THAILAND LAND TITLING - A PHOTOMAPPING PERSPECTIVE

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Abstract

The Land Titling Project in Thailand aims to complete the issue of an estimated 15 million title deeds to eligible landholders over a 20 year period. Boundary adjudication, document conversion and index mapping onto the UTM system are based mainly on the use of rectified photomaps. Total photomap production will need to reach a peak of nearly 7000 per year during the second 5 year phase of the Land Titling Project if the Department of Lands is to succeed in its objectives.Production techniques and problems in the existing system are outlined and the implications of introducing new technology in the digital photogrammetric area, together with an upgrading of traditional photographic processing facilities is discussed.

Introduction

Photomapping products of varying scales are required to under-pin a number of basic areas within the cadastral mapping and land titling functions of the Thailand Department of Lands(DOL).

Photmaps are used as -

- source documents upon which systematic boundary identification and adjudication is carried out over large rural areas of Thailand (1:4000 map scale)
- base documents providing UTM photo control to enable transformation of older cadastral maps (based mainly on uncoordinated, non-rectified photo enlargements) to new standard UTM gridded map sheets which are subsequently used in document conversion to full land title deeds.
- topographic bases upon which the mosaicing and compilation of uncoordinated survey documents can take place so that an ordered system of urban cadastral index maps (based on the UTM) can be created (mainly at a map scale of 1:1000)

When a photogrammetric section is presented with the task of providing over 105,000 photomaps over a period of 20 years it has to seriously consider a correct balance between traditional cartographic accuracy and presentation standards on the one hand and the final end-user's demand for high productivity on the other. The Department of Lands has chosen photogrammetric rectification as the core of its photomap production process because -

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- for a given area rectification has been estimated as six to eight times quicker than orthophotography.

- rectification is less complex and technically less demanding than orthophotography and therefore better suited to a project where production speed is a key element.

- the relative cost of equipment between rectifiers and orthophoto-projector is obviously a vital element with reduced chance of prolonged break-downs in the less sophisicated rectification equipment.

- rectification has long since been viewed as a practical and suitably justifiable answer to photo-mapping in Thailand as legal titles are only issued in the predominantly flat agricultural regions.

- the high accuracy normally associated with orthophoto mapping for base topographic mapping purposes was not considered significant because the main purpose of the project is ensuring that eligible landholders receive proper title deeds in the shortest possible time.

The format of the standard 1:4000 photomap

Unlike many national topographic map series the DOL sheet format is based on UTM grid coordinates rather than a geographic coordinate system. This means there is a constant photomap image area of 500 mm x 500 mm (2 km x 2 km in the terrain) regardless of latitude position.

An overlap of 20 mm. with all surrounding photo map sheets has also been provided (often called a "bleeding edge" technique).

This type of format allows the 1:4000 map sheet numbering system to be used as an indirect referencing system to UTM coordinate values. The first part of the map sheet number refers to the national 1:50,000 series map, produced by the Royal Thai Survey Department (RTSD), in which the 1:4000 sheet is located. If a 1:4000 sheet straddles the border between 1:50,000 topographic maps then a decision on naming is based upon which topographic map contains the major area. This " major area " technique is also applied to the cross-referencing of parcel numbers to 1:4000 map sheets during land administration procedures.

The final four digits used in the 1:4000 map number relate to the most south-westerly UTM grid intersection appearing on the photomap. The first two digits refer to the Eastings and the second two digits refer to the Northings of the grid reference numbers which appear on the Royal Thai Survey Department 1:50,000 national topographic map (ie. the one km. and ten km. grid values in both Easting and Northing respectively - see figure 1).

Therefore to obtain full UTM coordinate values final reference has to be made to the relevant 1:50,000 map sheet.

Full grid coordinates are added to a final cadastral map overlay at a later stage together with parcel data , road names and adjoining map sheet index.

All map frame surround information is incorporated into a "negative mask" and is exposed using a vacuum contact frame prior to the aerial photographic image exposure on the rectifier.

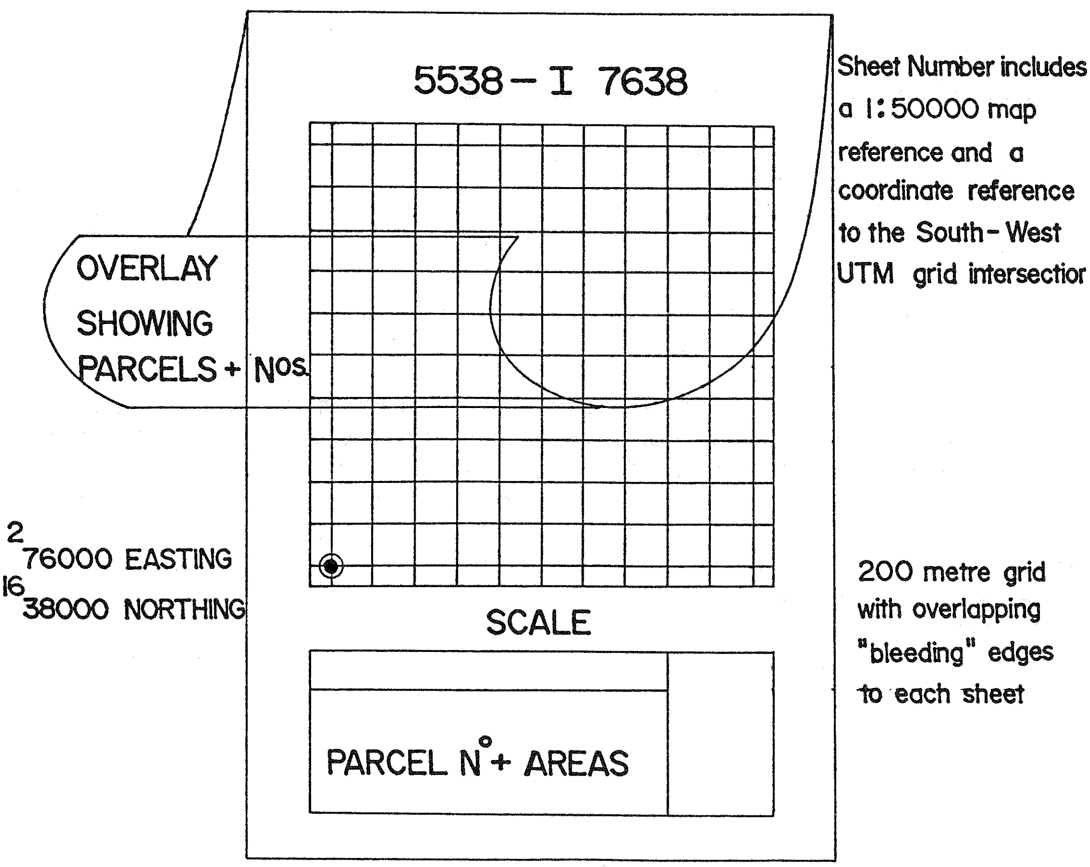


Fig. I - I : 4000 sheet format

Aerial photographic aspects

During the initial five years of the Land Titling Project three different aerial photography contracts were awarded covering an area of approximately 65,000 square kilometres.This area of coverage will double in the second and third 5-year phases as production of photomaps peaks at approximately 7000 sheets per year.

The Royal Thai Survey Department (RTSD) is intimately involved in this phase of the production, being responsible for security aspects during the flights and also for the processing of original aerial negatives. At the present time original negatives are kept at the RTSD and diapositives are produced on automatic dodging printers together with proof prints before delivery to the Department of Lands.

During the first year of the project wide-angle aerial photography at 1:24,000 photo scale was chosen as it was just within the maximum range of the Zeiss rectifiers (6.5 times enlargement). This would produce a very economical result as four standard 1:4000 photomaps (2 km. x 2 km. format) could be made from the one aerial photograph using about 75% of the photo format.

Rectification would have involved -

- initial rectification to 1:8000 (3 times enlargement)
- switching off vanishing point control
- using x and y photo carrier movements to position the individual 1:4000 photomap sheets in turn on the easel.
- changing magnification scale to 6 times for final adjustment and exposure at 1:4000

However real concerns were expressed regarding operator inconvenience and comfort at extreme rectifier ranges together with constant movements of the photo carriers thus increasing the risk of wear as well as accidents. This resulted in a rethink of the photo-scales requested for subsequent years in Phase I of the Project.

Traditionally the photo scale of 1:15000 has been favoured by a number of other agencies in Thailand so this was chosen as the preferred rectification photo scale (3.75 times rectification enlargement). However to prevent the increase in time required for aerial triangulation and consequent survey control it was planned to fly a high level coverage at 1:50,000 photo scale for purely control derivation purposes. Despite a three-fold increase in aerial photographic contract fees the increased production rate for rectification control has enabled photomap production to get off to a good start early on in the project (see Table 1 for a comparison of the number of sheets generated per model for each photo scale.

For both the 1:24,000 and the 1:50,000 aerial triangulation coverage Kodak Panatomic X (2412) was chosen to maximise resolution and identification potential prior to control transfer to the 1:15,000 low-level rectification coverage (which uses Kodak Plus-X 2402 aerial film).

The split-level photo coverage has also been applied to the urban mapping task where aerial triangulation uses a 1:22,000 photo scale and rectificaiton uses 1:6000 photo scale plus a normal angle lens to reduce building relief displacement and consequent loss of ground detail. Kodak Plus X 2402 film is used in both high and low-level coverage for urban mapping.

"Sheet corner" control points are located approximately and marked on the diapositives by reference to a gridded UTM topographic map sheet. Using the "split-level" aerial photography these "sheet-corner" control points have to be point-transferred to the low level rectification diapositives.

Control for rectification

One of the main factors that has enabled the full potential of photomap production to be realised was a change from using traditional field survey methods to aerial triangulation techniques for the provision of rectification control.

During the initial 5 year phase of the Land Titling Project four doppler satellite sets were purchased to provide absolute position fixing by translocation from the first order RTSD control network. Many of these doppler points were used as corner horizontal control points for the block adjustments. Intermediate control was generally derived using traditional electronic distance measurement traverses of up to 50 km. (plus stellar azimuth observations every 10 km. approximately). Discussion has already begun about the possibility of acquiring Global Positioning Systems during the fifth year of the Project.

Historically, analytical photogrammetric techniques evolved from an early reliance on overseas processing and adjustment of model observations for aerial triangulation (in Stuttgart, W.Germany). Later, batch processing using the computer facilities available at the National Statistics Office became the accepted method (1979- 1985).

During the early stages of the Project it was recognised that in-house block adjustment facilities were a necessary adjunct to the overall efficiency of photomap production. Consequently the two existing Wild A8 stereoplotters were linked to a Data General DG20 Desktop micro-computer. The system software was set up in foreground/background mode with Wild's RAP2/ATD2/ATI software being modified slightly to enable the simultaneous operation of the two steroplotters. This is made quite feasible because of the low data transfer rates encountered generally during aerial triangulation observations. Another 16-bit micro-computer, a DG30 , with its larger memory (512 K bytes) and hard disk capacity (38 M bytes) was also purchased in late 1985 to independently carry out block adjustments using the PAT-M software suite.
A data line facilitated file transfer between the two systems using Wild software (SER)

Independent Model adjustment (AIM) had already been used for some time prior to the Land Titling Project so a number of key staff were familiar with the method. It is generally easier to grasp the overall concepts of model adjustments especially where no pre-processing of observations is necessary. As the Project is essentially cadastral in nature, no accurate vertical control is required and this again made AIM the natural choice as the lack of quality in vertical control (mainly interpolated from 1:50,00 topographic mapping) would not unduly influence the planimetric accuracy of the block adjustments.Other reasons favouring the choice of a model adjustment method would be the generally quicker turnaround in results and the possibility of working with larger block sizes.

Table 1 below catalogues some aerial triangulation statistics from the earlier experiences of block adjustment in the Land Titling Project.

TABLE 1 : SAMPLE BLOCK ADJUSTMENT STATISTICS FROM LAND TITLING PROJECT

Block Name	Photo Scale	Block size parameters Models	Sheets	Points	Horizonbal Sigma Naught Metres	Microns	Run Times sec./model
BRO100**	1:50,000	146	1396	1723	0.67	13.4	42.7
NRA0101	1:50,000	137	1224	1596	0.66	13.2	49.5
NRA0102	1:50,000	100	900	1107	0.60	12.0	27.6
NRA0201B	1:24,000	152	337	734	0.44	18.3	31.6
NRA0301	1:24,000	203	440	980	0.54	22.5	41.4
NRA0302	1:24,000	242	518	1114	0.40	16.7	51.3
BR0201	1:24,000	112	226	514	0.36	15.0	34.8
NRA2	1:24,000	279	594	1255	0.35	14.6	15.3
BKK01	1:22,000	42	1223	1388	0.26	11.8	72.9
BRO11	1:15,000	24	288	400	0.27	18.0	40.0

** First block adjustment using in-house facilities in early 1986

. All the above blocks were flown with wide-angle lens photography.

. Average distance between planimetric survey control points around block perimeters was between 4 and 6 photo base lengths. Only the last two urban blocks listed (BKK01 and BRO11) had closer control spacing of between 1 and 2 photo bases in order to reduce the risk of error propogation, when such a large factor was involved between photo scale (1:22,000) and final map scale (1:1000)

. Computer run times per model are only approximate indicators as they are heavily influenced by other operations such as file editing or control base plotting on the TA table.
The average number of runs to achieve a satisfactory result was estimated between 5 and 7. The slowest run time on block BKK01 can be attributable to the large number of points per model generated by an urban block adjustment.

- The largest block that has been attempted so far (NRA2) was run using PAT-M4 (Planimetry only) to reduce the result turn around time to a reasonable level. This option should be used more often in "flat terrain" situations, with projection centre coordinates deleted from the model coordinate file.

- All survey control points were field identified "natural features", mainly paddy field dike intersections. The possibility of introducing independently surveyed double control points at block corners together with targetting of these critical points has been discussed in order to reduce the risk of undetected gross errors being left in the final adjustment results.

- A test run was devised, using block BRO100, where 8 additional check points were made available, without weakening the perimeter control, in order to assess absolute errors in a block. -

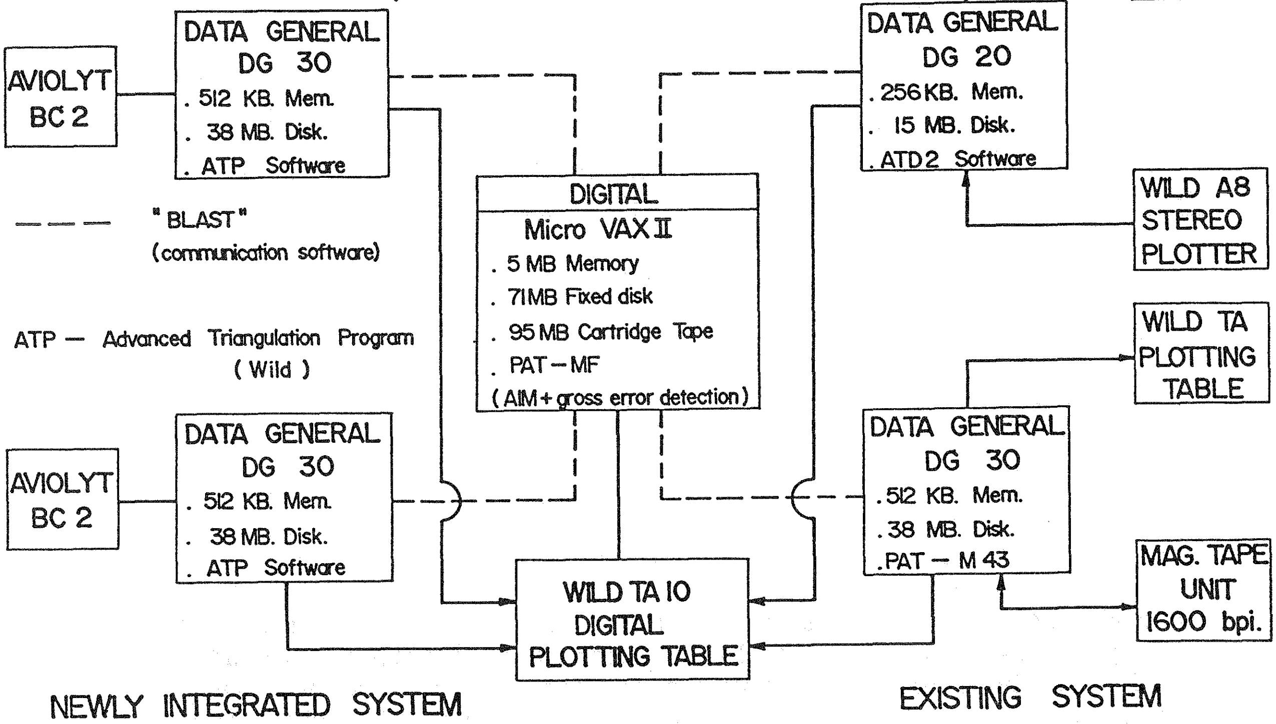
  R.M.S. check residuals in X was 1.3 metres
  R.M.S. check residuals in Y was 1.7 metres

- Even though target accuracy criteria for "sigma naught" of between 15 and 20 micrometers have generally been achieved, there are inconsistencies in the results tabled, which demonstrate some scope for improvement in the overall aerial triangulation system.

- The Photogrammetric Division possesses a DG30 version of the PAT-MF software (Wild version of PAT-MR) which includes the "robust estimation" option for the detection of gross errors, however it has limited performance on the 16-bit Data General microcomputer. At the time of writing there are real hopes that a newly purchased MicroVax II, 32-bit super-microcomputer, operating under a virtual memory system, will provide more efficient block adjustment services for the Division, including "robust estimation".

- Recently installed BC2 analytical plotters will ensure more consistently accurate model observations than the present A8 analogue stereoplotters with the added provision of systematic film distortion corrections at the data collection phase. "Blast" communications software will provide a file transfer mechanism between the various "Data General" and "Digital" computer components in the overall system configuration (see Figure 2)

Figure 2 — DIGITAL PHOTOGRAMMETRY
(AERIAL TRIANGULATION)



- Rectification control base sheets are plotted on a Wild TA digital plotting table interfaced to the DG30 micro computer. A locally developed program searches the adjusted coordinates file for the relevant sheet control. The four exact UTM map sheet corner grid intersections are also plotted in order to register the control base sheet with a 50 cm. glass grid used on the rectification easel.

- Although not a primary consideration for the Land Titling Project aims, the Department also decided to acquire optional colour graphics screens (Tektronix 4207) and digital mapping software to anticipate future growth in this area in Thailand, during the next decade.

Photomap production and reproduction

The Photogrammetric Division has traditionally responded to a very limited demand for two or three copies of each photomap sheet by producing a "copy" aerial negative from the originally supplied diapositives and then rectifying onto positive projection print film as a final product on the easel.

A longer view option requires the production of an intermediate negative transparency on the easel plane using the original diapositives to carry out rectification. Reproducible material can then be provided for the production of -

- normal projection print film for cadastral field work
- screened positive transparencies for subsequent diazo copies
- positives on bromide (resin-coated) papers.

In the context of a relatively small and irregular demand for large-scale cadastral mapping products, traditional high quality offset-printing methods do not supply an economic or efficient reproduction answer. A vacuum contact printer using an ultra-violet light source will be used to copy transparent mapping components without the risk of slippage and one directional enlargement which can occur in normal diazo exposure and processing equipment. It will be possible to register and expose multiple components to produce photomap/cadastral linemap composites with processing still possible using the diazo developer section only. The new range of "daylight" films and papers will also need to be assessed as they can be processed in the same "rapid-access" chemistry to be used in the recently installed automatic roller-transport processor.

Cartographic flexibility in the production and reproduction of mapping products can be maintained by employing a low-bed horizontal process camera. To prevent confusion in parcel identification and numbering, precision enlargements (to 1:500) will be required in congested inner urban areas of metropolitan Bangkok and larger regional cities. There will also be occasions when rural maps sheets at 1:4000 will require enlargements if parcel sizes become too small at that scale. Difficulties encountered using the extreme range of the rectifier coupled with photo-carrier shifts can be overcome by using a process camera in a two-step rectification and precision enlargement procedure. To reduce the relief displacement over high-rise inner city blocks photo scales of 1:10,000 can be used instead of 1:6000 if a process camera is available.

Photographic processing

Pl otolaboratory techniques are about to enter a transitional phase as traditional dish processing of black-and-white mapping products gives way to automated, rapid-access equipment. The first roller-transport processor has recently been installed in its through-the-wall configuration and practical training will focus on densitometric control of the overall photomap production process using small portable densitometers for data gathering. The adaptability and cooperation of staff in this area will be a critical factor in achieving higher productivity and more consistent quality in the future.

The problem of hilly terrain

In the northern provinces of Thailand, agricultural regions are confined to valleys separated by forested hills. The usefulness of rectified photomaps will rapidly diminish in these remote areas but fortunately the percentage of the title deeds required here is quite small. However new approaches will need to be assessed -

- purely ground survey techniques could be used following the adjudication process
- rectification by facets could be another procedure employed using extra minor control points

- it may be possible to enter cooperative arrangements with another Thai agency which possesses orthophoto equipment, having first produced digital profiles on the analytical plotters
- a study will be initiated into the economy and efficiency of using the analytical stereoplotters to provide accurate cadastral boundary surveys by coordinating parcel corners, adjudicated and pricked on the rectified photomaps returned from the field offices. Village surveys in remote areas may also benefit from photogrammetric plotting if vegetation cover is sufficiently light.

Conclusion

Obviously many challenges and frustrations lie ahead as the perpetual struggle between quality and productivity is continued. As production targets are progressively achieved the Photogrammetric Division will be able to devote more energy to upgrading product quality, accuracy and flexibility. This will enable the Department of Lands to play an even more active role in the area of Land Information that will no doubt evolve in Thailand in the near future.

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