Cadastral Survey Techniques in Developing Countries.
with Particular Reference to Thailand

P. WILLIAMSON

"...Siam has given another proof of her determination to grasp and adopt 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 legislation."
-Giblin, 1902.

(Director of the Royal Survey Department, Siam; Licenced Surveyor, N.S.W.)

Abstract
The benefits of an efficient cadastral, survey and land registration system to developing countries are described. The legal, and particularly the technical procedures in creating a cadastre are discussed. The use of ground and photogrammetric survey techniques are highlighted. The reasons for restricting, the introduction of efficient cadastral survey systems are considered. Thailand is used as an example of a country which has, shown much flexibility in improving its cadastral system to better meet the needs of its developing economy. In this regard, the institutional and legal arrangements in the Thai cadastreal system are described, as is the development of the cadastral survey system. As an indication of continuing flexibility, the future direction of the Thai cadastral system is discussed.

Introduction
The benefits of an efficient cadastral system to developing countries are widely recognised and have been previously discussed at length; reference should be made to Binns (1953), West (1969), Larsson (1971), United Nations Economic and Social Council (1973), Dale (1976) and Simpson (1976) for detailed discussion. Such benefits may be summarised as follows:
1. The introduction of a cheap, secure and efficient system of recording and transferring interests in land.
2. The reduction of boundary disputes and expensive related litigation.
3. The ability to increase the availability of long-term credit by using land titles as security. In urban areas this leads to increased land development and an improved land market. In rural areas it promotes long-term farm planning, better cropping patterns, long-term crops and soil conservation practices, and enables the farmer to buy more efficient equipment and invest in farm improvement programmes.
4. The ability to establish an efficient and equitable land taxation system. With such a system all land parcels can have a tax levied on them, based on a realistic value. In simple terms, land cannot be taxed unless the location, size and ownership of the land is known.

5. The ability to prepare an up-to-date large scale cadastral map which has many uses other than for land registration and conveyancing. The maps can be used for local administration, planning, utility authorities and many private organisations.
6. The use of the cadastral system to control land transactions and ownership. For example, many countries desire to restrict ownership of land by aliens.
7. The use of the cadastral system as the basis for land reform. Without such a system land reform can be a lengthy process with a reduced chance of success.
8. The development of a cadastral system, and particularly the creation of the cadastral maps in a systematic manner, which makes it possible for a Government to determine the amount of State land it owns. This fact alone has been sufficient justification for some countries to carry out a systematic cadastral survey.
9. The creation of an efficient system based on title registration in a form which is readily computerised. With the advances in computer design, in conjunction with reduced costs for computers, simple, computerised non-graphic "land information systems" are becoming a realistic proposition for many developing countries.

The technical procedures for achieving the above benefits and goals are widely recognised and have been discussed at length by the previously listed authors.

Generally, the process of creating a cadastral system can be considered in two parts; the legal or quasi-legal and administration area which is responsible for adjudication of boundaries and rights in land and the creation of an efficient recording system for those rights in appropriate registers; and the technical area which includes cadastral surveying and mapping. In general, the limitation on carrying out adjudication and establishing registers is the availability of personnel with some administrative background in the land registration system; this does not appear to be a major problem in developing countries. The cadastral surveying and mapping function, however, does create a problem since usually it requires a large number of extensively trained personnel, and often expensive and high technology equipment. This paper will concentrate on cadastral surveying and mapping as the major technical limitation to improving cadastral systems. Although it is recognised that the other quasi-legal aspects are just as important and in many cases can become a serious limiting factor in introducing a system because of inflexible legal statutes or regulations.

There are two basic approaches which may be adopted for cadastral surveying and mapping; one based solely on ground survey techniques and one using a combination of photogrammetric and ground survey techniques. Ground survey techniques are the basis of most cadastral survey systems, since photogrammetry has only been used for cadastral purposes in the last 30 years or so. Ground survey techniques suit the sporadic isolated survey approach which is usually a component of land registration, conveyancing or alienation systems based mainly on the "user pays" principle. Such systems are usually the quickest to introduce, and the cheapest and the most expedient for Governments in the short-term.

Methods utilising photogrammetric techniques on the other hand, are generally only suitable for systematic adjudication and surveyor large-scale projects and require a substantial financial commitment from the Government.

1. P. WILLIAMSON. B.Surv., M.Surv., Sc. (N.S.W.) M.I.S. Aust., Registered Surveyor, Senior Lecturer, School of Surveying, University of New South Wales. During part of 1982-83 served as an adviser to the Australian Development Assistance Bureau on cadastral surveying and land registration in connection with a World Bank project in Thailand.
before the benefits of the system are realised. Such a system usually requires the Government to carry out the original adjudication and survey for the issue of land titles. It should be emphasised that all cadastral surveys which utilise photogrammetry require at least some field completion. The photogrammetric method can only be used where the physical boundary, or some point indicating the boundary is clearly evident on the aerial photograph. In general, areas with tree cover or in villages and urban areas. a large proportion of ground survey completion is often required.

Many countries initially introduced numerical ground survey techniques in the latter part of the 19th century or the early part of the 20th century; in some cases, such surveys have been sporadic or isolated and in other cases they have been connected to a national Geodetic framework. Whatever the situation, many of these survey systems have been characterised as being slow and expensive. requiring highly-trained personnel and usually giving limited benefits outside the primary land registration or conveyancing function. The main reasons for restricting the introduction of efficient systems which may utilise photogrammetry can be summarised as follows:

1. The lack of financial resources to obtain and process aerial photography.
2. The lack of a small cadre of trained photogrammetric personnel to process the photography.
3. A perceived urgency by Government which favours the short-term benefits of a sporadic ground survey.
4. The political and legal system within the country, particularly concerning land policy, land administration and cadastral survey.
5. Vested interests, particularly within the legal and surveying professions.
6. The influence and tradition of a past colonial era. This aspect particularly applies to a number of countries previously under British rule (also see Williamson, 1982).
7. The professional background and experience of the surveyors and land administrators who operate the system.
8. The system adopted by the respective Government for recognising and allocating land rights and the nature of the rights granted.

The change from a fully numerical survey system, where the bearing and distance of each boundary is measured and where corners are usually coordinated, to one based on photogrammetry using graphical methods, particularly in rural areas, is often difficult, as discussed above. Unfortunately, the adherence to the fully numerical approach often restricts development and is usually not in the best interests of a developing country.

One country which has recognised the deficiencies of traditional numerical survey methods and has taken positive steps to find suitable solutions, and continues to do so, is Thailand. The lessons that Thailand has learnt and the solutions found may be of interest to other developing countries which have similar problems and topography. It should be noted that other countries in South East Asia, such as the Philippines and particularly Indonesia (Tromso, 1979A, 1979B), have also used the same methods - Thailand in their cadastral operations.

Thailand has an area of 513,115 km. and a population of 47.8 million. About half the country is flat river delta with the remainder hilly to mountainous forest lands. By law, no agricultural activities are permitted more than 40 metres above the delta or valley floor. Thailand has the largest area of arable land of all South East Asian countries and is the world's second largest rice exporter. After the United States of America. The capital of Thailand is Bangkok which has a population of about 5 million, which comprises about two-thirds of the urban population in the country.

In order to place in perspective the cadastral achievements of Thailand, the legal and institutional arrangements within its cadastral system are briefly described.

Institutional and Legal Arrangements in the Thai Cadastral System

The legal system in Thailand is based on codified law. The major legislation affecting land ownership and administration is the Land Code. 1954. This relatively modern legislation describes the powers and duties of the Minister responsible for administering the Act and of the Director General of the Department of Lands. It has provisions for the allocation of State land and land acquisition: contains procedures for the issue of documents evidencing rights in land, cadastral surveys and the operation of the title register: and defines controls on maximum land holdings by religious bodies, aliens and certain limited companies, partnerships or associations operated by aliens. The law governing dealings in land is contained in the Civil and Commercial Code, 1932. More detailed controls are imposed by Ministerial and Departmental Regulations. In principle, the title registration system in Thailand is based on the Australian Torrens system. It is of interest 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. Specifically, Mr R. W. Giblin, a licenced surveyor from New South Wales, was the Director of the Royal Survey Department in Thailand from 1901-1910. He helped establish the title registration system based on a simplified version of the Australian Torrens system and the cadastral survey system based on a trigonometric network. (See Giblin, 1902, 1904, 1905, 1907; Editorial, 1910; Bhuwadol. 1913; Lowe, 1922.)

Land may be divided generally into two types: land with some document evidencing ownership or an interest in the land; and land without any documented title. The second category is land which is either legally or illegally occupied. The illegally occupied land comprises a considerable amount of land in Thailand and is usually in the reserved forest areas but may be other Government land. In this latter category, the occupiers do have possession rights which are valid against other private individuals but not against the State. Such persons cannot transfer their possession rights to other persons through registration. (For further details on this aspect and on land reform generally in Thailand, see Kemp, 1981; Yano, 1968; Ratanakorn, 1978, Ram say, 1982.)

There are two major forms of documents evidencing rights in land in Thailand which are negotiable and can be registered:

1. Title deed (chanod NS4): a certificate of ownership (Figure 1).
2. Certificates of utilisation (NS3: -nor sor sarm. NS3K: -nor sor sarm kor) - a certificate showing that the owner has fulfilled certain conditions, particularly relating to occupation and utilisation of the land. In simple terms, the certificates evidence possession. Once certain conditions are satisfied, such certificates can be converted to a full title deed.

Both types of documents have the same form as a Torrens title in Australia. The front of each document shows the legal and survey identifiers for the title and includes a simple diagram of the parcel. The reverse side of each document shows details of all dealings with the parcel. There is a duplicate...
document for each parcel; one is held in the local land office, and one is held by the owner. Both types of documents are fully negotiable subject to the Land Code. In practice, there is little difference between the two forms; banks will lend equally, irrespective of whether the land has a title or certificate of utilisation. The major difference between the two concerns the method of survey. There are other types of documents evidencing rights in land in Thailand; however, they are not negotiable.

The system of title registration in Thailand is similar to Torrens’ original concept, which was based around an efficient, simple and secure conveyancing system. The Thai system does not have the complexities of its Australian counterparts which have overriding interests and operate within State laws which have inherited many of the complications of English land law. In Thailand, the transferring of rights in land and the mortgaging of land is carried out at the appropriate land office. Land titles are held in provincial land offices while certificates of utilisation are held in district land offices. In simple terms, both parties to the transaction fill out the appropriate forms (with the assistance of a land officer) and pay the required fees. Both the original title document and the duplicate are amended immediately. On average, transfer of title or a dealing takes less than a day from the time the parties agree to deal.

In accordance with the Land Code, all cadastral surveys in Thailand, including those for the subdivision of land, are carried out by and are the sole responsibility of the Department of Lands; there are, however, a small number of statutory exceptions. As a consequence, the Department is the largest surveying organisation in Thailand. Even though fully computational surveys using coordinates are carried out in some cases, boundary definition is heavily influenced by occupation, land use and physical monumentation of the boundaries; this aspect of the system is similar to the "general boundary" concept. The legal provisions which support this concept in Thailand are as follows:

1. Under the Land Code, the Director General may petition the court to order cancellation of documents evidencing rights in land where a person has made no use of the land and has left it lying waste for over 10 consecutive years for title deeds, or for five consecutive years for certificates of utilisation.

2. Under the Civil and Commercial Code where a person has peacefully and openly possessed a property belonging to another with the intention of becoming its owner, for an uninterrupted period of 10 years, the person acquires the ownership of the land.

3. Under the Civil and Commercial Code where an area is specified in the sale of land, if there is a deficiency or excess of less than 2% of the total area the buyer is bound to accept it.

The Department of Lands has four major functions:

1. Registration of rights in land 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, particularly land titles and certificates of utilisation.
4. Land administration.

The staff of the Department totals nearly 10,000. This figure does not include a large number of casual field staff who are hired as required. The Department has over 3,000 surveyors on its staff, with the vast majority having either a three year full-time surveying certificate or a five year full-time diploma.
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order control network in Thailand presently consists of 362 triangulation stations, together with 200 first order traverse stations. The network includes 66 Laplace stations, 60 Doppler satellite stations and a large number of gravity stations. The geodetic coordinates are based on a 1954 adjustment. The RTSD has also surveyed a large number of second and third order stations as control for topographic mapping (Royal Thai Government, 1983). For mapping, the RTSD uses the Universal Transverse Mercator projection, which covers Thailand with two zones. The country is covered by basic topographic mapping at 1:50,000 on a 15' x 15' format (Royal Thai Government, 1977, 1983).

Since 1903, cadastral surveying and mapping has been based on 29 independent coordinate origins. The origins of these systems were originally the tops of mountains and pagodas, but in recent times the intersections of meridians of longitude and parallels of latitude have been adopted such that the cadastral map sheets can be located on the I 50,000 topographic map series. Consequently, the relationship of the independent coordinate systems to the UTM system can be found by mathematical transformation. The coordinated cadastral control is generated outwards from the independent origins on a plane coordinated system. Control stations consisting of buried and numbered concrete monuments are placed about every 500 metres. Azimuth control is determined by solar observations about every 10 kilometres.

The adjudication of boundaries and the issuing of documents of title for NS3, NS3K and NS4 certificates are similar and will not be discussed here other than to say they are done quickly in the field and in a systematic manner. The survey procedures which are different and are the subject of this article are discussed below.

I. Cadastral Surveys for Land Titles (NS4)

As stated previously, there are two categories of cadastral surveys for land titles - first and second class. The majority of existing first class surveys are in urban areas. Most individual surveys for subdivisions in urban areas, including Bangkok, are surveys of land titles. First class surveys only amount to about 10% of systematic surveys for land titles. These systematic surveys are usually carried out in village and urban areas where cadastral maps ranging from 1:500 to 1:2000 are prepared. This category of surveys is only carried out where there is sufficient cadastral control.

The procedure for producing systematic first class surveys is as follows:

(a) boundaries are adjudicated, adjudication documents are signed by all adjoining owners and numbered concrete blocks (100mm x 500mm) are placed at each corner;
(b) all boundary corners are surveyed by radiation from the control traverse using theodolite and chain;
(c) all calculations are checked in the field. The final calculation is done in Bangkok where the cadastral map is plotted by computer; an automatic flat-bed plotter has been used by the Department of Lands for this purpose since 1967 (see Figure 2); and
(d) the final plan is checked in the field; certificates of title are prepared and issued by a temporary field office set up for the systematic survey.

Second class surveys comprise approximately 90% of systematic surveys for land titles. Within this class, approximately 80% are based on rectified photomaps at 1:4000 in rural areas and 20% on traverse and tape surveys at

The Development of the Cadastral Survey System in Thailand

Thailand has continually re-assessed the performance of its cadastral survey system over the years. The Department of Lands first commenced carrying out cadastral surveys in 1903, using fully computational ground survey techniques based on coordinated traverse networks observed with theodolites and chains. In 1954, the first and second class cadastral surveys for land titles described below were introduced. The first class surveys were based on the previously adopted computational techniques. The second class surveys were introduced to speed up the process of issuing land titles. These surveys use graphical techniques in conjunction with the coordinated traverses. In 1962, the use of rectified aerial photomaps at a scale of 1:4000 was adopted for second class surveys to further increase productivity.

The surveys for NS3 certificates of utilisation were introduced in 1954 and were based on simple isolated tape surveys. To increase the output of certificates of utilisation, the system of issuing NS3K certificates based on unrectified aerial photomaps at an approximate scale of 1:5000 was introduced in 1972. This last programme has been so successful that the Department of Lands has adjudicated, surveyed and issued over 7 million NS3K certificates for land parcels in the last 10 years, a number approximately equal to the total number of land parcels in Australia.

The geodetic control network and basic topographic mapping in Thailand are the responsibility of the Royal Thai Survey Department (RTSD). The first

APPROXIMATE NUMBER OF PARCELS IN THAILAND:

Title deed -NS4 3.7 million Certificates of utilisation " 8.3 million Government land (approximate) " 0.5 million Undocumented lands (approximate) 2.7 million Illegally occupied lands within forest reserves (approximate) 1.0 million

TOTAL AREA OF THAILAND 51.3
State Lands 3 1.2
Permanent reserved forest 25.9
Public domain 2.0
Government real estate 1.0
Other government land 0.5
Ponds, swamps and other waterways 1.8
Private Lands 20.1
Title deed : NS4 3.7 million Certificates of utilisation " 8.3 million Government land (approximate) " 0.5 million Undocumented lands (approximate) 2.7 million Illegally occupied lands within forest reserves (approximate) 1.0 million

16.2 million


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The Australian Surveyor, September, 1983. Yo. 31. No
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1: 1000 in village and urban areas. The survey process based on rectified photo-maps is as follows:

(a) photography was flown at 2300m with a wide angle camera, resulting in a photoscale of 1: 15,000 (also see Stürfel, 1971, and Khama\'undara, 1978). The photography was flown with 2 km between tight lines with 80% end lap and 42% side lap. No signalisation of OBoundaries or other control points was carried out in the field;

(b) four horizontal control points are determined by ground methods from the cadastral control. Occasionally photogrammetric control is determined by the Department using aerotriangulation techniques; the Department has the equipment and access to a recent block adjustment programme for this purpose. Vertical control for the adjustment is scaled off the existing topographic mapping since the rectified photomaps obviously show no heights or contours;

(c) rectified photomaps are prepared at 1:4000 on a 500mm x 500mm format, representing 2 km x 2 km on the ground. It should be noted that virtually all legally developable land in Thailand is relatively flat and is consequently ideally suited to the use of rectified p-aps, and

(d) the photomaps are used only for issuing land titles in those areas where the physical boundaries of each parcel are clearly visible on the photograph. In such case the adjudication process about marking of comers and corner numbers are also marked on the photomap and on a transparent overlay. Comers and corner numbers are also marked on the photo-map (similar to Figure 4). Areas are determined graphically.

In locations where the boundaries are not visible from the p-ap, the surveys are carried out based on the coordinated traverses, but only tapes and optical squares are used; sometimes the triangle survey method is accepted and only the tape is used. The cadastral map is plotted at 1: 1000 to 1:4000, depending on the detail. (See Figure 3, which shows this survey method for a subdivision.) Areas are calculated graphically.

Individual surveys for updating the cadastral maps of land titles are carried out at the provincial land office. These offices usually have a large staff of surveyors who are mainly involved in performing surveys for the subdivision of land and the redefinition of boundaries.

2. Cadastral Surveys for Certificates of Utilisation

The issuing of certificates of utilisation (NS3) was phased out after 1972 in favour of the photogrammetric method used for NS3K certificates. Adjudication of boundaries, measurement of boundaries (not angles), marking of comers and the preparation of certificates was the same as the process for issuing NS3K documents which follows. The major difference is that the boundaries of NS3 parcels are not charted or plotted on any overall plan -each parcel is measured in isolation. Along with NS3K documents and maps, all documents relating to NS3 certificates are kept in district land offices, as distinct from NS4 documents which are kept in provincial land offices.

The great majority of NS3K certificates are issued as a result of systematic survey. Approximately 80% of such certificates are issued on the basis of an enlarged aerial photograph at an approximate scale of 1:5000; the same photo-
graphy is used as a means to issue land titles. Each photomap covers an area of 2 km x 2 km, which can be located on the 1:50,000 topographic map series. As with land titles, the method is only used where boundaries are plainly evident on the photograph (see Figure 4).

These systematic surveys are performed in a similar manner to land titles. One difference is that it is the landholder’s responsibility to mark boundary corners with wooden stakes or posts. In rice paddy areas, the farmers rarely mark the corners since they accept the dike as the boundary. Also they have seen the surveyor “measure” the boundary and mark the boundary on a transparent overlay of the photomap. Approximate areas are determined graphically.

In the 20% of cases where boundaries are not visible on the photomap (usually in villages), isolated ground surveys are carried out using tape methods. Only the surveys are not based on any control. These surveys are related to the photomap by comparison of details on photographs and on the ground to determine the position and shape of parcels. No theodolites or compasses are used – the map is simply built up by measured triangles (see Figure 5). All other procedures are as previously described. In the village areas, posts are usually placed at corners unless a physical monument already exists. These isolated surveys are plotted on transparent sheets which are attached to the 1:5000 photomap in which they are located.

The Future Direction of the Thai Cadastral System

The Royal Thai Government (RTG) recognised during the preparation of the Fifth National Economic and Social Development Plan (1982-1986) that the existing cadastral system would have to be improved if the Plan was to meet its national objectives. In order to achieve these objectives, the Government has decided to undertake a project to issue land titles to all legally occupied lands in Thailand over a twenty-year period. As part of the project, the Government recognises a number of secondary objectives, including:

1. An improved land administration system.
2. An improved and more equitable taxation system - based on land values.
3. Increased agricultural productivity through improved security of tenure, particularly on undocumented lands.
4. Poverty eradication.
5. An improved land registration and conveyancing system.
6. Reduction in the amount of litigation arising out of boundary disputes (during 1981 the Ministry of Justice indicated there were a total of 12,452 civil and criminal cases brought before the courts arising out of boundary disputes. The majority of these cases were in undocumented areas).
7. The systematic determination of Government land in the Kingdom. The Department of Lands and the RTG recognised that the specific objectives of the project, in order to achieve the above goals, would be:
   1. An accelerated programme for cadastral surveying and mapping and issuing land titles, particularly for undocumented lands, which would require a fundamental reappraisal of existing cadastral procedures.
   2. The conversion of all NS3 and NS3K certificates to NS4 titles; the long-term deficiencies of a cadastral system based on unrectified photo-maps were recognised.
3. The decentralisation of many cadastral functions from the head office in Bangkok to the provincial land offices together with the decentralisation of all land registration, conveyancing and cadastral surveying functions to the district level.

4. The combination of the two existing cadastral mapping systems (the system for land titles based in the provincial offices and the system for NS3K certificates of utilisation based in the district offices) into one system based on UTM and utilising 1:4000 rectified photomaps as a base.

5. An improved and accelerated programme for re-mapping urban areas in Thailand, particularly Bangkok, at a basic scale of 1:1000.

6. The establishment of a simple non-graphic land information system for Thailand to assist in the administration of land taxation and monitoring land ownership.

The procedures under consideration to achieve the above objectives include the use of Doppler satellite positioning techniques, analytical plotters, computerised digitising systems, as well as a number of other “state of the art” techniques. It must be emphasised, however, that the basis of the system will still be a simple graphical cadastral, utilising photomaps in both rural and urban areas.

Conclusion

Thailand is a country which has continually re-assessed the performance of its cadastral operations to see if the system is meeting the objectives of the country, and where the system has been found wanting it has been flexible enough to change direction accordingly. There is a lesson to be learnt by many developing countries from the manner in which cadastral operations have been managed in Thailand and from the methods it has used to achieve its objectives.

The flexibility described above is evident in the cadastral survey procedures adopted by the country. They have evolved from a purely computational approach through various forms of graphical methods. The latest system adopted, which was introduced in 1972, has been so successful that over 7 million parcels have been adjudicated, surveyed and had documents issued: this number of parcels approximately equals the total number of land parcels in Australia.

The institutional arrangements for the cadastral system in Thailand have also encouraged flexibility within the system. One Department administers the central components which are common to all cadastral systems, namely title registration, cadastral surveying and large-scale mapping - recently a Central Valuation Authority has also been established within the Department. The desirability of such administrative arrangements has also been recognised by some States of Australia during the last decade.

Even though Thailand has achieved considerable success in the past with its cadastral arrangements, it has recently re-assessed the present system and has consequently decided to introduce major improvements in the near future.

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