ordinates provided, an affine transformation fits the control with residual errors less than 1.5 mm. The NS3K maps are to be transformed by digitizing to produce a 1:4000 UTM map with an extent of 2 km by 2 km showing:-

(i) cadastral boundaries
(ii) annotated unique parcel number for each parcel
(iii) map border and grid with crosses at 0 meter intervals
(iv) map title and name of bidder

From the digital parcel boundary data, polygons are to be automatically created by computer software and the land area computed for each parcel, and a listing output showing the parcel areas indexed by parcel number. The area should be shown in units of square meters. The allocation of parcel numbers should start at the top left of the map sheet and work across the sheet from left to right, in bands of defineable width (eg 40 mm), and work down the sheet. Also the placement of the parcel annotation should be made automatically at the parcel centroid. (the parcel number in the listing must coincide with the parcel number annotated on the maps). Parcel boundaries must only be digitized once and during plotting there must not be any overplotting.

Test Requirement

Use of an affine transformation (ARC Manual 1985) model to create UTM map co-ordinates from the given control.

In addition to a set of output from an affine transformation a projective transformation model may be used to produce a second set of output.

Digitizing of both the given maps number 155 and 156, editing and edge sheet matching as required, to produce UTM map number one at 1:4000 with extent [E 178 000 N 1664000] to [E 180 000 N 1666 000].

Note
- (i) all boundary lines are straight line segments.
- (ii) Thai script characters are to be ignored for the purposes of the benchmark.
- (iii) the map should be plotted onto drafting film using wet ink pens.

Transformation Models

Affine Model

$$X = Ax + By + C$$

$$Y = Dx + Ey + F$$

where map co-ordinates (X,Y) are computed from digitized co-ordinates (x,y) and six parameters are solved from at least 3 non-colinear control points.

Projective Model

$$X = \frac{Ax + By + C}{Gx + Hy + I}$$

$$Y = \frac{Dx + Ey + F}{Gx + Hy + I}$$

where map co-ordinates (X,Y) are computed from digitized co-ordinates (x,y) and eight parameters are solved from at least 4 well distributed control points.

The system configuration must support the concurrent tasks with less than 2 seconds response to common graphic digitizer and edit commands, less than 2 seconds for operating system commands and screen edits, and the plotter must never halt during plotting for lack of data, under the following concurrent processing load.

APPENDIX 3

<u>บัญชีรายชื่อจังหวัดแยกตามภาค</u>

<u>ภาคกลาง</u> (CENTRAL) CODE 1 ; C

หมายเลข NUMBER	จังหวัด	PROVINCE	รหัส CODE
10	อ่างทอง	ANGTHONG	110 ; C10
11	อยุธยา	AYUTTHAYA	111 ; C11
12	กรุงเทพ-ธนบุรี	BANGKOK-THONBURI	112 ; C12
14	ฉะเชิงเทรา	CHACHOENGSAO	114 ; C14
15	ชัยนาท	CHAINAT	115 ; C15
24	กาญจนบุรี	KANCHANABURI	124 ; C24
30	ลพบุรี	LOPBURI	130 ; C30
34	นครนายก	NAKHONNAYOK	134 ; C34
35	นครปฐม	NAKHONPATHOM	135 ; C35
38	นครสวรรค์	NAKHONSAWAN	138 ; C38
43	นนทบุรี	NONTHABURI	143 ; C43
44	ปทุมธานี	PATHUMTHANI	144 ; C44
62	สมุทรปราการ	SAMUTPRAKARN	162 ; C62
63	สมุทรสาคร	SAMUTSAKHON	163 ; C63
64	สมุทรสงคราม	SAMUTSONGKHRAM	164 ; C64
65	สระบุรี	SARABURI	165 ; C65
67	สิงห์บุรี	SINGBURI	167 ; C67
71	สุพรรณบุรี	SUPHANBURI	171 ; C71
79	อุทัยธานี	UTHAITHANI	179 ; C79

Provincial Names and Codes According to Region

ภาคเหนือ (NORTHERN) CODE 2 ; N

หมายเลข NUMBER	จังหวัด	PROVINCE	รหัส CODE
18	เชียงใหม่	CHIANGMAI	218 ; N18
19	เชียงราย	CHIANGRAI	219 ; N19
23	กำแพงเพชร	KAMPHAENGPHET	223 ; N23
27	ลำปาง	LAMPANG	227 ; N27
28	ลำพูน	LAMPHUN	228 ; N28
29	เลย	LOEI	229 ; N29
31	แม่ฮ่องสอน	MAEHONGSON	231 ; N31
40	น่าน	NAN	240 ; N40
48	พะเยา	PHAYAO	248 ; N48
51	พิจิตร	PHICHIT	251 ; N51
52	พิษณุโลก	PHITSANULOK	252 ; N52
53	แพร่	PHRAE	253 ; N53
70	สุโขทัย	SUKHOTHAI	270 ; N70
74	ตาก	TAK	274 ; N74
80	อุตรดิตถ์	UTTARADIT	280 ; N80

ภาคตะวันออกเฉียงเหนือ (NORTHEASTERN) CODE 3 ; D

หมายเลข NUMBER	จังหวัด	PROVINCE	รหัส CODE
13	บุรีรัมย์	BURIRUM	313 ; D13
16	ชัยภูมิ	CHAIYAPHUM	316 ; D16
22	กาฬสินธุ์	KALASIN	322 ; D22
25	ขอนแก่น	KHONKAEN	325 ; D25
32	มหาสารคาม	MAHASARAKAM	332 ; D32
33	มุกดาหาร	MUKDAHAN	333 ; D33
36	นครพนม	NAKHONPHANOM	336 ; D36
37	นครราชสีมา	NAKHONRATCHASIMA	337 ;D37
42	หนองคาย	NONGKHAI	342 ; D42
49	เพชรบูรณ์	PHETCHABUN	349 ; D49
60	ร้อยเอ็ด	ROIET	360 ; D60
61	สกลนคร	SAKONNAKHON	361 ; D61
68	ศรีษะเกษ	SISAKET	368 ; D68
73	สุรินทร์	SURIN	373 ; D73
77	อุบลราชธานี	UBONRATCHATHANI	377;D77
78	อุดรธานี	UDONTHANI	378 ; D78
82	ยโสธร	YASOTHON	382 ; D82

ภาคตะวันออก (EASTERN) CODE 4 ; E

หมายเลข NUMBER	จังหวัด	PROVINCE	รหัส CODE
17	จันทบุรี	CHANTHABURI	417 ; E17
20	ชลบุรี	CHONBURI	420 ; E20
55	ปราจีนบุรี	PRACHINBURI	455 ; E55
59	ระยอง	RAYONG	459 ; E59
76	ตราด	TRAT	476 ; E76

ภาคใต้ (SOUTHERN) CODE 5 ; S

หมายเลข NUMBER	จังหวัด	PROVINCE	รหัส CODE
21	ชุมพร	CHUMPHON	521 ; S21
26	กระบี่	KRABI	526 ; S26
39	นครศรีธรรมราช	NAKHONSITHAMMARAT	539;S39
41	นราธิวาส	NARATHIWAT	541 ; S41
45	ปัตตานี	PATTANI	545 ; S45
46	พังงา	PHANGNGA	546 ; S46
47	พัทลุง	PHATTHALUNG	547 ; S47
50	เพชรบุรี	PHETCHABURI	550 ; S50
54	ภูเก็ต	PHUKET	554 ; S54
56	ประจวบคีรีขันธ์	PRACHUAPKIRIKHAN	556; S56
57	ระนอง	RANONG	557 ; S57
58	ราชบุรี	RATCHABURI	558 ; S58
66	สตูล	SATUN	566 ; S66
69	สงขลา	SONGKHLA	569 ; S69
72	สุราษฎร์ธานี	SURATTHANI	572 ; S72
75	ตรัง	TRANG	575 ; S75
81	ยะลา	YALA	581 ; S81

ตัวอย่าง บัตรประจำแปลงที่ดิน

กรมที่ดิน ทด.

กระทรวงมหาดไทย

สำนักงานที่ดิน

อ. ดอกคำใต้ จ. พะเยา

ด้านหน้า (FRONT SIDE)

บัตรประจำแปลงที่ดินหมายเลข ๒๔๘๐๐๒๓๕๙๗

2480023597

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วันออกบัตร เจ้าหน้าที่ออกบัตร

ด้านหลัง (BACK SIDE)

Example of Proposed Parcel-ID Card

APPENDIX 4.1

```
I========================================I
I    ***        SELECT FUNCTION       *** I
I========================================I
I                                        I
I         MAP IDENTIFIER    =    1       I
I                                        I
I         PARCEL DETAILS    =    2       I
I                                        I
I         OWNER DETAILS     =    3       I
I                                        I
I         EXIT              =    4       I
I                                        I
I========================================I

ENTER FUNCTION NUMBER : 1
ENTER PARCEL-ID : 1120303590
```

```
I========================================I
I    ***      SELECT MAP SCALE        *** I
I========================================I
I                                        I
I       SCALE   1: 250     =    1        I
I                                        I
I       SCALE   1: 500     =    2        I
I                                        I
I       SCALE   1:1000     =    3        I
I                                        I
I       SCALE   1:2000     =    4        I
I                                        I
I       SCALE   1:4000     =    5        I
I                                        I
I========================================I

ENTER OPTION NUMBER : 3
```

Menu Selection in Program "WATTANA"

```
PARCEL IDENTIFIER : 1120303590

MAP IDENTIFIER     : 5136 / III - 7214 - 1:1000 /  3

UTM ZONE           : 47

PARCEL REFERENCE IN MAP : B,1


DO YOU WANT TO PLOT THE MAP (Y/N) ?



                PARCEL DETAIL

PARCEL IDENTIFIER      : 1120303590
CADASTRAL MAP NUMBER : 5136 / III - 7214 - 1:1000 /  3
UTM ZONE : 47          PARCEL REFERENCE IN MAP : B,1
PARCEL NUMBER WITHIN THE ABOVE MAP : 3441
THE AREA OF PARCEL IS ABOUT :   0 RAI -0 NGAN -13 TARANGWA (   .005 HECTAR)
TYPE OF TITLE : CHANOD (TITLE DEEDS)
LAND USE        : COMMERCIAL BLDG
LAND VALUE      :  550000.  BAHT
CO-OWNERSHIP   :  NO
THE LOCATION OF THIS PARCEL IS IN
TAMBON (LOCALITY)     : BANGJAK
AMPHUR (DISTRICT)     : PRAKANONG
CHANGWAT (PROVINCE) : BANGKOK-THONBURI
PAARK (REGIONAL)      : CENTRAL
OWNER NAME : MISS.        P. KUNYA
TYPE OF LAST REGISTRATION :  MORTGAGE


TO BE CONTINUED (Y/N) ? y



                OWNER DETAIL

OWNER NAME : MISS.         P. KUNYA
PERSONAL-ID CARD NUMBER : 1120359834
TAX-ID CARD NUMBER       :   -
AGE OF OWNER : 32
NATIONALITY OF OWNER : THAI
ADDRESS OF OWNER : 154       MOOTHEE : -
ROAD/OR OTHERS    : RIMTHANGRODPHAISAIPADREW
TAMBON (LOCALITY)     : PRAKANONG
AMPHUR (DISTRICT)     : PRAKANONG
CHANGWAT (PROVINCE) : BANGKOK-THONBURI
POST CODE              : 10110
OWNER FATHER NAME : MR.           KENGJUANG
OWNER MOTHER NAME : MRS.          SUEKIM
DATE OF LAST REGISTRATION :   FEBRUARY   13 , 1986


TO BE CONTINUED (Y/N) ? y
```

Results of Map-ID, Parcel Detail, and Owner Detail in English

ข้อมูลแปลงที่ดิน

หมายเลขประจำแปลงที่ดิน : 1120303590

ระวางแผนที่หมายเลข : 5136 / III - 7214 - 1:1000 / 3   โซน : 47

เลขที่ดิน ในระวางแผนที่ : 3441   ตำแหน่งอ้างอิงแปลงที่ดินในแผนที่ : B,1

ที่ดินแปลงนี้มีเนื้อที่ประมาณ : -   0 ไร่   - 0 งาน   - 13 ตารางวา

ประเภทของเอกสารสิทธิ์ : โฉนด   ไม่มี กรรมสิทธิ์รวม

ที่ดินตั้งอยู่   ตำบล บางจาก

อำเภอ พระโขนง   จังหวัด กรุงเทพ-ธนบุรี

ชื่อผู้มีสิทธิ นางสาว   กัญญา พงศ์เมธีกุล

ประเภทของการใช้ที่ดิน : อาคารพาณิชย์   ราคาที่ดิน : 550000. บาท

ประเภทการได้มา (รายการจดทะเบียนครั้งสุดท้าย) : จำนอง

Parcel Detail in Thai Scripts

ข้อมูลผู้ถือกรรมสิทธิ์แปลงที่ดิน 1120303590

ชื่อผู้มีกรรมสิทธิ์ นางสาว กัญญา พงศ์เมธีกุล

อายุ 32 ปี สัญชาติ ไทย

หมายเลขประจำตัวของกรมการปกครอง 1120359834

หมายเลขประจำตัวผู้เสียภาษีของกรมสรรพากร -

ที่อยู่ บ้านเลขที่ 154 หมู่ที่ -

ถนน/หรืออย่างอื่น ริมทางรถไฟสายแปดริ้ว

ตำบล พระโขนง อำเภอ พระโขนง

จังหวัด กรุงเทพ-ธนบุรี รหัสไปรษณีย์ 10110

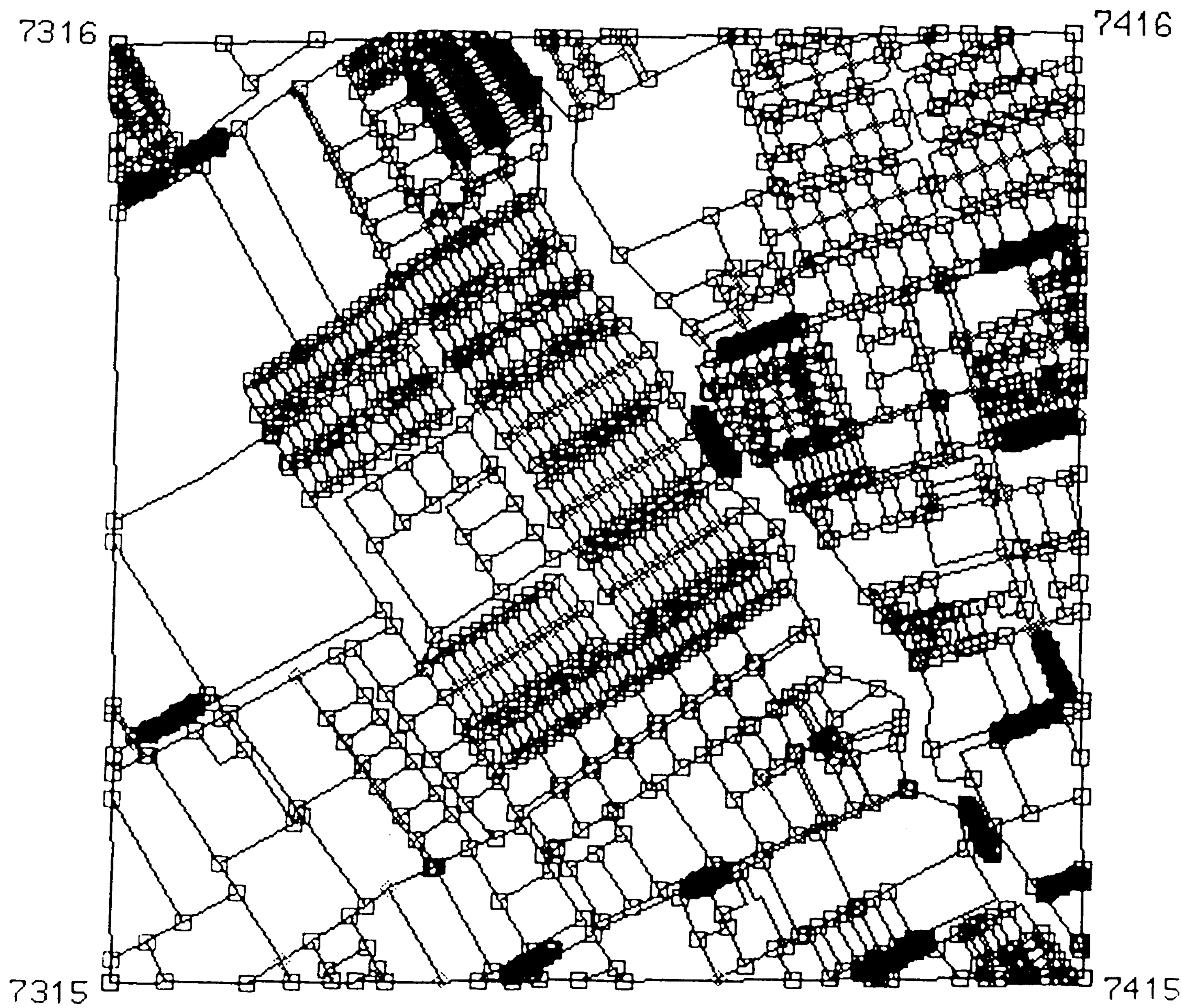
ชื่อบิดา มารดา : นาย - นาง เค้งจวง-ชิวกิม

วันจดทะเบียน : วันที่ 13 กุมภาพันธ์ พ.ศ. 2529

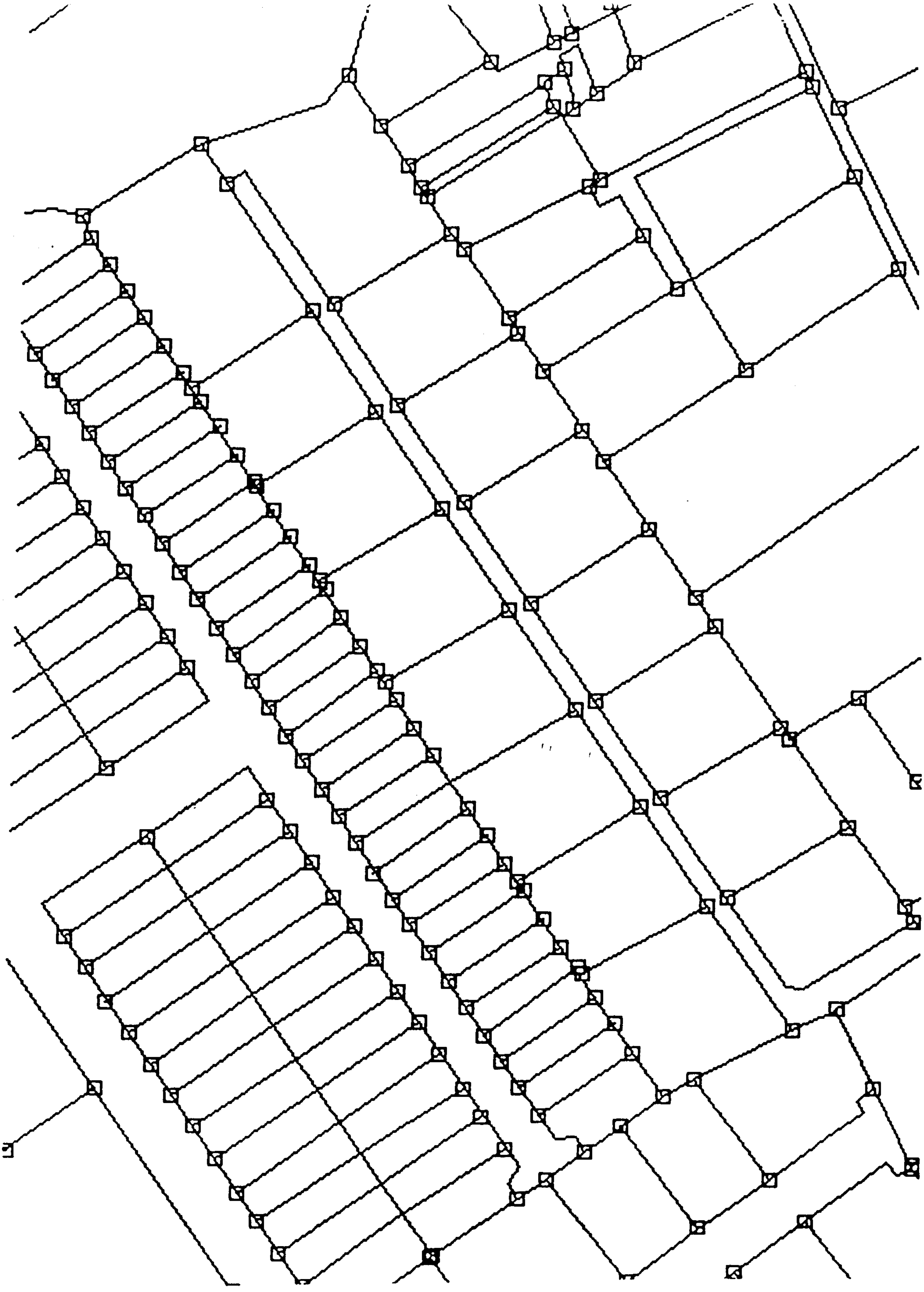
Owner Detail in Thai Scripts

APPENDIX 4.2

Digitized Coverage of Cadastral Index Map
Map-ID : "5136 III - 7214 - 1:1000/4"

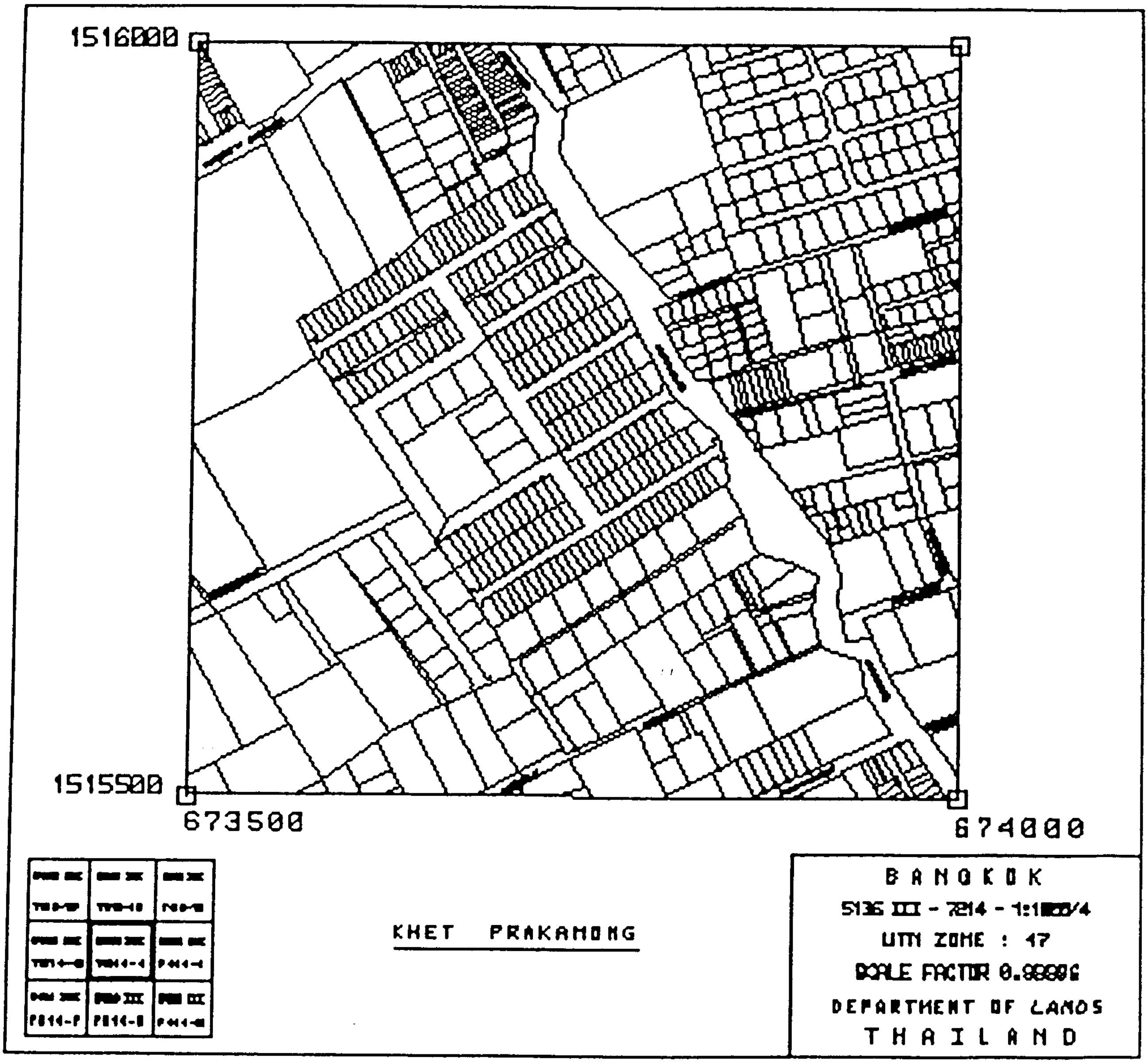


Draw Nodes with Errors (Errors = Dangle + Pseudo)

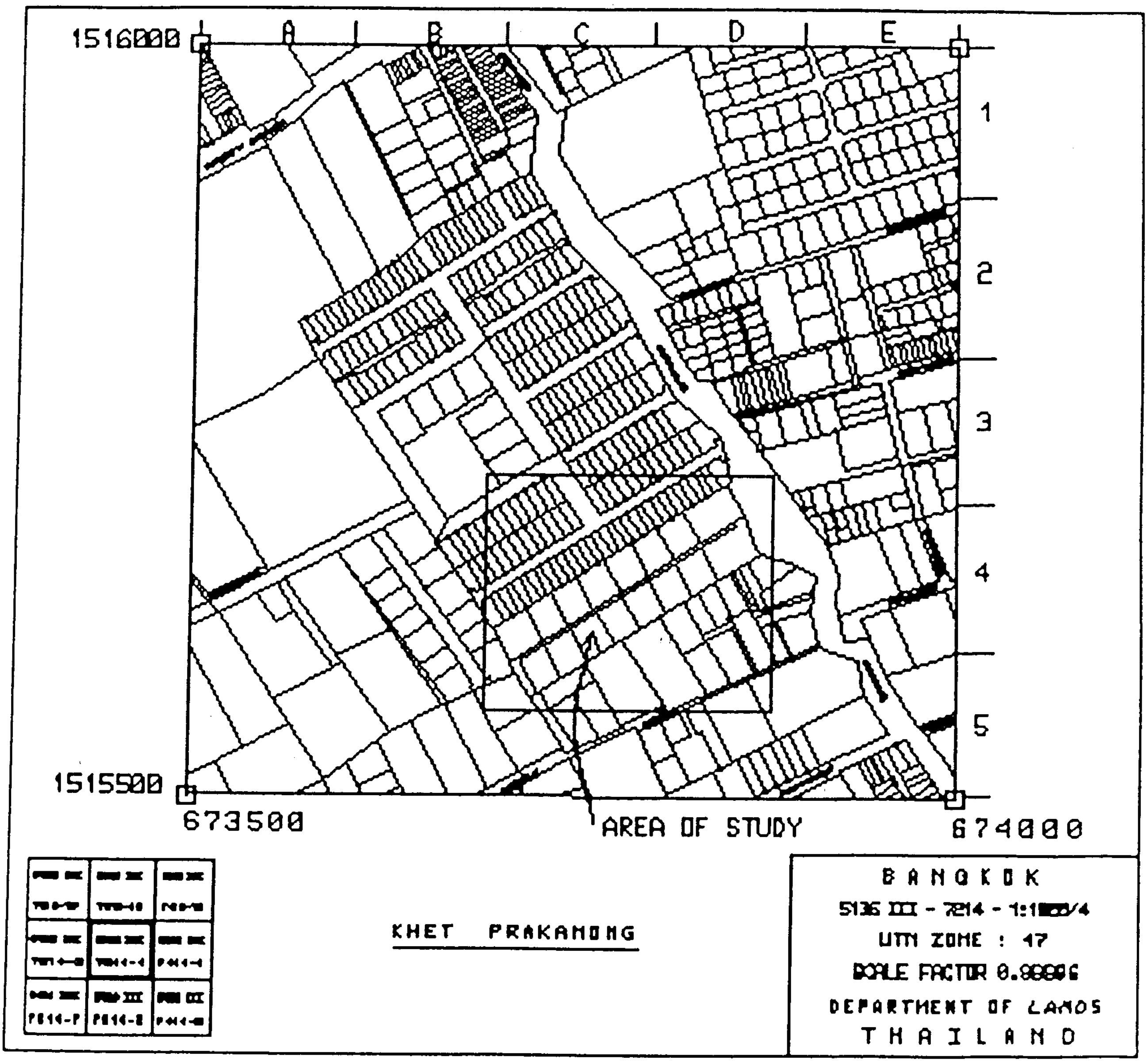


Draw Nodes with Dangle (Zoom)

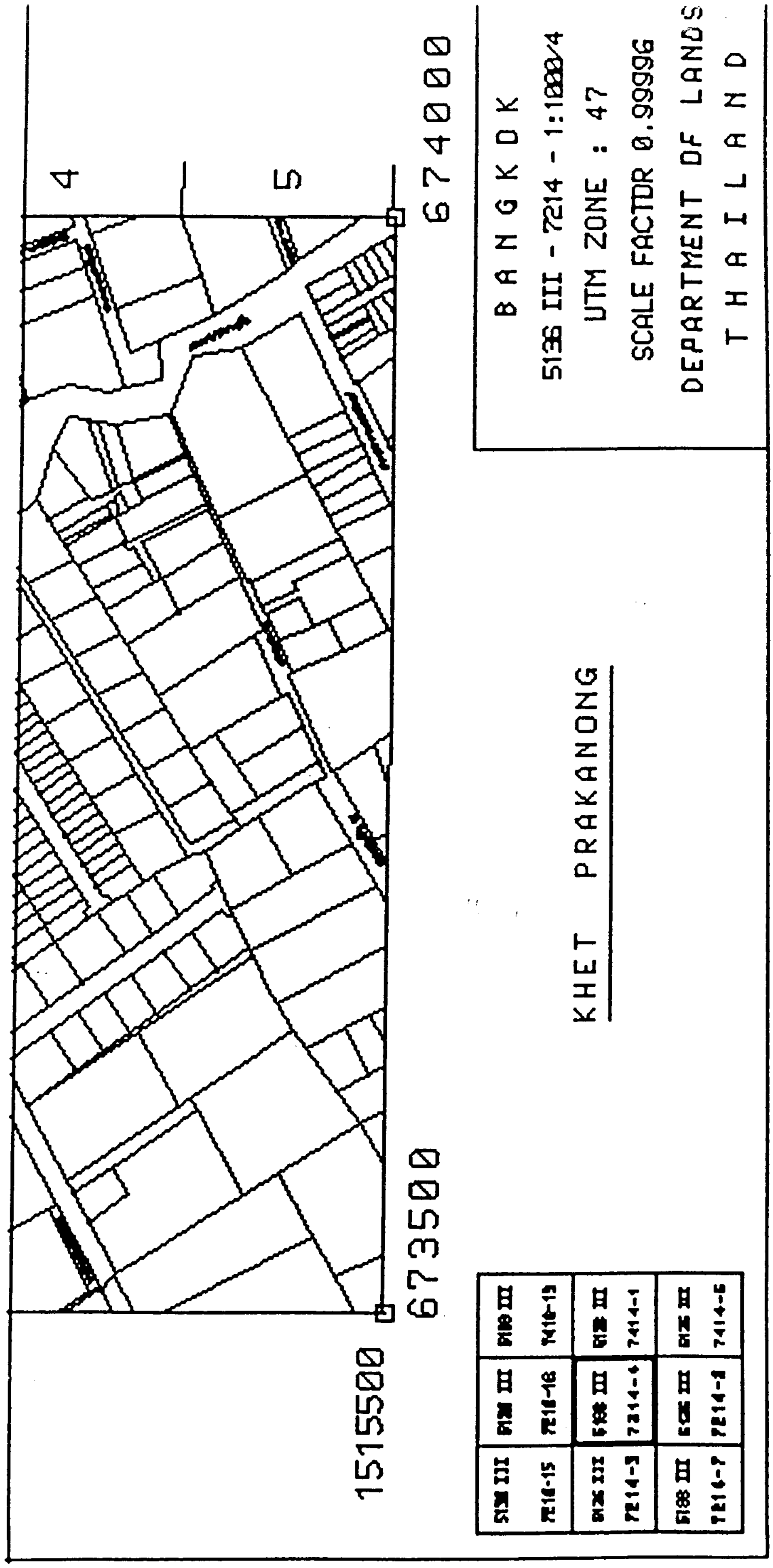
Draw Nodes with Errors (After 1st Clean)



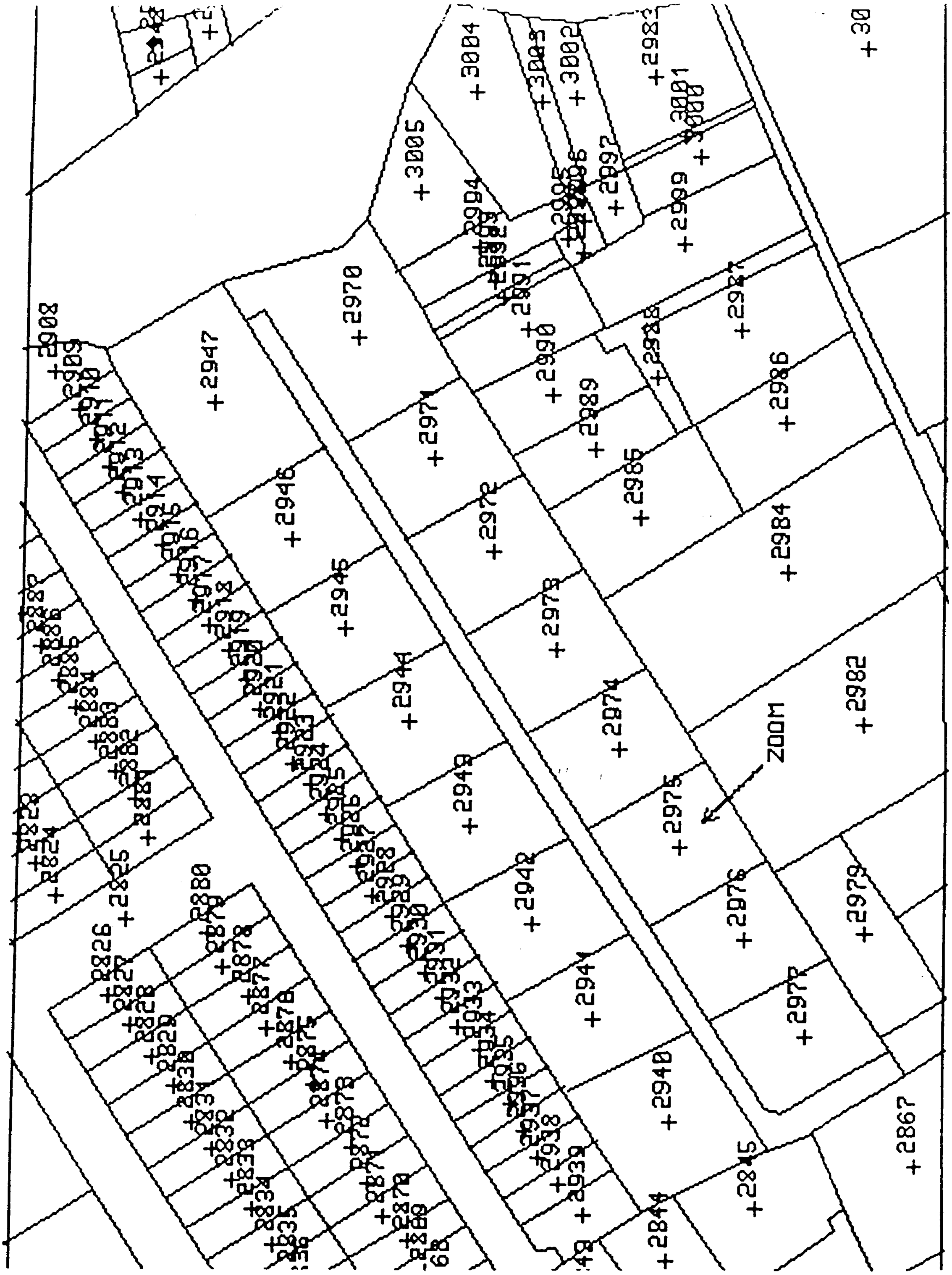
Draw Coverage in Map Type Form (After Editing)



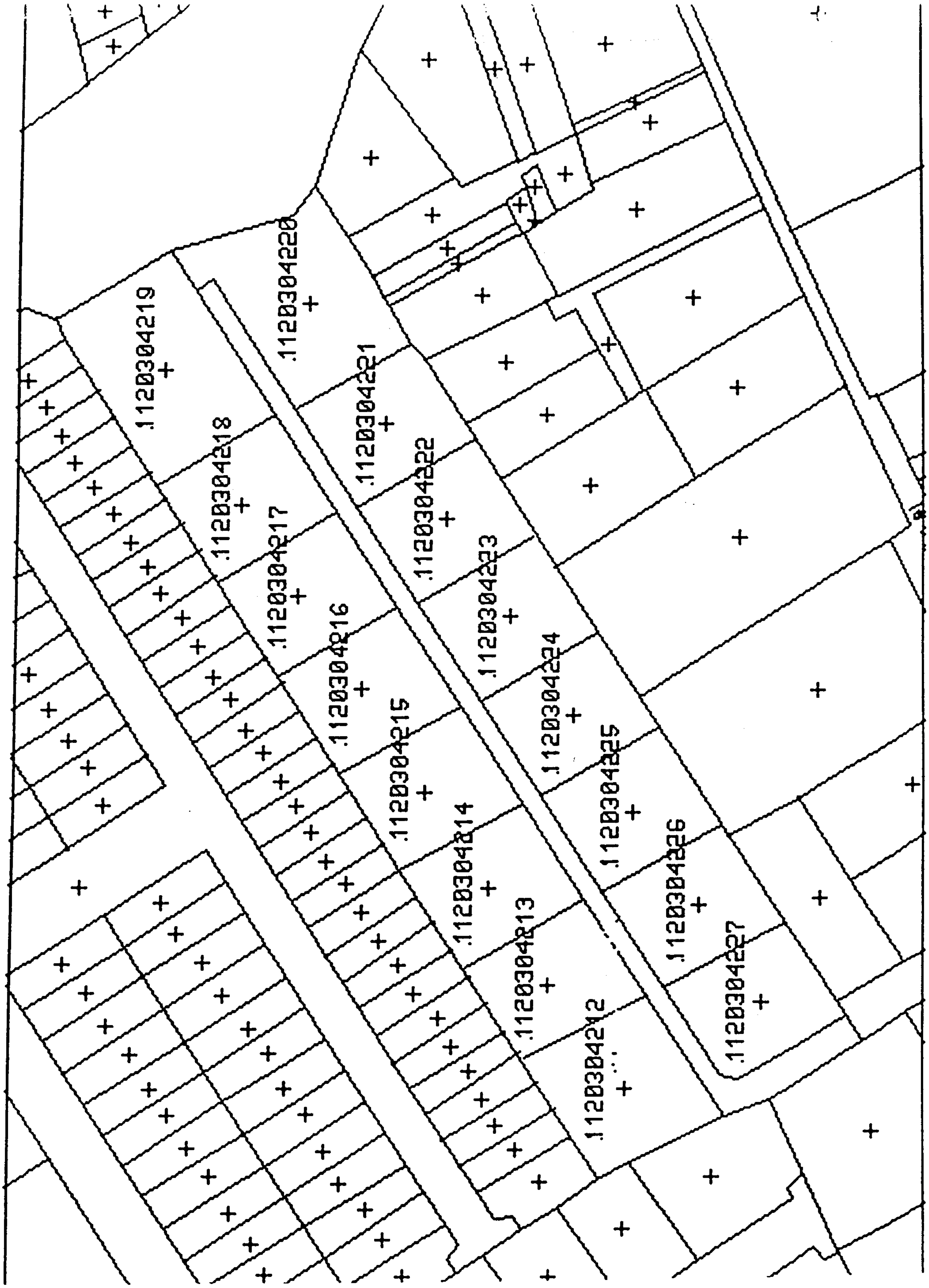
Draw Coverage with Proposed Location Identifier



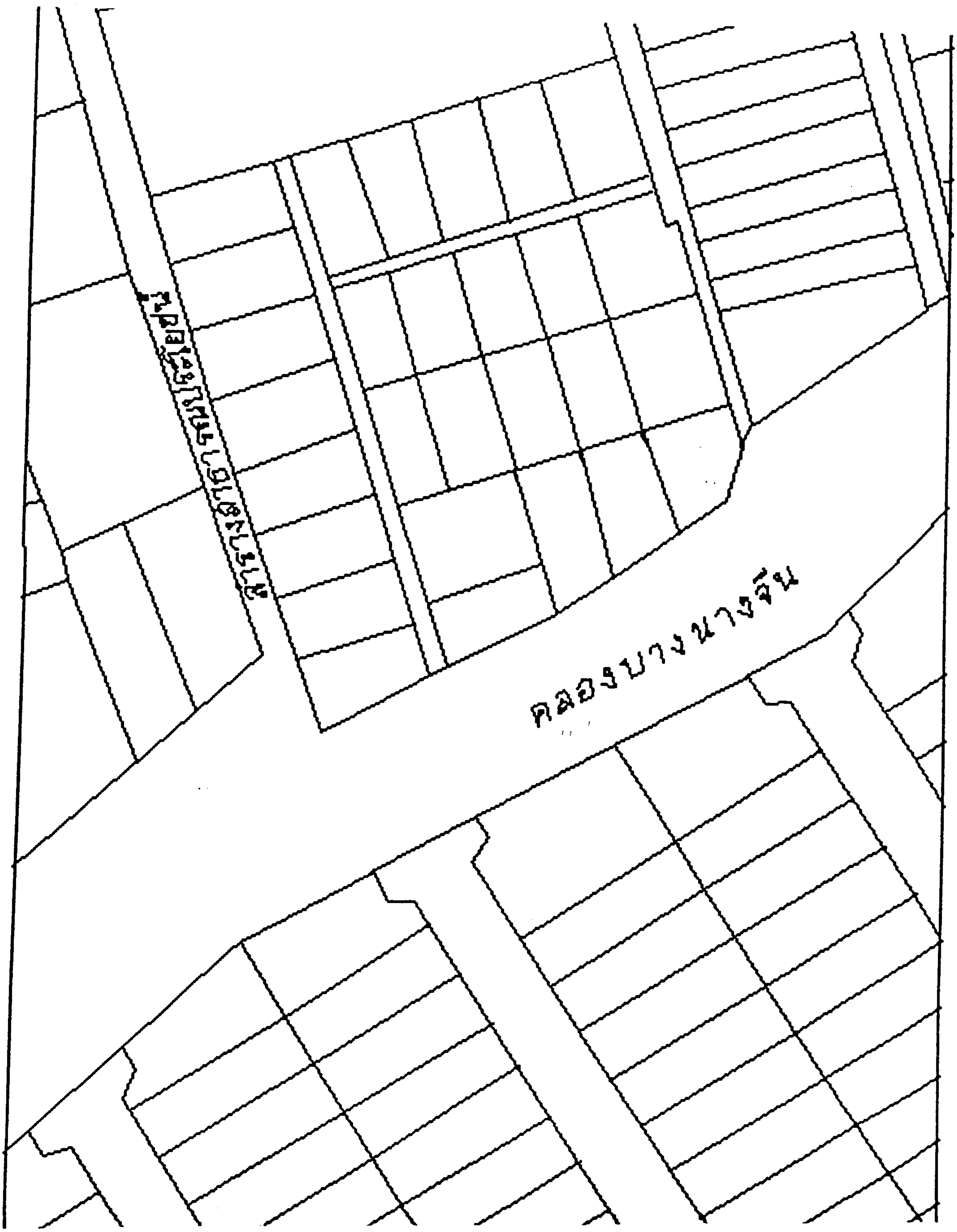
Draw Annotation of Coverage (Zoom)



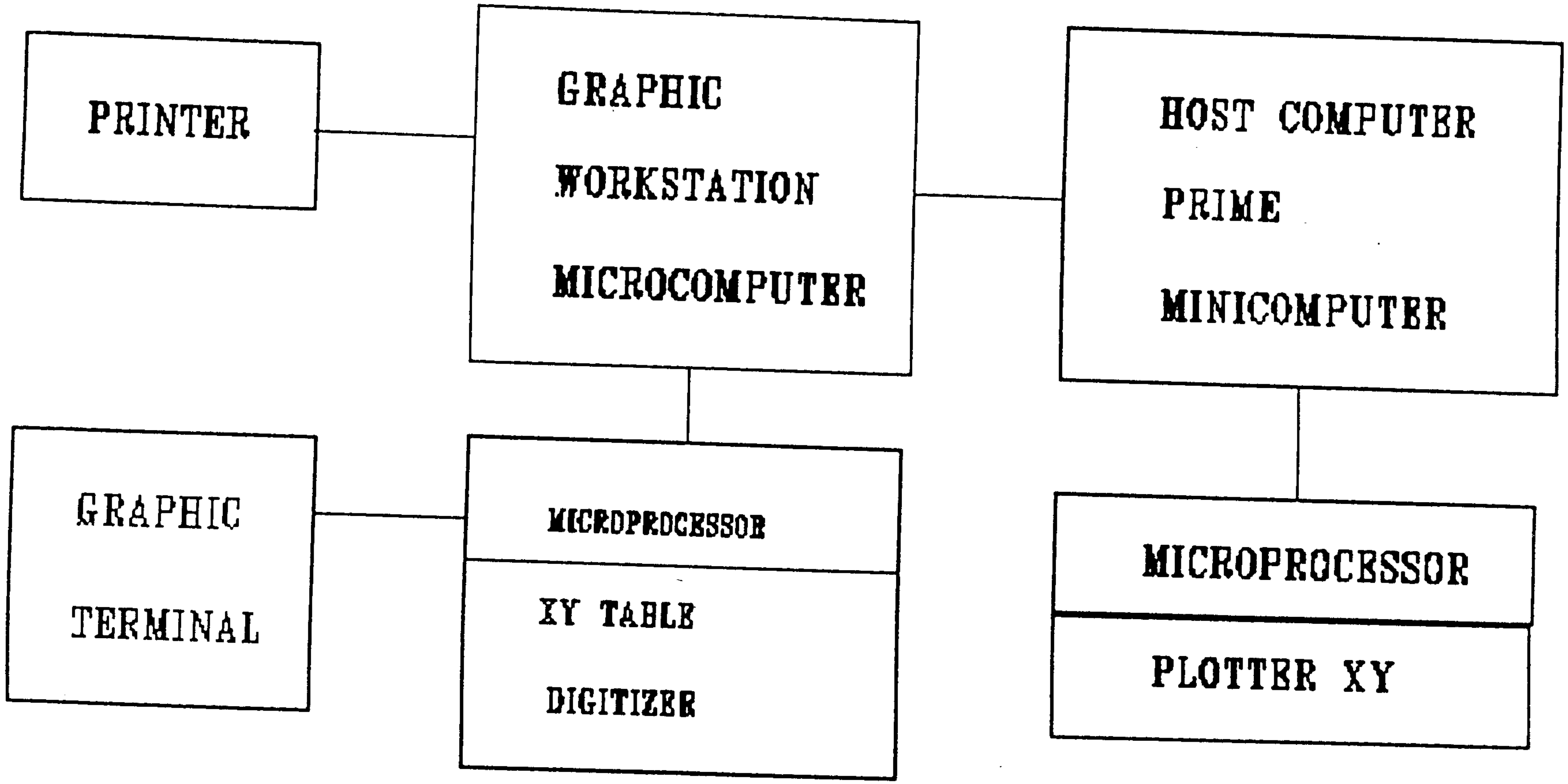
Draw Label Ids (Current Parcel Number Used in DOL) of Coverage



Draw Zoomed Coverage Showing Proposed Land Parcel-ID



Zooming Part of Coverage



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