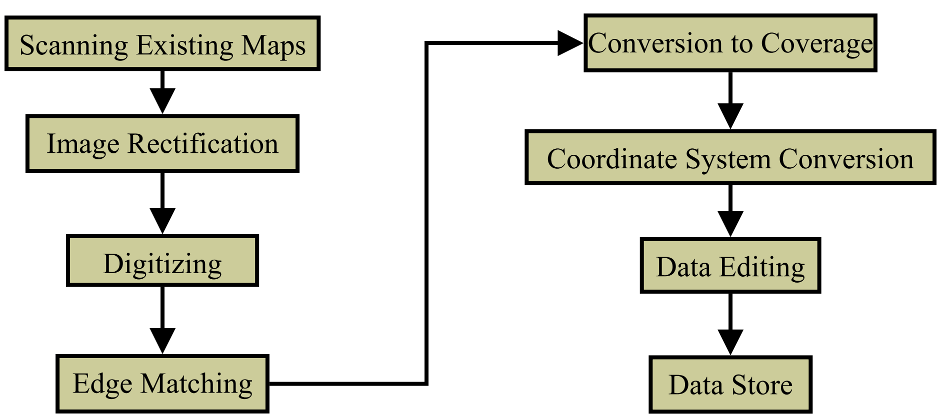
CHAPTER5 FLOW OF GIS DATA GENERATING AND UPDATING

Based on the preparatory works mentioned in Chapter 2, and after geodetic datum network survey (Chapter 3) and aerial photography (Chapter 4), GIS data generating and updating were implemented for the Mekong GIS Database Establishment. For the implementation, eight types of source materials were used. The basic source material for the whole Study area was the existing 1:100,000 topographic maps made in 1982, based on which the basic framework of database was prepared. Other source materials were the existing 1:50,000 and 1:25,000 topographic maps, satellite images, aerial photographs, land use data, contour data, place name data and so on. The roles played by these source materials are presented below.

Type of Source Material		Role
Map (1:100,000)	old data (1982)	basic framework
Map (1:50,000 and 1:25,000)	new data	updating
Satellite image	new data	updating
Aerial photo	new data	updating
Place name extracted from 1:100,000 map	old data (1982)	basic data
Place name from UXO and NSC	new data	updating
Contour data from MRC and UXO	existing data	basic data
Land use data from NOFIP (FIPC)	existing data	basic data

From these source materials, several flows rose individually and joined each other before accomplishing the GIS Database. The whole system of flows is rather complicated, but a general flowchart from map scanning to final data store is exemplified below.

Basic Procedure



The flowchart for the whole processes of the GIS data generating and updating in this Study is presented on the next page. More detailed flows are presented individually in describing each process in Chapter 6 and Chapter 8.

Insert whole flowchart

CHAPTER6 ORTHO SATELLITE IMAGE PREPARATION

In accordance with the Inception Report, 1:100,000 SPOT ortho satellite images were printed out on paper for the whole Study area. This was completed in the fourth year. A reason for printing was that printed images facilitated identification of changed features such as changed rivers, land use and some large objects, since satellite images would be the best and easiest source material providing up-to-date information. Another reason for printing was that printed images at a scale of 1:100,000 could be the most convenient base in the process of topographic feature updating. Namely, the printed images were used as the base map, on which satellite interpretation results were marked and aerial photo interpretation results were also marked through manual transcribing from photos.

For printing ortho satellite images, first the ortho data must be prepared. The NGD counterparts generated the ortho data from SPOT image data under the guidance of a Team member. Through this work, four (4) counterparts have mastered the technology necessary to generate the ortho data.

Ortho satellite image preparation from original data is exemplified in Figure 7.

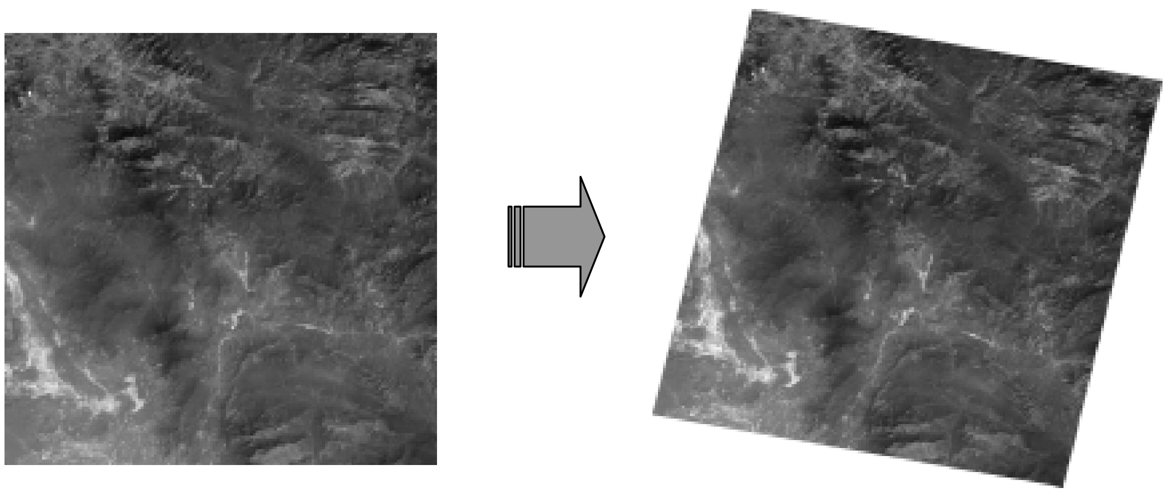


Figure 7: Original Image (left) and Ortho Satellite Image (right)

The number of SPOT scenes used for the Study was 129. The index map is shown in Figure 10 on the page 33 together with the index of 1:100,000 topographic maps.

The process of ortho satellite image preparation is shown in the flowchart on the page 31.

For generating ortho satellite images, Ground Control Points (GCPs) are a requirement. They must be selected at a necessary density with well-balanced positions from the vector data of roads and rivers prepared in the previous years. Clear points such as road intersections and river junctions must be found in the vector data. But the greater part of the Study area is mountainous. Therefore, that meant that roads, which provide clear GCPs, were not necessarily found at necessary densities and positions. Besides, the chronological gap between the old 1:100,000 scale topographic map and new ortho satellite image was so large that many roads had been altered. Therefore, it was hard to select all of necessary GCPs from the vector data alone.

To solve this problem, the Team member prepared shaded relief images using DEM, because shaded relief images are helpful to visually find remarkable points such as intersections of ridge lines and valley lines.

Every SPOT image scene covers more than two quadrangles of 1:100,000 topographic map sheets. The DEM was compiled for each scene. In view of saving the data volume and processing time, resolution was set to be 30 meters. A piece of DEM is visualized in Figure 8.

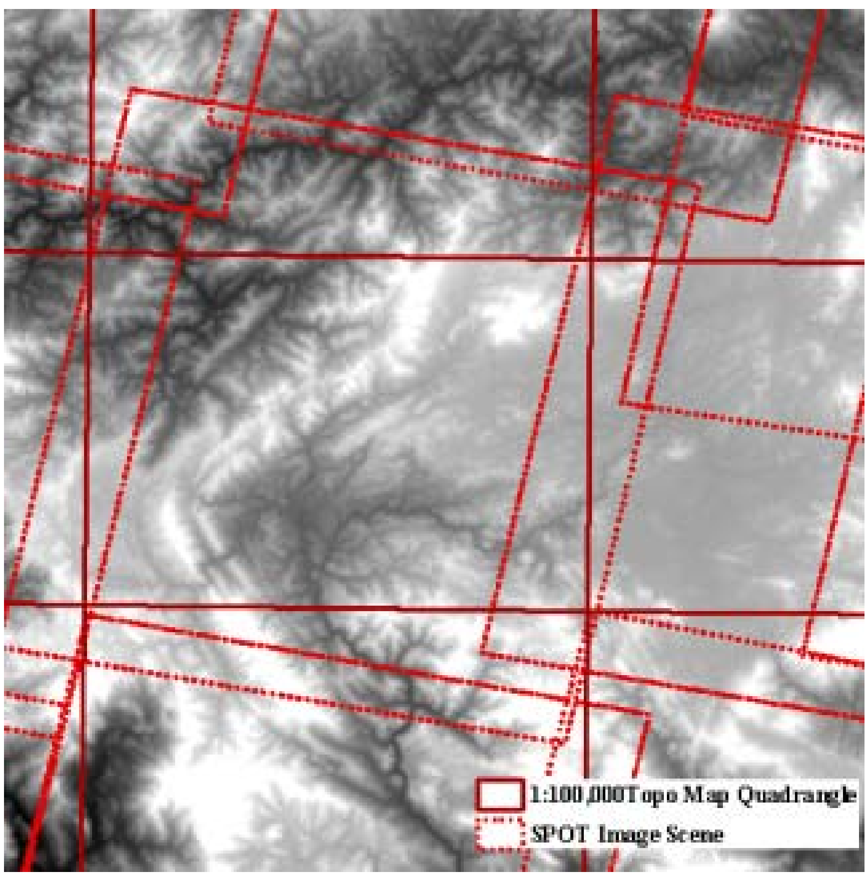
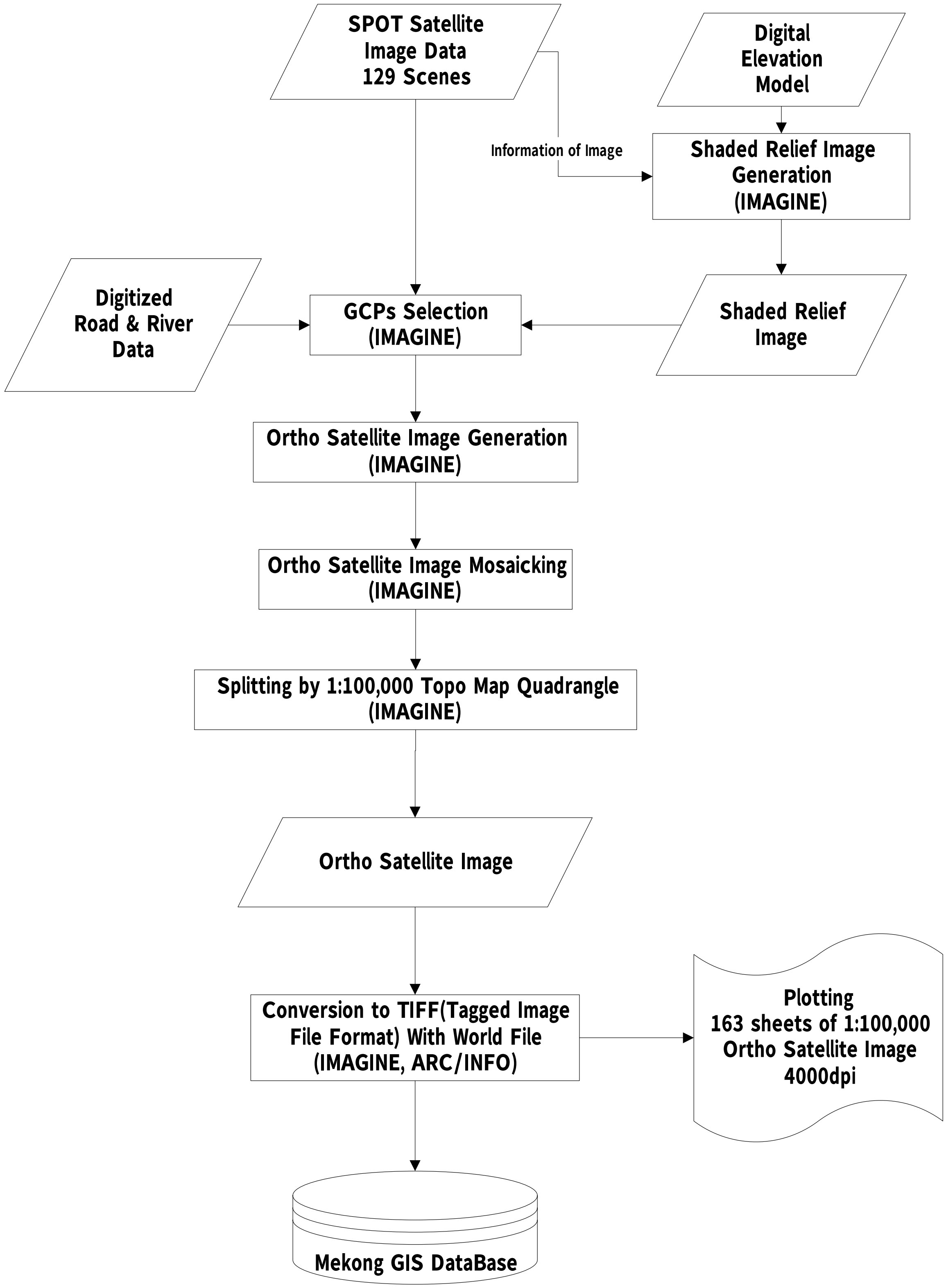


Figure 8: Visualized DEM


SPOT Satellite Image Data 129 Scenes
Digital Elevation Model
Information of Image
Shaded Relief Image Generation (IMAGINE)
Digitized Road & River Data
GCPs Selection (IMAGINE)
Shaded Relief Image
Ortho Satellite Image Generation (IMAGINE)
Ortho Satellite Image Mosaicking (IMAGINE)
Splitting by 1:100,000 Topo Map Quadrangle (IMAGINE)
Ortho Satellite Image
Conversion to TIFF(Tagged Image File Format) With World File (IMAGINE, ARC/INFO)
Plotting 163 sheets of 1:100,000 Ortho Satellite Image 4000dpi
Mekong GIS DataBase

For selection of GCPs, it is required that a shaded relief image would be easily compared with the correspondent satellite image. Therefore, the solar altitude and azimuth to be used for shading were chosen to be equal to those of the satellite image. A pair of shaded relief image and satellite image is exemplified in Figure 9.

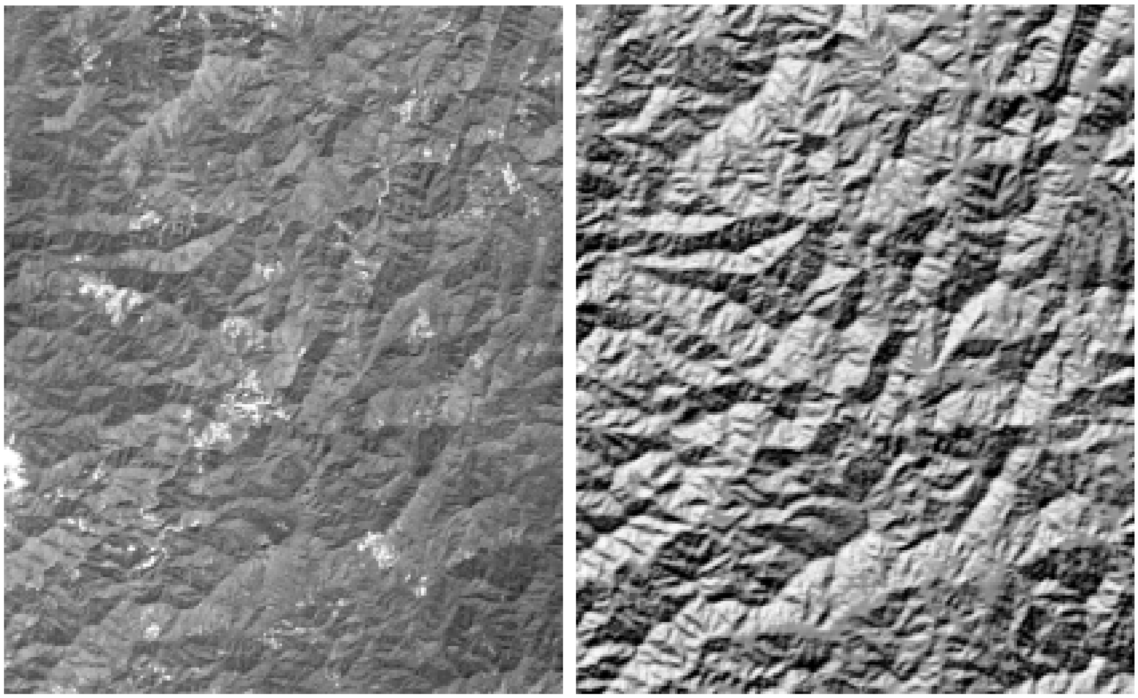


Figure 9: SPOT Image (left) and Shaded Relief Image (right)

After careful review, all 163 sheets of 1:100,000 scale ortho satellite images were output to paper in Japan. A high precision plotter and corresponding paper were used instead of an ordinary inkjet plotter and paper so that the counterparts would be able to easily perform the manual transcribing work after photo interpretation. The printing resolution was 4,000 dpi. The index of SPOT scenes is shown in Figure 10 together with the index of 1:100,000 topographic maps.

Technical Remarks

For this work, selection of GCP is the most important process for generating high quality ortho satellite images. GCP should be selected at a necessary density and well-balanced position. At the same time, it is emphasized that GCP should be picked up very carefully with high precision. To help GCP selection, shaded relief images were output from DEM in this Study.

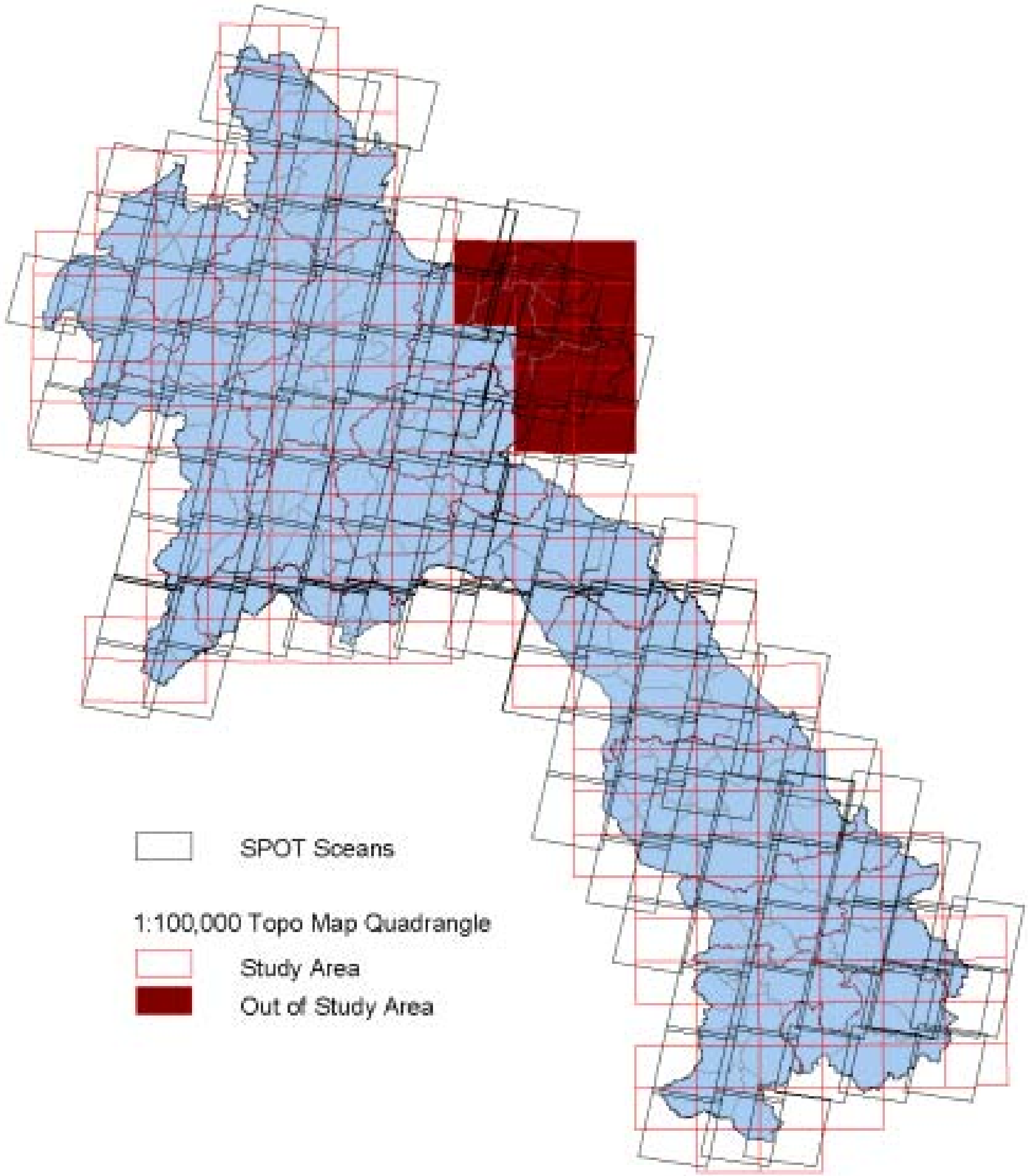


Figure 10: SPOT Image Scene and 1:100,000 Topographic Map Quadrangles

CHAPTER7 AERIAL PHOTO INTERPRETATION AND FIELD CHECK

In general, aerial photo interpretation is one of the measures for geographic data creating and updating. In this Study, photo interpretation played an important part for supplementing the unsatisfactory interpretation of satellite imagery. Under the guidance of the Team, the NGD counterparts carried out photo interpretation using the existing aerial photos taken after 1996 and the new photos taken by JICA as a part of this Study in 1999. The purpose was to identify the changed artificial features such as roads, villages, small objects, water bodies and land use that cannot be identified by satellite images. The Bolikhamxai area and Bolaven Plateau in the southern four Provinces were excluded from the photo interpretation area, because these areas were covered by new topographic maps that provide the recent information of topographic features.

7.1 Preparation of Aerial Photo Interpretation Keys

In the first year, photo interpretation keys were prepared in the form of sheets. These keys are helpful tools to give a common basis for identification of topographic features to interpreters. Referring to the 1:100,000 topographic maps and SPOT satellite images, the Team and the counterparts extracted the topographic features appearing in the photos of the Bolikhamxai, Savannakhet and Champasak areas and selected a sample from each extracted feature to use as the key. Afterward, the Team and the counterparts conducted field verifications of these keys.

After field verification, each feature's key was compiled into one sheet. About 40 sheets were completed. Each sheet contained the following:

a stereoscopic pair of aerial photos or a single aerial photo where the relevant feature appears,

the responding part of topographic map and satellite image,

the terrestrial photo of the feature,

the feature's symbol and

an explanatory note about the feature and its peculiarity in appearance.

Both a Laotian version and an English version were prepared. Keys of small objects, especially in urban areas, were redesigned to be suitable for small-scale (1:50,000) photos. In the initial stage, the Team members took charge of making the sheets by using PCs. Late, the counterparts carried out this work using software such as Adobe Illustrator (drawing software) and Adobe Photoshop (image manipulation software). This software was also used for illustrating the symbols. These operations were helpful for counterparts to understand the concepts of raster, vector, layer and so on. Through the work, counterparts prepared some Laotian documents pertaining to the map's legend and photo interpretation. A sheet of the key is exemplified as Appendix D.

7.2 Aerial Photo Interpretation of Topographic Features

Aerial photo interpretation for updating of artificial topographic features was conducted in the second and the third years.

For this work, the counterparts were required to be knowledgeable about the definitions of features that appear in the 1:100, 000 topographic maps. They were also required to master how to orient a pair of photos and to identify the peculiar appearance of each topographic feature on the photo. They fulfilled these requirements through the above-mentioned preparation of keys as well as through referring to the keys.

The counterparts were also required to have the capability of stereoscopic vision with stereoscopes. Without stereoscopic vision, it is not possible to perform desirable interpretation from a viewpoint of efficiency and quality. Therefore, a test on ability of stereoscopic vision was given to them. It revealed that nearly 80% of the counterparts were able. The rest of them acquired the ability through training after the test.

The following photos were used for photo interpretation of topographic features.

1:20,000	Color	Vangviang area	1,347 photos	(8,960 km²)
1:16,000	Monochromatic	Vientiane area	2,064 photos	(4,540 km²)
	Ditto	Savannakhet area	1,832 photos	(3,830 km²)
	Ditto	Champasak area	1,934 photos	(4,270 km²)
1:50,000	Monochromatic	Other areas	3,903 photos	(150,000 km²)
		Total	11,080 photos	

In the second year, the NGD counterparts started actual photo interpretation for three areas (Vientiane, Savannakhet and Champasak), which were approximately 12,600 km². The number of photos used was approximarely 5,800. Seven (7) counterparts participated in the work, taking turns by group. They identified changed artificial features referring to the existing topographic maps. Mirror stereoscopes and pocket-type lens stereoscopes were used. The changed features were marked directly on the photos with water-soluble colored pencils or colored ink (red, blue and green). Small towns and villages were delineated as polygon.

In the third year, six (6) of the counterparts concentrated on the work, which was conducted using the 1: 50,000 monochromatic photos for the northern and central regions of the country and using the 1: 20,000 color photos for Vangviang area. The number of photos used was about

5,400. Interpreted topographic features were mainly artificial features (i.e. roads, villages, small objects and water bodies).

Technical Remarks

For aerial photo interpretation, stereoscopic vision and correct orientation of photos are vital. Although ability of stereoscopic vision can be acquired by practice in general, it depends on physical condition of person. All the counterparts were able to make stereoscopic observation.

Orientation of photos must be fully mastered, because, without correct orientation, it is entirely impossible to make stereoscopic vision.

After acquisition of above abilities, the interpreter is required to have knowledge on definition of each topographic feature.

Last, the interpreter must learn the peculiar appearance of each topographic feature with interpretation keys.

7.3 Field Check of Topographic Features

Quality of photo interpretation depends on the quality of the photos, photo scale, and the interpreter's experience. During the aerial photo interpretation work, the counterparts carried out field check on the features such as urban areas, small objects, roads and bodies of water in the Vientiane area under the guidance of the Team. The results are as follows:

(1) Newly established schools and temples tended to be mistakenly identified as similar objects in shape on the photos.

(2) Roads were correctly identified, but road type was not identified in cases of indistinct surface tone on the photos.

(3) Urban areas were correctly identified due to their distinctive features on the photo. But isolated houses were not easily identified.

(4) Bodies of water were correctly identified.

Unsatisfactory results for newly established schools, temples, road types and isolated houses were caused primarily by lack of experience, but through field checking the interpreter's skill was eventually improved.

Technical Remarks

It is judged that the counterparts have mastered identification of the features for this Study at least. When they identify other features, however, they need to learn the appearance of these features on photos. But, there will be no difficulty for them because of experience.

To beginners, instruction and interpretation keys must be provided by experienced staff.

7.4 Photo Interpretation of Land Use

The National Office of Forest Inventory and Planning (NOFIP) conducted "Nationwide Reconnaissance Survey of Land Use and Forest Cover in Lao P.D.R. (NRS)" within the frames of the Lao-Swedish Forestry Co-operation Program. It was initiated in 1987. Within the survey, land use and forest cover were classified based on aerial photo interpretation and remote sensing, and represented in digital maps. Twenty-three (23) classes of land use were classified based on the improved FAO system.

According to the NOFIP report, the aerial photos taken in the 1980s by the USSR were interpreted. The results of interpretation were overlaid with SPOT satellite images taken in the 1990s. Then, through tracing and digitizing process, the land use and forest cover data were generated. Field check was done from 1992 to 1998. The Team obtained this land use data and made an agreement with the Steering Committee to update the data using recent aerial photos.

In the fourth year, in accordance with the agreement the counterparts conducted photo interpretation of land use and forest cover using the 1: 16,000 photos for Vientiane area; 1:20,000 photos for Vangviang area; and the new 1:50,000 photos for the Northern Region of the country excluding Louangphabang Province. A scene of photo interpretation work is shown in Figure 11 on the next page. The interpreted areas are shown in Figure 12 on the next page too.

Figure 11: Photo Interpretation Work

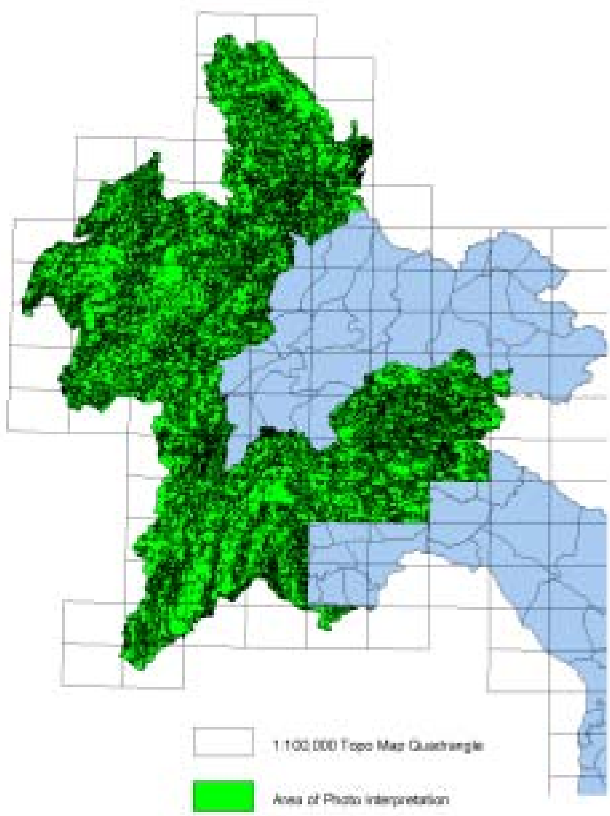


Figure 12: Interpreted Area

The southern four provinces (Salavan, Xekong, Champasak and Attapu) were not interpreted because the recent aerial photos were not available for the greater part of the area. For updating, ortho satellite images were used.

The central three provinces (Bolikhamxai, Khammouan and Savannakhet) were also not interpreted because new NOFIP data, updated through other projects, was available. Louangphabang Province was left out from the work, too, because an updating project of NOFIP was ongoing.

The classes of land use and forest cover in NOFIP data are different from those of the existing 1:100,000 topographic maps, and the number of classes is larger. It is necessary to integrate both classification systems. The Team decided to adopt NOFIP classification with a few exceptions.

The initial plan was to update only three classes of the NOFIP classification system. But during the work, it became clear that considerable discrepancies between the existing NOFIP data and the new data were widespread and that the discrepancies were rather irregular in size and direction. Because it was foreseen that adjusting for discrepancies within the three classes would take too much time, the Team decided to interpret all classes of the NOFIP system, except for bodies of water and urban areas.

During interpretation work, the counterparts conducted field excursions in the Vientiane area to access the landscape of typical forests. The final results of interpretation were marked directly on the photos with colored pencils. The classified categories are shown in Table 8 and Table 9.

Table 8: List of Land Use Classes (NOFIP)

NUMBER	CODE	FOREST TYPE
		Current Forest
11	UDE	Upper Dry Evergreen Forest
12	LDE	Lower Dry Evergreen Forest
13	UMD	Upper Mixed Deciduous Forest
14	LMD	Lower Mixed Deciduous Forest
15	DD	Dry Dipterocarp Forest
16	GE	Gallery Forest
17	S	Coniferous Forest
18	MS	Mixed Broadleaved and Coniferous Forest
19	P	Forest Plantation
		Potential Forest
21	B	Bamboo
22	T	Un-stocked Forest Areas
23	N	Natural Regeneration
24	RA	Ray
		Other Wooded Area
31	SH	Savannah

32	SR	Heath, Stunted and Scrub Forest
		Permanent Agriculture Land
41	RP	Rice Paddy
42	AP	Agriculture Plantation
43	OA	Other Agriculture Land
		Other Non-forest Land
51	R	Barren Land and Rock
52	GE	Grassland
53	SW	Swamps
54	U	Urban, Built-up Areas
55	OA	Other Areas
56	C	Cloud, Cloud Effects
		Water Bodies
61	W	Water Bodies

Table 9: List of Land Use Classes (Mekong GIS)

NUMBER	CODE	FOREST TYPE
		Current Forest
11	DE	Dry Evergreen Forest
13	MD	Mixed Deciduous Forest
15	DD	Dry Dipterocarp Forest
16	GE	Gallery Forest
17	S	Coniferous Forest
18	MS	Mixed Broadleaved and Coniferous Forest
19	P	Forest Plantation
		Potential Forest
21	B	Bamboo
22	T	Un-stocked Forest Areas
24	RA	Ray
		Other Wooded Area
31	SH	Savannah
32	SR	Heath, Stunted and Scrub Forest
		Permanent Agriculture Land
41	RP	Rice Paddy
42	AP	Agriculture Plantation
43	OA	Other Agriculture Land
		Other Non-forest Land
51	R	Barren Land and Rock
52	GE	Grassland
53	SW	Swamps
54	U	Urban, Built-up Areas
55	OA	Other Areas
		Water Bodies
61	W	Water Bodies

Technical Remarks

Forest type classification required an ability of forest type interpretation with a special knowledge and experience of forestry. From this point of view, the present results are in need of improvement.

When larger scale photos are interpreted for smaller scale mapping, it is essential to generalize the polygons in the course of interpretation. It is, however, not easy to perform generalization. The counterparts are required to have more experience of polygon generalization for improving the data.

7.5 Transcribing

Before digitizing the interpreted topographic features, the counterparts were required to transcribe these results from the aerial photos onto the 1:100,000 ortho satellite images, in accordance with the initial plan. There were 163 sheets of satellite images prepared for each quadrangle of the 1:100,000 topographic maps. (Preparation of these sheets is described in Chapter 6.) The reason for transcribing was that it was more advantageous to use the satellite images instead of the photos, because, if digitization is done based on every photo individually, it would take much processing time and the propensity for errors would be great due to the large number of photos and limitations of working space.

For this reason, in the fourth year, the NGD counterparts manually transcribed the entire interpretation results of topographic features marked on the photos onto the 1:100,000 satellite images with drafting pens, comparing the photo and satellite images.

For transcribing, the counterparts were inevitably required to have an ability to interpret the satellite images. They acquired the ability by finding distinctive features on the satellite images, i.e. roads, drainage patterns, etc. that appeared in the photos. Categories of interpreted objects were distinguished with colored ink. To minimize the number of errors, as a final step, the Team members and the counterparts checked the finished sheets.

The interpretation results of land use and forest cover were not transcribed onto the satellite images. They were transcribed onto another polyester film sheets at a scale of 1:50,000. (This is described in Chapter 8.)

Technical Remarks

For transcribing points, lines and polygons from photos to satellite images, it was required to compare the both images. Therefore, the counterparts needed to be familiar with satellite images as well as photographic images. They have attained the standard level of ability. Also, in this process, the counterparts were required to be very careful for precise plotting.