

## Utilization of GIS for Road Management

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### 1. Common possession of survey measurement results

At present, about 90 percent of road management by local municipalities or the central government is managed by road registers, the Road Management Act. Therefore, only very few roads are managed by plane rectangular coordinate systems covering the area from city control points to road boundary points. However, due to a recent rise in the cost of land near roads and the increase of buildings (which will lead to clarification of land ownership and more applications for construction permits), the demand for proper site adjustment is rising sharply. As the total station systems are becoming more popular, the acquisition of digital coordinate data is being widely adopted. Therefore, efficient data management by using data bases is rapidly becoming an important aspect.

- (1) Plane rectangular coordinate systems
- (2) Annual survey measurement, boundaries confirmed — not confirmed
- (3) Reasons for transfer, previous owners, area sizes, registration dates
- (4) Cadastral maps

For proper road management, survey measurement results must possess data accuracy which will aid future road improvement work and installation/management of water supply/sewage systems. If accidentally lost, the data must be restored immediately. Also, data base control must be effected by the measurement results, such data and functions must be able to respond to inquiries from road-side residents.

### 2. Management of the latest information

As mentioned above, we can state that the adjustment of road registers according to the Road Management Act has nearly been completed. However, a saying as it is usually said by the people who are engaged in road management, "roads are alive", road conditions vary from year to year (shapes, roadside facilities, pavement conditions, road occupying structures, accessory buildings, etc.), and as a result accurate information management is rather difficult. The methods generally adopted to manage information are the control of shapes and locations by means of maps attached to the road registers, as well as the recording of extension status, area sizes, and site numbers through the use of road ledgers (or one's own control-use ledgers). For the sake of ensuring the accuracy of any information, obtained, the work of obtaining data on road extensions or area size changes is subcontracted to professional surveyors. Nevertheless, various complicated minor matters still exist. For instance, data related to replacement dates or types of lights resulting from installation changes in roadside illumination systems must be updated or the necessity to extend the renewal limit dates of road occupying structures must be confirmed. All such factors have lead intensified the demand for data bases, which will permit prompt and easy data updating.

- (1) Updating of figures/diagrams (permits for new road construction, width expansion, territory determination, territory changes, bridges, tunnels, railroad crossing, pedestrian walks, roadside ditches, protective fences, illuminating lamps, traffic signs, road information display boards, pavement renewal, road occupying structures, etc.)
- (2) Updating of attributes (road permit records, Road Management Act records, Construction Ministry report ledgers, Home Affairs Ministry report ledgers, government statistical report, etc.)

Management should be exercised by using the data bases on which attributes and figures/diagrams are integrated, and functions should be provided to permit retrieval and the output of applicable figures/diagrams or attributes whenever such output is required. Furthermore, a function to management history of the adjustment and renewal of road lines is also required.

### 3. Filing of various documents

Grade Advancement and efficiency upgrading are in demand for road management operations. Moreover, another increasing need that we have encountered lately is the availability of efficient filing systems for the various documents related to the office automation of administration procedures, such as documents related to consultations, examinations, exchanges, or explanations to local residents. For instance, as part of road boundary examination procedures, application submission forms for examinations, attached supporting documents, witness reports, etc. are all important for determining site ownership rights. However, most of these documents are stored in lockers or storages often used for secondary purposes or are seldom utilized effectively for their intended objectives. Sometimes, the design drawings or structural design diagrams used for the initial construction are required at the time of subsequent repair work or restoration work after damage is caused by a disaster. Quite frequently, it is not possible to locate the desired drawings or diagrams within a reasonable amount of time.

Singly filing individual documents or filing documents in a systematic way combining them with road information will greatly contribute improving the efficiency of the handling procedures, as well as upgrading information services for residents.

#### 4. Calculation processing functions

In the present automobile society, road traffic volume is expanding at a for greater speed than new road construction and road improvement. Therefore, functions, which can analyze networks and predict future traffic volumes, calculate existing congestion levels, and map road construction plans have now become essential.

At the same time, network analysis functions dedicated to establish measures to cope with inclined surface disasters, selecting detour routes when accidents occur, and transmitting effective information for newly developed roads are also required. Furthermore, installation of optimum traffic information boards which road conditions and the development of fast, accurate information display means should efficiently contribute to preventing secondary accidents.

#### 5. GIS application

Requirements for the establishment of effective road management systems can be summarized as follows on the basis of what has been explained above.

- (1) Common possession of survey measurement results
- (2) Control of the latest information
- (3) Proper filing of various documents
- (4) Effective calculation processing functions

Conventionally, except for survey measurement results controlled through FD or MT (ground control points, aerial triangular measurement results, etc.), Mylar bases, examination documents, and ledgers are used to effect control through correction and revision once or twice annually. Furthermore, as a result of the promotion of OA(Office Automation), only a very few documents are filed on microfilm. Moreover, even at departments/sections where paper filing systems are well established, system irregularities occur as a result of personnel transfers. Finally, no system has yet been established to map future traffic plan.

The advantages obtained by employing GIS (Geographic Information System) lie in achieving (multiple-purpose) data utilization and in sharing data bases. Providing highly accurate measurements will enable not only effective data controls, but also efficient utilization of improvement plans in the form of design-use drawings. Furthermore, the availability of accurate drawing information will permit sharing a variety of management work. Since many users will commonly own and jointly utilize the same data, new data utilization methods can be cultivated and will ultimately lead to a better system.

## 6. Concept of the new system structure

In structuring new systems, the data base concept shown in Fig.1 can be established on the basis of road management requirements in order to achieve a maximum utilization of GIS.

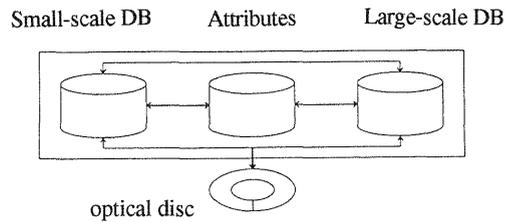


Fig.1 Data Base Concept

### 1) Utilization of GIS

The basic functions of GIS are utilized to structure system with the following objectives.

- Improvement of program development efficiency
- Maintenance of survey measurement accuracy
- Utilization of analysis functions (calculation of figures/diagrams, and use of the relationship between them)
- Use of diversified output functions

### 2) Utilization of optical filing systems

Positioning an optical filing system within an entire system, can be expected to offer the following advantages.

- Simplification of data input/output (on-site staff can effect output very easily like operating a copy machine, and can effect input by merely pressing one button.)
- Storage, retrieval, and output of large volumes of data
- Document editing through the utilization of image processing functions
- Confirmation of document contents by the creation of high-precision images

Table 1 summarizes the respective data features of the optical filing system and GIS, while Table 2 outlines the features of the overall system. By utilizing all the advantages, the system's functional capability can be fully realized.

### 3) Utilization of EWS

As shown in Fig.2, within the entire system, the major control systems are structured by EWS, and the road management systems are established by vector data. Data bases of this vector data can be stored on multiple layers. As shown in Fig.2, small-scale data (scale of 1/25,000 to 1/50,000) can be stored for network analysis and simulation-type utilization in management facilities.

vector data	raster data
calculation function	high-density storage
laser printers,electrostatic plotter	laser printer output
information exchanges	information exchange

Table 1 Data Features

E W S	optical filling
high-speed operation function/costs high program expandability high-level contraollability operation in an office environment	simple input/output image editing function high-precision image display function large-volume data storage

Table 2 System Features

To make localized utilization aimed at facility management possible, large-scale data (scaled at 1/300 to 1/1,000) is stored. As a result, data from drawing of different scales to best suit the relevant purposes can be stored. In this manner, structuring the data base with internally unified coordinate systems, will make the system capable of mutually exchanging data. Small-scale data bases are provided with individual calculation functions, and if small-scale data bases can perform index functions for large-scale data bases.

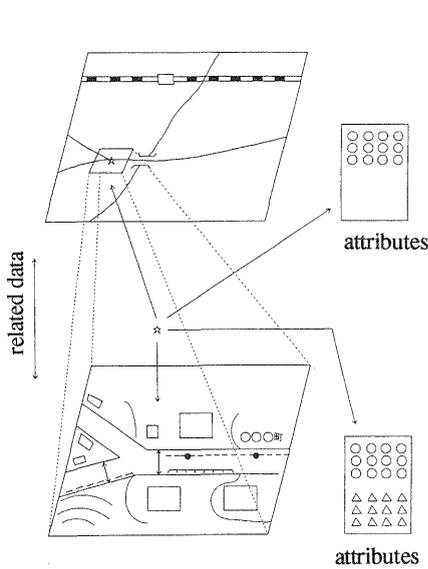


Fig. 2 Correlations among the vector data

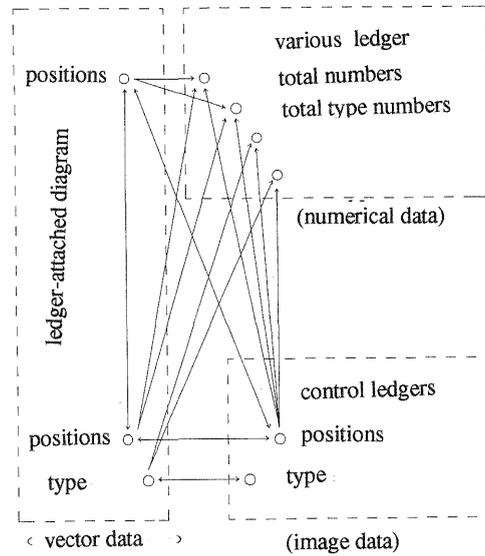


Fig. 3 Correlations among the various data

#### 4) Interfaces between EWS and optical filing

By establishing interfaces between EWS data bases that primarily use vector data bases and data bases in optical disks that hold image data, the following effects can be expected.

- Vector data bases and raster data bases will be unified (unification of large-scale or small-scale maps with documents and photos, handwritten documents, etc.)
- Data base utilization will become more efficient (optical disk control of large-volume attribute data)
- Data will be made consistent by the single-source unification of small-scale/large-scale and image data bases

Fig.3 shows the status of the correlations among the various types of data.

#### 5) Utilization of ARC/INFO

Recently, GIS that employs relational-type data bases are rapidly being developed and operated. Therefore, in Fig.1, we illustrate a road management system that uses ARC/INFO (product of ESRI Inc., USA) as the system's nucleus. About 7,000 ARC/INFO sets have been installed all around the world, and of which 200 sets have been installed in Japan. This system possesses the following features.

- No dependence on hardware ranging from PC/EWS to large-capacity, general purpose computers
- High-level GUI (graphic user interfaces) functions
- Planning-type, facility management-type data bases
- Network/topographical analysis functions
- High program expandability

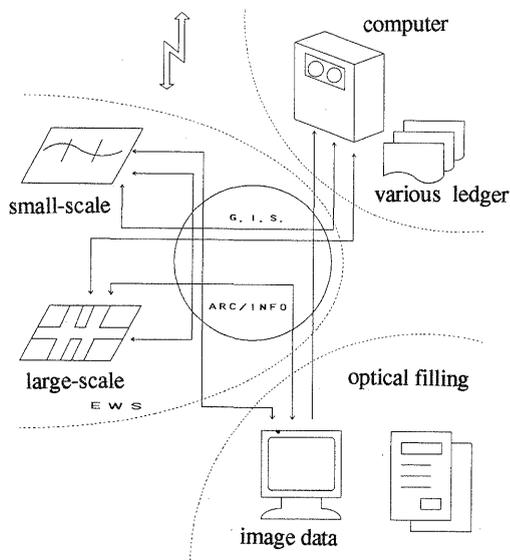


Fig.4 Relation among the various data

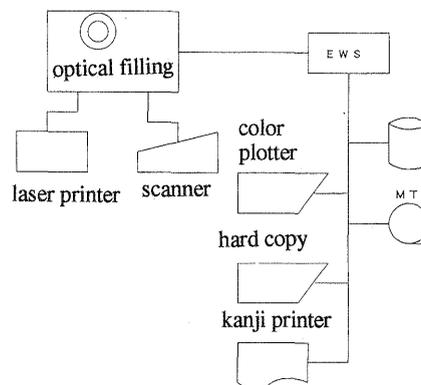


Fig.5 Hardware block diagram

## 6) Hardware configuration

Fig.5 illustrates the basic hardware configuration. With optical filing systems integrated into the systems centering around EWS, the overall structure consists of color electrostatic blocks, color copiers, kanji printers, and other peripheral devices. A series of EWS exchange data by using LAN (Local Area Network:Ethernet).

We believe that effective hardware utilization can be achieved by adopting methods which use general-purpose computers to control large-volume data and to realize functional divisions of the examination output results, counter inquiry procedures, etc., by effecting data changes with the EWS.

## 7. Newly developed application functions

The following is application software that can be used by utilizing the ARC/INFO.

### 1) Road network control subsystems

When constructing new roads, by calculating the travel speed and congestion distribution levels in conventional road usage, variations can be estimated in traffic flow on road networks, including newly constructed roads.

### 2) Accident preventive inspection information control subsystem

By analyzing road conditions for safety, data can be prepared to enable a priority judgment to be made regarding repair plans in coordination with the present traffic volume. Furthermore, the progress of the repair plans themselves can be controlled.

### 3) Traffic census data control subsystem

By controlling the present traffic volume data, the priority of road repair plans can be determined based on the obtained accident statistics data and road pavement examination data. Then basic materials can be prepared for use as long-term repair guidelines for prefectural road networks.

The above mentioned are the results of the development of application functions following the purchase of digital road data prepared by the Japan Digital Road Management Association. This data is converted to numerical values from topographical maps scaled at 1/25,000 ~ 1/50,000. By using this data, the development of support functions for planning operations becomes easier from analysis procedures of conducting macroscopic comprehension of prefectural road networks.

## 8. Conclusion

Conventional road management systems have been individually developed in the form of facility management type (ledgers, documents/drawings control) and permit information control. (road occupying structures, special vehicle traffic). As result, data could not be possessed in common and consequently, wide-scope data utilization was impossible. On the other hand, a road management system utilizing GIS makes possible completely new system into which plan-supporting functions are incorporated, as are facility information/permit information controls.

In conclusion, we wish to list the following themes, which should be tackled in the future.

1) Maintenance timing and methods

Data correction and updating are important tasks to ensure that [accurate and timely] information is available. Besides the improvement of operation procedures when the system is introduced, effective data correction/updating remain themes of prime importance to ensure the proper maintenance of data bases.

2) User interfaces

At many government municipalities, work processors, personal computers, etc. have become more popular recently. Furthermore, there is an increasing desire to use EWS systems to update data with as much ease as using a work processor. Although GUI has been well developed by using bar menus, pull-down menus, or eye controllers, we believe that there is still room for improvement.

3) Response improvement

As a result of improvements in hardware processing functions, the response speed of a GIS that employs relational data bases has been drastically increased. However, to effectively take care of the many inquirers who often form long lines at office counters, increased speed in total response (including retrieval, displays, and output) is required. This certainly is another important point which deserves to be studied further in connection with the structuring of future systems.

REFERENCES

Namiki,T.,1992.Development of road maintenance system using digital road map.12th ARC/INFO users conference proceedings(in printing).