EXPERIENCE IN DIGITAL PHOTOGRAMMETRIC MAPPING

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ABSTRACT

It is one of new and necessary ways to produce digital maps with computer assisted analog stereoplotter and analytical plotter, which are effective tools to acquire geographic data. In the course of digital photogrammetric mapping, the author makes a study of the standard procedure, and emphasizes the preparations for photogrammetric digitizing, the digitizing of geographic data, the data conversion and the digital data quality evaluation.

1. INTRODUCTION

In Taiwan, we are starting the construction projects under the Six-Year National Development Plan. From the projects, we know that it's a natural tendency for digital photogrammetric mapping to combine step by step the analysis functions of geographic information with related attributes data and to provide the digital maps for decision making divisions. After over three years' research on digital mapping, the author states in this article his experience in making digital cartography with digital photogrammetry.

2. OPERATION PROCEDURE OF DIGITAL PHOTOGRAMMETRIC MAPPING

The ways of operating digital photogrammetric mapping depend on terrain, map scale, purposes, instruments, accuracy requirements, etc., but the operation procedure is similar, including the following steps.

a) Planning the Production of the Photogrammetric Project
b) Control Point Survey
c) Anti-airphoto Signal Setting
d) Aerial Photographing
e) Pricking
f) Field Affirmation
g) Aerial Triangulation
h) Acquiring Digital Data through Stereo Plotting
i) Field Survey
j) Data Edition and Compilation
k) Creation of Standard Exchange File
l) Arrangement of Result and Documents

As mentioned above, step (a) through step (g) are the same as those of traditional photogrammetry, so I don't make any statements on them, but put the emphasis on step (h) through step (l).

3. ACQUIRING DIGITAL DATA THROUGH STEREO PLOTTING

When we digitize topographic data with computer aided analogy plotter or analytical stereo plotter, the following steps are usually included:

3.1 Preparations Before Stereo Plotting

3.1.1 Definition of Data Structure and Feature Code

According to the digitizing purpose, we have to first plan and define the data structure to meet the requirement of geographical information application. The most popular way at present is to show the relation among all geographic data elements with the hierarchy structure. Uniform feature code, which actually represents digital geographic data through specific alphanumeric code, is important for the data exchange and transmission among different users and the establishment of the map data base.

Take for example the process standard of topographic data recommended by the Ministry of Interior.

Major Code	Category
A00000000	Control Points
B00000000	Administrative Boundaries
C00000000	Urban Plan Boundaries
D00000000	Cadastral Boundaries
E00000000	Buildings
F00000000	Terrain
G00000000	Public Utility
H00000000	Vegetative Surface Features
J00000000	Transportations
K00000000	Hydrography
L00000000	Statistical Boundaries

Example:

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              Transportations
               (J00000000)
        _____|_____
        |                     |
      Road                 Railway
   (J1A000000)          (J1B000000)
   ____|_____
   |                      |
 Roadway        Divided Highway
(J1A010000)       (J1A020000)
         _____|_____
         |                     |
 Planning Road      Road under Construction
 (J1A010020)           (J1a010030)
```
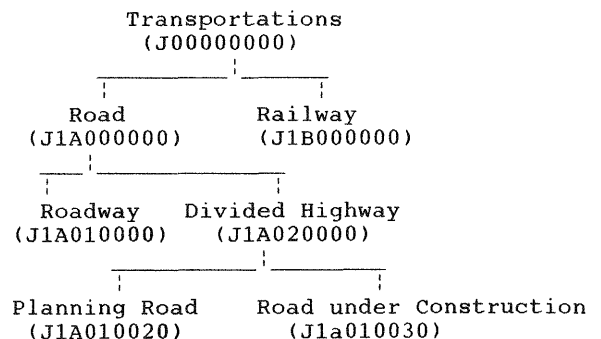
Fig. 1 Hierarchy Structure

3.1.2 Function Definition

Through function definition, we are able to simplify complex operation command procedure to increase working efficiency in digitizing. Besides, we can also set data types while digitizing geographical features to meet the requirements of operation. Function definition includes the following items:

a. symbols : individual objects (such as booths, towers); indication of sign objects (such as hot springs, pastures); sub-sign objects (such as post offices, schools, temples); vegetations (such as tea plantations, rice field, orchards).

b. line types : such as traffic routes, administrative boundaries and vegetation boundaries.

c. screen display controls: such as "ZOOM", "PAN" and "REDRAW".

d. editting commands: such as "ERASE", "MOVE", "CHAMFER", "ROUTE".

e. drawing commands: such "GRID", "ORTHO", "OSNAP", "PARALLELS".

3.1.3 Orientation Correction and Digitizing Parameter Setting

With the help of the computer's calculating abilities, we not only can reduce much orientation correction time but can store correct orientation elements and their measurement tolerance to guarantee map production quality. As for digitizing parameter setting, we select data density, symbol scales, contour intervals, etc. according to different scales.

3.2 Some Points on Digitizing to be Noticed

3.2.1 First check if there are any adjacent data files and if the planimetric and height accuracy of map connection serves our needs.

3.2.2 Select one obvious control point as the elevation base point of the model measurement.

3.2.3 After the setting of digitizing boundaries, digitize objects in the sequence of transportation systems, hydrography, buildings, vegetation, network of public utilities, terrain, etc. and then store planimetric features as well as relief features according to feature codes and digitizing layers.

3.2.4 Special items should be noted in digitizing

a. planimetric boundaries : Many planimetric features are adjacent to each other, and so to keep the data complete, we often copy and reproduce the adjacent data for future use.

b. the continuity of line type data : Roads, railways, rivers, etc. are shown through continuous multiple polylines, while buildings are shown through closed multiple polylines.

Since there are special meanings in the continuous line type data, in digitizing we should put things in position without any interruption.

c. attributive symbols of planimetric features : While digitizing, it is necessary to show the attributes of the planimetric features, which are usually distinguished by simple alphanumeric, symbols, lines, etc. For example, among various buildings, "R" stands for concrete building and "B" for brick house. Numbers represent floors, so "4R" means concrete buildings of four floors. And arrows usually symbolize river directions.

4. FIELD SURVEY

We take some photos and script maps to mapping areas and identify all kinds of planimetric features, such as names and annotations, administrative boundaries, classification of roads, buildings and structures, river directions, vegetation and land use classification and the shadows on the photos. The data acquired through field survey can be drawn on the photos or on the transparent paper. The precise digital coordinates for the use of editing maps can be gained through electric survey instruments to increase the accuracy of planimetric data.

5. DATA EDITION AND COMPILATION

After stereo plotting and field survey, we have to edit data and correct topographic data. Besides, to promote map efficiency we have to take into consideration such as the map types, purposes and scales to complete map design. It costs much time and care to compile and edit geographic data, so to improve the working efficiency of the digital photogrammetric plotter, off-line operation procedure is usually adopted. According to the data gained through field survey, we should first edit plane data and appropriately correct disconnected or unreasonable areas, including overshot, undershot, overlay and useless nodes.

These corrections are combined for editing according to data layers. When contour and plane maps are combined with each other, we should take much notice of how to get the contours across roads, houses, rivers, etc.

In compiling data, scales and purposes should be taken into account. Although digital maps and paper maps differ in

the ways of processing and displaying, yet for the convenience of computer's and man's using digital maps (including visualization, measurement analysis and navigation), the following items have to be considered in designing maps.

5.1 Map Sheets Size

To be accessible, easily used and carried, the size of each map sheet is defined depending on its scale.

5.2 Projection Selection

Directions, distances, areas, shapes, etc. on maps are produced with projection method the user needs to keep the accuracy of the data.

5.3 The Unity of Symbols and Legends

Natural or artificial features on the surface of the earth often can't display the true shapes on the maps, so they are usually replaced by some signs. Uniform signs are called symbols. As for legends they are important tools to help users to visualize maps and are combined demonstrations.

5.4 The Size and Density of Annotation

Annotations are helpful to users to distinguish the names and characteristics in the maps and to identify the relation between the points, the directions and the positions, etc. Annotations usually show the importance and disposition with different sizes and styles, but the density and size should be properly shown in order not to influence the spread of geographical information.

5.5 Color Selection

Colors add beauty to maps. If colors are properly selected, maps will appear good in clarity and brightness. The harmony of colors is very important for the use of map and the feature which the colors symbolize should be also noticed.

For example: blue stands for water;
green for vegetation;
brown for contour;
red for roads and cities;
etc.

6. CREATION OF STANDARD EXCHANGE FILE

Supplying the standard transfer format of the digital map data is the necessary step to promote the data exchange among the map makers and the map users. Different graphic data files are produced because different graphic software packages are used. If there is need of exchanging data among different systems, the file transfer is executed through data transfer programs. From experience, we learn that in the transfer of Chinese

annotations, symbols, legends and colors mistakes are often made. The main reason for this is that the government has not made definite digital map data formats, so many users can only use current commercial GIS or CAD packages as their data transfer formats.

7. ARRANGEMENT OF RESULTS AND DOCUMENTS

On results and documents, we should notice whether photo errors, aerial triangulation errors, inner and outer orientation measurement accuracy correspond with survey rules and error limits. On the check of digital maps, we should put emphasis on whether the data are reasonable and consistent. In every operating procedure, inspecting and recording are needed so that the accumulation of step errors can be avoided. The efficient checking ways are statistical evaluation and field check. If digital map data reach the National Map Accuracy Standard (NMAS), then they are stored in the media.

According to the "Basic Topographic Data Process Standard" final report (Shyy, 1987) recommanded :

7.1 Digital photogrammetric mapping accuracy evaluation models

7.1.1 Plan Accuracy

$$O_p^2 = [O^2(\text{aerial triangulation}) + O^2(\text{orientation}) + O^2(\text{measurement})] * (\text{photo scale})^2$$

7.1.2 Height Accuracy

$$O_h^2 = [O^2(\text{aerial triangulation}) + O^2(\text{orientation})] * (\text{photo scale})^2 + O^2(\text{measurement}) * (\text{flight height})^2$$

7.2 Digital topographic data accuracy evaluation with field check

7.2.1 X-Direction

$$RMSx = \text{sqr}[(D*D)/N]$$
$$D*D = d_1^2 + d_2^2 + \ldots + d_n^2$$
$$d = X(\text{model coordinate}) - X(\text{field coordinate})$$

7.2.2 Y-Direction

the same as above section 7.2.1.

8. CONCLUSION

Digital photogrammetric mapping is a tendency to develop. However, in stereo plotting, some procedures are changed and more items are needed, so we need much time to digitize and edit data. Therefore, we need to modify analogy stereo plotters with computer aided mapping equipment, so that they can share

more digital mapping work. Besides, with
the help of computer graphy the beauty
and visualization in the map are easily
displayed. But with the operating ways
of traditional legends and symbols, much
unimportant work has to be done and huge
data storage is produced.   All these
items should be improved to meet the re-
quirement of digital photogrammetric
mapping.

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