

# FROM SATELLITE IMAGE TO MAP - A NEW GUIDE MAP FOR FINNISH RURAL AREAS

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## Abstract

In the research project called "A Guide map for Finnish Rural Areas" we have developed an entirely new map production process as well as the map output. The goal was to develop a map for different distribution purposes, for emergency vehicle use as well as for general transportation. The source information was gathered as follows: land use information was interpreted from Landsat satellite images, height zones were generated from a DEM, roads and names were digitized manually on the screen, residential information was retrieved from the nationwide building register. In the production process, both vector and raster techniques were used. The final map output was designed to match the quality and type of source information. The Intergraph MGE-system (Map Publishing application) on Unix-workstation was utilized in the project.

KEY WORDS: Satellite image, DEM, Map design, Cartographic theory

## 1. INTRODUCTION

In Finland, the new addressing system for rural areas obliges communes to update their road addresses and address-maps. Iisalmi is a town of about 24 000 inhabitants in the central part of Finland. A new address-map for rural areas came into being in Iisalmi in spring 1991. Already before that year, some ideas had appeared about more versatile use of the guide map. Emergency services, post, other distribution activities, tourism, and general transportation need a proper map when navigating in the countryside.

In Iisalmi a digital map database with Intergraph's hardware and software has been under construction for many years. This project has been quite successful and it has given some good practical experience to the staff.

The Finnish National Board of Survey produces thematic map data from satellite images. The existence of this data and its usefulness for digital map production contributed to starting the project described in this paper. 'The Guide Map for Rural Areas' is a totally new map type. The aim of this six-month project was to define the information contents of the map as well as the layout and production process for the new map type.

The following partners were involved in the project: Geodata Ltd. as an expert in raster data manipulation, the town of Iisalmi, the National Board of Survey (NBS) as the producer of digital data, and Helsinki University of Technology (HUT) as the performer of the research. A pilot project producing the guide map for Iisalmi was included in this research project.

This article gives an overview of the data sources used in the project, the production process of the map, and the design of the map.

## 2. DATA CAPTURE

### 2.1 Land use information

NBS produces thematic maps interpreted digitally from Landsat and Spot satellite images. Landsat 4 and 5 Thematic Mappers are the most commonly used data sources. The resolution of Landsat images is 30 meters. After rectification, resolution is improved to 25 meters. There are seven channels available for different wave lengths of light.

Satellite data is manipulated by a segmentation process. Segmentation generates regions from pixels that have homogeneous densities within a certain tolerance. Segmentation is performed digitally using the Australian Disimp software. Mode filtering method is used in internal examination of the segments.

Different channels provide different information. One channel is used to interpret waters. Reliability for water interpretation is high, 95-98%. Swamps are difficult to interpret, so a swamp mask taken from a Topographic Map 1:50 000 is used as additional information. Field is the most difficult theme to separate from images. Reliability for field areas is about 50%. A field mask of the Topographic map 1:50 000 is therefore used in interpretation. Percentage rates for reliability are taken from tests made in NBS. There are altogether 55 different classes in land use and forest interpretation. Classes can be merged with each other to achieve the ideal result for cartographic presentation. There are the following classes in the original interpretation: water, field, open area, clear felling, sapling stand, open swamp, pine swamp, spruce swamp, pine stand, spruce copse, broadleaf forest and mixed stand. Forests are divided into subclasses by their timber volume.

Interpreted data is delivered in digital raster files or as photographic material in the required coordinate system (National Board of Survey, 1991).

Data was input into the Intergraph's system as a raw raster file.

It was warped to a real coordinate system using the software module called I/RAS C. In the final outputs each land use class is displayed with a certain color, which is read from a color table. Colors were designed by editing the color table.

## 2.2 Digital elevation model

NBS produces digital elevation models based on digitized contour lines of the base map. DEM has a grid structure and the size of one pixel is 50 x 50 meters. Software that generates the model is tailored in NBS. Hill shadings for map presentations can also be computed from the DEM.

Height information in the Guide Map for Rural Areas is represented as elevation zones. No hill shadings were used. Zones were generated as a combination of the satellite image and the elevation model. Intergraph's MapPublisher software was used to run the logical operations between elevation model and satellite image.

## 2.3 Roads

### Road Database

NBS is establishing a nationwide Road Database. The following linear objects are described in the database: middle line of the road, bridge, ferry connection and crossing. Other geometric objects in the database are parallel lanes, railway junction, light traffic crossing, barrier and dead-end road junction. Geometric objects have the following attributes: the name and the number of the road, surfacing of the road, the road maintainer, trafficability and one-way or two-way information (Marttinen, 1991). Road classification is based on the Basic Map 1:10 000/1:20 000. The database is by now in the design stage, complete digital information will be achieved sometime in the future.

### Digitizing

In our pilot project, roads were digitized in the following stages: first, the Topographic Map 1:50 000 was scanned. Second, the so-called "red roads" were vectorized automatically using Intergraph's I/VEC software. "Red roads" include the main and local roads. Third, we scanned the Basic Maps within the test area. Fourth, all the remaining trafficable roads were digitized on the screen. At the same time, road names were stored and roads were classified. Here, the classification was based on the road map 1:200 000 (GT-map).

## 2.4 Residential information

There is a digital nationwide building register in Finland including coordinates, address, use, owner and some other details of every building. We transferred this register into Intergraph's graphics with an application program made in HUT. The real estate identifier was stored into the graphic element as an attribute.

## 2.5 Other sources

### Place-names

Place-names of the Finnish Aeronautical chart 1:500 000 and road map 1:200 000 (GT-map) are available in digital format. These place-names are too sparse for the guide map 1:50 000. Therefore we collected all names by digitizing on the screen. Text font and size were chosen by the type of the object.

### Municipal boundaries

The Finnish National Board of Survey has produced a digital file of municipal boundaries. This file was transferred into Intergraph's file format.

### Addresses

In the new addressing system in Finland, every house will have an address that is composed of the name of the road and a number that indicates distance from the starting point of the road. Numbers were generated by a routine of the MicroStation software plus an application program (Figure 1).

### Railroads & power lines

Railroads and power lines were digitized on the screen by utilizing the scanned Basic Map 1:10 000/1:20 000.

### Waterways

Rivers and creeks were digitized on the screen. Digitizing was based on the scanned water element of the Topographic Map 1:50 000.

### Coast-lines

Coast-lines were produced by an automatic vectorization process. The process was performed with Intergraph's I/VEC software. Satellite data was used as input data.

## 3. DESIGNING THE MAP COLORS, SYMBOLOLOGY, AND LAYOUT

### 3.1 Starting points for designing

An essential part of this research was to design a map presentation that matches the requirements of prospective map users as well as possible. The primary user of this guide map is a car driver. Therefore, the roads must be clearly presented on the map. In addition, objects which are in the close vicinity of roads are important. The map user must have some fixed points to help navigating. Railroads, power lines and waterways

crossing a road are easily perceivable objects. It is also important to distinguish roads of different classes from each other even when the map is read in bad light or very urgently.

The scale of this guide map was a given constraint, 1:50 000. The scale places certain restrictions on the map design. One problem is the density of the buildings. Texts and symbols must be presented as small as possible so that all the objects fit on the map.

The basic idea in the map design was to reflect the real atmosphere of the landscape in the graphical presentation. This means the visual connection between the general appearance of the map and general appearance of the terrain. Imhof (Imhof, 1982) says: 'Topographical maps of medium and small scale appear most naturalistic when their color design most closely approximates the colors seen from ground level at corresponding viewing distances'. Therefore, it was decided to be use green as the main color in our Guide Map.

### 3.2 Elevation zones

In the original land use interpretation there are 55 classes. After generalization there are three classes left in the guide map: waters, fields, and uncultivated areas. At a scale of 1:50 000, more than three classes would lead to a fragmented appearance. On the other hand, field as an open agricultural land area is the most important land use class for one who is travelling by car.

#### Color design

Imhof (Imhof, 1982) presents three different methods of utilizing area tinting in terrain and topographic cartography:

1. To represent different land use classes by color tints.
2. To express the elevation zones of the earth's surface by color tints.
3. To combine these two methods.

In our research, method 3 has been used. Land use and elevation information are combined to produce elevation zones.

For each of these three objectives, there are three differing possibilities or approaches for color representation (Imhof, 1982):

- A. "Stress on the closest imitation that can be made of natural colors."
- B. "Conventional symbolic colors can be used for the hypsometric layers as well as for bringing out other elements."
- C. "Attempts can be made to combine these two principles named above - naturalism and symbolism. Strictly speaking, most cartographic solutions are such combinations or compromises."

In our Guide Map for rural areas, method C is used. Yellow is

used for the fields and green for uncultivated areas.

The most difficult part of hypsometric tinting is always the selection of colors for the elevation layers. Many color scales based on different principles can be used in choosing elevation zone colors. We chose the principle 'the higher, the darker'. The aim in this principle is to keep the low-lying zones, which are thickly populated with built-up areas, lines of communication, etc., as light as possible. Because of the relatively low relief of Finnish landscape, 'the higher, the darker' method gives the most natural appearance for Finnish rural areas (Figure 1).

#### Heights of hypsometric steps

The number of suitable, relatively light, and easily distinguishable color tones is only six to ten. According to Imhof, there are six solutions to the problem of defining the elevation steps (Imhof, 1982):

1. Equidistant steps.
2. Two sequences of equally vertical interval steps in combination.
3. Steps of equal area.
4. Irregularly changing step heights.
5. Steps based on an arithmetical progression or additive steps.
6. Steps based on a geometric progression.

Imhof states that method 6, 'geometric progression', fits well both low-lying areas and high mountains. Anyway, method 1, 'equidistant steps', is used in the Guide Map for Rural Areas. This is because terrain in Finland is slightly hilly and quite homogeneous. There are population and built-up areas both in low and high areas.

### 3.3 Finishing the layout of the map

Intergraph's MGE Map Finisher (MGFN) is a software module that gives possibilities to finish the map presentation. Grids, legends, and indexes can be generated. MGFN also provides feature selection, resymbolization, and complexing. We used MGFN in creating reference grids of a 5 km square with index letters on the sides and numbers at the top and bottom. A text index in alphabetical order was generated showing the location of text within a reference grid. MGFN includes symbol libraries for map symbols. For example, church symbol, and north arrow are ready-made standard symbols from these libraries. When a database is used with graphics, area thematic classification can be made automatically.

#### 4. OUTPUT PROCESS

Intergraph's MGE Map Publisher (MAPPUB) software makes the color separation process for map data in raster format. The color separation process accepts only raster information, so vector data must be rasterized before the process. The number of raster files corresponds the number of map features. Every feature has its color definition as a RGB-value. MAPPUB reads the Run Length Encoded raster files, color definitions, printing priorities, and masks. From this input data, it outputs one color file for each printing color. These raster files can be plotted as color-separated, composited films by the film recorder.

#### 5. HARDWARE AND SOFTWARE SOLUTIONS

The town of Iisalmi, Geodata Ltd., and the Institute of Geodesy and Cartography in HUT are working with Intergraph's workstations and softwares. Therefore it was easy to choose Intergraph as a platform for this research. Series 6040 and 2000 graphic workstations running under the operation system Clix (Intergraph's version of Unix) were used.

The production process of this map can be done totally with Intergraph's software products. Only one file format translator and some controlling macros were made as applications in this project. MicroStation is CAD software which is the basic product for all products mentioned below. Spatial data in vector format was manipulated and stored with MicroStation in our project. MGE (Modular GIS Environment) is a GIS environment that can handle both spatial and attribute data. I/RAS B can be used to handle binary raster files, often scanned material such as maps and documents. I/RAS B was used to handle scanned base maps, scanned water masks, etc. I/RAS C can be used to handle continuous tone images, RGB images, and greyscale images. Satellite data and the elevation model were handled by I/RAS C in our project. MGE Map Finisher (MGFN) was used to give a map presentation to the digital files. MGE Map Publisher (MAPPUB) was used to do a color separation process. MAPPUB contains many routines for raster file conversions that were used in this project. I/VEC is software for automatic vectorizing. Coastlines and main roads were vectorized with I/VEC.

#### 6. CONCLUSIONS

This project gave valuable experience in the use of different digital files. Land use information produced from satellite images proved to be very useful in map production. However, interpreted information is not useful for map presentation without processing. Map design seems to be vitally important. When land use data is combined with the DEM in raster format, it is important that the size and the position of the pixels is the same in both sources.

Different digitizing methods were tested in the project. On-screen digitizing proved to be a precise and fast method in digitizing the roads. Automatic vectorizing is useful when there is a lot of data to deal with. It is important to prepare the vectorizing process so that the result will be dense enough and possibly classified, too.

A lot of data was manipulated in raster format. Scanned base map, water mask, field mask, DEM, and land use data were raster files. In the test area - about 50 km x 50 km - files were quite fast to handle. Merging of raster files to the map production process was easily done. Raster and vector data were processed together without insuperable problems.

A major part of this research was designing the map. Technically, planning was easy to do. The most difficult part of planning was to find suitable colors for the elevation zones. The traditional theory of cartography which is documented e.g. in books by Imhof, offers a solid basis and useful solutions for the design problems also in the computer assisted environment.

Modern software modules can offer versatile possibilities for map data processing. However, when a new map production process is to be designed, the designer must be able to perform some applications of his or her own. This is because, there are always some bottlenecks in the process which cannot be solved without application programs.

#### 7. REFERENCES

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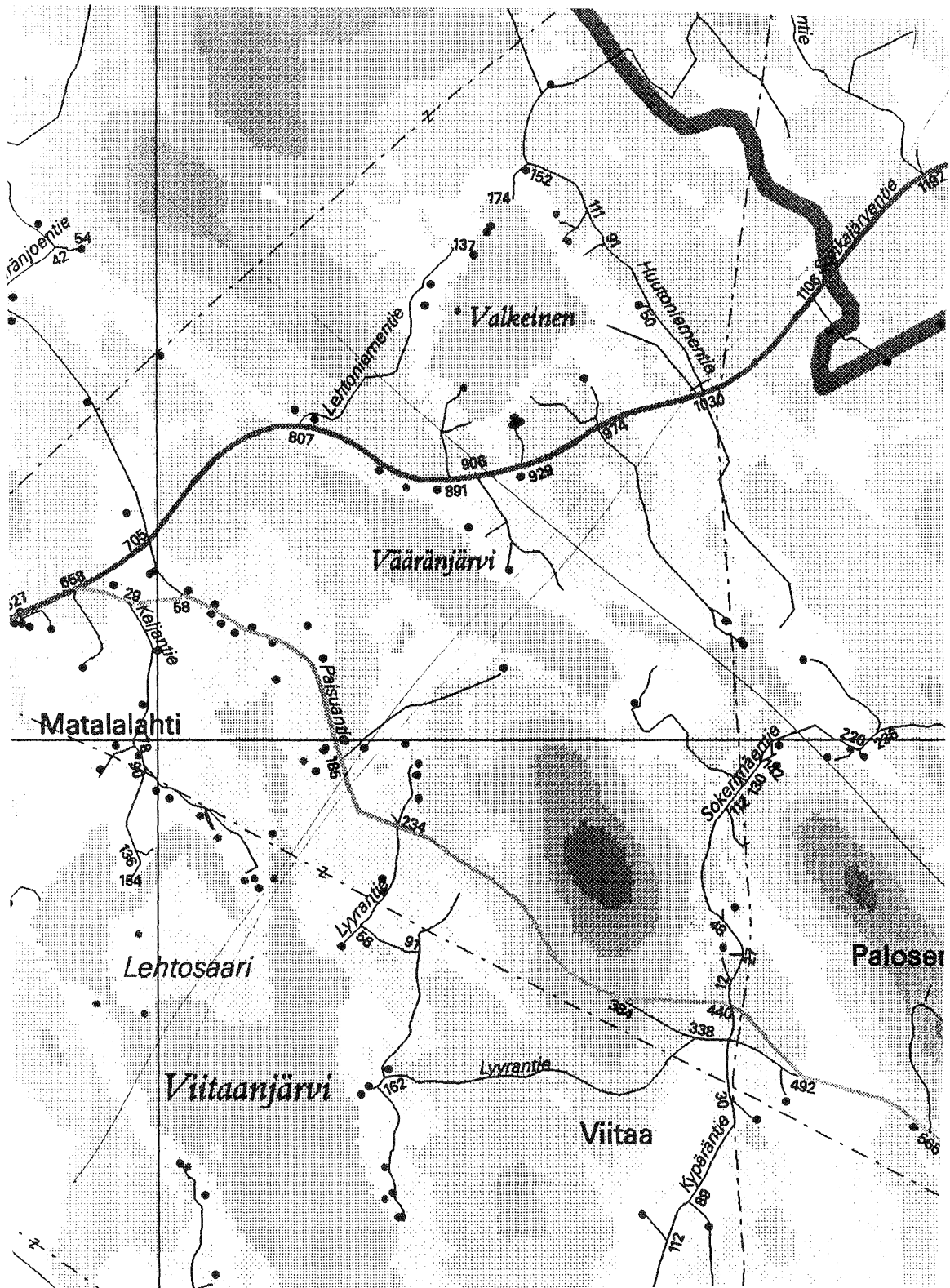


Figure 1: A part of the Guide Map for Rural Areas in Iisalmi, Finland.

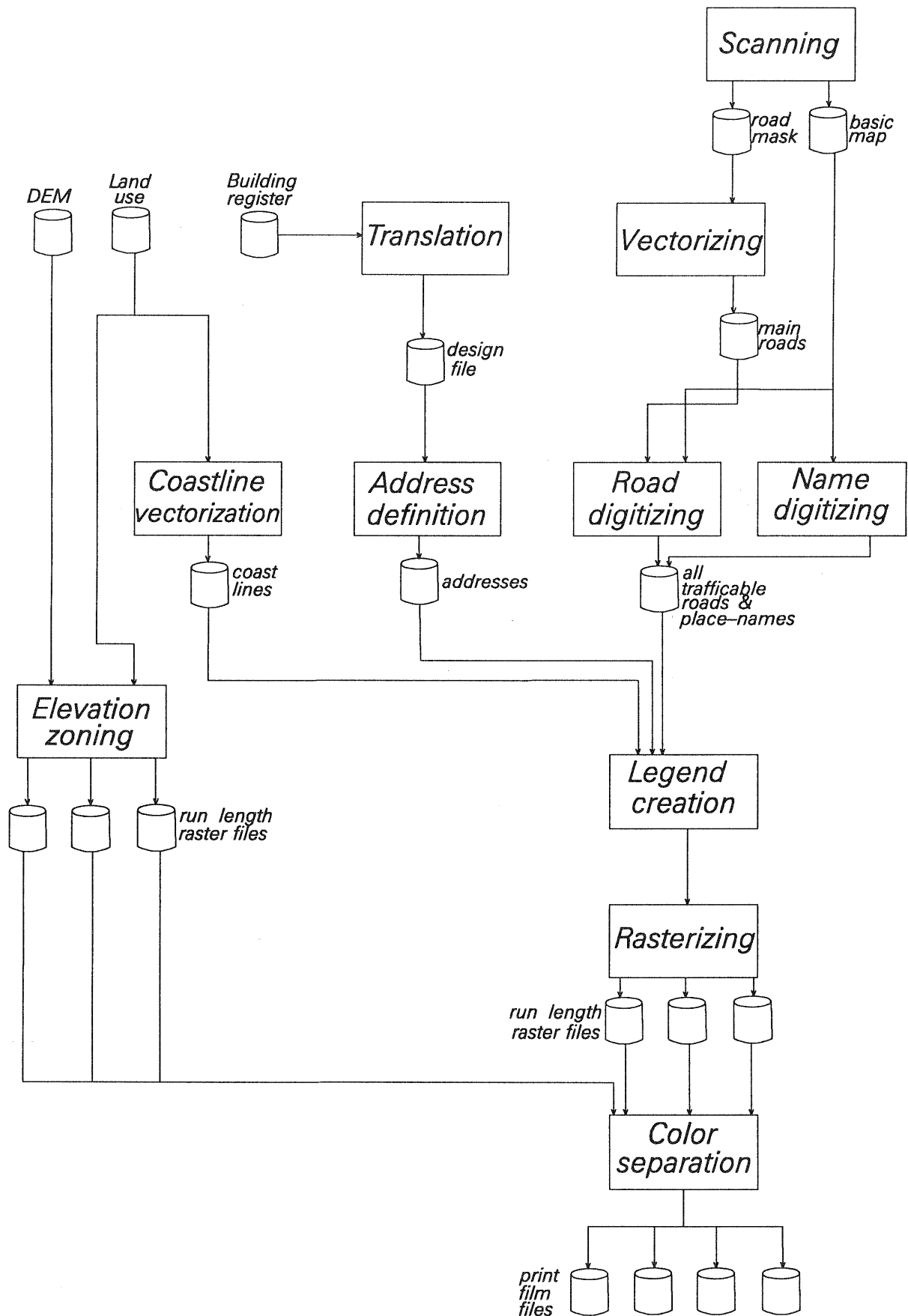


Figure 2. Production process of the Guide Map for Rural Areas.