DIGITAL MAPPING OF TSUCHIURA CITY

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Introduction

In usual photogrammetry, a topographic map has been prepared by plotting on a papre by analog plotters after measuring locations and altitudes of the points and objects from parallax differences of the pairs of aerial photographs. However, the significant development of computer technologie recently made it practicable to computerize the whole processes of collection of the digital data in aerial photogrammetry, editing for final mapping from the original sheets, and provision of digital data to the geographical information system.

Such computer assisted mapping method is highly expected for its extraordinary potential for future development and many useful applications and is currently under active researches and studies for technical development also in Japan.

The Geographical Survey Institute of the Ministry of Construction has prepared a draft for the standard of the digital mapping in order to establish the method as the future photogrammetric technology.

Tsuchiura Urban Planning Map (1/2,500) is the first map made by the digital mapping procedure in accordance with these tentative standards. In this paper, the new techniques used in this digital mapping process and various problems that require attention will be introduced.

1. Outline of Processing System

Area compiled as the digital maps is 64 km^2 of whole Tsuchiura city. The products as the result of the present work were fifty Urban Planning Maps in scale of 1/2,500 and six magnetic tapes storing as the data base on the digital maps.

The flow of the whole processes is as shown in Fig. 1. In these processes, the points differing from mapping processes hitherto used are:

(a) the digital data of topography and planimetric features are stored in magnetic tapes with classification codes describing the related map symbols when maps are plotted from the aerial photographs,

(b) editing is done through dialoques or by batch processing on a computer graphic display,

(c) scribing sheets are made from the data by XY-plotter, from which the original negative blocks are directly produced, and

(d) magnetic tape files with classified data elements are produced as the results of digital mapping at the same time when plotted.

The summaries of each work related to data collection, map editing and output process are described on the following paragraphs, respectively.

2. Data Collection

(1) System used for the data collection

Since the purpose of this work is not only compilation of maps but also preparation of digital data files of topography and planimetric features, three dimension coordinates of the necessary points should be obtained during plotting process. Meanwhile, the current map symbols in Japan are classifies into about 120 kinds for the topographic map. Therefore, these map symbols must be properly coded for identification, and so the most important problem is how it should be done. Then, it will be generally considered that the chance for such coding should be selected from the following three cases:

(a) in process of data collection,

(b) in process of digital compilation, and

(c) in process from data collection to digital compilation.

From a standpoint of efficiency, it was decided to be most practical to do it in process of (a), because graphic data are collected in chance of identification of the details of the planimetric features on aerial photographs.

Analytical plotter such as Wild AC-1 has been available for such purposes of data collection, but it has not such function of dealing with so many different type of symbols.

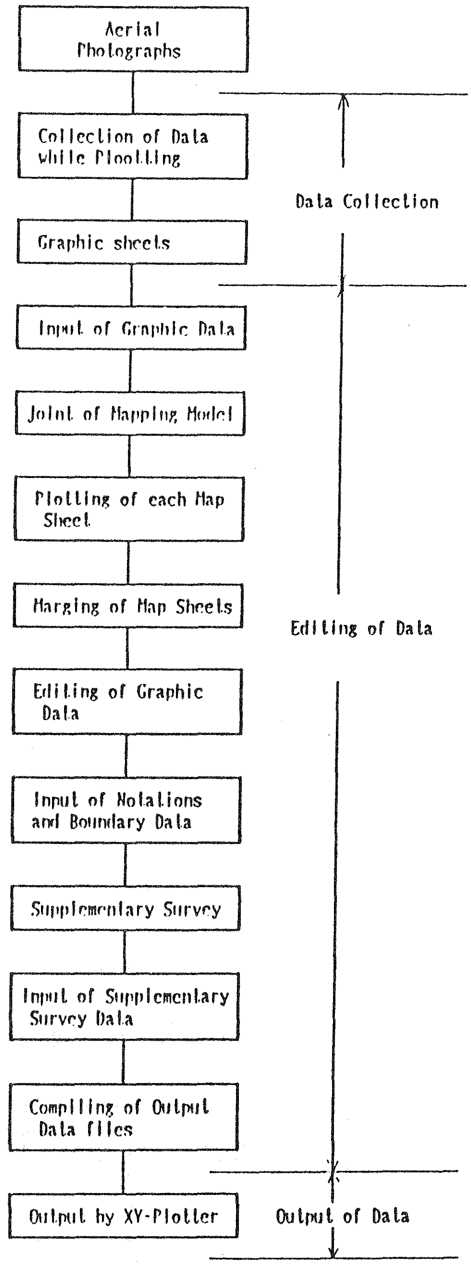

Fig. 1 Work Flow Chart

We have pursured a method whereby coordinate data as well as code data matching graphic symbols in use can be collected simultaneously and efficiently. As a result, we have developed A-CAMS (Asahi Computer Assisted Mapping System) which consists of an analog map plotter, a function keyboard for code matching, a personal computer and a coordinate recorder.

The special feature of the A-CAMS is the provision of the function keyboard which enables determining and code-matching while data are being collected by the analog map plotter without reducing the total efficiency (Ref. Fig. 2-1 and 2-2).

This system has been designed to record codes corresponding to every map symbols while operating almost similar functions as the analytical plotter, i.e., plotting of straight lines, curved lines and right angles as well as drawing symbols and entering elevation values by pushing one key for each entry with the function keyboard placed in front of the operator. Forethemore, it has been made so as not to interrupt plotting works of the operat-

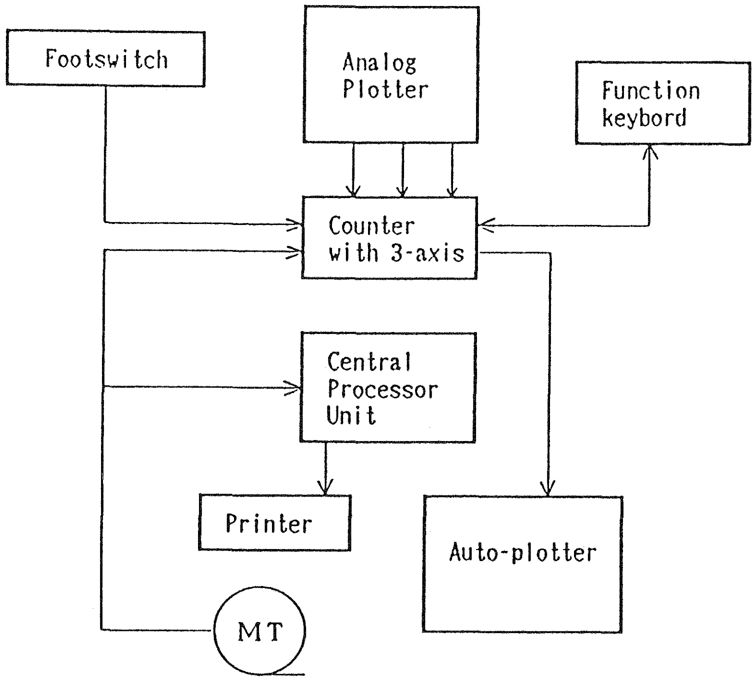

Fig. 2-1 Composition of A-CAMS

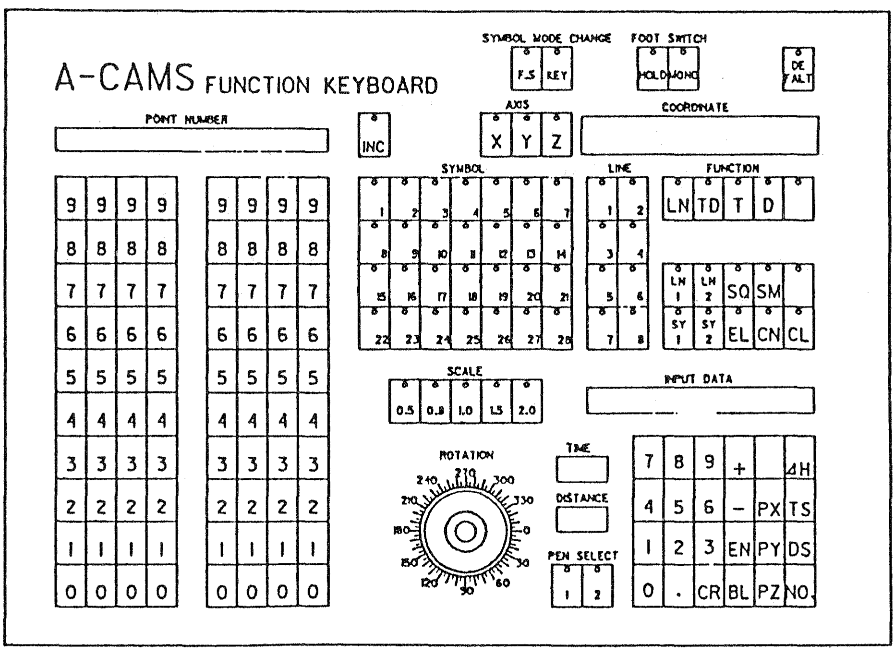

Fig. 2-2 Arrangement of Function Keyboard

or as far as possible so that he can smoothly continue working for graphic data collection.

(2) Collected Data Elements

There are about 120 different data elements for plotting a set of urban planning maps. These are first classified into general and fine classifications to bring data into proper 1-to-1 correlation with each code (Ref. Table 2-1 and 2-2).

General classification is made in reference to the point numbers on the function keyboard while fine classification is done by using 16 different types of linear marks.

As shown in Table 2-2, 208 data items can be listed by the general classification containing 13 sections. And this 1-to-1 correlation to all the types of map symbols used in the urban planning maps is enough for such data elements.

POINT NO.	General classification
10,11	Road
12	Bridge
20,21	Railroad
30	Building
40	River
41	River structure
42	Coastline
43	Coastal structure
50	Plant
51	Composition
52,53	Terrain representation
60	Contour line
70 ~72	Small objects

Table 2-1 Data Code (general Classification)

General classification	LINE NO.		Fine classification
1 0 road	LN-1	1	real width road
		2	walking road
		3	narrow pavement
		4	road in garden
		5	secession belt
		6	under constractor
		7	safety zone
		8	unclassified
	LN-2	1	stone steps
		2	existing sidewalk
		3	crossing bridge
		4	
		5	tunnel
		6	
		7	
		8	unclassified

Table 2-2 Data Code (Fine Classification)

(3) Method for Data Collection

Graphic data are collected by using the code matching list shown in Table 2-2 and function keyboard while referring to aerial photographs of the sites.

Data collection, similar to case of analog mapping, is carried out, firstly, for roads that constitute the infrastructure, and then for railroads, rivers, buildings, plants and contour lines in that order.

The process different from the existing mapping procedures is that the operation is carried out according to the direction by the function keyboard and the data are collected in a way suitable to standardized data setting. For example, a certain direction is specified along which the collection of data such as roads, buildings and contour lines must be proceeded. Mapping, therefore, will be carried out under such directional restrictions. And more, when roads and structural enclosures are overlapped with each other on a map, the separate data for each object must be obtained in digital mapping while either one of data can be plotted according to the priority in the case of analog mapping.

Until operators become accustomed to the procedure, they have to pay much more attentions for each of their operations than would have been necessary for the existing methods. As a result, the actual mapping process become slower. However, the time spent for obtaining data could be raised in a level only 20 % to 30 % longer than by ordinary analog mapping process.

3. Editing of Data

(1) System used for Editing of Data

In order to edit the digital data of topography and planimetric features in the computer, a graphic processing system capable of efficiently processing enormous amount of data of 3 MB to 4 MB per a map is necessary. For this work, a computer mapping system INTERGRAPH has been applied. The configuration of the system is as shown in Fig. 3-1.

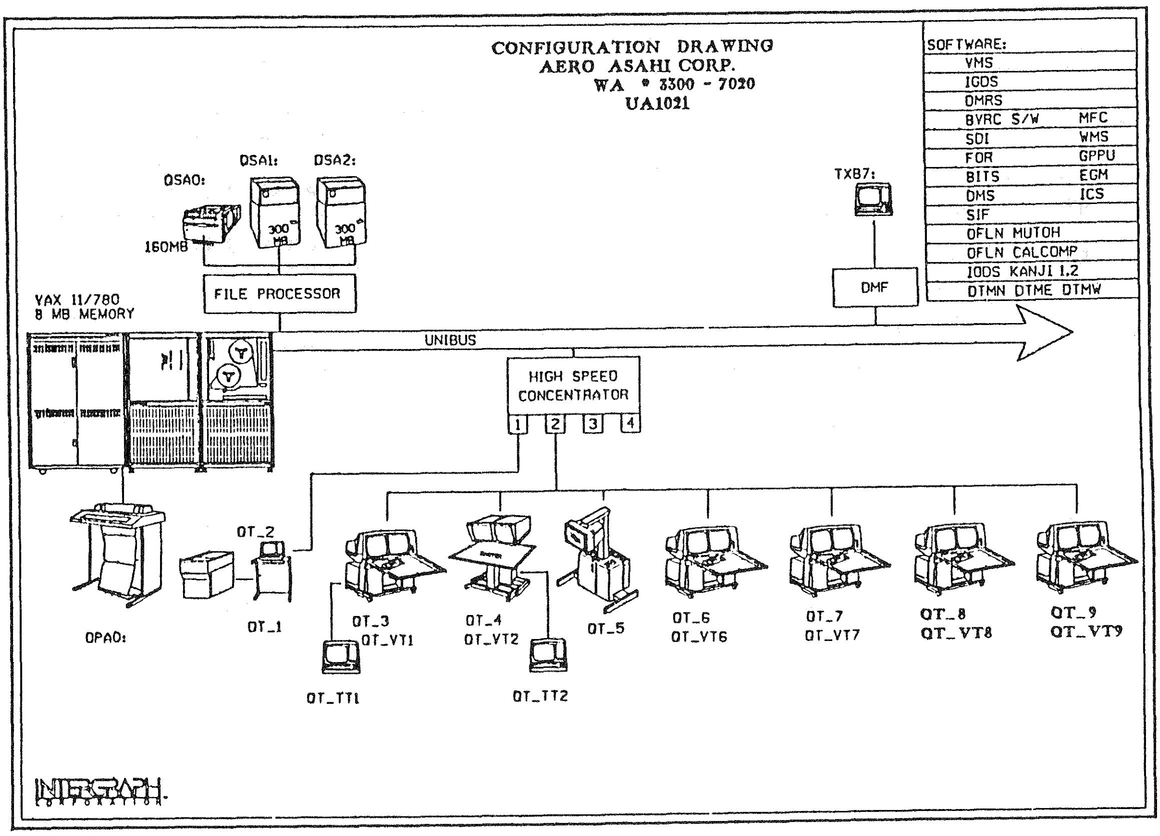

Fig. 3-1 Configuration of Graphic File Processing System (INTERGRAPH)

The special features of INTERGRAPH are as follows.

(a) A graphic file can be stored in 63 layers.

(b) 32 graphic files can be displayed in overlap in addition to a file being processed.

(c) Many of the graphic processing subroutines of the user's programs can be utilized, and the reference and the rewrite can be done at a very high speed by the system's processor.

(d) The work station has two graphic screens and A0 size digitizer for real time editing.

(2) Graphic Data Input into Graphic Editing System

The topographic and planimetric data are first coded in accordance with the corresponding map symbols and then generally classified into eight graphic files depending on the code, and, furthermore, input into the graphic editing system after provided with layer numbers in accordance with the fine classification (Ref. Fig. 3-2 and Table 3-1).

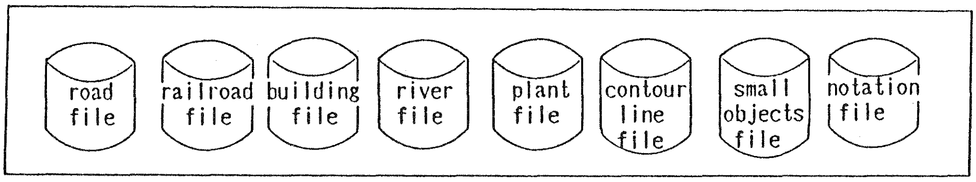

Fig. 3-2 Configuration of Graphic Files

layer	data name
1	real width road
2	walking road
3	narrow pavement
4	road in garden
5	secession belt
6	under constractor
7	safety zone
:	:
:	:
63	

Table 3-1 Classification of Layers of a Road File (example)

Graphic elements which are input with the respective layer numbers, can be turned on and off by layer groups for graphic display, and therefore, this system enables to process for graphic editing while displaying only the required information. There are seven input patterns such as planes, circles, lines, arcs, points, central locations, directions and notations.

(3) Editing Process

Flow of editing process is as shown in Fig. 3-3.

As the first step of map editing process, a plotting output chart (a graphic sheet) in which different types of linear marks are arranged in relation to each layer of eight files is prepared and, then, the layers are checked with this graphic sheet and aerial photographs. It is the most important part of the work since all the subsequent works will be carried out through layer controls.

Since graphic data are filed in each graphic model unit, after erasing of overlapped parts and matching of the respective coordinates, cutting out of each map sheet from a number of models joined together is carried out. The notation data such as datum points, place names and facility names, and also their location data are input the respective map sheet files.

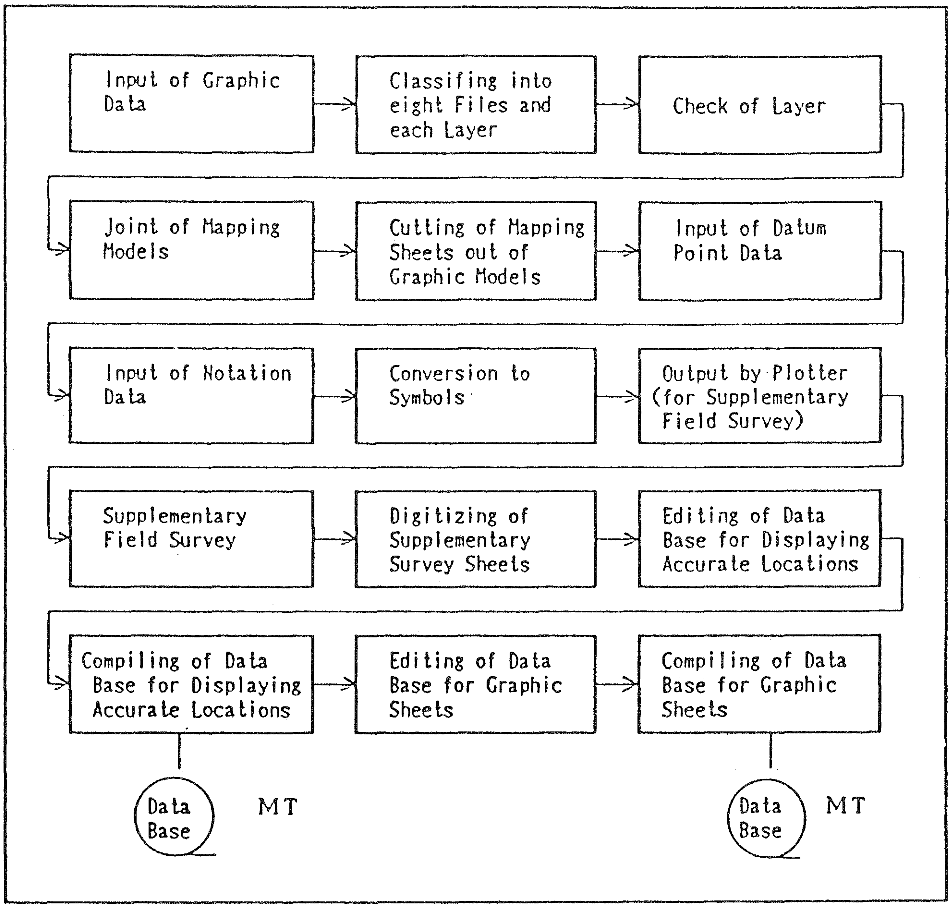

Fig. 3-3 Flow Chart for Data Processing

Each graphic file thus prepared is output by XY-plotter after graphic symbols are patterned with the corresponding elements. Portions which are illegible on aerial photographs or deteriorated by secular changes shall be reaffirmed by supplementary survey and the sheet output by XY-plotter is corrected by using their results, and then, the graphic processing system digitizes this graphic sheet and input into the related map sheet files.

Files will, then, be edited upon the completion of input and processing works, as described above, for the compilation of data bases. There are two kinds of data bases, one for displaying accurate locations and the other for output of map sheets. The compilation of data bases for displaying accurate locations, includes squaring of buildings, rearranging entagled contour lines, checking of contour lines and elevation control points, jointing dotted lines, and checking and correcting of directions, while the preparation of data base for output of map sheets, includes transference, interruption, symbolizing, selection/adoption and rejection/rearrangement.

In map editing process, considerable amount of factors which require operator's judgement are involved, and much of them are carried out through computer dialogues. Such operations as the squaring of buildings, determining the directions of building lines, interruption of contour lines by roads, buildings and notes, and patterning of symbols are processed, as a batch, by the proper programs in order to save time and costs as much as possible and to increase the efficiency of the editing process.

4. Data Output

(1) Preparation of Original Maps by XY-Plotter

The original maps are, after graphic processing, drawn out of the data bases by XY-plotter through scribing method (Ref. Fig. 4-1 and 4-2).

Such map symbols as the hachures and landslides or bright spots and shades on water surface, etc., are not suitable to be drawn by XY-plotter. Then, they must be touched up on the originals. These problems must be further studied for future computer mapping processes.

In the case of existing analog mapping processes, so each line has to be drawn by hand tracer with ink, it takes many days. Consequently, weights and features of lines differ from one operator to another by their skills.

Digital process, on the other hand, is much more accurate in terms of location and so, the required interval of time and the quality of results are much more consistent as each line is scribed by XY-plotter in predetermined thicknesses. The production of original maps was the part most efficiently carried out all the processes.

(2) Preparation of Data Base

Since the data base in digital mapping is for multi-purpose application of information and the interchangeability of data, the data structure will be strictly standardized. Then the basic principles in preparation of data base are:

(a) Data are filed in blocks for each map sheet.
(b) Data are handled as elements for each subject item such as buildings, bridges, etc., and as sub-elements for figures and letters forming the elements.
(c) Elements are classified according to the types of topography and planimetric features by using the classification codes. It enables to pick out the related elements contained in the map whenever required.
(d) Graphic data in the map are classified into planes, lines, circles, arcs, points, directions, notations and attribute data according to their characters.

The outline of the data structure ia as shown in Fig. 4-3 and the meanings of each data record in this figure are as follows.

(a) Map Sheet Records
These are records containing the related sheet information and are placed at the head of a block of data for each map sheet.

(b) Element Records
These are prepared for each element as the basic unit of data (a building, a bridge, etc.) of map sheets and are placed in front of sub-element records.

(c) Sub-element Records
These are prepared as a pair with either one of coordinate, notation or attribute records for each sub-element and are placed in front of each element record. And each one falls under applicable one of the eight items : planes, lines, circles, arcs, points, directions, notations and attributes.

(d) Coordinate Records
These are prepared for recording the coordinate data of figures or symbols and are placed behind sub-element records.

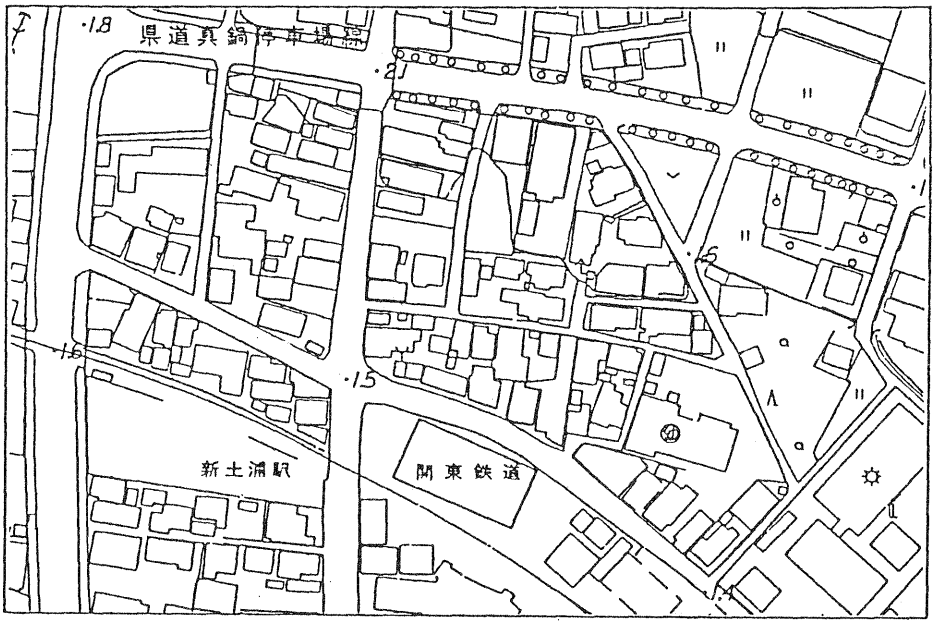

Fig. 4-1 Graphic Sheet from the Correct Location Data Base

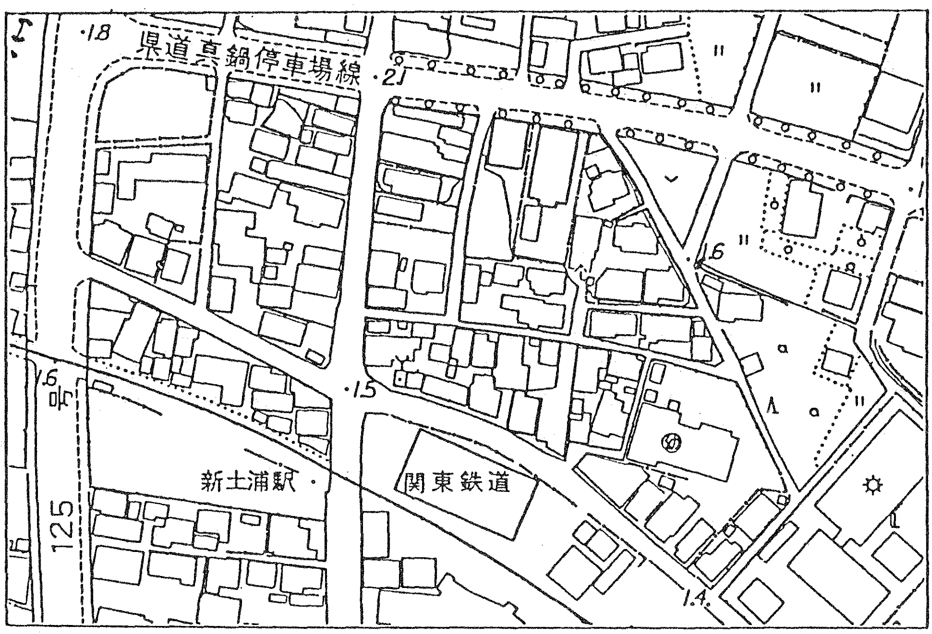

Fig. 4-2 Graphic Sheet from the Map Drawing Data Base

(e) Notation Records

These are prepared for recording the data of Kanji and other characters and the coordinate data of the indicated positions and are placed behind sub-element records.

(f) Attribute Records

These are the attribute data related to each graphic figures such as the numbers of stairs of a building, heights of control points, etc., and are placed behind sub-eleemnt records.

Example : Element Records
(General Classification - Building, Fine Classification - School)

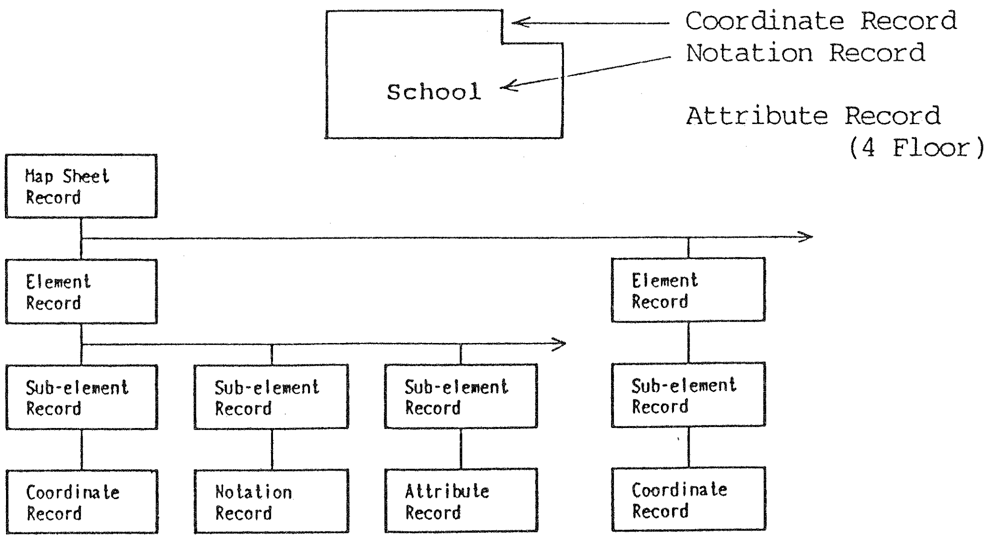

Fig. 4-3 Outline of Data Structure

5. Conclusion

Digital Tsuchiura Urban Planning Maps of 50 sheets covered the entire area (64 km^2) of Tsuchiura City were compiled in scale of 1/2,500 by A-CAMS system. Although the similar digital mapping has been tested in Japan, this was the first case of the practical application of the digital mapping process for the acutal preparation of the Urban Planning Map.

It has taken us 30 percent more time and costs as compared with the traiditional analog mapping process. The causes for the extra time and costs consumed were because the basic draft employed in analog mapping process was nearly applied to digital mapping process as it was and therefore the present work made batch processing difficult and were obliged to take computer dialogues on a display in editing process.

The another problem was that the graphic processing specifications for computer mapping should be prepared as the different types of the graphic processing specifications for manual map plotting.

However, the present digital mapping process enables us to prepare the well structured data during the map compilation, and therefore, we believe that it was the satisfactory results and could no doubt be put to wide range of practical application. We will continue our efforts for further technical development on automating of the process for minimizing time and costs required in map compilation.