CHAPTER8   GIS DATA COLLECTION, GENERATION, UPDATING AND STRUCTURING

The Team and the NGD counterparts digitized 163─175 sheets of the 1:100,000 topographic maps covering the Study area for generating GIS data of topographic features, administrative boundaries and elevation point. In addition, the Team collected some existing data such as village names, contour data and land use data from other organizations with the cooperation of the NGD counterparts. The Team applied these collected data for establishing the Mekong GIS Database with some necessary updating.

8.1   Features in the 1:100,000 Topographic Map

The counterparts digitized the topographic features of the 1:100,000 map under the guidance of the Team. Then, they updated the data with new information from recent topographic maps and aerial photos. The following data layers were finalized and stored in the GIS database:

> Road (line)
>
> River (line)
>
> River (polygon)
>
> Elevation point (point)
>
> Small objects (point)

8.1.1 Features in the Bolikhamxai Area

One hundred and twelve (112) sheets of 1:25,000 topographic maps of the Bolikhamxai area were available as source materials for updating the existing 1:100,000 topographic maps for the southern part of Bolikhamxai Province and the northern part of Khammouan Province. These sheets were prepared in 1995 in technical cooperation between NGD and JICA. The index of map sheet is shown in Figure 13 on the next page.
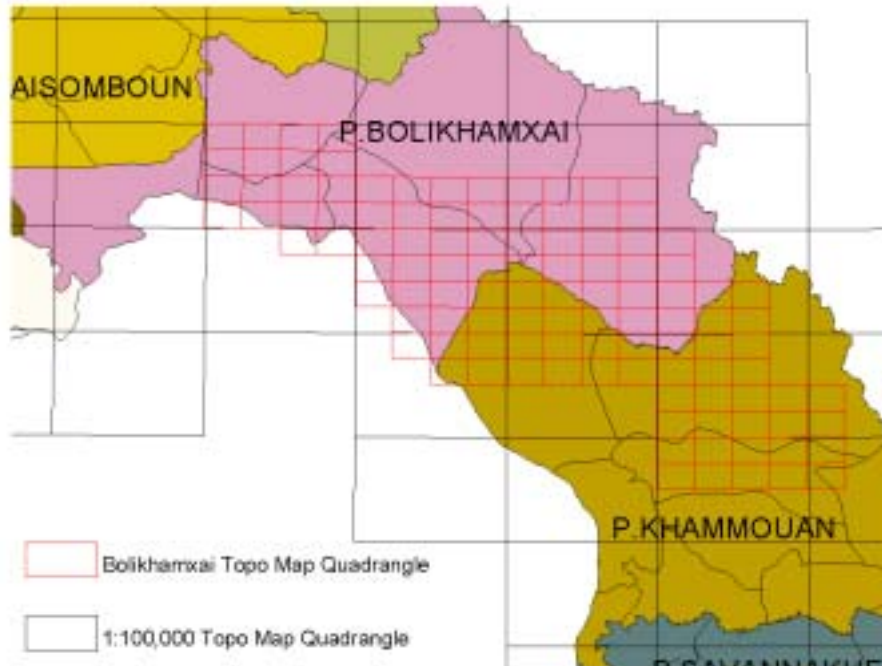
Figure 13: 1:25,000 (Bolikhamxai) Map Quadrangle

The 1:25,000 topographic maps have more up-to-date information than the 1:100,000 topographic maps. The datum is Indian-1975, the projection is UTM and spheroid is Everest. Through an examination by GPS survey, it was confirmed that accuracy was high enough for updating the topographic feature data. Therefore, instead of photo interpretation, these topographic maps were used for updating of road, river, built-up areas and small objects for this area.

These maps (paper) were scanned first. After image rectification, the above-mentioned data were digitized on the raster image. The process is shown in the flowchart on the next page.

```
┌─────────────────────────────────────────┐
│      Bolikhmaxai 1:25,000 Topo Map       │
│       (112 Sheets of Paper Map)          │
└─────────────────────────────────────────┘
                    │
                    ▼
          ┌──────────────────┐
          │  Scanning 300dpi │
          │     (TruInfo)    │
          └──────────────────┘
                    │
                    ▼
          ┌──────────────────┐
          │ Image Rectification │
          │     (IMAGINE)    │
          └──────────────────┘
                    │
                    ▼
┌───────────────────────────────────────────┐
│            Data Digitizing                 │
│              (ArcView)                      │
│ [Road, River, Built-up Area, Small Objects]│
└───────────────────────────────────────────┘
                    │                  │
                  Road                 │
                  River                │
               Built-up Area      Small Objects
                    │                  │
                    ▼                  │
          ┌──────────────────┐         │
          │   Edge Matching  │         │
          │     (ArcView)    │         │
          └──────────────────┘         │
                    │                  │
                    ▼                  │
          ┌──────────────────┐         │
          │ Conversion to Coverage ◄───┘
          │    (ARC/INFO)    │
          └──────────────────┘
                    │
                    ▼
          ┌──────────────────┐
          │ Coordinate System Conversion │
          │    (ARC/INFO)    │
          └──────────────────┘
                    │
                    ▼
          ┌──────────────────┐
          │     Appending    │
          │    (ARC/INFO)    │
          └──────────────────┘
                    │
                    ▼
┌───────────────────────────────────────────┐
│  Splitting by 1:100,000 Topo Map Quadrangle│
│              (ARC/INFO)                     │
└───────────────────────────────────────────┘
                    │
                    ▼
            ┌──────────────┐
            │   Data of    │
            │  Bolikhamxai │
            └──────────────┘
```
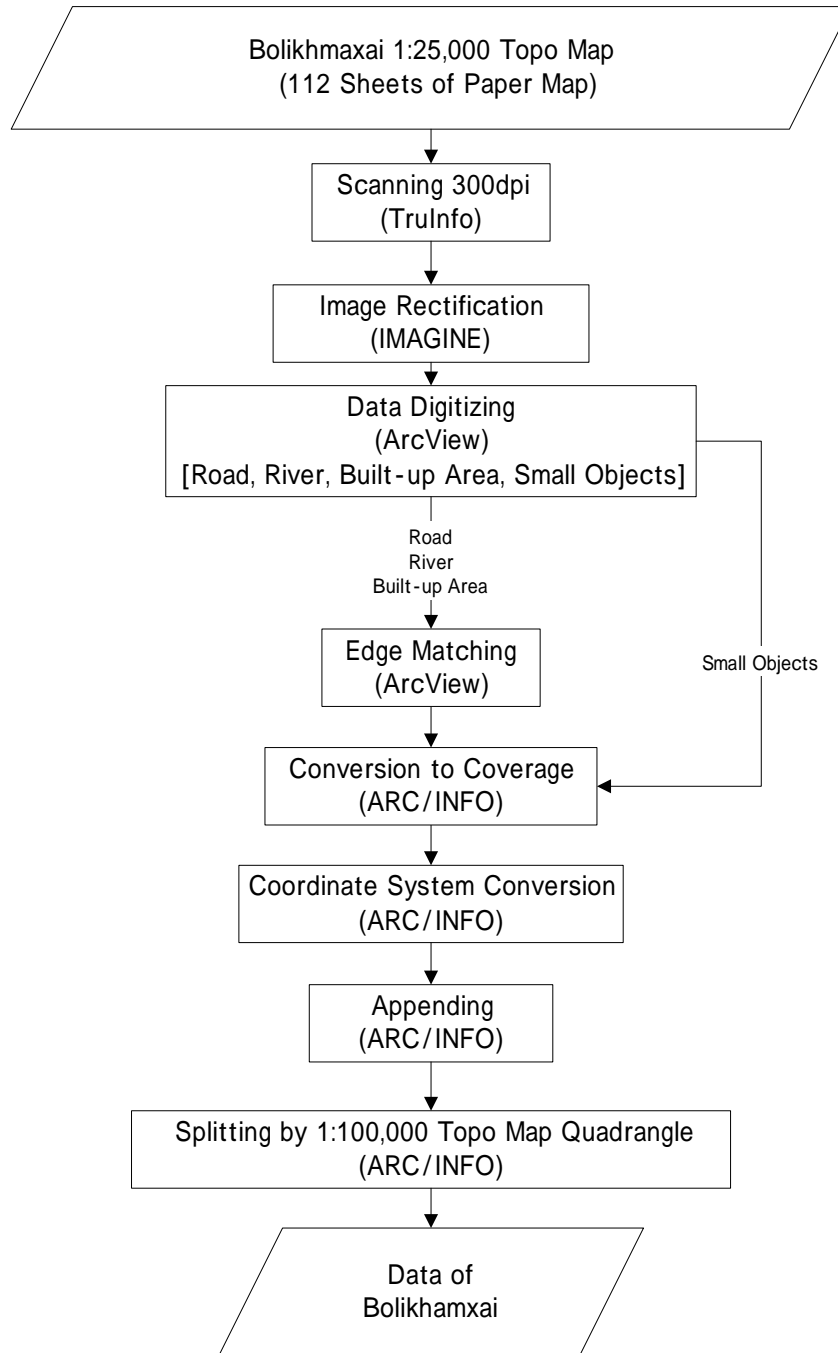
8.1.2 Features in the Southern Four Provinces

In the 1960s, the American Army Service (AMS) prepared 1:50,000 topographic maps for the whole country. After then, eighty-one (81) sheets for the southern four provinces (Salavan, Xekong, Champasak, and Attapu) were updated during 1997─1998 with the assistance of

Vietnam. Therefore, it was considered that they had more up-to-date information than the 1:100,000 topographic maps made in 1982. Through examination it was confirmed that the error was smaller than in the 1:100,000 topographic maps, but the topographic features were not more up-to-date than in the 1:100,000 maps. According to the report on the updating and an interview with the NGD engineers who worked on the updating:

(1)   For the greater part of the areas, the same aerial photos taken for the 1:100,000 topographic mapping were used for updating. Only ten (10) map sheets, which include Bolaven Plateau, were updated by using new aerial photos taken in 1994.

(2)   In addition, the old photos were used for updating land use and roads only. The rest of the features were simply copied from the old AMS maps.

The index of the updated map sheets is shown in Figure 14.
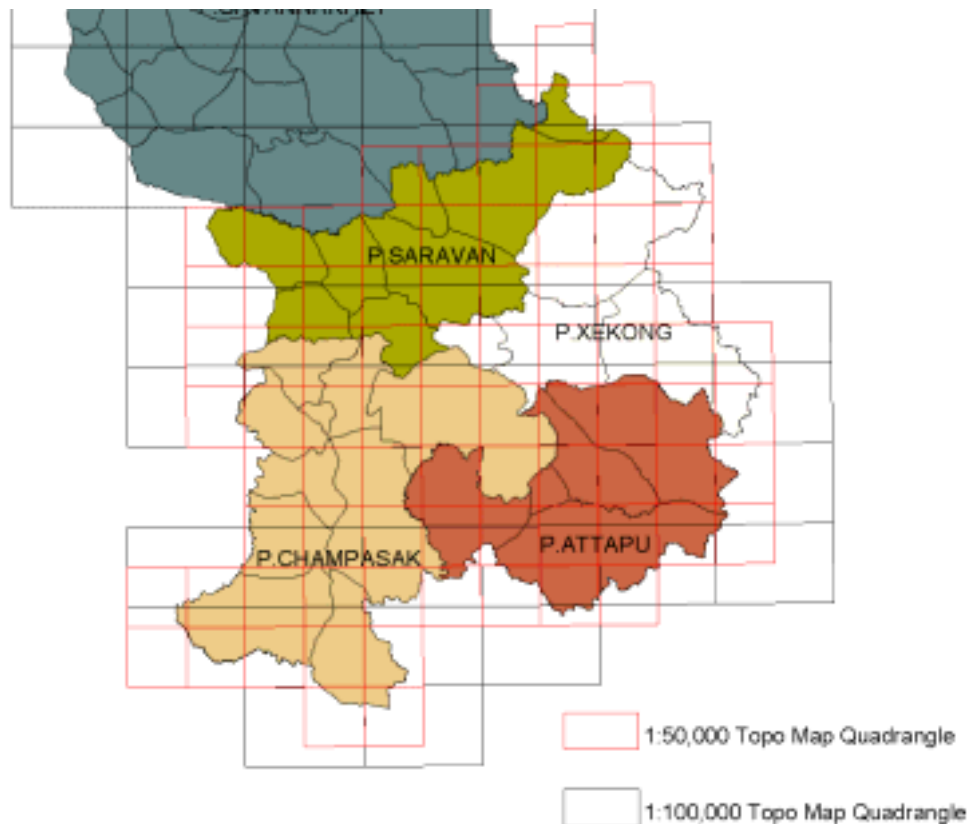
Figure 14: 1: 50,000 (Southern Four Provinces) Map Quadrangle

Based on the verification results, the Team and NGD agreed that the ten map sheets should be applied for data updating first. In accordance with the agreement, the ten maps (paper) were scanned. After image rectification, roads and rivers were digitized on the raster image. The process is shown in the flowchart below.

```
        ┌─────────────────────────────┐
       /   Southern Four Provinces     /
      /    1:50,000 Topo Map          /
     /     (10 Sheets of Paper Map)  /
    └─────────────────────────────┘
                  │
                  ▼
        ┌──────────────────────┐
        │   Scanning 200dpi     │
        │   (TruInfo)           │
        └──────────────────────┘
                  │
                  ▼
        ┌──────────────────────┐
        │  Image Rectification  │
        │  (IMAGINE)            │
        └──────────────────────┘
                  │
                  ▼
        ┌──────────────────────┐
        │   Data Digitizing     │
        │   (ArcView)           │
        │   [Road, River]       │
        └──────────────────────┘
                  │
                  ▼
        ┌──────────────────────┐
        │   Edge Matching       │
        │   (ArcView)           │
        └──────────────────────┘
                  │
                  ▼
        ┌──────────────────────┐
        │ Conversion to Coverage│
        │ (ARC/INFO)            │
        └──────────────────────┘
                  │
                  ▼
        ┌──────────────────────────┐
        │ Coordinate System Conversion│
        │ (ARC/INFO)               │
        └──────────────────────────┘
                  │
                  ▼
        ┌──────────────────────┐
        │     Appending         │
        │   (ARC/INFO)          │
        └──────────────────────┘
                  │
                  ▼
        ┌────────────────────────────────────┐
        │ Splitting by 1:100,000 Topo Map Quadrangle│
        │ (ARC/INFO)                         │
        └────────────────────────────────────┘
                  │
                  ▼
       ┌─────────────────────────┐
      /   Data of Southern        /
     /    Four Provinces         /
    └─────────────────────────┘
```
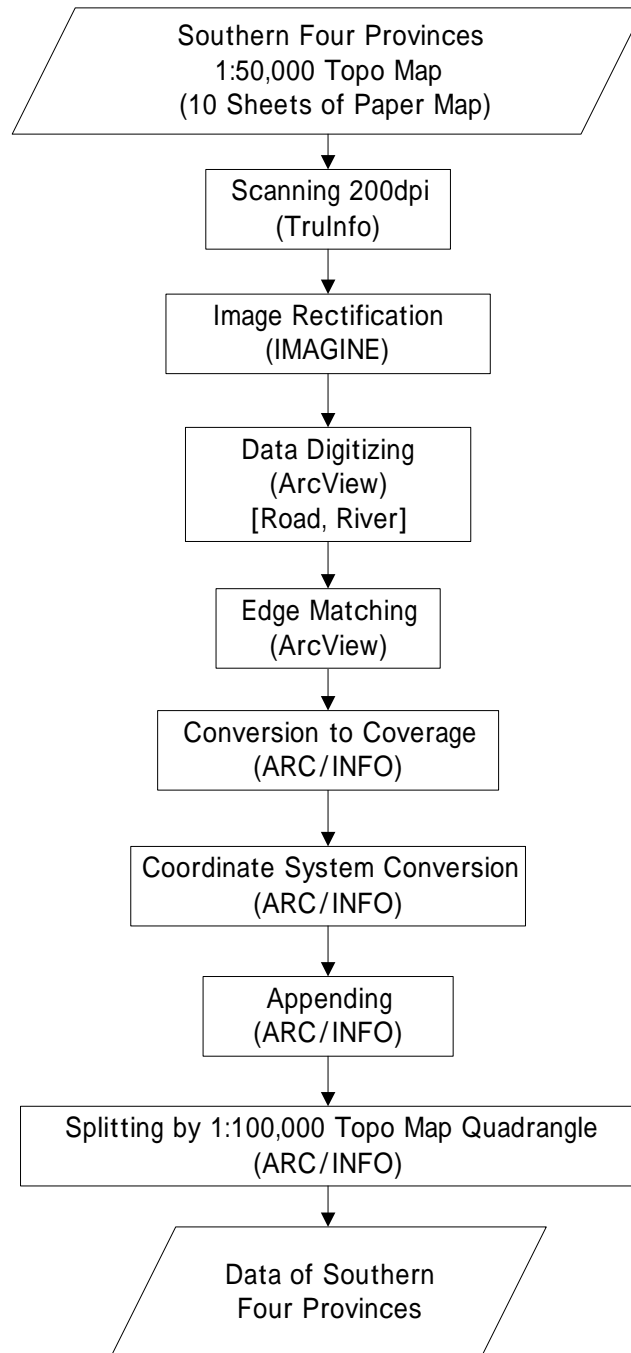
For updating the rest of the area that had not been updated by new aerial photos, the Team eventually applied ortho satellite images as the only provider of recent information obtained. As a result, small features have not been well updated.

8.1.3 Road and River in the Whole Study Area

The existing 1:100,000 topographic maps (polyester film) for the whole Study area were scanned. After image rectification, roads and rivers were digitized on the raster image. Then, the data were updated with new data of Bolikhamxai area and southern four provinces and the results of aerial photo interpretation transcribed on ortho satellite images. Final data were stored in the database. The process is shown in the flowchart below.

```
          ┌──────────────────────────────────────┐
          │  1:100,000 Topo Map (Polyester Film)  │
          │            [Road, River]              │
          └──────────────────────────────────────┘
                             │
                   ┌───────────────────┐
                   │  Scanning 400dpi   │
                   │     (TruInfo)      │
                   └───────────────────┘
                             │
                   ┌───────────────────┐
                   │ Image Transformation│
                   │     (Trprj98)      │
                   └───────────────────┘
                             │
                   ┌───────────────────┐
                   │  Data Digitizing   │
                   │    (VecEdit98)     │
                   └───────────────────┘
                             │
                   ┌───────────────────┐
                   │ Conversion to Coverage │
                   │     (ARC/INFO)     │
                   └───────────────────┘
                             │
                   ┌───────────────────┐
                   │ Coordinate System Definition │
                   │     (ARC/INFO)     │
                   └───────────────────┘
                             │
                        Plotting
                             │
                      Error Checking
                             │
                          Error ──Yes──►  Conversion to Shapefile
                             │                  (ArcView)
                            No                      │
                             │               Screen Editing
                             │                  (ArcView)
                             │                      │
                        Plotting ◄──────── Conversion to Coverage
                             │                  (ARC/INFO)
                      Error Checking
                             │
```
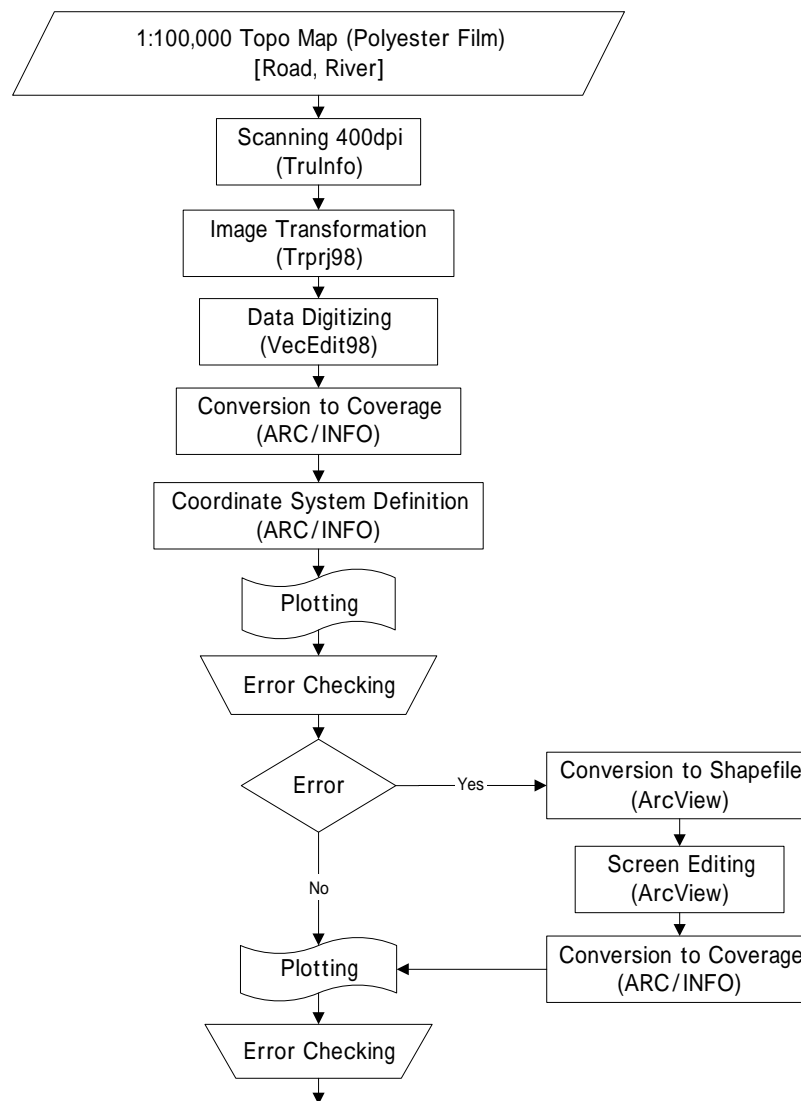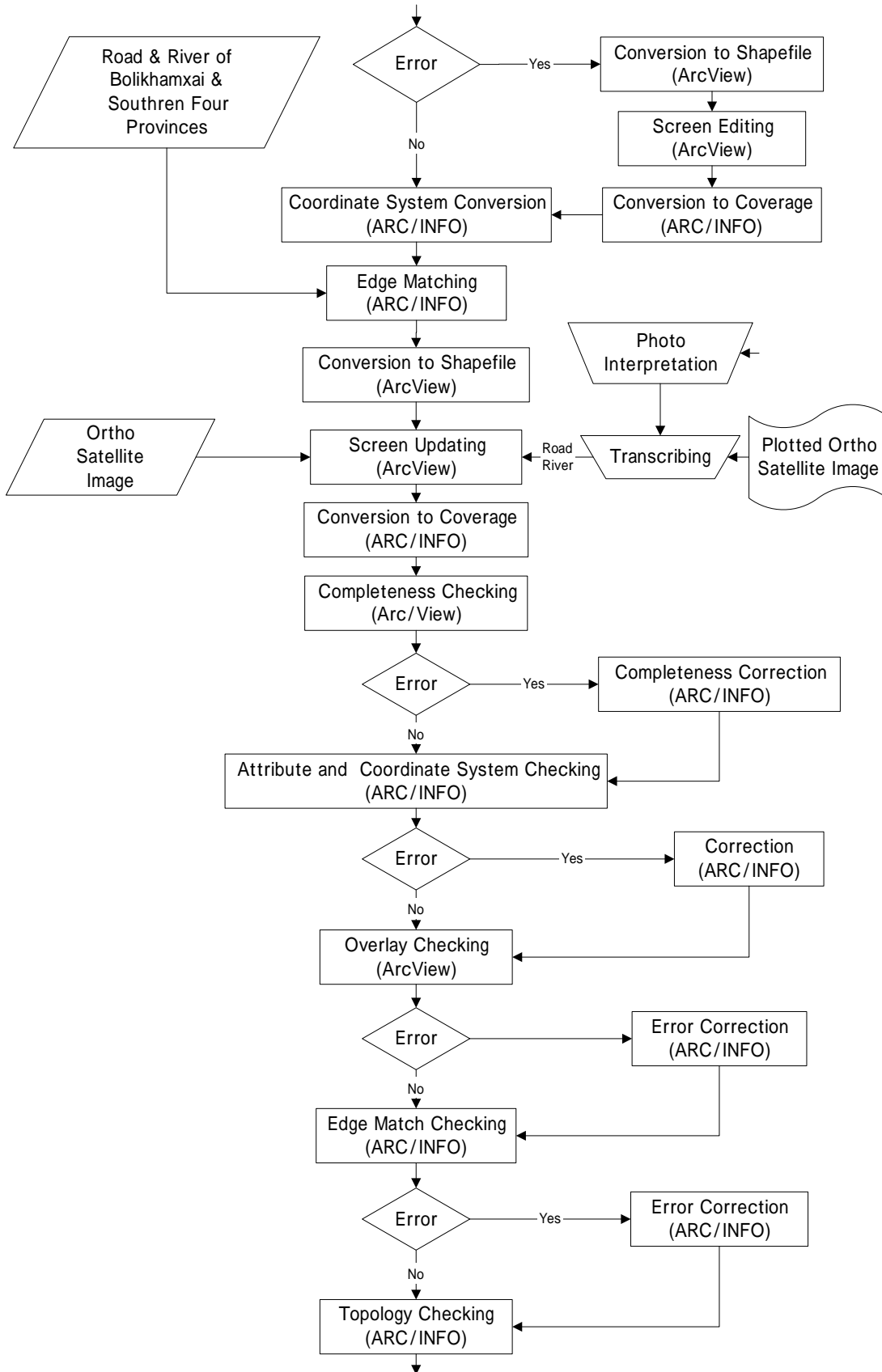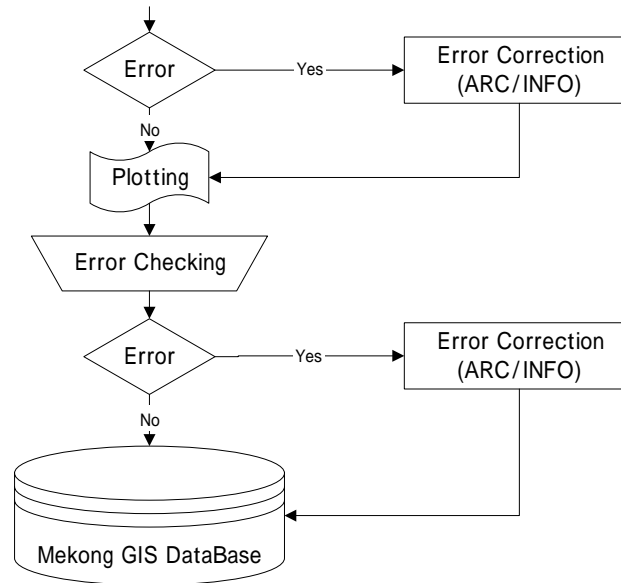
8.1.4 Elevation Point and Small Objects in the Whole Study Area

The existing 1:100,000 topographic maps (paper) for the whole Study area were scanned. After image rectification, elevation point and small objects were digitized on the raster image. Then, the small objects data were updated with new data of Bolikhamxai area and the results of photo interpretation transcribed on ortho satellite images. Final data were stored in the database. The process is shown in the flowchart on the next page.

Technical Remarks

It is judged that the counterparts have acquired ability of generating and updating these topographic features. Most of the processes were highly automatic. However, screen updating, data digitizing, edge matching and data checking were laborious work, which required the operators to be very careful. Without carefulness, mistakes in inputting data and attributes were apt to occur. Mistakes in data checking were also apt to occur.

```
                    ┌─────────────────────────────────┐
                    │    1:100,000 Topo Map (Paper)    │
                    └─────────────────────────────────┘
                                    │
                                    ▼
                        ┌───────────────────────┐
                        │   Scanning 600dpi      │
                        │      (TruInfo)         │
                        └───────────────────────┘
                                    │
                                    ▼
                        ┌───────────────────────┐
                        │  Image Transformation  │
                        │      (Trprj98)         │
                        └───────────────────────┘
                                    │
                                    ▼
                        ┌────────────────────────────┐
                        │  Data Digitizing (VecEdit98) │
                        │ [Elevation Point, Small Objects] │
                        └────────────────────────────┘
                                    │
                                    ▼
                        ┌───────────────────────┐
                        │  Conversion to Coverage │
                        │      (ARC/INFO)        │
                        └───────────────────────┘
                                    │
                                    ▼
                        ┌───────────────────────────┐
                        │ Coordinate System Definition │
                        │       (ARC/INFO)           │
                        └───────────────────────────┘
                                    │
                                    ▼
                             ┌──────────┐
                             │ Plotting │
                             └──────────┘
                                    │
                                    ▼
                             ╱ Error Checking ╲
                                    │
                                    ▼
                                ◇ Error ◇ ──── Yes ──→ ┌──────────────────────┐
                                    │                   │ Conversion to Shapefile │
                                    │                   │      (ArcView)        │
                                   No                   └──────────────────────┘
                                    │                              │
                                    │                              ▼
                                    │                   ┌──────────────────────┐
                                    │                   │    Screen Editing     │
                                    │                   │      (ArcView)        │
                                    │                   └──────────────────────┘
                                    │                              │
                                    ▼                              ▼
                             ┌──────────┐          ┌──────────────────────┐
                             │ Plotting │ ◄─────────│ Conversion to Coverage │
                             └──────────┘          │      (ARC/INFO)       │
                                    │               └──────────────────────┘
                                    ▼
                             ╱ Error Checking ╲
                                    │
                                    ▼
   ┌──────────────────┐         ◇ Error ◇ ──── Yes ──→ ┌──────────────────────┐
   │  Small Objects of │            │                   │ Conversion to Shapefile │
   │    Bolikhamxai    │            │                   │      (ArcView)        │
   └──────────────────┘            No                   └──────────────────────┘
            │                        │                              │
            │                        │                              ▼
            │                        │                   ┌──────────────────────┐
            │                        │                   │    Screen Editing     │
            │                        │                   │      (ArcView)        │
            │                        │                   └──────────────────────┘
            │                        ▼                              │
            │          ┌───────────────────────────┐   ┌──────────────────────┐
            └─────────→│ Coordinate System Conversion │◄──│ Conversion to Coverage │
                       │       (ARC/INFO)           │   │      (ARC/INFO)       │
                       └───────────────────────────┘   └──────────────────────┘
                                    │
                                    ▼
                        ┌───────────────────────┐        ╱ Photo ╲      ╱ Aerial ╲
                        │ Conversion to Shapefile │       │Interpretation│  │photograph│
                        │      (ArcView)         │        ╲        ╱      ╲        ╱
                        └───────────────────────┘             │
                                    │                          ▼
   ┌──────────┐        ┌───────────────────────┐   Small  ╱Transcribing╲  ┌──────────────┐
   │  Ortho   │ ──────→│   Screen Updating      │◄─Objects─│            │◄─│ Plotted Ortho │
   │ Satellite│        │      (ArcView)         │          ╲          ╱   │ Satellite Image│
   │  Image   │        └───────────────────────┘                          └──────────────┘
   └──────────┘                    │
                                    ▼
```

```
                    │
                    ▼
        ┌───────────────────────┐
        │ Conversion to Coverage│
        │      (ARC/INFO)       │
        └───────────────────────┘
        ┌───────────────────────┐
        │ Completeness Checking │
        │      (Arc/View)       │
        └───────────────────────┘
                    │
                    ▼
             ◇ Error ◇ ──Yes──▶ ┌───────────────────────┐
                                │ Completeness Correction│
                                │      (ARC/INFO)        │
                    │ No        └───────────────────────┘
                    ▼                        │
  ┌──────────────────────────────────────┐  │
  │ Attribute and Coordinate System Checking│◀┘
  │              (ARC/INFO)               │
  └──────────────────────────────────────┘
                    │
                    ▼
             ◇ Error ◇ ──Yes──▶ ┌───────────────────────┐
                                │      Correction        │
                                │      (ARC/INFO)        │
                    │ No        └───────────────────────┘
                    ▼                        │
        ┌───────────────────────┐           │
        │   Overlay Checking    │◀──────────┘
        │      (ArcView)        │
        └───────────────────────┘
                    │
                    ▼
             ◇ Error ◇ ─────────▶ ┌───────────────────────┐
                                  │    Error Correction    │
                                  │      (ARC/INFO)        │
                    │ No          └───────────────────────┘
                    ▼                        │
        ┌───────────────────────┐           │
        │  Edge Match Checking  │◀──────────┘
        │      (ARC/INFO)       │
        └───────────────────────┘
                    │
                    ▼
             ◇ Error ◇ ──Yes──▶ ┌───────────────────────┐
                                │    Error Correction    │
                                │      (ARC/INFO)        │
                    │ No        └───────────────────────┘
                    ▼                        │
        ┌───────────────────────┐           │
        │   Topology Checking   │◀──────────┘
        │      (ARC/INFO)       │
        └───────────────────────┘
                    │
                    ▼
             ◇ Error ◇ ──Yes──▶ ┌───────────────────────┐
                                │    Error Correction    │
                                │      (ARC/INFO)        │
                    │ No        └───────────────────────┘
                    ▼                        │
             ⌇ Plotting ⌇◀───────────────────┘
                    │
                    ▼
          ⬡ Error Checking ⬡
                    │
                    ▼
             ◇ Error ◇ ──Yes──▶ ┌───────────────────────┐
                                │    Error Correction    │
                                │      (ARC/INFO)        │
                    │ No        └───────────────────────┘
                    ▼                        │
          ╔═══════════════╗                 │
          ║ Mekong GIS DataBase ║◀──────────┘
          ╚═══════════════╝
```

8.2　　　Administrative Boundary

There are 18 administrative units of provincial level in Laos. They are Vientiane Municipality, Xaisomboun Special Region and 16 provinces. Each administrative unit is divided into several districts. Districts in Laos total 142. In the second year, the NGD counterparts generated data of these boundaries and stored them in the Mekong GIS Database under the guidance of the Team.
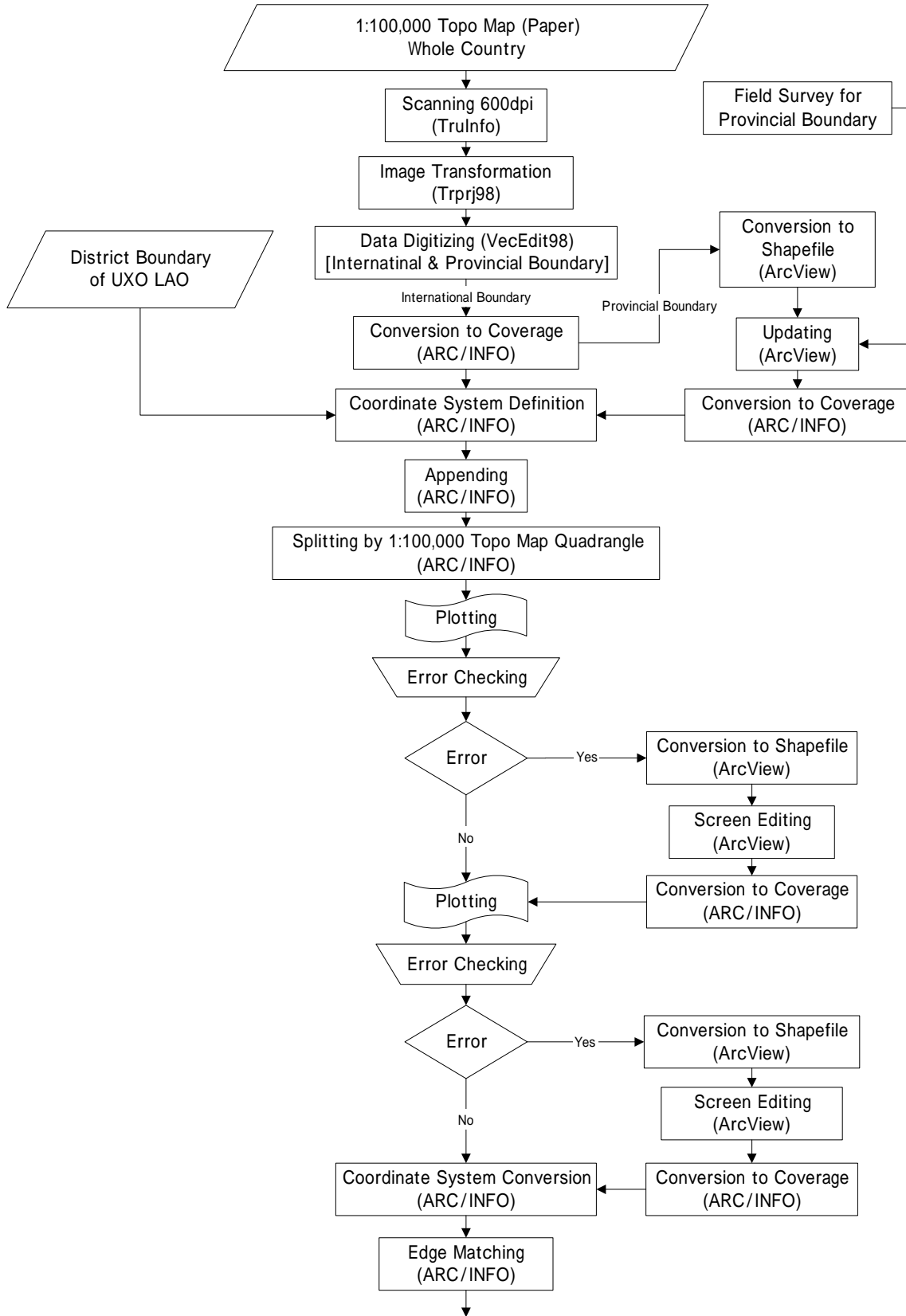
Many of the administrative boundaries of Lao, including international boundaries, are not fixed at present. Therefore, the administrative boundary data stored in the Mekong GIS Database is partially tentative. Since the technique for amendment or revision of administrative boundaries has been transferred to the counterparts, the data could be updated by NGD when necessary in the future.
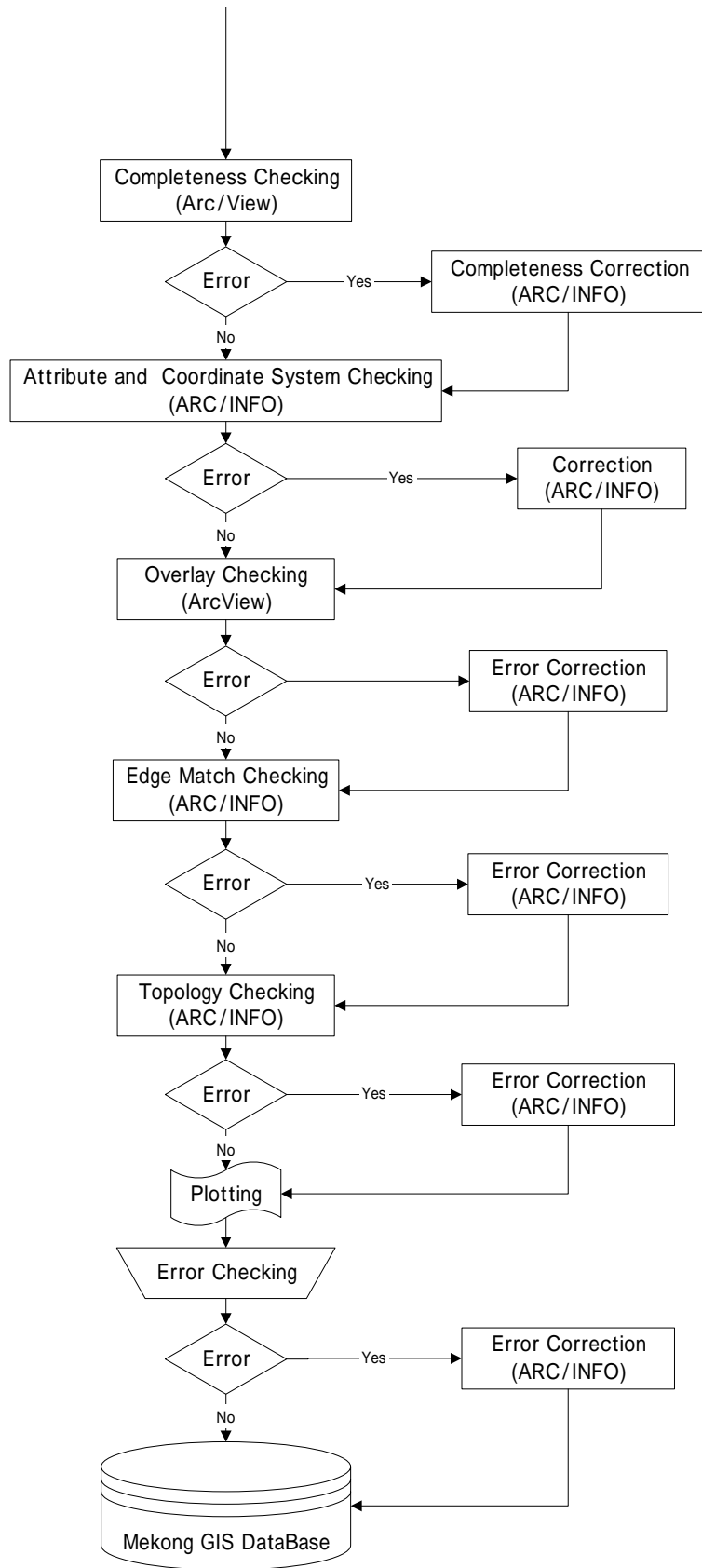
8.2.1 International Boundary and Provincial Boundary

The administrative boundaries given in the 1:100,000 topographic maps are international boundaries and provincial boundaries. There are another printed maps at a scale of 1:1,500,000 that provide the latest provincial boundaries.

Generating of administrative boundary data is an important work for the NGD counterparts, because it provides them with the opportunity to receive basic training in essential processes such as digitizing, data conversion and editing. Therefore, before starting the actual work, the Team prepared a training stage in the first year.

After training, the NGD counterparts started actual work with scanning 175 sheets of the 1:100,000 topographic maps (paper) for the whole country in the second year. They carried out field survey in a few places for updating the location of provincial boundaries. The process is shown in the flowchart on the next page.
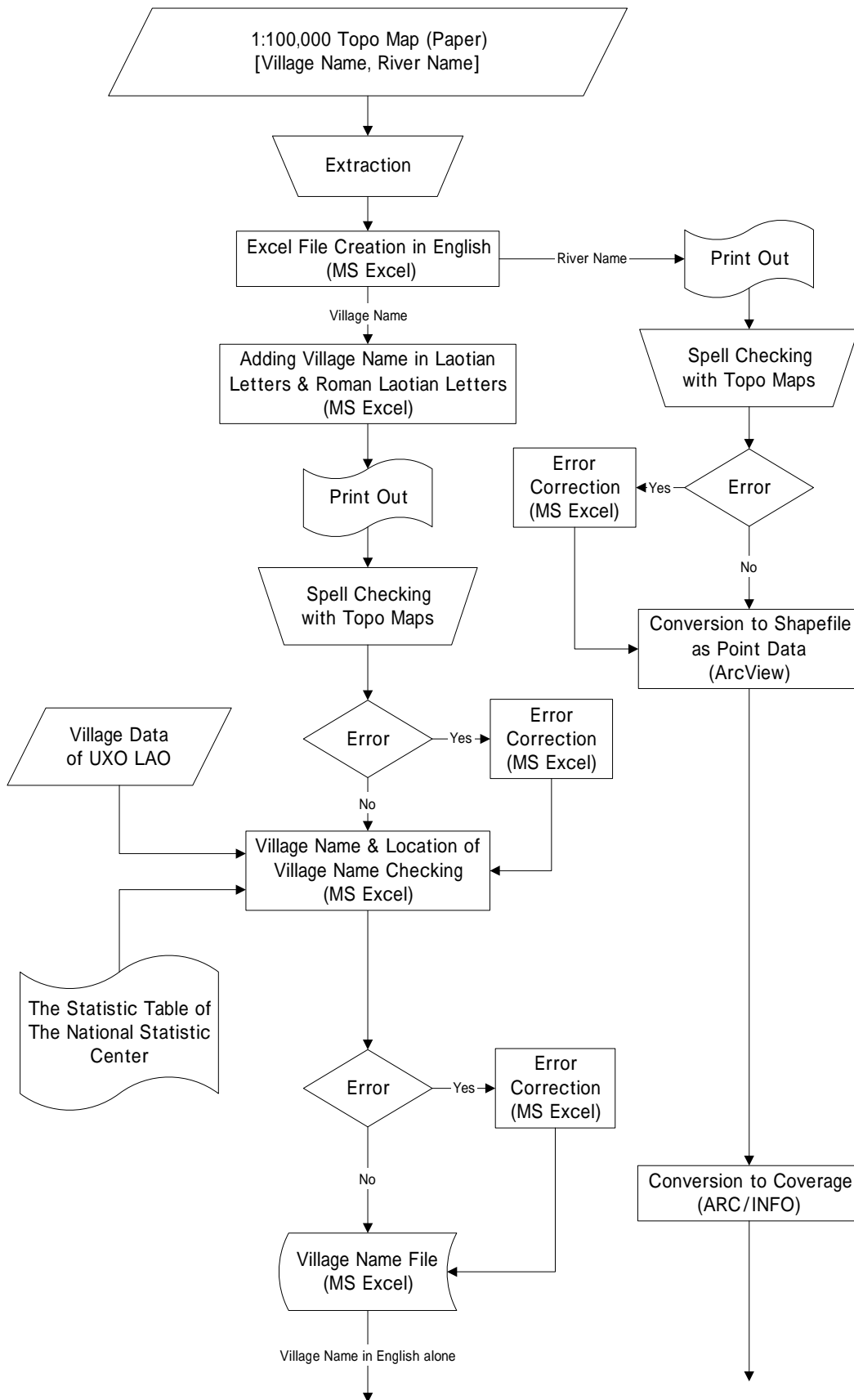
```
                    ┌─────────────────────────────────┐
                   ╱  1:100,000 Topo Map (Paper)       ╱
                  ╱   Whole Country                    ╱
                 └─────────────────────────────────┘
                              │
                              ▼
                   ┌──────────────────────┐        ┌──────────────────────┐
                   │  Scanning 600dpi     │        │  Field Survey for    │
                   │  (TruInfo)           │        │  Provincial Boundary │
                   └──────────────────────┘        └──────────────────────┘
                              │
                              ▼
                   ┌──────────────────────┐
                   │  Image Transformation│
                   │  (Trprj98)           │
                   └──────────────────────┘
                              │
                              ▼
  ┌──────────────────┐   ┌──────────────────────────────────┐   ┌──────────────────┐
 ╱ District Boundary ╱   │  Data Digitizing (VecEdit98)     │   │  Conversion to   │
╱  of UXO LAO       ╱    │  [Internatinal & Provincial      │   │  Shapefile       │
└──────────────────┘     │  Boundary]                       │   │  (ArcView)       │
                         └──────────────────────────────────┘   └──────────────────┘
                    International Boundary │  Provincial Boundary         │
                              ▼                                           ▼
                   ┌──────────────────────┐                    ┌──────────────────┐
                   │  Conversion to       │                    │  Updating        │
                   │  Coverage (ARC/INFO) │                    │  (ArcView)       │
                   └──────────────────────┘                    └──────────────────┘
                              │                                           │
                              ▼                                           ▼
                   ┌──────────────────────┐                    ┌──────────────────┐
                   │  Coordinate System   │◄───────────────────│  Conversion to   │
                   │  Definition (ARC/INFO)│                   │  Coverage(ARC/INFO)│
                   └──────────────────────┘                    └──────────────────┘
                              │
                              ▼
                   ┌──────────────────────┐
                   │  Appending           │
                   │  (ARC/INFO)          │
                   └──────────────────────┘
                              │
                              ▼
               ┌──────────────────────────────────────┐
               │  Splitting by 1:100,000 Topo Map     │
               │  Quadrangle (ARC/INFO)               │
               └──────────────────────────────────────┘
                              │
                              ▼
                   ┌──────────────────────┐
                   │  Plotting            │
                   └──────────────────────┘
                              │
                              ▼
                   ┌──────────────────────┐
                   │  Error Checking      │
                   └──────────────────────┘
                              │
                              ▼
                       ◇ Error ◇ ──Yes──►  ┌──────────────────┐
                              │             │  Conversion to   │
                              │             │  Shapefile       │
                              │             │  (ArcView)       │
                              │             └──────────────────┘
                              │                      │
                              │                      ▼
                              │             ┌──────────────────┐
                              │             │  Screen Editing  │
                              │             │  (ArcView)       │
                              No            └──────────────────┘
                              │                      │
                              │                      ▼
                              │             ┌──────────────────┐
                              ▼             │  Conversion to   │
                   ┌──────────────────────┐│  Coverage(ARC/INFO)│
                   │  Plotting            │◄└──────────────────┘
                   └──────────────────────┘
                              │
                              ▼
                   ┌──────────────────────┐
                   │  Error Checking      │
                   └──────────────────────┘
                              │
                              ▼
                       ◇ Error ◇ ──Yes──►  ┌──────────────────┐
                              │             │  Conversion to   │
                              │             │  Shapefile       │
                              │             │  (ArcView)       │
                              │             └──────────────────┘
                              │                      │
                              │                      ▼
                              │             ┌──────────────────┐
                              │             │  Screen Editing  │
                              No            │  (ArcView)       │
                              │             └──────────────────┘
                              │                      │
                              │                      ▼
                              ▼             ┌──────────────────┐
               ┌──────────────────────────┐│  Conversion to   │
               │  Coordinate System       │◄│  Coverage(ARC/INFO)│
               │  Conversion (ARC/INFO)   │ └──────────────────┘
               └──────────────────────────┘
                              │
                              ▼
                   ┌──────────────────────┐
                   │  Edge Matching       │
                   │  (ARC/INFO)          │
                   └──────────────────────┘
                              │
                              ▼
```

```
                          │
                          ▼
              ┌───────────────────────┐
              │ Completeness Checking  │
              │      (Arc/View)        │
              └───────────────────────┘
                          │
                          ▼
                      ◇ Error ◇ ──Yes──→ ┌───────────────────────┐
                          │              │ Completeness Correction│
                          No             │      (ARC/INFO)        │
                          ▼              └───────────────────────┘
     ┌──────────────────────────────────────┐        │
     │ Attribute and Coordinate System Checking│←─────┘
     │            (ARC/INFO)                  │
     └──────────────────────────────────────┘
                          │
                          ▼
                      ◇ Error ◇ ──Yes──→ ┌───────────────┐
                          │              │  Correction    │
                          No             │  (ARC/INFO)    │
                          ▼              └───────────────┘
              ┌───────────────────────┐          │
              │   Overlay Checking     │←─────────┘
              │      (ArcView)         │
              └───────────────────────┘
                          │
                          ▼
                      ◇ Error ◇ ────────→ ┌───────────────┐
                          │               │ Error Correction│
                          No              │  (ARC/INFO)    │
                          ▼               └───────────────┘
              ┌───────────────────────┐          │
              │  Edge Match Checking   │←─────────┘
              │      (ARC/INFO)        │
              └───────────────────────┘
                          │
                          ▼
                      ◇ Error ◇ ──Yes──→ ┌───────────────┐
                          │               │ Error Correction│
                          No              │  (ARC/INFO)    │
                          ▼               └───────────────┘
              ┌───────────────────────┐          │
              │  Topology Checking     │←─────────┘
              │      (ARC/INFO)        │
              └───────────────────────┘
                          │
                          ▼
                      ◇ Error ◇ ──Yes──→ ┌───────────────┐
                          │               │ Error Correction│
                          No              │  (ARC/INFO)    │
                          ▼               └───────────────┘
                      ┌─────────┐                │
                      │ Plotting│←───────────────┘
                      └─────────┘
                          │
                          ▼
                  ╱ Error Checking ╲
                  ╲───────────────╱
                          │
                          ▼
                      ◇ Error ◇ ──Yes──→ ┌───────────────┐
                          │               │ Error Correction│
                          No              │  (ARC/INFO)    │
                          ▼               └───────────────┘
                   ╭──────────────╮              │
                   │ Mekong GIS    │←─────────────┘
                   │  DataBase     │
                   ╰──────────────╯
```

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8.2.2 District Boundary

There are 142 districts in Laos. The boundaries are not indicated in the 1:100,000 topographic maps and there is no record in NGD. But it was found that UXO Lao had approximated district boundary data for the whole country. Therefore, the Team obtained it from UXO Lao. UXO Lao had conducted field surveys for the location of villages and their names. Its data includes recent positions of villages with attributes of village name and district code. Using the data, UXO Lao had approximated the district boundaries by drawing lines between the villages of different districts and digitized them. In spite of approximated data, the Team added it to the Mekong GIS Database because it was the only data regarding district boundary in Laos.

8.3   Place Name

The NGD counterparts extracted names of rivers and villages in the whole country from the 1:100,000 topographic maps and made a detailed list with each code number by using Excel software. The list was printed out for proofreading and corrections.

Then, the counterparts checked the villages' names against those from the UXO Lao database, which is more recent. The entire list, which was written in Roman letters, was checked and corrected referring to the statistic tables published by the National Statistic Centre. The counterparts also checked the names of rivers and added them to digitized river data (line) as attribute.

Last, this identifying information was stored in the GIS database. The process is shown in the flowchart on the next page.

```
                      ┌─────────────────────────────────┐
                     /  1:100,000 Topo Map (Paper)        /
                    /   [Village Name, River Name]        /
                   └─────────────────────────────────┘
                                    │
                                    ▼
                         ╱───────────────────╲
                         ╲     Extraction      ╱
                          ╲─────────────────╱
                                    │
                                    ▼
                  ┌─────────────────────────┐                                    ┌───────────┐
                  │  Excel File Creation      │────River Name──────────▶          │ Print Out │
                  │  in English (MS Excel)    │                                    └───────────┘
                  └─────────────────────────┘                                          │
                                    │                                                  ▼
                              Village Name                              ╱─────────────────────╲
                                    │                                   ╲   Spell Checking      ╱
                                    ▼                                    ╲  with Topo Maps      ╱
                  ┌─────────────────────────┐                            ╲──────────────────╱
                  │  Adding Village Name in   │                                    │
                  │  Laotian Letters & Roman  │                                    ▼
                  │  Laotian Letters (MS Excel)│          ┌──────────┐       ◇───────────◇
                  └─────────────────────────┘            │  Error     │◀─Yes─◇   Error     ◇
                                    │                     │ Correction │      ◇───────────◇
                                    ▼                     │ (MS Excel) │            │
                             ┌───────────┐                └──────────┘            No
                             │ Print Out │                      │                   │
                             └───────────┘                      │                   ▼
                                    │                           │       ┌─────────────────────┐
                                    ▼                           └──────▶│ Conversion to Shapefile│
                         ╱───────────────────╲                          │  as Point Data (ArcView)│
                         ╲   Spell Checking    ╱                         └─────────────────────┘
                          ╲  with Topo Maps    ╱                                    │
                           ╲─────────────────╱                                     │
                                    │                                               │
  ┌──────────────┐                  ▼                  ┌──────────┐                 │
 /  Village Data  /            ◇──────────◇            │  Error     │               │
/   of UXO LAO    /   ───┐     ◇   Error    ◇──Yes──▶  │ Correction │               │
└──────────────┘        │     ◇──────────◇            │ (MS Excel) │               │
                        │           │                  └──────────┘               │
                        │          No                        │                     │
                        ▼           ▼                         ▼                     │
            ┌──────────────────────────────┐                                       │
            │  Village Name & Location of    │◀──────────────────────────────      │
  ┌─────┐   │  Village Name Checking         │                                      │
  │     ├──▶│  (MS Excel)                    │                                      │
 The Statistic└──────────────────────────────┘                                     │
 Table of The           │                                                          │
 National Statistic     ▼                                                           │
 Center          ◇──────────◇            ┌──────────┐                              │
                 ◇   Error    ◇──Yes──▶  │  Error     │                             │
                 ◇──────────◇            │ Correction │                             │
                       │                  │ (MS Excel) │                             │
                      No                  └──────────┘                             ▼
                       ▼                        │           ┌─────────────────────┐
            ┌──────────────────┐                │           │ Conversion to Coverage│
            │  Village Name File │◀──────────────┘           │    (ARC/INFO)         │
            │   (MS Excel)       │                           └─────────────────────┘
            └──────────────────┘                                       │
                       │                                               │
            Village Name in English alone                              ▼
                       ▼
```

```
        │                                              │
        ▼                                              ▼
┌──────────────────────┐          ┌──────────────────────────────┐
│ Conversion to Shapefile │         │  Coordinate System Definition  │
│      (ArcView)          │         │         (ARC/INFO)             │
└──────────────────────┘          └──────────────────────────────┘
        │                                              │
        ▼                                              ▼
┌──────────────────────┐          ┌──────────────────────────────┐
│ Conversion to Coverage │         │ Adding the River Name to Digitized │
│      (ARC/INFO)         │         │   River (Line) Data as Attribute   │
└──────────────────────┘          │            (ArcView)             │
        │                          └──────────────────────────────┘
        ▼                                              │
┌──────────────────────┐                               │
│ Coordinate System Definition │                       │
│        (ARC/INFO)           │                        │
└──────────────────────┘                               │
        │                                              │
        ▼                                              │
┌──────────────────────┐                               │
│ Coordinate System Conversion │                       │
│         (ARC/INFO)          │                        │
└──────────────────────┘                               │
        │                                              │
        ▼                                              │
┌────────────────────────────────────┐                │
│ Splitting by 1:100,000 Topo Map Quadrangle │          │
│              (ARC/INFO)               │               │
└────────────────────────────────────┘                │
        │                                              │
        ▼                                              │
    ╭─────────────────────╮ ◄─────────────────────────┘
    │  Mekong GIS DataBase  │
    ╰─────────────────────╯
```

8.4   Contour

Aiming to generate a Digital Elevation Model (DEM), the Team and the NGD counterparts prepared contour data for the whole Study area.

The initial plan of the Study was to generate contour data from the existing 1:100,000 topographic maps because these maps could provide more recent contour data than AMS's 1:50,000 topographic maps. Therefore, on an experimental basis, the Team guided the counterparts in scanning the contours on a sampled sheet of 1:100,000 topographic maps. Afterward, the counterparts converted the raster data to vector data using R2V software. They improved the contours and gave an elevation value to each contour on the screen using VecEdit software.

Through studying the USSR's report, it was found, however, that the contour in the 1:100,000 topographic map was just a copy of the AMS's 1:50,000 topographic maps.

It was also found that there had been an existing contour data and DEM prepared by the Mekong River Commission (MRC). MRC implemented the "Watershed Classification Project"

(WSCP) with the assistance of the Swiss Government in 1994. The executing agency was the Forest Division of the Agriculture Department of MRC, and the counterpart agency in Laos is the National Office of Forest Inventory and Planning (NOFIP). In order to grasp the status of the Mekong River Basin, MRC established a Digital Elevation Model (DEM) by digitizing the contour of 1:50,000 topographic maps made by AMS in the 1960s.

Therefore, from a viewpoint of good use of existing data, the Team investigated the WSCP report. According to the report, generation of the contour data and DEM took the following steps.

(1)   Contours of the AMS's 1:50,000 topographic maps were traced on overlaying transparent sheets at the interval of 10 meters for flat areas, 20 meters for gentle slope areas and 40-20-40 meters for steep slope areas.

(2)   The sheets were scanned to generate raster data.

(3)   The raster data was geo-referenced by the geographic coordinates. The contours were automatically converted to vector format by a raster to vector conversion software. An elevation identity was given to each contour.

(4)   The errors caused by the automatic conversion software were manually corrected.

(5)   Based on the contour data, the DEM was generated by ARC/INFO GRID module. The elevation of each grid cell was calculated by interpolation. River and the elevation point data were also used.

(6)   DEM of 50-meter grid was finalized.

The Team inspected the WSCP contour data in details and found that the data has some errors. Based upon the agreement with the Steering Committee, the Team updated the WSCP contour data in the third year. The process is shown in the flowchart on the next page.

```
  ┌─────────────────┐                          ┌─────────────────┐
 ╱  MRC/WSCP       ╱                          ╱  UXO LAO        ╱
╱   Vector        ╱                          ╱   Raster        ╱
╲   Contour Data ╲                          ╲   Contour Data ╲
 ╲───────────────╲                           ╲───────────────╲
          │                                           │
          │                                           ▼
          │                                 ┌──────────────────────────────┐
          │                                 │ Conversion from Raster to Vector │
          │                                 │            (R2V)              │
          │                                 └──────────────────────────────┘
          ▼                                           │
┌──────────────────────────┐                          ▼
│ Verification of the Data │                 ┌──────────────────────────┐
│   (ARC/INFO, ArcView)    │                 │  Updating and Editing    │
└──────────────────────────┘                 │       (ArcView)          │
          │                                  └──────────────────────────┘
          │          ┌──────────────────────────────┐          │
          └─────────▶│   Conversion to Coverage     │◀─────────┘
                     │        (ARC/INFO)            │
                     └──────────────────────────────┘
                                 │
                                 ▼
                     ┌──────────────────────────────┐
                     │ Coordinate System Conversion │
                     │  and Attribute Redefinition  │
                     │        (ARC/INFO)            │
                     └──────────────────────────────┘
                                 │
                                 ▼
                          ┌──────────────┐
                          │  Appending   │
                          │  (ARC/INFO)  │
                          └──────────────┘
                                 │
                                 ▼
                 ┌──────────────────────────────────────┐
                 │ Splitting by 1:100,000 Topo Map Quadrangle │
                 │              (ARC/INFO)                │
                 └──────────────────────────────────────┘
                                 │
                                 ▼
                       ┌──────────────────────┐
                       │   Rubber Sheeting     │
                       │     (ARC/INFO)        │
                       └──────────────────────┘
                                 │
                                 ▼
                          ╭──────────────╮
                          │ Mekong GIS DataBase │
                          ╰──────────────╯
```
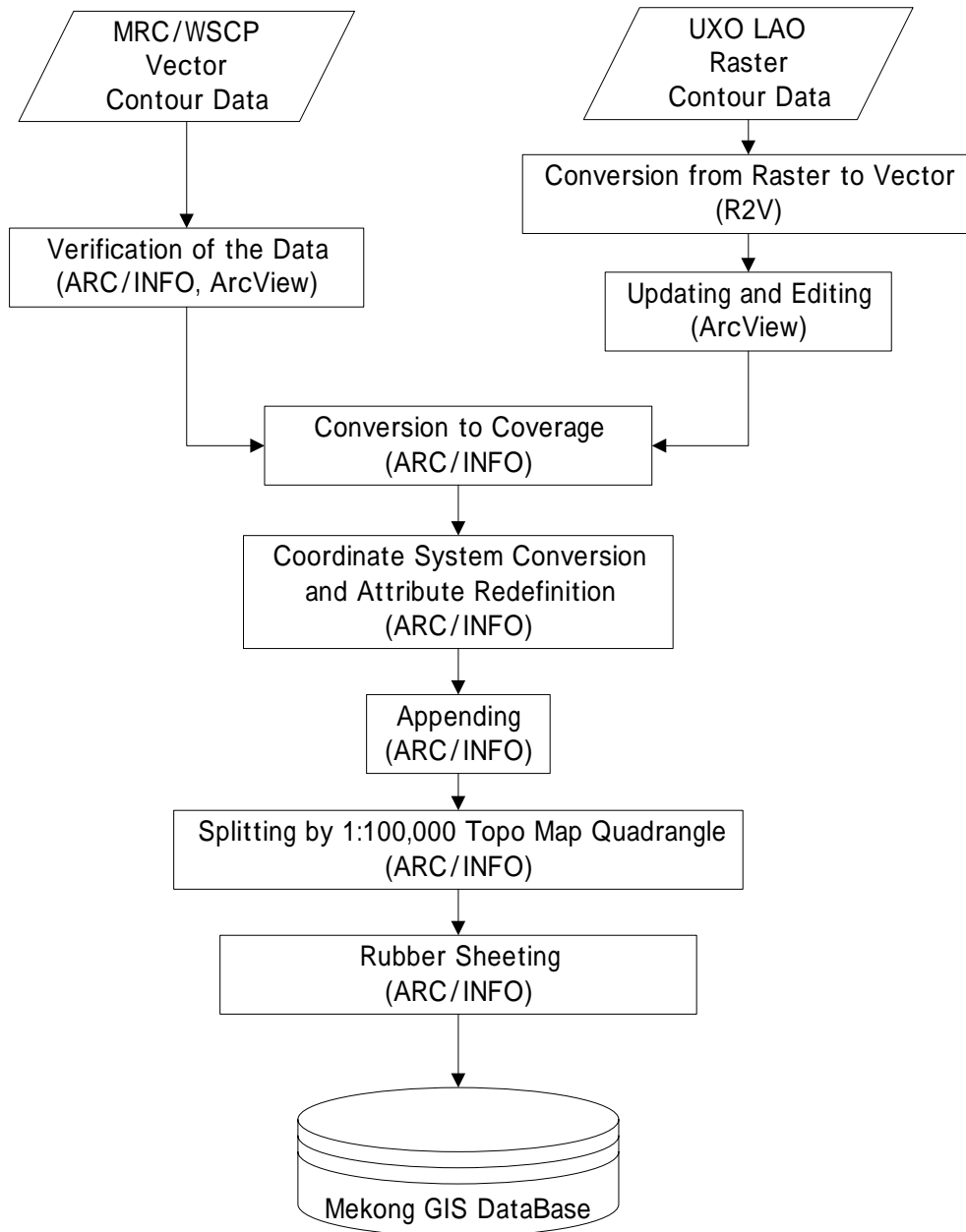
There should be 367 sheets of 1:50,000 topographic map for covering the Study area. But, it was found that MRC did not complete 19 sheets that overlapped international borders. Therefore, available sheets totaled to 348.

Through the above-mentioned inspection, it was found that among the 348 completed sheets 21 sheets were made from lower quality maps instead of the 1:50,000 maps. In accordance with the agreement with the Steering Committee, these sheets were updated. With the cooperation of

UXO Lao, the Team obtained scanned image data for 16 map sheets and updated the MRC contours based on the scanned image data by screen digitizing.

According to the WSCP report, the projection definition of the contour line data was:

Projection	UTM
Zone	48
Unit	meter
Datum	Indian 54
Spheroid	Everest

All maps sheets should be defined by the above projection parameters. Through the inspection, however, it was found that the projection of 30 sheets had not been defined. Therefore, the Team carried out projection conversion, the first work being the definition of projections for these sheets by UTM, zone 48, Datum of Indian 54 and spheroid of Everest. The second is converting all the contour data into the 1:100,000 topographic map projection as:

Projection	Geographic
Unit	DD
Datum	Vientiane 1982
Spheroid	Krasovsky

The Arc Attribute Table (AAT) for all 348 sheets must have the same format. If not, the sheets cannot be appended together. Through the inspection, however, it was found that there were 8 types of attribute definitions in the AAT files. They had to be unified into the same table definition.

According to the GIS database design, the final GIS database should be compiled by quadrangle of the 1:100.000 topographic maps. Therefore, the Team converted the contour data of the 1:50.000 map into each quadrangle of the 1:100,000 map through data appending and splitting. The relation between the quadrangles of the 1:50,000 map and 1:100,000 map is shown in Figure 15 on the next page.
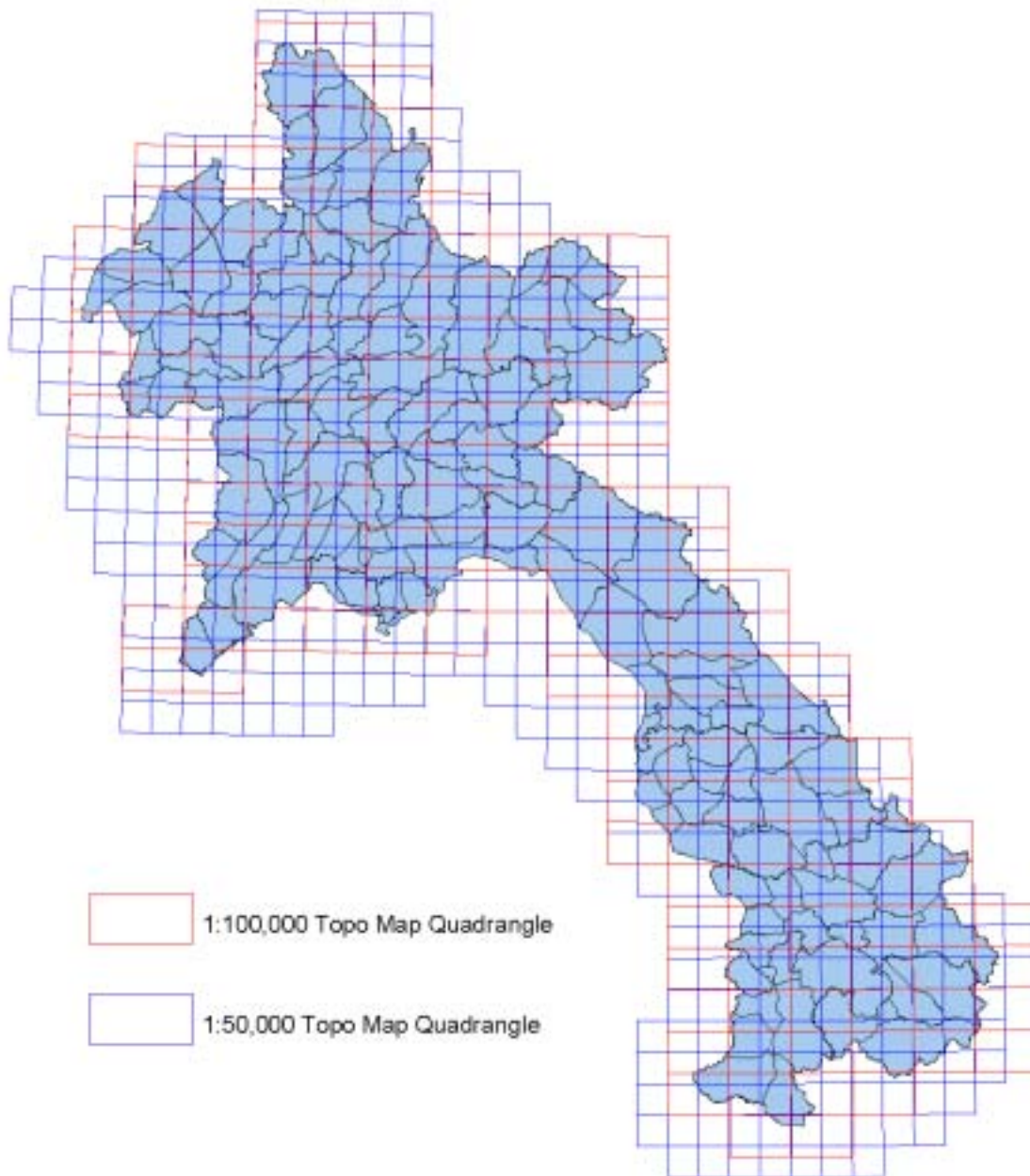
Figure 15: 1:100,000 Map Quadrangle and 1:50,000 Map Quadrangle

The updated WSCP contour data needed to be in conformity with the river data and elevation point data generated from the 1:100,000 topographic maps. But, projection conversion from the AMS's 1:50,000 map to the 1:100,000 map revealed that some small discrepancies occurred between them. In order to generate contour data of higher quality, the Team used the rubber sheeting tools in Arc/Info. The process was as follows:

(1)   Check plots were prepared by overlaying the scanned 1:100,000 topographic maps and the updated WSCP contours for each map sheet.

(2)   The discrepancy between both data was calculated for each map sheet.

(3)   Based on the discrepancy, a link file was generated for each map sheet and the contour data was adjusted to match exactly to the 1:100,000 contour data.

Technical Remarks

Most of the processes are automatic, but carefulness is vital particularly in identifying contours and inputting their attributes.

8.5   Digital Elevation Model (DEM)

In the fourth year, a new DEM was generated for the whole Study area from the above-mentioned contour data, elevation point data and administrative boundary data, which had been prepared for every quadrangle of 1:100,000 topographic map as described in the previous Sections. The process is shown in the flowchart below.
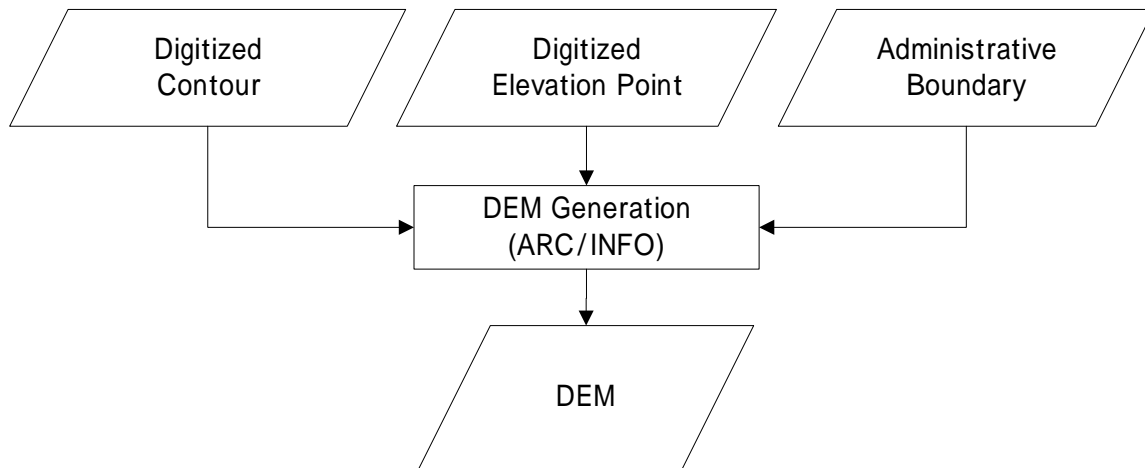
After completion, the DEM was stored in the GIS database. Also, as described in the Chapter 6, the DEM was applied for generating shaded relief images as well.
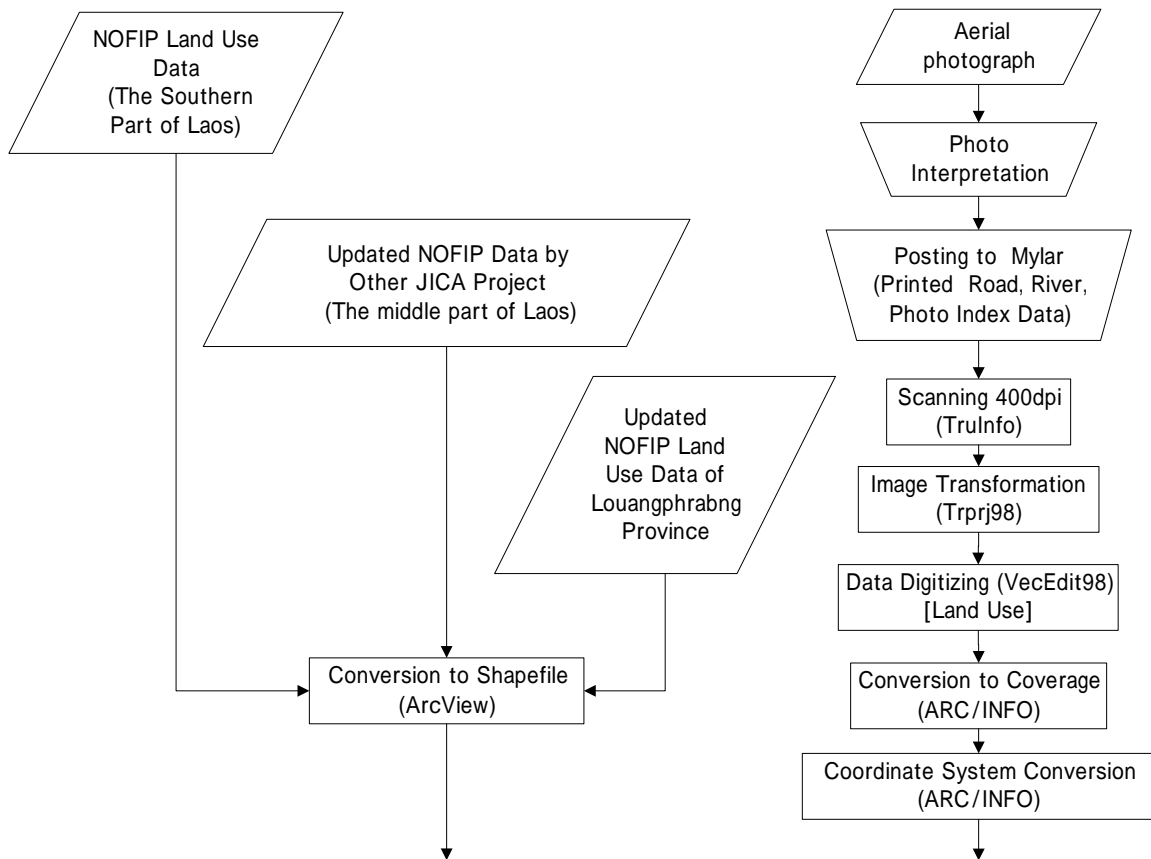
Technical Remarks

DEM generating was the first experience for the counterparts. But, the operation was rather simple due to highly automatic processes.
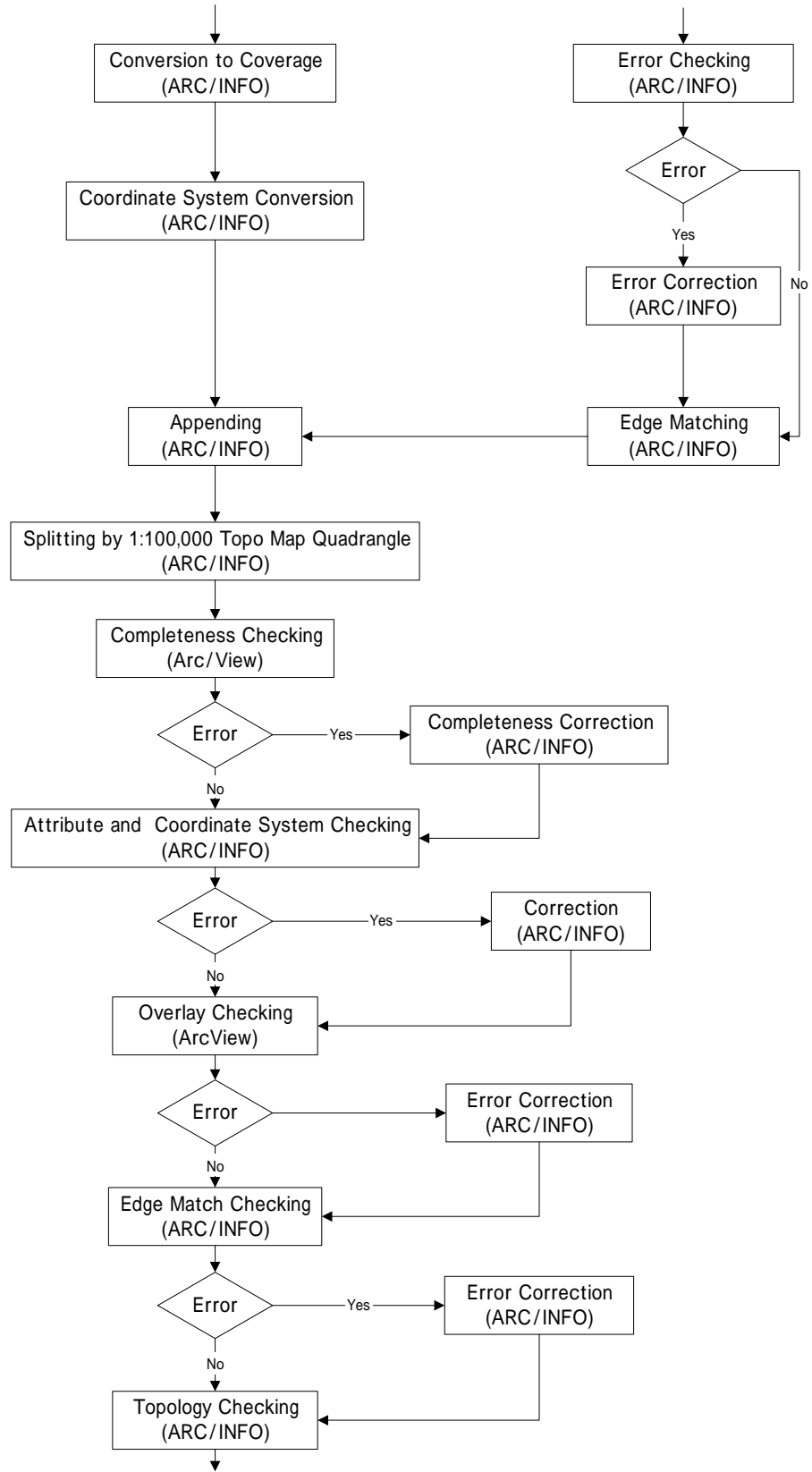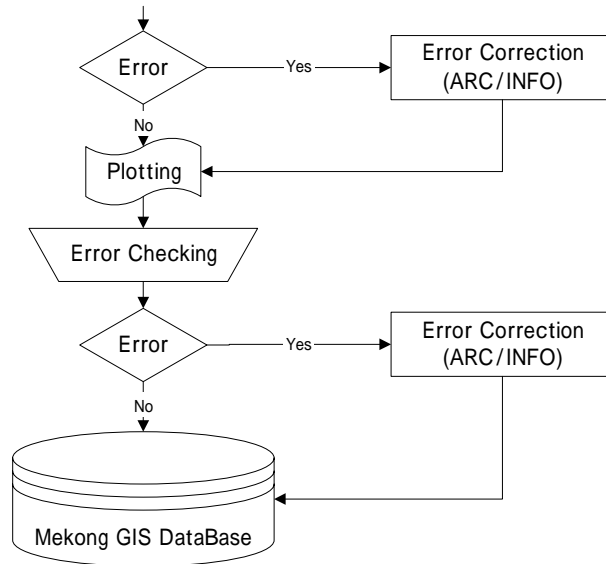
8.6 Land Use

As mentioned in Chapter 4, the NGD counterparts classified land use and forest cover by aerial photo interpretation for the northern region (excluding Louangphabang Province) for updating the NOFIP data prepared in the 1980s.

After photo interpretation, the counterparts conducted data digitizing and updating under the guidance of the Team. First, road data, river data and photo index data were printed on polyester film sheets at a scale of 1:50,000. Next, interpreted land use and forest cover marked on the photos were manually transcribed onto the polyester film sheets. Then, the sheets were scanned. After image rectification, the land use and forest cover were digitized. The datum of the NOFIP data is Indian 60, projection is Transverse and spheroid is Krasovsky. All of the data were integrated by the Mekong GIS coordinate system and split into each quadrangle of 1:100,000 topographic map and stored in the database.

The process from photo interpretation to data updating is shown in the flowchart below.

```
┌──────────────────────┐                    ┌──────────────────────┐
│ Conversion to Coverage│                    │   Error Checking      │
│     (ARC/INFO)        │                    │    (ARC/INFO)         │
└──────────────────────┘                    └──────────────────────┘
            │                                           │
            ▼                                           ▼
┌──────────────────────┐                          ◇ Error ◇ ──── No
│ Coordinate System     │                            │              │
│   Conversion          │                           Yes             │
│    (ARC/INFO)         │                            │              │
└──────────────────────┘                            ▼              │
            │                            ┌──────────────────────┐   │
            │                            │  Error Correction     │   │
            │                            │    (ARC/INFO)         │   │
            │                            └──────────────────────┘   │
            ▼                                        │              │
┌──────────────────┐         ┌──────────────────────┐              │
│   Appending      │◄────────│   Edge Matching       │◄─────────────┘
│   (ARC/INFO)     │         │    (ARC/INFO)         │
└──────────────────┘         └──────────────────────┘
            │
            ▼
┌────────────────────────────────────┐
│ Splitting by 1:100,000 Topo Map     │
│     Quadrangle (ARC/INFO)           │
└────────────────────────────────────┘
            │
            ▼
┌──────────────────────┐
│ Completeness Checking │
│     (Arc/View)        │
└──────────────────────┘
            │
            ▼
        ◇ Error ◇ ──── Yes ──►  ┌──────────────────────┐
            │                    │ Completeness Correction│
           No                    │     (ARC/INFO)        │
            │                    └──────────────────────┘
            ▼                                │
┌────────────────────────────────────┐      │
│ Attribute and Coordinate System     │◄─────┘
│   Checking (ARC/INFO)               │
└────────────────────────────────────┘
            │
            ▼
        ◇ Error ◇ ──── Yes ──►  ┌──────────────────────┐
            │                    │    Correction         │
           No                    │    (ARC/INFO)         │
            │                    └──────────────────────┘
            ▼                                │
┌──────────────────────┐                     │
│  Overlay Checking     │◄────────────────────┘
│    (ArcView)          │
└──────────────────────┘
            │
            ▼
        ◇ Error ◇ ────────────►  ┌──────────────────────┐
            │                     │  Error Correction     │
           No                     │    (ARC/INFO)         │
            │                     └──────────────────────┘
            ▼                                 │
┌──────────────────────┐                      │
│ Edge Match Checking   │◄─────────────────────┘
│    (ARC/INFO)         │
└──────────────────────┘
            │
            ▼
        ◇ Error ◇ ──── Yes ──►  ┌──────────────────────┐
            │                    │  Error Correction     │
           No                    │    (ARC/INFO)         │
            │                    └──────────────────────┘
            ▼                                │
┌──────────────────────┐                     │
│  Topology Checking    │◄────────────────────┘
│    (ARC/INFO)         │
└──────────────────────┘
            │
            ▼
```

The data updated in this Study did not match with the updated data of Louangphabang Province and the middle three provinces. This was caused by the difference of method and data sources. The former is by interpretation of 1:50,000 monochromatic aerial photos, while the latter is by remote sensing of 1:50,000 SPOT-XS (multi-band) images. For the southern four provinces, the NOFIP land use data was not updated. Therefore, the land use and forest cover data, as a whole do not have high uniformity in surveying date and classification.

Technical Remarks

Most of the processes are automatic, but carefulness was vital in data digitizing, edge matching and error checking and correction.