Kuwait Utility Management System（KUDAMS）

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An international tender was called at Kuwait Municipality to create the most sophisticated Geographic Information System (GIS) in the period of 6years. It contains the establishment of national geodetic network, creations of cadastral database, utility database, digital topographic mapping and delivery of software and hardware. Due to the weather conditions in Kuwait, aerial photography can be carried out in winter. Therefore, project area was divided into 4 progress areas in order to take aerial photographs every year. This paper describes the difficulties encountered to execute the big project.

1. Purpose

For the purpose of efficient execution of administrative activities with strategic utilization of Geographic Information System (GIS), Surveying Department of Kuwait Municipality drew up a project called Kuwait Utility Data Management System (KUDAMS) in 1983. Main objectives of this project are to establish national geodetic network covering the entire country and construct comprehensive management system for the cadastre data of the urban area about 580 km^2 as well as the underground utilities with the aid of computer technology.

The GIS for the KUDAMAS was not only the largest in scale but also utilized the cutting-edge technology in those days and, therefore, received high acclaim as the word first full-blown Facility Management System.

2. Outline of the System

Graphical and non-graphical data about the topography, cadastre and underground utilities in the urban area of Kuwait were all digitized and recorded in the databank. Whenever necessary, these data can be output on the computer display or as a hard copy in the form of graphic images or tabulated lists.

Data maintenance can be performed in real time by various inputting and editing devices. The system has been maintained and managed by Kuwait Municipality officials themselves since its completion.

The following are the main operations related to the system construction.

1. Establishment of geodetic network
2. Creation of cadastre database
3. Creation of underground utility database
4. Digital photogrammetry
5. System construction (both hardware and software)
6. Training of Kuwait Municipality officials

Figure 1. Location of Kuwait

3. Contents of Database

3.1 Establishment of Geodetic Network

Centralized information management, that is, to manage various data under the same coordinate system, is crucial for effective usage of data in GIS system.

Consequently, establishment of high precision national geodetic network was required. Surveys including the first-order geodetic network (101 stations), second-order geodetic network and first-order leveling network were carried out and permanent markers were installed accordingly at each station.

Furthermore, for cadastre surveying control points, data collection and investigation on 50,000 BTPs (Boundary Traverse Point) were carried out, and as a result, 6,000 BTPs were confirmed. Markers were installed at the confirmed points and their coordinates were measured in the course of digital map making.

All these results were input in the database on the basis of the KTM (Kuwait Transverse Mercator), the new national geodetic coordinate system, which would be the basis of all the data for the KUDAMS.

3.2 Creation of Cadastre Database

Instead of using traditional way of mapping i.e. graphic method, numerical cadastre mapping was introduced so as to manage cadastre data by computer. The scale for basic maps is 1/500, and information such as boundary points, boundary lines between parcels, the new as well as old addresses of the parcels and the name of parcel owners were recorded in the database. Other kinds of attribute information were kept in the Regional Legal Affairs Bureau, and, due to their confidential nature, the officials of the Survey Bureau themselves had to input such data. They include registration certificate numbers, names of parcel holders, ratio of ownership, cadastre map numbers and registered cadastre.

Underlying concept of constructing the database in Kuwait Municipality was to create "multi-purpose cadastre database", which allowed efficient management of administrative activities. This means that the database could be used not only for registering parcels by digitizing cadastre maps but also used as a GIS system in urban planning, management of underground utilities and administrative activities.

In multi-purpose cadastre, in general, the present state of land ownership is clearly shown by simply selecting some of the graphic data prepared by other administrative organizations and overlapping them each other. These graphic data include topographic maps, schematic drawings, electric facility control charts, land use maps, transportation maps, agriculture-related maps, hydrographic maps, forest maps, mineral resources maps, etc.

In addition, one of the purposes of creating multi-purpose cadastre is that it stores attribute information (non-graphic information) in database and therefore, such information can be used to calculate cadastral statistic data, assess prices of land, evaluate taxation, and thus can be used as the basic materials for national census and economic statistics.

The following were used as source materials in data input.

- Surveying field notes: about 800 volumes
- Cadastre maps: about 4,000 pieces
- Schematic drawing: about 500 pieces
- Register control ledgers: about 3 meter

Figure 2 Operation Scene

3.3 Creation of Underground Utility Database

Field surveys and measurements were carried out on 12 items of each of 7 kinds of underground facilities.

Markers were set on all the structures such as manholes that could be seen on the ground so that they could be identified on aerial photographs. In digital photogrammetry their positions were measured and recorded in the database along with the results of field surveys. Later, they were output on a 1/500 topographic map for the management of underground utilities.

Items that constitute the database were city water (water supply and waste water reuse), street lams, telephone, electricity (high-voltage and low-voltage), gas, rainwater drainage and sewage.

Other necessary materials for database such as layout drawings, construction drawings, etc. were collected from the related government ministries and agencies. These materials were used to identify exact location of structures in the field surveys. As long as 3,000 km of city water was input in the database.

Information showing present state of underground utilities was recorded and saved in the form of layers to allow central management of these utilities along with cadastre database.

3.4 Digital Photogrammetry

An aircraft for aerial photographing was brought from Japan. Due to sand storms, the period for aerial photographing was limited only from December to March, and this was the most difficult job. Entire area was divided into 4 parts for annual aerial photographing. It took 4 years to complete shooting of the whole area.

In order to keep the same level of accuracy between underground utility maps and cadastre maps, it was determined the scale of topographic maps for the whole are should be 1:500.

Analytical plotters were used to measure topographic features so that their coordinates could be directly recorded in a digital format. This also contributed to maintaining of accuracy. Coordinates of building corners, walls, roads, curb stones, minor diameters, underground utilities, street lamps, counter lines as well as crossline information were measured and recorded.

Furthermore, entire country was covered with photomaps at the scale of 1:10,000, while residential areas were covered with topographic maps at the scale of 1:2,000.

Figure 3　Assembling an Aircraft

Figure 4　Investigation of Underground Utilities (sensor)

3.5　Systems (Hardware and Software)

GIS system in the KUDAMS project was expected to perform the following functions.

1. Various utility data (both graphic and non-graphic data) should be managed in a centralized manner.
2. Precision and reliability of utility data should be improved and uniformity among the data should be achieved.
3. Inputting, editing and outputting of various data can be performed in a simple manner.

As a result, the following were to be achieved.

1. Standardization of utility data
2. Quick updating of secular changes
3. Easy output of maps and statistic data
4. Prevention of accidents during the execution of the work
5. Facilitating inter-availability of various data among the different ministries concerned
6. Easy safekeeping

Upon completion, GIS system would exert great impact on the daily administrative task.

3.6　Training of Kuwait Municipality Officials

Upon completion of data production, the system was required to turn over to Kuwait Municipality. Then, the officials of Kuwait Municipality were supposed to engage in system control and data maintenance.

Therefore, the same systems with the same functions were created both in Kuwait and Japan. The one in Japan was exclusively used for data production and Japanese staff worked in three shifts to advance delivery date.

On the part of Kuwait Municipality, on the other hand, input of the classified data was carried out by the municipality officials themselves. This is because such data were kept at Regional Legal Affairs Bureau and not allowed to take out.

The operations were carried out under the supervision of the Japanese. Cadastre database was finally completed with 5-year of strenuous efforts of about 5 officials of Survey Bureau of Kuwait Municipality and about 20 Japanese engineers.

Figure 5　Staff of Survey Bureau

4. Conclusion

All the contracted jobs were completed in 1990 and the final product was delivered to Kuwait Municipality in the presence of Director General of Survey of Kuwait. Without a long cooperation with the officials of Survey Bureau of Kuwait Municipality for 7 years, we could not have accomplished such a difficult job. Unfortunately, the system was damaged and most of its function was lost in Gulf War. However, I heard that a new database was re-constructed from the backup data kept in Japan and now it is functioning very efficiently in day-to-day administrative work in the Survey of Kuwait.

Establishment of Database for Geographic Information Systems of the Capital Area of the Republic of Madagascar
- GIS Applications for Urban Facilities Management -

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Abstract

The Study of the "Establishment of Database for Geographic Information Systems of the Capital Area of the Republic of Madagascar" produced three types of geographic information database for urban base maps, land-use/land-condition maps, and urban facilities were built. This report relates to the development of the urban facility database and introduces the background for the development and database production. First, the target facilities (road, sewerage, water supply, electricity, and communications facilities) were selected. Then, the items and structure of the database were determined on the basis of the results of a hearing survey undertaken for the required GIS functionality at the related organization. Finally, the information necessary for urban facility management was entered into the database.

1. Outline

1.1 Outline of the Study

The Study of the "Establishment of Database for Geographic Information Systems of the Capital Area of the Republic of Madagascar" was carried out from October 1998 to November 1999, with the implementing organization being Japan International Cooperation Agency (JICA).

Various types of geographic information necessary for formulating city plans (including urban base, land-use/land-condition, and urban facility management maps) were produced digitally and stored in the database. The basic operation system provided for the database (Infrastructure Management System – IMS) was also developed.

1.2 Background

The living environment in the Republic of Madagascar varies greatly between the urban and rural areas, just like in any other developing countries, and the movement of the population from the rural to the urban area is remarkable. The Metropolitan Antananarivo shows a similar tendency, for which the increase in population was drastic. The resulting living conditions have since worsened, and the urban facilities could not cope with the demographic increase.

Under these circumstances, the City of Antananarivo and the Government of Madagascar decided to formulate a concrete city plan in accordance with the Master Plan prepared by the United Nations Development Program (UNDP).

1.3 Objectives

In the above-mentioned background, the Study of the "Establishment of Database for Geographic Information Systems of the Capital Area of the Republic of Madagascar" was undertaken with the objectives of developing the databases for urban base maps, land-use/land-condition maps, and urban facilities.

Figure 1. Study Area

2. Target Urban Facilities

2.1 Selection of Target Facilities

The guidelines for development of the urban facilities database were established as follows:

① To acquire the data that allow a better understanding of the existing conditions of the urban facilities in the city and surrounding areas.
② To develop the database that can be used effectively for city plans and urban facilities construction plans, as well as for the management and maintenance of urban facilities.

③ To develop the database with an architecture that allows the simple and fast building and updating of data.

Following these guidelines, a survey of the database functionality was made with the related agencies, and the urban facilities and related agencies to meet the said guidelines were selected for the database to be built as described below.

a. Roads: Agency, not specified
b. Water supply: JIRAMA (Electricity and Water Company of Madagascar)
c. Sewerage: AGETIPA (Executive Agency and Public Infrastructure Works of Antananarivo)
BDU (Urban Development Bureau)
TECSULT
d. Electricity: JIRAMA
e. Communications: TELEMA (Telecom Malagasy)

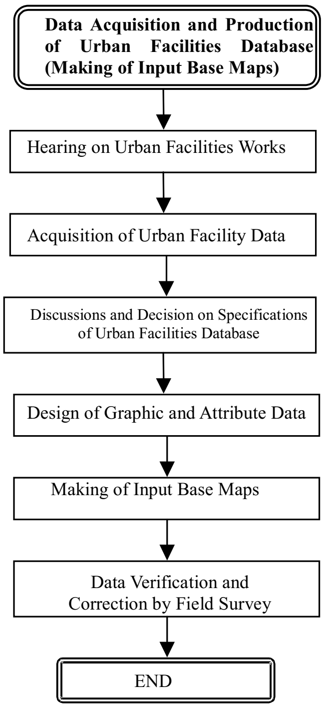


Figure 2. Flowchart of Data Acquisition and Production of Urban Facilities Database (Making of Input Base Map)

2.2 Study with the Related Agencies

A hearing survey with the agencies related to urban facilities was made for the following items:

① Procedures of urban facilities maintenance and management works
② Materials (data) used for urban facilities maintenance and management works
③ Issues and problems in urban facilities maintenance and management works
④ Relationship with other agencies related to urban facilities
⑤ Effective use of materials (data) following the establishment of the database

The survey on Items ① and ② shows clearly that the drawings of the facilities had often been used in the maintenance and management works, and that the retrieval of those drawings took considerable time.

The survey on Item ③ shows that it was important to efficiently update the drawings for maintenance and management of urban facilities, and that there were problems of lost drawings and method of taking custody of the drawings.

The survey on Item ④ shows clearly that the related agencies prepared individually the drawings for maintenance and management.

The survey on Item ⑤ shows clearly that, if the database of the materials (data) for maintenance and management of urban facilities is produced, then the works of maintenance and management would improve substantially.

2.3 Data Acquisition for Facilities Management

Two types of materials for the maintenance and management of urban facilities were collected:

① Drawing materials (data): Topographic maps and facility completion drawings as used for maintenance and management of urban facilities.
② Statistic materials (data): Forms and registers

3. Analysis of Collected Materials

3.1 Classification of Collected Materials

The materials that were collected from the agencies related to urban facilities were classified according to the following categories:

① Graphic materials from which the geographic locations can be specified: Piping and cabling drawings
② Graphic materials from which the geographic locations cannot be specified: Structural drawings
③ Text materials related to the graphic materials: Contracts and agreements
④ Text materials unrelated to the graphic materials: Various forms

3.2 Analysis of Collected Materials

The materials categorized as ① through ④ in 3.1 above were analyzed. The analysis clarifies the following matters:

- Dates of the materials, which were defined for almost all materials.
- From the materials ①, the locations of most facilities could also be defined on the city base map database. These graphic materials included the text information, which was deemed useful for the maintenance management works.
- The materials ② and ③ had a low frequency of utilization in the maintenance and management works.
- Some of the materials ④ were available following the production of the database.

4. Requirements for Facilities Management and Examination of GIS Functions

4.1 Requirements for Facilities Management

The hearing survey undertaken for the maintenance and management works at the agencies related to individual urban facilities clarifies the following requirements:

① The rational methods of custody of materials for facilities maintenance and management and retrieving the necessary materials, whenever needed
② The function for a fast retrieval of necessary materials for the facilities maintenance and management by designating the scope and number of copies.
③ The functions for a statistic process (such as addition, subtraction, multiplication, or division) of the numerical information in the materials for facilities maintenance and management and for obtaining immediate results.
④ The function of mutual correlation of the materials in a simple manner, since a large number of materials relate among them.

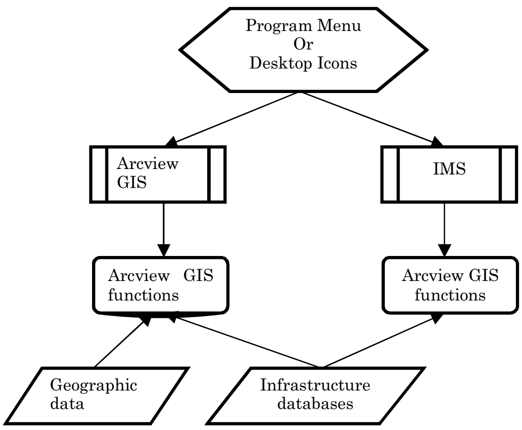
4.2 GIS Functionality

Based on the discussions on the requirements as described in 4.1 above, the following functions could be run on the GIS software (ArcView):

① Graphics-based functions: Scroll, zoom and scaling of graphics, display of specific items, and color designation.
② Retrieval functions: Retrieval through key codes, locations, and other conditions
③ Statistic functions: Data sum-up
④ Display (output) functions: Display and output of cut-out parts of drawings, specific items, and statistic calculation results

4.3 Infrastructure Management System (IMS)

The IMS was configured using the ArcView software. The IMS architecture is shown below.



IMS Configuration

Figure 3. IMS Configuration

① Input system
- Graphic input system
- Attribute data input system

② Management systems
- Urban base map IMS (Inactive database)
- Road IMS (Active database)
- Water supply IMS (Active database)
- Sewerage IMS (Active database)
- Electricity IMS (Active database)
- Communications IMS (Active database)

③ Functions of management systems
The four functions as described in 4.2 GIS Functionality were implemented.

5. Database Development

5.1 Decision of Data Items

The collected materials, the requirements for the facilities management, and the GIS functionality were examined to decide the following data items for each database:

① Road database
Graphic data: Road center line, road width lines, section lines, etc.
Text data: Road width, road number, road structure type, etc.

② Water supply database
Graphic data: Boundary, conduits, valves, and other facilities
Text data: Boundary name, conduit number, valve number, etc.

③ Sewerage database
Graphic data: Manholes, conduits, etc.
Text data: Watershed name, manholes, conduit number, etc.

④ Electricity database
Graphic data: Facilities (such as substation), power line, poles, etc.
Text data: District number, power line number, pole number, etc.

⑤ Communications database
Graphic data: Manholes, poles, armored cables, distribution units, etc.
Text data: Manhole number, pole number, armored cable number, etc.

Table 1. Graphic Coordinate Data Format

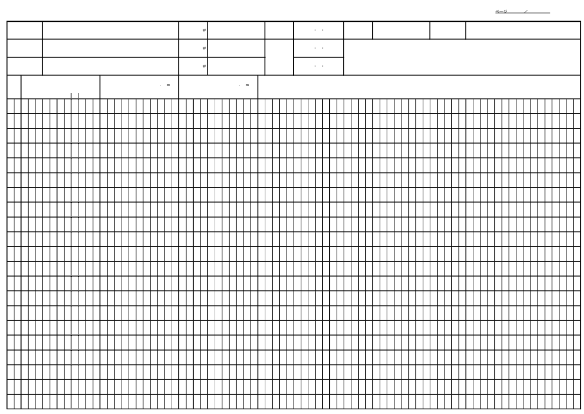
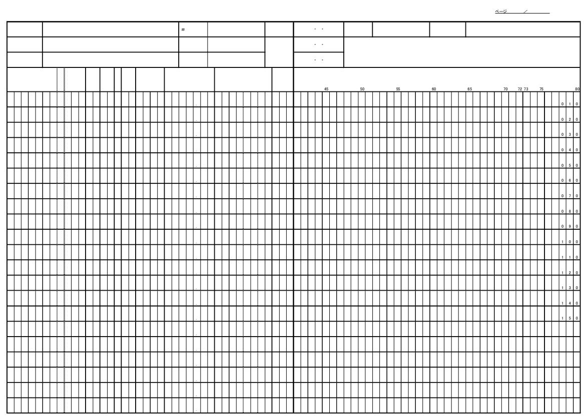


Table 2. Attribute Data Format



5.2 Design of Graphic and Attribute (Text) Data

The graphic and attribute data were built as follows:

① The graphic data were configured with points, lines, and polygons.
② The attribute data were defined by data type, display size, and number of characters.
③ As two or more data files are used simultaneously, the required key codes were set and the relational files defined.
④ The display windows for displaying graphic and attribute data were defined.

5.3 Data Entry

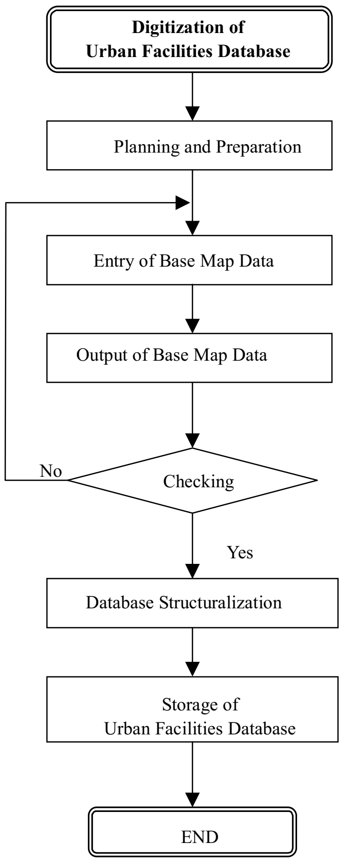


Figure 4. Flowchart of Digitization of Urban Facilities Data

The neat lines for a 1/2,000 map sheet were defined on the urban base map database and the data entry was made in the neat line unit.

5.3.1 Entry of Graphic Data

The input base map for the graphic data was prepared from a 1/2,000 map and the data were entered in the input map.

5.3.2 Entry of Attribute Data

A data sheet was prepared for the attribute data which were entered in the sheet before being input in the system.

5.4 Data Quality Control

5.4.1 Guidelines for Quality Control

Visual and logical checks were made for each process of developing the database and the minimization of data errors was adopted as the guideline for quality control.

5.4.2 Quality Control

In accordance with the above guideline, the data quality control was performed under several conditions, and various quality control methods (such as visual check, same check by two or more persons, and logical check through computer) were adopted and executed.

6. GIS and its Future Issues

For this Study, a limited number of data items, such as roads, water supply, sewerage, electricity, and communications, were selected from the urban facilities, and the database on those items was built for a limited range of areas of Antananarivo City.

6.1 Map Data in Building the Infrastructure Management Database

When building the urban facilities database, it is important to specify the geographic location of each facility. Should it be otherwise, the mutual relations between the facilities would be unclear, and operating the infrastructure management system would be hard to handle. Therefore, the urban base map database (map data) used to specify the geographic locations of urban facilities constitutes an essential instrument for building the infrastructure management database.

6.2 Operation of Infrastructure Management System (IMS)

(1) Validity of the IMS

Only five items of urban facilities in a limited area were adopted to develop the database. Though the database was built for a limited area and number of facility items, the GIS was used and the database became a powerful tool to understand the actual conditions and execute the construction or improvement plans for the urban facilities. The GIS will thus be instrumental in formulating the city plans in Antananarivo City.

(2) Review and Discussions on the IMS

A very limited basic infrastructure management system was configured in this Study. This system will allow a suitable management of the urban facilities. However, for an improvement of the system, it is necessary to carry out the study (work study) related to the detailed works of the administrators of the facilities, the procedures of the works, and the utilization of the materials (graphic and attribute information). Further, the functions of the IMS and the database design should be reviewed and discussed while taking into account the results of the study. When building the expanded database, the following issues should be treated:

① Discussions on expansion of the targets for the database development
② Discussions on information items to be covered by the database
③ Discussions on areas to be covered by the database
④ Standardization of material forms to be prepared for the urban facilities
⑤ Improvement of input base maps and attribute data creation

manual
⑥ Improvement of tools for building the database
⑦ Establishment of a method for systematic database quality control

7. Conclusion

A good deal of human resources will be required for the operation of the GIS that is usable for urban facilities management. To this end, the technology transfer must concern not only the building and operating of the Infrastructure Management System, but also the training of staff of the following categories:

- Engineers in the work-study and analysis
- GIS engineers
- Engineers in database development

The above issues must be dealt successfully for an effective use of the GIS, so as to cope properly with the actual situation of the Republic of Madagascar.

An Asset Mapping in East Timor

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Abstract

The riot, which happened after the local referendum held in September 1999, heavily damaged infrastructure in East Timor. An asset mapping system is a management system of water pipelines in East Timor on purpose of understanding a current condition of water supply and launching a new development plan as part of the rehabilitation plan of infrastructure. Information described the present condition related to water pipeline, which was heavily damaged over the country, has been entered into a database. The management system of water supply have begun operating in fall 2000, which would be a foundation of the development plan of facilities in the future.

1. Background of East Timor

East Timor is 14,609 square kilometers in area, whose population in 1999 is 890,000. Since it became a colony of Portugal in the sixteenth century and Portugal gave a half of the western part of Timor Island to the Netherlands in the seventeenth century, Timor Island has been divided into two parts under two different countries, the eastern and western part of the Island. Socialist regime of Portugal carried out liberation policy to colonies outside of the country in 1975. As a result, power between the moderate and the independent parties launched a civil war and the independent party declared the sovereign of democratic republic of East Timor. Soon after the declaration, pro-Indonesian militiamen occupied the entire land of the country and established the provisional government of East Timor. The following year, Indonesia integrated East Timor as the 27th province of their territory.

As East Timor has been ruled by the Indonesian government under the amalgamation policy, citizen’s resistance against the government has begun and force to seek their independence has grown. While UN deployed a mission in East Timor to keep peace and order in 1999, popular consultation to suggestion of special autonomy was held and the riot against the referendum happened by the pro-integration. The UN sent off Multinational Army to East Timor in September 1999 and established UNTAET. The establishment of UNTAET evacuated Indonesian Army from East Timor. The capital of East Timor is Dili, which has a population of 200,000. A common language is Tetung and about 90 % of the population is Catholic.

2. Water facilities in East Timor

It is not possible to find out details of the condition about the development of water facility in Dili during the government ruled by Indonesian because the storage building for government publications and documents was burned. But according to hearings to officers, who belong to division of water facility of UNTAET, it is said that three locations of facilities for purifying water and pipeline network in Dili was developed as well as water facilities and pipeline network in other few cities, by the assistance of Australian government since 1993.

At the same time, it began to operate a system to design water facilities in Dili, which is utilized such as CAD (Computer Aided Design), automated mappings, PC, and so on. The system makes it possible to register and manage data of drawings, which are designed and established in planning of a new water facility, and associated data, which are records of repairs and the maintenance expected in the future.

Water facilities became a target of the riot to cause serious damage since fall 1999 and three water purification plants in Dili have been torn down, and pipeline leakages were found everywhere because many water pipelines in the city was destroyed. In addition, the system was demolished, which designed water facility assisted by Australian government and already started operating, and there is no means to find out the system.

Numerous water facilities in cities other than Dili have been damaged and cannot supply water. Even if they can, the quality of water is not enough for drink.

3. The basic plan of an asset mapping system

The basic plan for an asset mapping system was established in Dili. The targets for the plan are Dili, the capital of East Timor, and other growing cities as follows;

Aileu, Ainaro, Atauro, Baucau, Ermera, Gleno, Liquica, Los Palos, Maliana, Maubisse, Manatuto, Same, Suai, Viqueque

3.1 Status of maps

Since it is not possible to find a map as the use of base map, it is collected topographic maps managed by UNTAET and maps developed during planning of the rehabilitation.

- Topographic map: 1/25,000 scale map printed by Australian Army in 1999 based on an original map, which is surveyed in 1990 to 1992 by BAKOSURTANAL Indonesia.
  Coordinate system: Origin of Indonesia (1974), WGS84 coordinate system is added.
  Projection: Transverse Mercator
- Topographic map: 1/2,000 scale digital map in the area of Dili created by JICA in 2000 through aerial survey.
  Coordinate system: WGS84
  Projection: Transverse Mercator
- Pipeline network map: scale and years of the preparation are not known and whose area covered only Dili.
- A map related to water supply and sanitary planning in East Timor: scale and years of the preparation are not known and whose area covered only Dili.
- Collection of plans related to the PETA LOKASI plan: scale and years of the preparation are not known and whose area mainly covered Dili, including some other rural cities. Descriptions of topography importantly related urban planning, natural environment, present conditions and future vision of public facilities. (Some part are damaged.)

Out of items above, the scale of 1/25,000 topographic maps was made enlarge or reduce into 1/50,000, 1/10,000, 1/5,000 and etc. so that it can be used for other different purposes.

3.2 Introduction of GIS

Since 1993 Dili introduced CAD by assistance from Australian government to carry out the development of facilities. This system has a main purpose to support designing and a consistency in designing new facility and estimating the cost at the same time. However, it is not effective in organizing data for the maintenance to update records for repairs of facilities. Since there is no database integrated drawings and associated data, it required making changes for two different databases individually. Because of that, it is often found such mistakes that CAD data were made changes while data associated with the construction history were not updated or wrong addresses were entered. This system employed GIS to make up for the disadvantage of CAD system and GIS software, called ArcView, can make both drawings and associated data integrate.

Following functions of geospatial analysis allow this system to apply for various goals in the future.

- Search drawings and retrieve tables

Identify dates established water facilities and find pipelines constructed more than 15 years ago

- Overlay

Create a plan to locate water facilities according to population data by overlaying topographic data and urban planning data.

- Buffering

Manage data about residents surrounding main roads

- Network

Analyze the pipeline network system

3.3 Hardware

PC (OS is Microsoft Windows NT) and a printer (connected to PC on network) are needed to carry out an asset mapping system.

3.4 Software

Applications used here to operate an asset mapping system are ArcView3.2, ArcPress3.0, and Office 2000.

4. Establishment of database

Most of data for an asset mapping system are geospatial data. Although it is necessary for the maintenance and management to establish a database of the data associated with drawings on a map, it has not been achieved yet since the demolition. This paper describes a target area, the city of Dili, and 14 cities in a different section.

4.1 The city of Dili area

Digital topographic data and 1/25,000 scale topographic maps produced a base map.

- 1/2,000 digital topographic data (digital topographic map created by JICA).
- Associated data･･･ data of facilities and pipeline network

Data for pipelines and water facilities (including river intake facilities, wells, water purification plants, distributing reservoirs, pump stations) are maintained on different layers separately using on 83 topographic maps of the city of Dili. Water facility has associated data (vector data), such as field photos, survey data, and etc. Although it is not certain when maps of pipeline network were completed and what kind of scale they were, they are converted into digital maps, identifying whether a pipeline is located or not according to results of field survey. Thus, data for pipeline network are established by rectifying victor data based on topography. Pipeline network has two associated data, diameter of pipelines and direction of water flow. Figure 1 shows one of pipeline network.

Figure 1. Pipeline network in Dili (displaying pipeline in bold)

4.2 Other 14 cities

Following topographic maps produces a base map.

- Raster data obtained from scanning 1/25,000 scale topographic map
- Associated data･･･locations of water intake facility, data for service area(vector), data obtained from field survey, data for sectional plans of facility location(vector), field photos, sketches(raster), etc.

The coverage to create topographic data is from the location of supply facilities to the service districts, which is identified by field survey in 14 cities. The size of coverage would vary among these cities because of following reason. The coverage would be lager in the region, which have long distance from service districts to source of water, while the coverage would be smaller in the cities, which have relatively short distance. In addition, data for supply facilities and service districts should be vector data and maintained as an independent layer, separating from topographic data. Figure 2 shows an example of displaying the map.

Associated maps of field survey and sectional plans of facility locations are scanned and converted into vector data by raster-vector conversion. Filed photos and sketches are raster data. Data of facilities include water intake facilities (rivers and spring water), wells, water purification plants, distributing reservoirs, pump stations, tanks for reducing pressure, and pipelines.

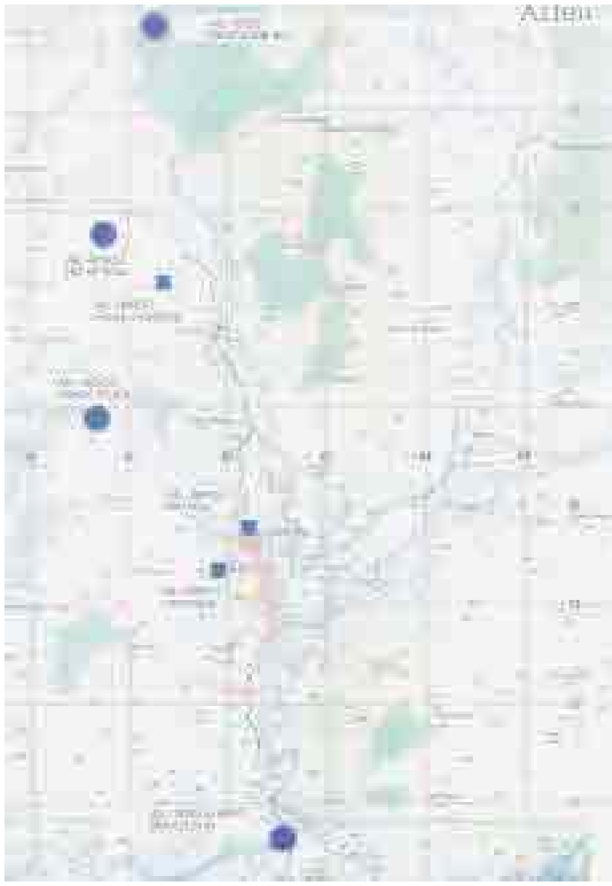

Figure 2. A present map described water pipeline in the rural area.

4.3 Data for the evaluation of facilities

It is raster data that entered as data of the evaluation of facilities, which describes the present condition and calculated cost to rehabilitate the deterioration in terms of entire water facilities from water intake facility to service area. Since Dili and other 14 cities have forms of data sheets in common, it is easy to display data through a filing function. Figure 3 shows a part of sheets.

5. Operation of the system

The operation of database has started after digital data were obtained from results of geographic survey. This system is operated by three PC, which is connected each other on network, and three PC are installed Office 2000 and two out of three installed ArcView. Although this system basically has functions to locate and search facilities, it is necessary in the future to increase additional functions, such as displaying drawings and updating database.

Town: Dili	**No. & Facility:** 23 - Bedoisi Resevoir	**Year of Construction** 1998	**Financed by:** Bia Hula
Existing Condition: *Structure:* Reinforced Concrete *Shape:* Rectangular *Dimension:* 5.8m x 5.6m x 2.2m. *Capacity:* 45m^3 *Function:* *Source of Water:* Bedoisi well *Ground level:* *Accessories:* overflow pipe washouts		**Photograph:**  (Date: June 2000)	
Evaluation: No ventilation & level gauge. Water leak was seen coming from the valve.			
Rehabilitation Plan: *1) Basic Calculation* Reservoir is constructed close to private houses. For continuous use in the future, minor rehabilitation is required. *2) Civil Work:* Construction of securtiy fence *3) Piping work:* Installation of flow meter and controller *4) Mechanical work:* none *5) Electrical work:* none *6) Miscellaneous:* Installation of chlorine dosage devices			
Estimated cost: US$7,379	**Construction schedule:**		**Priority:** A-2

Figure 3. Data for the evaluation of water facilities

6. Challenges for an establishment of setting the system

Summary of challenges to establish an asset mapping system are as below in targeting on technology transfer and the environment of setting the system.

6.1 Difficulties of technology transfer

Even though East Timor has been ruled by UNTAET since the riot, the political situation hasn't been settled yet and a significant amount of people still sheltered from East Timor to West Timor after an evacuation of Indonesian Army. Therefore, it has been little to give a chance to learn higher skills for ArcView, GIS software, and it was not enough to transfer advanced technology. There are several factors to emphasize as follows.

- Lack of personnel, who have experience to operate PC.

There are little specialists to learn how to operate the system, since the distribution rate of PC is low in general. It is not possible to find who had managed and operated the system to design water facilities before. Even if it is found a person who was responsible for the operation under the specialist before, the knowledge of hardware and software skills is poor.

- Lack of specialists, who have comprehensive knowledge of water system.

There are no specialists who know well about supply facilities in Dili ranging from water purification plants to houses of customers and comprehensive knowledge of water system in other 14 cities ranging from supply facilities to service areas.

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6.2 The environment of setting the system

Although it was possible to establish an asset mapping system under the condition that the rehabilitation of facilities for water management is still underdeveloped, it remains following issues in the environment of setting the system.

- High humidity and high temperature

PC is not necessary to prepare a special room for computer, but it is not possible to install PC in a room without high humidity and high temperature seen in tropical zone. When the power of PC is switched on, the thermometer shows 35 centigrade. Even if fan is set, it is not still efficient. It needs to be improved.

- Concerning of disk crash because of the instability of power

Electrical power often becomes out of service, although Dili receives a supply of electrical power from generating power plant. Or even not power down, there is clear evidence that the electrical power have unstable frequency on a regular basis. Although UPS is setting up between the system and a power source, it needs additional devices to stabilize frequency of electrical power.

- Time issues that it takes long time to recover the system because there are no extra parts to repair.

Since there is no shop in Dili to sell PC accessories and extra parts, it needs to go to Darwin, Australia or Bali, Indonesia to purchase these.

The Utilization of GIS Applications at Gas Companies in Japan and Other Asian Countries

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Abstract

It has been the most critical theme for gas companies to develop, manage, and maintain a network of gas pipeline accurately. Recent deregulations also make Geographic Information Systems (GIS) increasingly important. This paper describes overview of utilization and development of GIS at gas companies in Japan and other Asian countries and introduces case studies of the GIS development, the system development, and the specific applications (such as mobile and WEB GIS), which is applied by Tokyo Gas and Gas Malaysia.

1. Introduction

Turning to the twenty-fist century, the environment surrounding utility companies has become more difficult. A wave of globalization bringing deregulations, which is happening in particularly Europe and the United States, is pushing over to Japan gradually. This trend is already seen throughout communication industry and it is just a matter of time that energy and gas industry would have the same effect. To survive such an environment for utility companies, the most essential target strategy is exactly to realize infrastructure owned by the company and capture his own customers. It is true evidence that GIS will become most advantageous tool to achieve his strategy. Whether or not a company accurately realizes its own infrastructure is considered as not only a tool to survive this coming age of deregulation and competition but also a measurement to determine a company's rating.

This paper illustrates how gas companies of Japan and other Asian countries, introduce GIS, which plays an important role of strategy, and apply for their company strategy, giving examples of Tokyo Gas and Gas Malaysia.

2. The Utilization of GIS in Gas Company of Japan

2.1 History of GIS Development

There is no discussion to consider that the beginning of GIS development in Japanese gas business was from the gas accident of Tenroku, Osaka in 1969 and Itabashi, Tokyo in 1970. After these gas accidents, The Ministry of International Trade and Industry advised all gas companies to develop 1/500 scale map of gas pipeline. Tokyo Gas created gas pipeline maps, which had took ten years to complete since 1973, using a road map of local governments and Osaka Gas took aerial photos independently and developed gas pipeline maps. The effort to develop this gas pipeline maps was a major factor so that gas business could start GIS earlier than any other industries. Tokyo Gas has begun research and development of GIS since the end of 1970s, employed full-scale GIS in 1983; it was the first company amongst utility companies, and started data entry of 30,000 pipeline maps covered his own supply area.

Following Tokyo Gas, in the end of 1980, Hokkaido Gas, Seibu Gas, Osaka Gas, Touhou Gas, and Hiroshima Gas introduced GIS as well and began data of pipeline maps.

2.2 The Utilization condition of current GIS

Since Japanese gas companies confronted their necessity above mentioned, they have begun research and development and introduced GIS relatively earlier stage. Today more than 70 gas companies operate GIS system. Although the content of operations is a little different individually amongst companies, the figure 1 illustrates that GIS is applied for broad range of works as such as drawing plans, searching pipelines, maintaining facilities, preventing earthquake disaster, planning facility, and so forth.

GIS applications are particularly operated more important work associated with gas pipeline, such as drawing plans in plotter, searching pipelines, maintaining facility and calculating gas pressure and stream flow (network analysis).

In addition, 70% of gas companies introduced GIS use applications, which are integrated with Customer Information System (CIS), and it is clear that the form of integrated GIS combined with CIS is operated throughout all companies (Fig.1)

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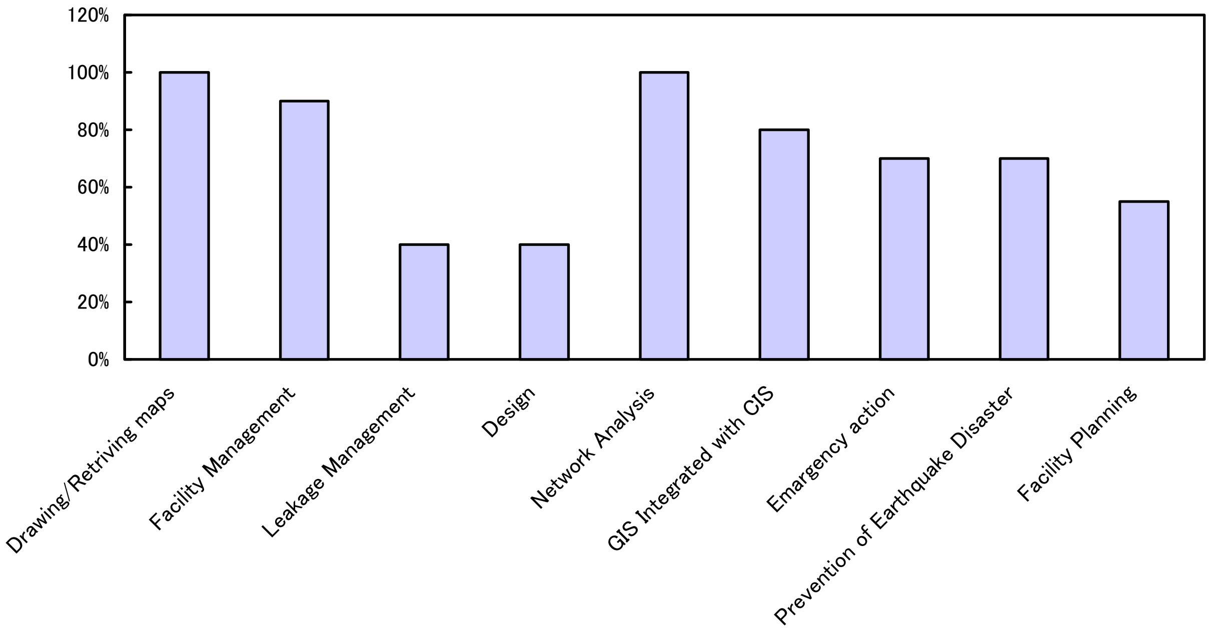

Figure 1. GIS Applications in Gas Companies

2.3 The utilization of GIS in Tokyo Gas

2.3.1 The Formation of GIS Development

The development process of GIS in Tokyo Gas has mainly three phases. Phase I is to achieve entry of 30,000 pipeline maps and the establishment of Automated Mapping and Facility mapping (from 1977 to 1987). Phase II is to integrate GIS with Customer's Information System; CIS (from 1988 to 1992). Phase III is to develop GIS in mobile and strategic fields (since 1993). Table-1 explains geospatial database and applications created during each phase.

Table 1. The Formation of GIS development at Tokyo Gas

		Subject	Geospatial Database	Specific Applications
Phase I	Develop AM／FM	Conversion of Basic Maps and Development of Applications (from 1977 to 1987)	Build database for 30,000 maps of main/sub pipelines (main/sub pipelines, bulb, governor, topography, and place's names)	• Automated Mapping (AM) • Facility Mapping（FM）
Phase II	Develop integrated GIS	Completion of GIS integrated CIS and integrated database (from 1988 to1992)	Build database for 22,000 maps of supply pipelines (supply pipelines, gas meters, and shapes and names of houses)	• Integrated Information Retrieval System • Pipeline Network Analysis System • Design System
Phase III	Develop GIS	Mobile GIS and strategic GIS (Since 1993)	Enter strategic data (initial investment area and planning line, population projection data, and residential maps)	• Safety Planning System • Prevention and Rehabilitation for earthquake disaster • Emergency Safety Support System • Laser- Methane Locator System • Investment Planning Support System • Facility Investment Outcome Evaluation System

2.3.2 Total System Structure

Figure 2 shows the system structure of GIS in Tokyo Gas. It is clearly seen in the figure that both database of GIS and CIS are setting a computer located at the department of Information Communication in Makuhari, Chiba prefecture and each server of GIS and CIS is controlled by Compaq ALPH 8400 and IBM system respectively.

The host server is connected with each office in 64,000bps high-speed digital network and approximately 300 terminals including Engineering Workstation(EWS), Personal Digital Assistant (PDA), and mobile terminals and emergency car. The host server maintains a geospatial database and 80 terminals located at offices keep database update online and real time for every report for repairing work.

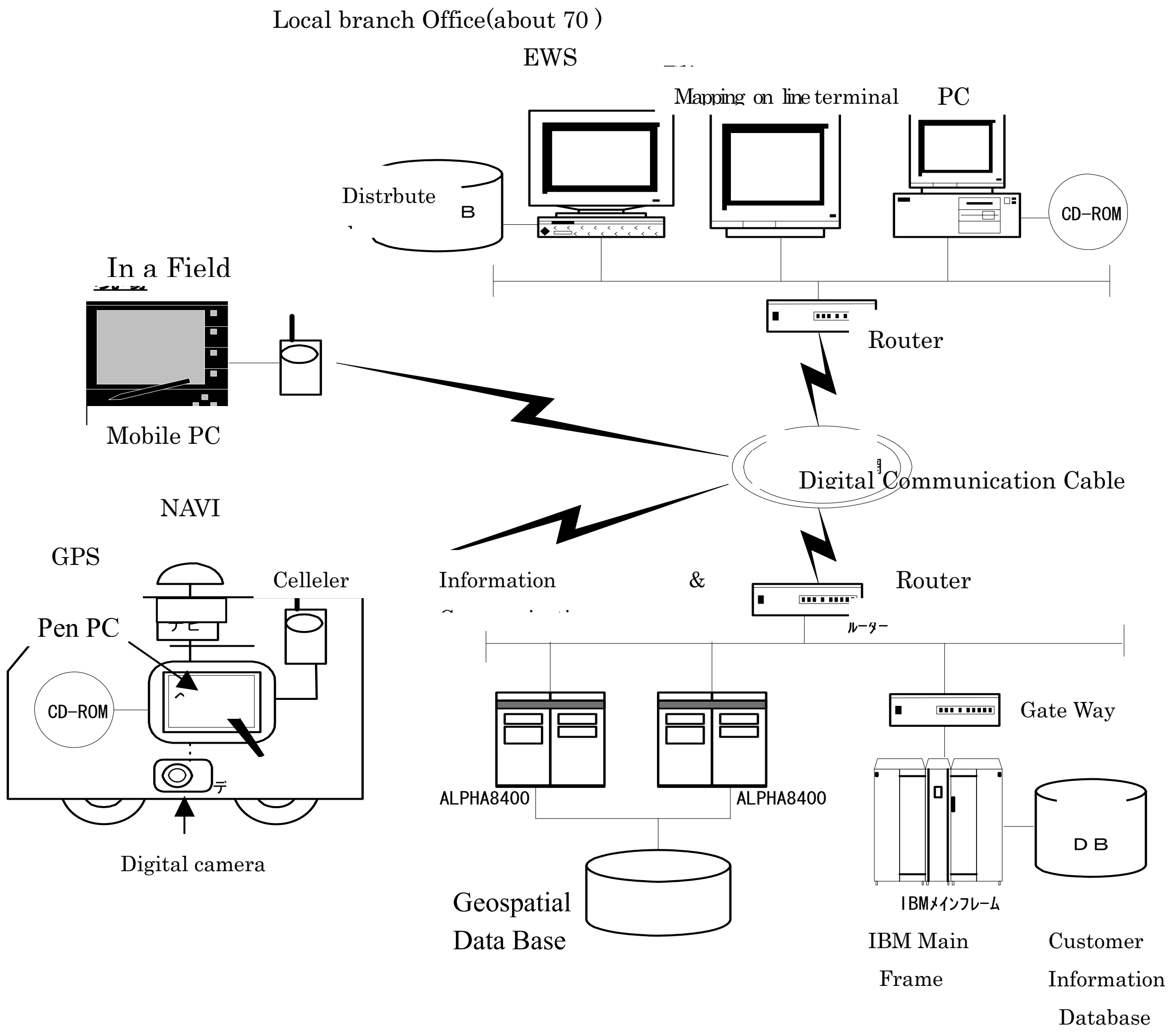

Figure 2. System Configuration

2.3.3 Mobile / WEB GIS Operation

The environments are called mobile and WEB GIS that everybody can simply and easily access to geospatial database by a personal computer at an office or PDA in a field. Tokyo Gas has run WEB GIS in about more than 5,000 OA terminals and PDA. Table 2 illustrates the utilization of WEB GIS in Tokyo Gas (Table 2).

Table 2. The Utilization of WEB / Mobile GIS at Tokyo Gas

Category of Systems	Applications /Subjects	Description	Use of Divisions
WEB GIS	Pipeline Facility Information Retrieval System	Show a view of a plan specified by addresses and the code of pipeline map and an information table of specified pipeline.	Company-wide
	Locating Residential Maps	Show a view of residential map, which is specified by addresses and landmark. In addition, it makes it possible to search the name of the closest station based on address automatically. (it is used as various guide maps like setting a l ink to the company's bulletin board on intranet)	Company-wide
	Locating Gas Meter Guide Maps	Show a pass of the examination on the map when it is entered the examination code of the area assigned by responsible individual. (It includes information about individual vacation and relocation, education for a new staff, and etc.)	Division of Gas Meter Examination
	Business Information Registration/ Inquiry （has been developing)	Register locations of expecting new buildings on the map and show a distribution map of buildings adjacent to them.	Business Division
	Guide for local branch offices / service offices	A system for which a company can guide information of local branch offices and service offices and company's services to customers, when received a customer call. Search the closest local office to customer's address and inquire notes of direction.	Division of Customer Service
Mobile GIS	Emergency Work Support System	An emergency car, which is reserved and ready to go to the sites of accidents and constructions, are installed a terminal, which is able to enter data by pen, so that staffs make inquiries about information of gas pipeline in a field. It has a mobile function to take notes in a field and send reports to offices.	Department of Emergency Work Support
	Prevention and Rehabilitation for earthquake disaster (under consideration)	Show a map on a mobile terminal and enter description of damage on the map while the damages by a large-scale of earthquake is repaired for rehabilitation. In addition, it is possible to enter restoration information in the computer about gas pipeline damaged by earthquake in a field.	Division of Safety Support
	Methane Locator System	A car installed a terminal, which is associated with Methane Locator System and Car Location Management System, automatically record locations of gas leakage.	Division of Safety Support
	Regular Inspection Work Support System	Show a location of pipeline to extend or a gas meter of the building specified for a regular facility inspection. In addition, show a building on a map, which should examine and particularly need to inspect, and support work planning.	Division of Safety Support
	Business Support System	Inquire a map of gas pipeline in the field expected to build, conduct research about the condition of gas pipeline surrounding a target building for sale , and register information about a promising customer's building on the map.	Division of Business

Following section introduces case studies of mobile and WEB GIS.

2.3.3.1 Emergency Protection Work Support System: EAGLE24

Emergency Protection Work is to perform an emergency course of action when it is received urgent accidents like fire or gas leakage. In this context, Tokyo Gas has divided its own supply area into eight districts and established a special department called "Gas Light 24" for each district. Each Gas Light 24 is composed of an Emergency Call Center and several Sub Centers and emergency cars, which stand by each center and are ready to leave, can go to the front in emergency.

The Emergency Call Center maintains GIS for reserving emergency cars and supervising work condition and makes an order properly which emergency car should go to a place according to its location when an emergency call is received. Each emergency car can receive an order from Emergency Call Center, such as geographical information of the field and accident information, via a mobile terminal. Mobile terminal allows a field crew to inquire gas pipelines in a field, take notes or make reports of the condition of a field, and send them out to other centers (Figure 3).

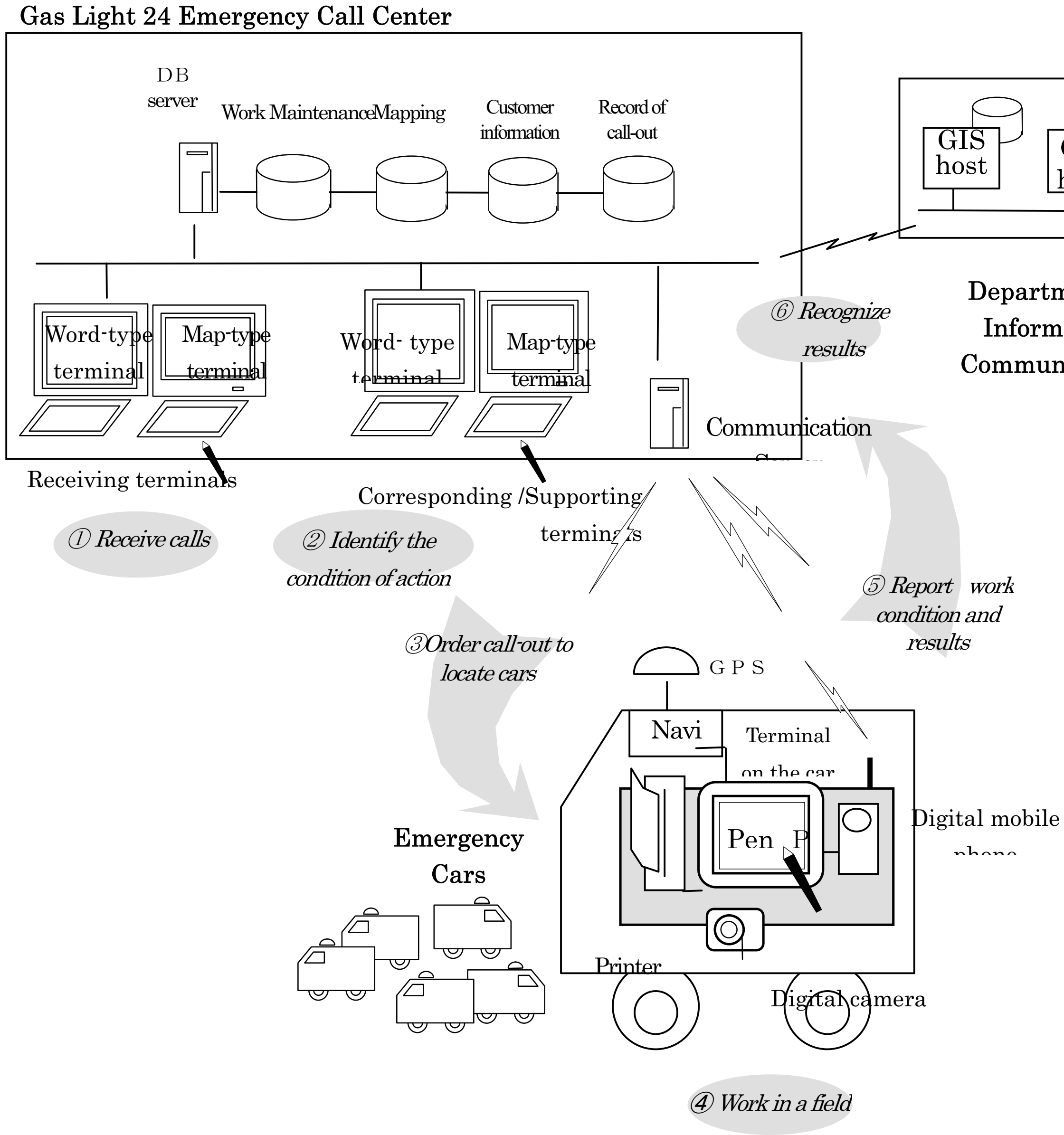

Figure 3. The System Structure Map of EAGLE

2.3.3.2 Business Support system

A system called Business Support System has been developing, which supports business operation with displaying status of gas pipes and customer information by means of PDA or mobile phones, when a staff sells services (solicit gas service, improvement and etc.) in a field. Figure 4 shows a pipeline map drawn by GIS (Figure 4).

Figure 4. The Utilization of WEB GIS on mobile phone

3. Present status of utilization of GIS in Asian Gas Companies

3.1 The Utilization of GIS at Gas Companies in other Asian countries

Introduction of GIS at gas companies in other Asian countries has begun since 1990s and GIS has been operated by a number of companies, such as Great Taipei Gas in Taiwan, Beijing Gas and Shanghai Gas in China, Seoul City Gas in Korea and others in Philippine, Singapore and Malaysia. Most of GIS applications are used the United States or European system like Intergraph, ESRI, and Smallworld, Inc. and the system architecture is applied for relatively new structure such as client/server system and LAN system.

3.2 GIS Operation of Gas Malaysia

Petronas Gas Bhd, Tokyo Gas, and Mitsui Company Limited. established Gas Malaysia in 1992 as a city gas business to employ abundant resource of Natural Gas in Malaysia. Gas Malaysia delivers gas to mainly Kuala Lumpur and industrial customers surrounding area, such as Shah Alam, Klang, and Seremban (Figure 5)

Although the number of customers are about 1,000, the sales of Natural Gas is approximately 600 millions cubic meters in volume per a year and the length of its pipeline is about 350 kilometer. Gas Malaysia introduced GIS in 1994 in order to maintain and plan its own Medium-High Pressure Network System and took five years to complete data entry of pipeline maps.

Currently, GIS is used for SCADA (Supervisory Control and Data Acquisition) as well as plotting and searching maps. Therefore, GIS performs pressure flow analysis (Network Analysis), one of geospatial analyses, and it is efficiently used for a primarily maintenance for Medium-High Pressure Network System and a future planning. In the future, it is expected that gas companies will implement mobile/WEB GIS to fulfill both works efficiently in fields and offices.
(Figure 6)

4. Conclusion

Although GIS initially introduced to manage their own infrastructure precisely, GIS has become an integrated type of application linked with a different system like CIS and play a very important role to backup the total management of a gas business. An important feature of GIS is that not only initial investment cost is huge for the entry of maps and plans into the computer but also the establishment of GIS brings a great advantage in the end. GIS makes it possible for companies to reduce cost in many work processes such as simplifying drawing plans and restructuring work outside of an office by mobile and WEB GIS.

Thus, it will be essential that gas companies in the world as well as Asia will introduce GIS system in the twenty-first century. Considered this situation, it is expected that GIS will be standardized by ISO/TC211 in 2002 to be able to manage system and data of GIS more easily. After standardized GIS, it is anticipated that more gas companies will operate GIS effectively.

Figure5. Supply Area of Gas Malaysia

Figure 6. The Result of Network Analysis

Study for Establishment of National Basic Geographic Data in The Republic of El Salvador

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Abstract:

The Study for Establishment of National Basic Geographic Data in The Republic of El Salvador was decided to conduct by the Government of Japan in response to the request of the Government of the Republic of El Salvador and Japan International Cooperation Agency (JICA) dispatched a study team organized by Pasco International Inc. to El Salvador, several times between March 1999 and July 2001. At the beginning of the study, main final products were digital topographic data for the whole country, however disaster maps and hazard maps were additionally added because the two large scale earthquakes occurred in January and February 2001.This study was an example how the several types of digital data for GIS were actually and effectively used.

1. Background

The Republic of El Salvador was heavily damaged by the Civil War from 1979 though 1992, the large-scale earthquake in 1986, the hurricane Mitch in 1998 and so forth. For the reconstruction and development, the Government of the Republic of El Salvador has been promoting economic development, reconstruction of infrastructure and protection of the natural environment, and requested the Government of Japan to establish national basic geographic data in digital format.

Accordingly, JICA undertook "The Study for Establishment of National Basic Geographic Data in the Republic of El Salvador" (the Study) in cooperation with the authorities of the El Salvadoran Government.

Meanwhile, in the course of the Study, an earthquake occurred in El Salvador on January 13, 2001 with a magnitude of 7.6 on the Richter scale, and another earthquake followed on February 13, 2001. For the urgent aid of the earthquake disaster, the additional preparation of the disaster maps of landslides caused by the earthquakes and hazard maps for landslides and debris flows to indicate potential danger of a secondary disaster were added to the objectives of the Study. The Study was started in March 1999 and continued to July 2001.

2. Objectives of Study

At the beginning of the Study, the main objectives were to create digital topographic data covering the whole country as the national basic geographic data, and to transfer the technology about the data creation and updating to the counterpart agency, Instituto Geográfico Nacional "Ing. Pablo Arnordo Guzman" (IGN), Centro Nacional de Registros, Ministerio de Economía in El Salvador.

Due to the two large-scale earthquakes occurred during the Study period, the final products were as follows:

1) Conventional topographic maps on a scale of 1/25,000 (approx. 3,700 km^2) for the area that there was not the existing 1/25,000 scale topographic maps
2) Digital topographic data for the whole country which positional accuracy is corresponding to the existing 1/25,000 scale topographic maps (approx. 20,740 km^2)
3) Digital disaster maps of the landslides resulted from the earthquakes in January and February 2001 (approx. 5,100 km^2)
4) Digital hazard maps for landslides and debris flows to indicate the areas susceptible to a secondary disaster (approx. 5,100 km^2)

3. National Basic Geographic Data

GIS spatial digital data was created as the national basic geographic data. The existing 1/25,000 scale maps were digitized, and for the areas where does not exist the paper maps, the new aerial photographs were used to create the digital data. A flow chart of the data creation digitizing the existing paper maps is shown on Figure 1.

19 layers of the digital topographic data were defined. Their categories and types were as follows:

- Administrative area, line and polygon
- Road, line
- Railroad, line
- Built-up area, polygon
- Building, polygon
- Settlement, point
- Well/Tank, point
- Utilities, line
- River centerline, line
- River, polygon

- Cartographic point, point
- Cartographic line, line
- Vegetation, polygon
- Land form, polygon
- Contour line, line
- Spot height, point
- Terrain, line
- Control point, point
- Annotation, point

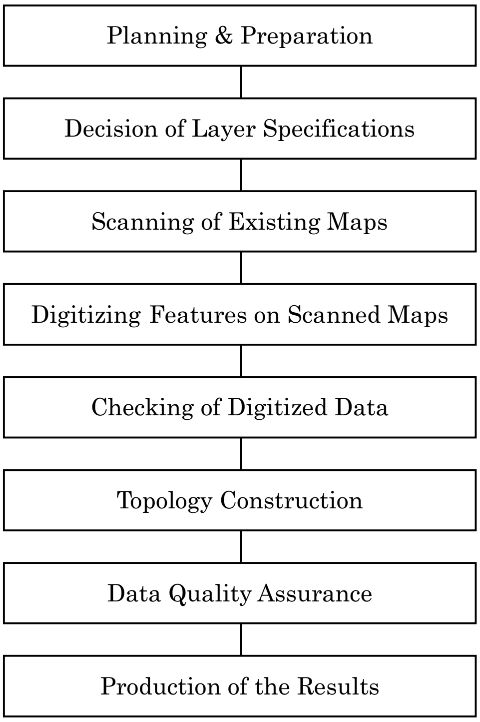

Figure1. Data Creation from the Existing Maps

4. Application to Disaster Prevention

When the digital topographic data were almost ready to be created, the two large-scale earthquakes occurred and El Salvador was seriously affected. Therefore, the urgent aid for the earthquake disaster was planed, and the creation of the following two data sets were determined as application of the digital topographic data: (i) disaster maps of the damaged areas resulted from the earthquakes and (ii) hazard maps of landslides and debris flows for the prevention of the secondary disaster.

However, there were some problems. The available digital topographic data should be updated because the data created from the existing maps had been prepared about 15-20 years ago. Moreover, there were not the recently taken aerial photographs covering the whole disaster areas and the study period left was very limited for updating the data.

4.1 Updating of the digital topographic data

Updating for limited major changes of roads, build-up areas and houses were decided and data collection was carried out in El Salvador for only three weeks.

Because the national basic geographic data created through the Study were digital data, it was rather easy and quick to update each layer , and variable reference data were used for updating by the same method. The topographic data were updated viewing the reference data like SPOT satellite images or scanned map images as background on a computer screen.

The reference data used to update the digital topographic data were the followings:
- SPOT satellite images
- Aerial ortho-photos (panchromatic, 1/5,000)
- The existing 1/5,000 topographic maps
- Tracking data of Mobile GPS

4.2 Extraction of Landslide Areas

Aerial photographs and satellite images were interpreted in order to locate landslides occurred by the earthquakes. The aerial photographs (panchromatic, 1/5,000 scale) were taken by IGN and the satellite images (panchromatic, 10 m resolution) were taken by SPOT IMAGE in France. The digital data of the landslide areas were prepared as follows:

1) The landslide areas were located by interpretation of the aerial photographs and the SPOT satellite images that were taken after the earthquakes.
2) Outlines of the landslide were plotted on the 1/25,000 scale topographic maps.
3) The extracted outlines of the landslide were converted to digital data and compiled with the digital topographic data.
4) Field survey sheets, field snapshots and the home page addresses that related to the two earthquakes were included as the digital format data.

4.3 Creation of Hazard Maps

The hazard maps for the steep slope and the debris flows were created. The existing 1/25,000 topographic maps were used to extract hazardous areas, and the extracted hazardous areas were converted to the polygon data and compiled with the digital topographic data. The extraction norms in the Study were as follows:

1) Hazardous area of steep slope

The area having the following conditions was defined as the hazardous area of steep slope:
- There is a slope of 30 degrees inclination or more.
- There are houses as protection objects on the existing 1/25,000 scale topographic maps within Area A and/or Area B in Figure 2. Here, H is the height of the slope.

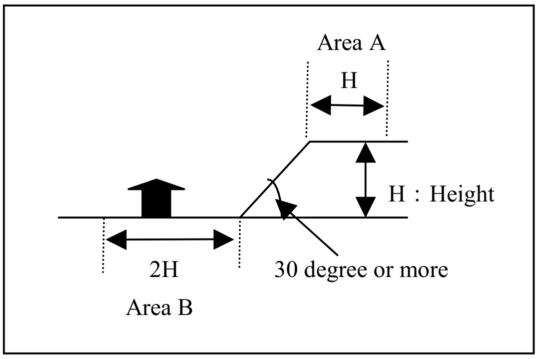

Figure 2. Hazardous Area of Steep Slope

2) Hazardous area of debris flow

The area having the following conditions was defined as the hazardous area of debris flow:

- The area from a place of 10 degrees streambed inclination to a place of 3 degrees streambed inclination (or 2 degrees streambed inclination in volcanic area).

An example of the disaster maps is shown on Figure 3, and an example of the hazard maps is shown on Figure 4.

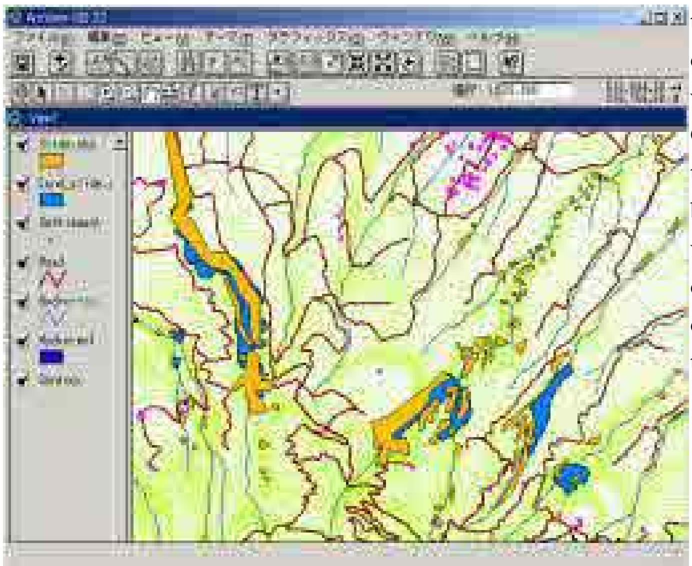

Figure 3. Example of the Disaster Map

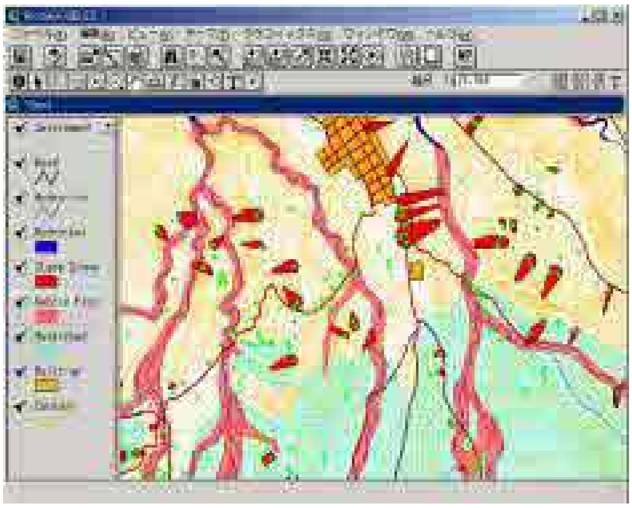

Figure 4. Example of the Hazard Map

5. Conclusion

Presentation of the Study and the products were held for related organizations several times in El Salvador, and samples of the digital topographic data were introduced worldwide through the Internet, so that the various parties can inquire for the digital data. It would be certain that the disclosed results of the Study will be effectively used by not only the El Salvadoran Government but the organizations of the countries encountering the same natural disasters. GIS digital data created as the national basic geographic data in the Study will be effectively used for variable spatial analyses and will be important for decision-making. Finally, it would be emphasized that any GIS data should be continuously updated and corrected for the use of the appropriate purposes.

Establishment of Base Map and Hazard Maps for GIS in the Republic of Guatemala

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Summary

Guatemala was hit by a large-scale hurricane in 1998 and serious damages affected the metropolitan city and its suburbs. In the aftermath of this disaster, a great number of supports for restoration and reconstruction were offered from several developed countries. The national topographic maps have not been revised and the old topographic maps have been used for the national effort to restore and reconstruct. A large segment of the population is still living in the stricken areas, as well as in other areas susceptible to similar disasters. There is a great fear that similar disasters may happen again. The Government of Japan is assisting in works for the development of a GIS database and hazard maps to be used in the national effort for restoring and reconstructing in Guatemala over the years, from 2001 to 2003.

1. Background and Outline of the Study

Some plate boundaries pass through Guatemala's national land and its periphery. The northern part of the country lies on the North American Plate, and the central and southern parts on the Caribbean Plate. Cocos Plate lies on the Pacific Ocean side in the southern part. There are many faults that run in parallel with these plate boundaries. The geological structure is thus very complicated. Furthermore, the geological features, such as volcanoes and volcanic ejecta sediments, which may cause disasters, are widely distributed in the metropolitan city of Guatemala, other main cities, and the neighboring areas of those cities. There are also many social problems in Guatemala that are caused by a weak social infrastructure resulting from the civil war that lasted for a long time, as well as from the poverty common in developing countries.

In such a fragile environment, the internal force of the earth can cause large-scale earthquakes and the eruption of active volcanoes. Meteorological disasters also have frequently occurred, such as the tremendous Hurricane Mitch that hit the Central American region in 1998. In particular, the metropolitan city tends to show high risk of disasters due to earthquakes, debris, mudflows, and volcanic ejecta.

This Study started in January 2001 with the aim to restore and reconstruct from the disasters caused by the Hurricane Mitch, develop the GIS database, create the hazard maps as basic materials required for countermeasures against such disasters, and manage and operate these resources using the GIS for national disaster prevention.

2. Details of the Study

The main items of this Study are establishments of the GIS and hazard maps. The counterpart agency for the GIS-related work is the IGN (National Geographical Institute) and that for the hazard map related work is the INSIVUMEH (National Institute for Seismology, Volcanology, Meteorology, and Hydrology). The objectives to build the GIS database and produce the hazard maps are certainly remarkable, but the final goal is to promote a disaster prevention reinforcement for each of the local governments and the residents, through an efficient use of the GIS and hazard maps, and to conduct the transfer of technologies in each stage.

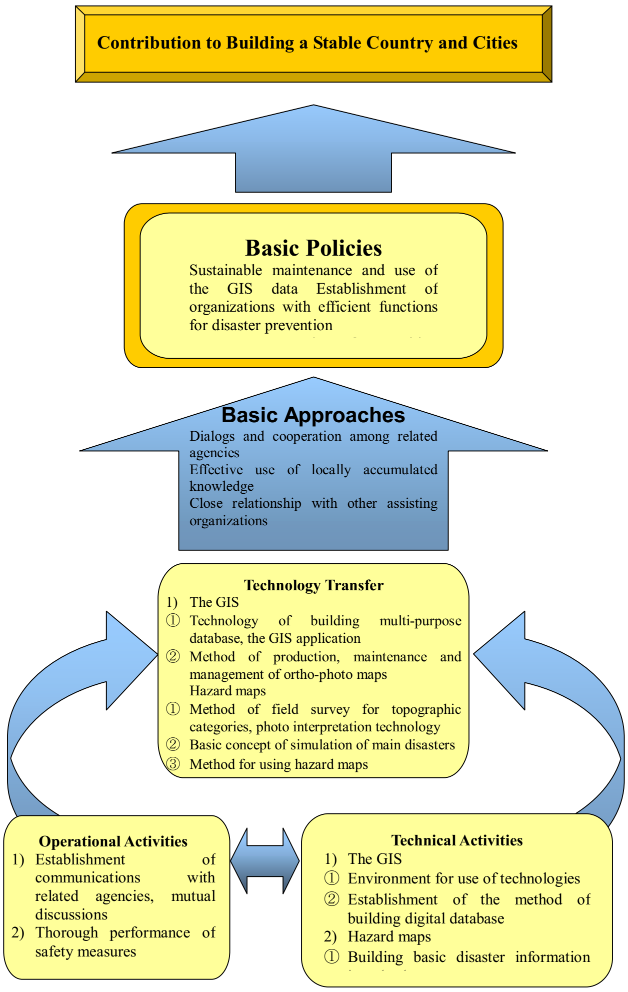

Fig. 1 Basic Policies of the Study

3. Production of Hazard Maps

The national land in Guatemala, with severe earthquake and volcanic activities, tends to be a passage for hurricanes, and cities and villages are distributed on that land. It is a well known fact that this country is prone to disasters. The demand for hazard maps is thus high and disaster prevention measures using the hazard maps must be taken.

The targets for hazard maps in this Study are earthquakes, volcanic disasters, hurricanes, floods due to heavy rain, and landslides (including slope avalanches, and debris flows).

Fig. 2 Image of Hazard Map (Assessment of risk of flooding)

4. Images of Hazard Maps

The hazard maps to be developed in this Study have not been completed yet within the fiscal year 2001, but the results obtained will be as follows. The disaster factors can be classified into those for which the dangerous districts can be predicted through simulation, and those that can be assessed statistically and qualitatively from the history of disasters, topographical and geological features.

5. Integration of Hazard Maps with the GIS and Total Disaster Prevention GIS

The basic data collected to produce hazard maps and the hazard maps are very important for the disaster prevention in Guatemala. There is a large volume of the GIS data that have been already arranged by the related agencies. The hazard-map GIS to be developed in the Study, that will be configured as a total disaster prevention GIS linking with the related GIS data, will be easier to utilize than the GIS configured as an independent system. It is thus preferable to build a total disaster prevention GIS based on technical discussions with the related agencies of Guatemala.

Items to be displayed by total disaster prevention the GIS (draft)

- Existing facilities
  Administrative organizations, police organizations, fire service organizations, military facilities, medical institutions, community centers, churches, parks and plazas, airports, heliports, highways, bridges, and ports
- Observatory facilities
  Meteorological offices, meteorological stations, hydrological stations, and seismographic stations
- History of disasters
  Chronological table of disasters, earthquake-stricken districts in 1976, Hurricane Mitch-stricken districts in 1998, volcanic ejecta distribution, past landslide points, table of damages, disaster photographs
- Disaster factors
  Topographical categories, surface layer geology, active faults, active volcanoes, and meteorological data
- Information on risks of earthquake disaster
  Districts with earthquake risks (districts in which an earthquake is easy to be amplified), districts with liquidization risks, and locations with landslide risks
- Information on risks of volcanic disasters
  Districts with risks of volcanic disasters
- Information on risks of landslide and flood
  Locations with risks of landslide and districts with risks of flood

6. Recommendations for Disaster Prevention Measures

The hazard maps should be utilized to inform the residents of the risks of various types of disaster and to take appropriate measures for their refuge in case of disaster. In addition, the hazard maps should also be drawn so that administrative officials can use them as basic materials for the area and facility development.

6.1 Promotion of Measures for Refuge using Hazard Maps

To minimize human casualties, it is most effective to establish a refuge system in case of disasters exclusive of abrupt earthquakes. First, the districts that are prone to dangers should be defined to regulate the land use in dangerous areas, and a refuge system to be applied in case of emergency should be established and the residents should be informed about it.

6.2 Support for the Establishment of Early Warning System

Various tasks are undertaken to establish the early warning system, including the installation of meteorological observatory equipment, establishment of a communication system, and development of an analysis system. For the establishment of an early warning system, it is necessary to understand well the wide-area atmospheric conditions, and it would be certainly rational to consider applying the warning system to the entire Central American area, and not only on a national level, since rivers extend across a wide region, flowing from one country to another.

6.3 Improvement of Building Standard Law and other Laws

The most serious consequences of earthquake are the collapses of buildings, especially the private houses. The structures of buildings in Guatemala are not designed to be earthquake-proof. Recent buildings use little adobe structure, but many of them are supported through lightweight blocks and reinforcing steel poles. They are thus not earthquake-proof. In case of serious earthquake, the collapse of buildings may constitute the main disaster factor. The revision of the Building Standard Law to ensure better earthquake-proof buildings is thus necessary.

In addition, laws related to river management, including construction of river structures, establishment of the flow observatory system, limitation of land use along a river, and promotion of appropriate land use, must be promulgated.

7. Conclusion

Through the arrangement of problems and tasks for the disaster prevention measures that have been evidenced by the results of this Study for three years, we can therefore recommend the kind of disaster prevention measures that is most suitable to a given disaster in Guatemala. The same technology used in Japan should not be provided, but the transfer of technology and the disaster prevention measures using hazard maps that are adequate for the local conditions of Guatemala will be recommended. In general, two methods for using hazard maps are to be considered, namely short-term use and long-term use of hazard maps.

① Short-term use
- Definition of dangerous districts requiring refuge, and provision of routes and place of refuge
- Disaster prevention training of residents

② Long-term use
- Disaster prevention facilities distribution plan
- Land use regulation
- Land use plan

In the short-term use of hazard maps, the protection of the life of the residents can be at least ensured. In the case of the long-term use, the land use regulation prohibiting residents to live in areas prone to disasters, the land use plan to reduce the eventual costs of damages, the installation and distribution of observatory equipment and the permanent disaster prevention measures such as construction of embankments and dams, should be considered not only for the protection of the residents' lives but also for minimizing the loss of property.

Disaster Information Management Activities using GIS in the Hanshin – Awaji disaster area

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Summary

The effects on use of GIS in the Disaster Information Management was proved by the Academic Volunteer Activities using GIS in the Hanshin – Awaji disaster area. This chapter introduces them and explains about the two kinds of usefulness of GIS uses in the debris removal processing and the decision support for an urban reconstruction planning.

1. Disaster Information Management Activities using GIS

1.1 Academic Volunteer Activities using GIS in Nagata ward

The Hyogo-Ken Nanbu Earthquake directly stroked under Kobe city on January 17, 1995. The damage of this earthquake was serious in Hanshin -Awaji disaster area. At the Northridge great earthquake of U.S. California in 1994, the emergency rescue operation was made on the base in GIS, but in Japan, it was not used for, although it was used for restoration works, such as the information processing for debris removal from collapsed private houses at local and regional administration office.

The Disaster Information Management Activities using GIS (DIMA-GIS), was carried out at Nagata ward Office in the western parts of Kobe city.(Kameda ,1995) The professor of the Kyoto University, Hiroyuki Kameda who is a chief of the special working group for a disaster prevention GIS in Japanese GIS Association , took the lead of this activity and Sigeru Kakumoto who is a visiting associate professor of DPRI-KU, supported the operation and development of the Disaster Management Spatial Information System (DiMSIS). And also Kansai branch director of Japanese GIS Association, Teruko Usui (professor of the department of Geography, Nara University) supported this activities by creating GIS database of damage and restoration. This chapter attempts to illustrate how GIS was socially useful for the restoration in the Hanshin – Awaji disaster area.

1.2 Disaster Information Databases and Time series Surveys by NUDPSC

Disaster Prevention Research Institute of Kyoto University (DPRI-KU),and Nara University Disaster Prevention Survey Commission(NUDPSC) created many databases of damage and restoration in the Hanshin - Awaji disaster area using GIS. The dead, building damage and the damage of a lifeline were inputted into damage information databases. (Usui,1995, 2000) And also restoration databases have a serial information on the place of the debris removal from collapsed houses and traffic impossible roads by a debris occupation which were surveyed by NUDPSC.

NUDPSC is an academic volunteer commission which is located at Usui laboratory at department of geography Nara University, and about 100 students have registered. The first survey was carried out by NUDPSC at the Hanshin-Awaji disaster area covered by 17 sheets of the map 1:10000,on February 9, 1995. NUDPIC inputted each debris removal place of houses and roads into the large scaled electronic map,1:2500, using ARC/INFO. This time series surveys has been carried out at 1 month intervals from February 1995 to July 1995, and at 3 month intervals from July 1995 to April 1999, and at 6 month intervals from April 1999 to October 2001. (Iwai,1998)

2. How was GIS useful in Hanshin-Awaji disaster area ?

2.1 Situation of the Debris Removal of Collapsed Houses after the Big Earthquake

The Figure 1 shows the distribution of debris removal sites of collapsed houses in February 1995 and April 1995. The number of the debris removals at Nishinomiya City was the highest in February. It can be explained by the traffic condition or the accessibility from a large city as OSAKA. The total of the debris removals increases more at the city of the eastern parts such as Nshnomiya、Ashiya City and Higashinada ward. On the other hand, it is a few at a western area such as Nagata and Suma wards where the traffic access from Osaka is worse.

More noteworthy is that there are a few debris removals in February, and the number of debris removals increases rapidly in April, especially at Nagata ward. The processing of debris removal of many collapsed houses was unprecedented work at local government offices in disaster area. It, therefore, was gropingly started at the beginning in February which rescue activities had mostly finished. Figure 1 indicates that the processing of debris removal at local government office began to proceed in April, and increased in the number of debris removals. The rapid increase in Nagata ward is due to the use of GIS in the disaster information management for the debris processing.

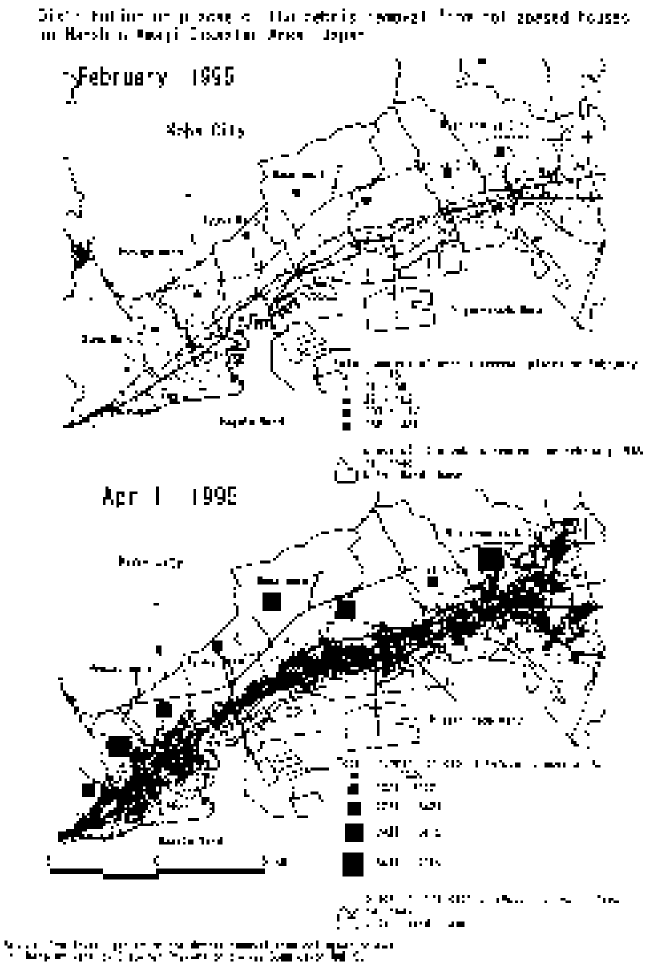

Figure 1. Distribution on places of the debris removal from collapseed houses in Hanshin-Awaji disaster area, Japan

2.2 The effects on use of GIS in the office work management of debris removals

Because many houses were private properties in Japan, the procedure of a legal application for a removal properties(collapsed houses) was necessary before the debris removal of the collapsed house. A local government checked whether there was no mistake in the declaration and had to confirm that an applicant was the rightful owner of the debris removal place. The office work for owner confirming, therefore, made it spend great labor and time. It seems reasonable to suppose that office works such as the checking and the owner confirming would cause a delay of the debris removal processing.

The DIMA-GIS, which was explained before, was carried out to help these office works at Nagata ward office from the beginning in March.

Nagata ward using GIS Higashinada ward not using GIS

Red site:debris removal in April
Green site: debris removal in May
Blue site: debris removal in June

Fig.2 Different distribution of debris removal ites between at Nagata ward and Higashinada ward in Kobe City

The effects on use of GIS was appeared at the rapid increase in the total of debris removals in April. The two kinds of different spatial pattern on Figure 2 shows the different situation of the debris removals in Nagata and Higashinada ward respectively, which suffered the heavy strike with the almost same damage ratio of collapsed houses. It follows from this that the aggregated spatial pattern indicates the effectiveness of the debris removal processing, because local public service workers of Nagata ward could easily realize where the collapsed houses were aggregated by the map visualization of GIS. In other words, Figure 2 shows why it could be removed efficiently by the use of GIS.

2.3 The effects on the decision support for detailed urban reconstruction planning

One more importance of the GIS use is the effects on the decision support for detailed urban reconstruction planning. According to Figure 3, which shows the number of debris removal sites, Nishinomiya city, Nagata ward and Higashinada ward in Kobe city had large damage of wooded houses in order of number of debris removal sites. But the progress of the restoration after the earthquake in Nishinomiya city and Higashinada ward was different from the restoration at Nagata ward.