

The Current Status and Reform Strategies of GIS Projects for Urban Infrastructure Management in Korea

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Key words: GIS, Urban Infrastructure, Underground Facility, NGIS Master Plan.

ABSTRACT

As IT has developed rapidly and 21st century has become highly information-based period, the level of informationization* has become the basis of development of a community. Furthermore, as the civic society has developed and the concentration on city has become more serious, it is required to make a decision reasonably through efficient management of basic facilities such as urban space and underground utility, and through analysis and rapid collection of every information. The pan-government organized Steering Committee in the NGIS master plan so that each department of the government, autonomous body and enterprise may promote the base to develop and utilize GIS.

The 1st NGIS master plan was established in May, 1995 and its first step was carried out in 2000. The 2nd NGIS(2001-2005) was established and the two-phased project is under way at present. Each municipality was trying to utilize GIS systematically in management of basic facilities such as water, sewage pipeline, road and transportation to promote efficient administrative affairs and administrative service for people. Also, they were striving to use GIS systematically to minimize the possibility of disaster and to deal with internal and external environmental changes actively and inconvenience caused by the increase and superannuation of urban basic facilities.

This research presented the reform direction of GIS to manage urban infrastructure efficiently on the basis of them, after finding state and problems of GIS related to city infrastructure focusing on underground utility which covered the majority of basic facilities.

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*Informationization: to have the activity be done in various social areas through producing, using and distributing the most of digital information

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1. INTRODUCTION

As Information Technology has developed rapidly and 21 century has become highly information-based period, the level of informationization has been the basis of development of a community. Furthermore, as the civic society has developed and the concentration on city has become serious, it is required to make a decision reasonably through efficient management of basic facility such as city space and underground utility, and through analysis and rapid collection of every information. The pan-government organized Steering Committee in NGIS master plan so that each department of the government, municipality and enterprise may promote the base to establish and utilize GIS. The NGIS master plan was established in May, 1995 and its first step was finished in 2000. The 2nd NGIS master plan(2001-2005) was established in 2000 and the two-phased project is under way at present. (refer to Figure 1)

Out of the first NGIS, the main project related to municipality directly and indirectly is shown in Table 1. At present fifty municipalities are subsidized or secure their own budget. And they are implementing the projects for developing information system for land management as well as for digital underground utility map such as road and water and sewage pipelines, digital topographic map and for developing urban information system. Especially, every municipality is striving to utilize GIS systematically to minimize the possibility of disaster, and to deal with internal and external environmental changes actively and inconvenience according to the increase and superannuation of basic facilities in city. It is also trying to utilize GIS systematically in management of basic facilities in city such as water, sewage pipeline, street and transportation to promote efficient administrative affairs and administrative service to people.

This research presented the reform direction of GIS to manage urban infrastructure efficiently on the basis of them, after finding state and problems of GIS related to city infrastructure focusing on underground utility which covered the majority of basic facilities.

2. THE STATE OF GIS PROJECT FOR MANAGEMENT OF CITY INFRASTRUCTURE

The project for informationizing municipality was launched on the basis of the 1st project for digitizing administrative affairs network('87-'91). Since 1992, the project of informationization has been implemented according to the mid and long term master plan of digitizing local administrative affairs. On the other hand, as the central government was influenced by gas explosion accidents in cities and development of technology for geographic information processing, the first NGIS master plan was established in 1995. Through utilizing geographic information, the accidents also accelerated the project for informationizing the

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integrated GIS in local government such as plans for digitizing thematic map and underground utility, based on the plans for digital mapping of national base map. Following that the Framework Act on Informationalization Promotion was passed by lawmakers in 1996, the Basic Master Plan for Encouraging Informationization(1996-2000) was established and the project for informationizing municipality was on the track of implementation. Plans for digitizing underground utility map were implemented to prevent the gas explosion accidents through efficient management of underground utility by GIS because the accidents took place often owing to inaccurate information about underground utility. Also, the nation implemented the plans for digitizing underground utility map consistently so that it made possible to prevent and to take quick measure in case there is an accident.

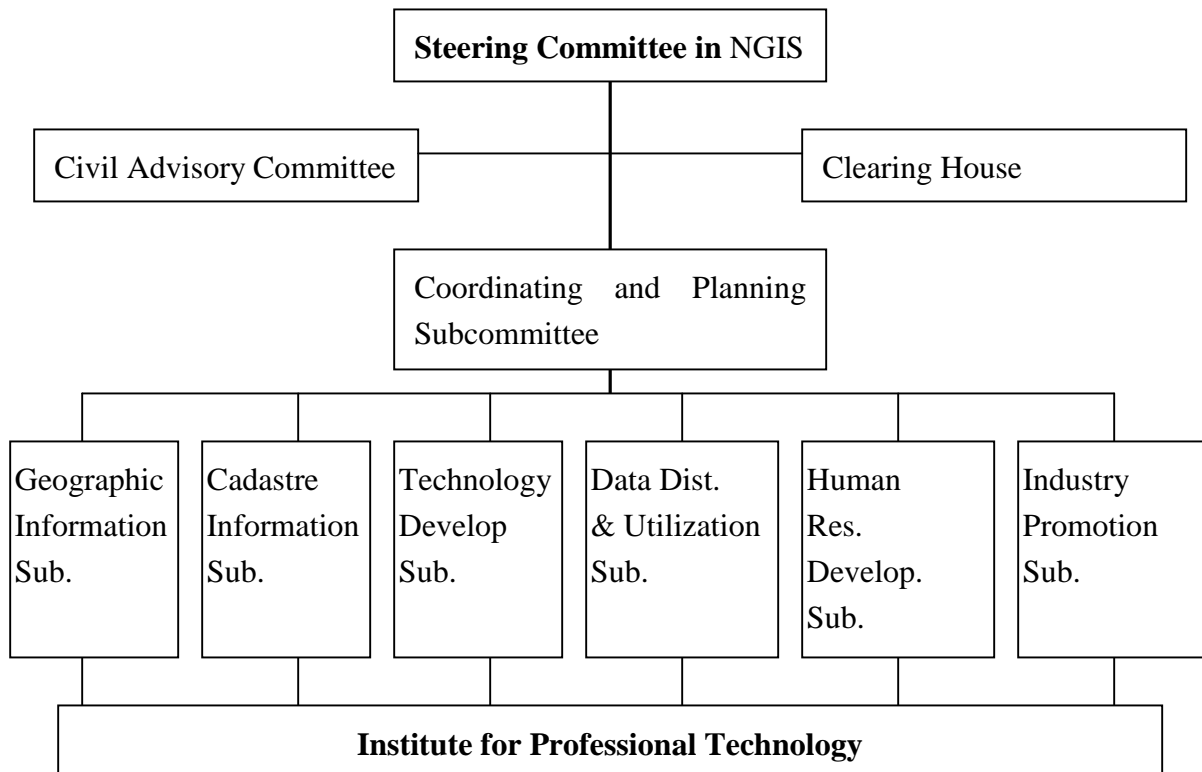


Figure 1. The two-phased Organization Structure in NGIS

2.1 The State of Implementing the Plans for Digitizing Underground Utility Map

The plans for digitizing underground utility map(investigation and digital mapping) was implemented according to the following reasons.

First, manpower and cost necessary for management of utility can be reduced through managing and integrating them, after digitizing location and attribute information(diameter of tube, material, date of building) about each underground utilities linked with each other complicatedly.

Second, the accident by an excavator could be prevented through managing and developing database for gas, water, sewage pipelines and electricity, communication lines that are laid under the ground using GIS.

Out of 79 municipalities, twelve cities were selected based on influence and the basis for managing underground utility was established through digitizing the affairs related to water and sewage pipelines of those cities step by step. It paved the way for managing city facility applicable for digitizing underground utility such as gas pipeline, communication, electricity lines, oil pipeline and heating lines. Furthermore, the accurate location of underground utility could be identified through digitizing, investigating the spot and arranging the database related to underground utility. The project will be extended to all 79 municipalities in near future.

The objects of the plans for digitizing underground utility map were seven utilities such as water and sewage pipelines, gas pipeline, electricity lines, communication, oil pipelines and heating lines. The main project was to digitize the affairs related to water and sewage pipelines. The states of laid underground utility and development of digital mapping are shown in Figure 2 and Table 2.

In terms of the state of developing utility in August, 2000, the goal quantity out of 79 municipalities managing water pipelines was a total of 97,946km. Out of them, 35,014km was developed, which meant 39.2% development. For 59,532km sewage pipelines, 15,250km was developed which meant 27% development.

<Table 1> The first NGIS Projects related to municipality

Name of the project	The details of the project	Resources	Period
The plan for digital topographic map	topographic map of 1:5000 scale (79 cities)	government: municipality = 50: 50	'95-2000
	topographic map of 1:5000 scale (national)	government: invest institute = 50: 50	'95-'98
	topographic map of 1:25,000 scale(national)	government's charge 100%	'96
The plan for digital thematic map	map for land use, topographic-cadastral map, administrative map, city planning map, road network, map for national land use	government/municipality/public institute in demand pay the cost together	'98-2000
The plan for digitizing underground utility	for the 1st phase until 2001, water and sewage pipelines, electricity lines, communication, gas pipelines, heating lines, oil pipelines in 19 cities	government/municipality/institute on managing utility pay the cost together	'97-2001
The project for technology development in	development of applied technology and core technology 1st phase: base technology until	government/private sector pay the cost together	'95-2003

GIS	1999 2nd phase: secure the capability of technology development until 2003		
The project for human resources development in GIS	short and long term professional manpower training	government pays the cost	'96-2000
The project for standardization in GIS	standardization in terms of international standards of spatial information database	government pays the cost	'95-2000
The project for digital cadastral map	digitizing existing cadastral map step by step	government/municipality pay the cost together	'98-2000
Pilot project for underground utility	implement the pilot project of developing management system of underground utility	government pays the cost	'96-'97
The project for developing useful system of public GIS	implement to develop useful system of public GIS such as land, soil, forest, under water, and topography	government/municipality pay the cost together	'98-2001
The nation supported GIS development research	implement the supported research	government pays the cost	'95-2000

<Table 2> The state of development of digitizing underground utility map
(Unit: km, million won, , sheet)

Utility	total length	length for digitization	state of development of digitizing underground utility					period of map sheet
			length	ratio	cost	coverage area	number of drawings	
water pipeline	97,946.0	89,411.0	35,014.2	39.2	45,052	2,197.71	14,274	'91 -
sewage pipeline	59,532.2	56,296.2	15,250.0	27.1	16,549	2,274.47	9,874	'90 -
regional water	2,076.7	1,968.7	605.6	30.8	5,027	64.56	-	'96-2003
gas pipeline	1,955.0	1,955.0	1,482.0	75.8	1,700	-	2,048	'99-2000.5
regional gas	16,629.9	16,559.2	12,932.6	78.1	33,967	-	33,711	'91-2000.3
electricity line	14,920.0	14,920.0	405.0	2.7	7,178	-	8,954	'99.10-
communication	111,545.0	111,545.0	111,545.0	100.0	NA	-	43,979	'87-'99
oil pipeline	920.0	827.0	0	0	0	0	0	-
heating pipelines	2,258.0	1,636.0	1,512.0	92.4	175	462.00	-	'99.4.22-
Total	307,782.8	294,108.1	178,746.4	60.6	109,648			

References: The state of development of GIS (the Ministry of Construction and Transportation)

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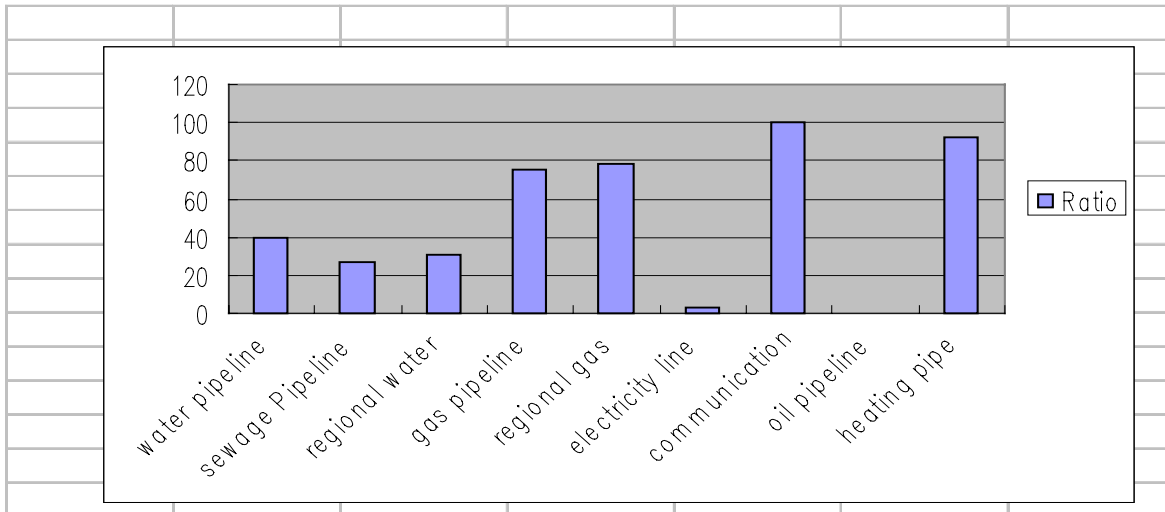


Figure2. The state of development of digitizing underground utility map

It was appeared to maximize the use, to secure quality data and to save budget when each municipality developed the GIS database of each utility in compliance with the plan for national digital mapping(topographic map and cadastral map) in implementing the plan for digitizing underground utility. It was required that the nation should take institutional measure such as data standardization, integration of applied system and accuracy of data on utility because there was difference among the organizations responsible for management of water and sewage pipelines, regional water pipeline, electricity line, gas pipeline, regional gas pipeline, heating line and oil pipeline.

2.2 The State of Use

Municipalities and affiliated institutions were beginners in using digital map and underground utility. Most institutions often used the drawing of digital mapping. So it was predicted that it would be more used according to the diffusion of GIS. To increase the use, the affairs applied by each municipality should be inspected and analyzed, which also to be reflected when developing database. Most municipalities used a digital map but the department using it that was originally related to their affairs. Now all the departments gradually got to use it. The applicable affairs were extending from simple use of drawing of existing digital map to focusing on the affairs.

3. ANALYSIS ON THE PROBLEMS OF DEVELOPMENT OF GIS FOR MANAGING URBAN INFRASTRUCTURE

Each municipality was trying to utilize GIS systematically in management of basic facilities of city such as water, sewage pipeline, road and transportation to promote efficient administrative affairs and service for people. Also, they were striving to use GIS systematically to minimize the possibility of disaster and to deal with internal and external environmental changes actively and inconvenience following the increase and superannuation of basic facilities in city. To manage underground utility efficiently which covered the

majority of basic facilities, this research focused on the problems presented during the process of implementing the project and GIS master plan to identify the problems and state of digitizing urban infrastructure.

3.1 The Preliminary Research for Developing GIS

GIS should be understood well enough to develop and introduce GIS. The information necessary for identifying GIS might be insufficient as GIS was not a standardized technology. Especially the well-known information about GIS was specific because it was related to technology and explanation for users was limited. As a result, it was important for users to share the experiences and exchange the information after the examples of introduction by other municipality were inspected. Consequently, the each municipality needed preliminary research on special environment and informationized mind when GIS was introduced. However, the research on this part was not conducted sufficiently when GIS master plan was established. As a result of analysis on master plan of each municipality, it was also to be appeared that the presented applicable measure to this technology was insufficient after analyzing national and international technology.

3.2 Development of System

3.2.1. The Characteristic of the Objective of Developing System

When GIS was detailed at some degree, it aimed for the system processing very quickly or an advanced technology. And seller focused on the technical benefits of that system. But there was a problem in use, maintenance and management of system by selecting the system with advanced technology and quick processing speed rather than identifying user's accurate request. Also, S/W and H/W were not used enough.

3.2.2. The Problem of Service and Introduction of System

A lot of difficulties were accompanied during the business meeting with other departments when system was introduced. Even though people in charge of the affairs understood the necessity of GIS, they sometimes didn't know about how to coordinate it on what item. Consequently, an independent system related to one's affairs was easy to introduce. It was being developed imprudently according to needs of related department although GIS was a system to be developed step by step according to master plan after standardization was established. Owing to this situation, system and data couldn't be exchanged with others and budget was wasted in duplicate investment and ambiguous affairs according to management of double data. Though it was actually reasonable for regional municipality to develop a common program and distribute to each municipality, it allowed each municipality to develop respectively. The nation knew that there was a plan to develop and distribute a common system but it was developing the program with the same objective as that of municipality.

The objective to digitize administrative affairs was to minimize people's inconvenience and to promote efficient administrative affairs and administrative service to citizens.

Development of useful system for service to citizens was insufficient because development was focused on users.

3.3 Development of Database

3.3.1. Sharing the Base Map

As a department and an affiliated institute had a different base map necessary for developing GIS in each municipality, there were a lot of problems being occurred. It could develop efficient system quickly for its affairs after it developed a base map according to each department.

However, the same base maps were used in many departments and basic information such as road and building could be used in each department. When the budget was sufficient, independent development could be conducted and duplicate investment could be avoided. There were a lot of problems with data maintenance and renewal when individual department developed a base map independently.

3.3.2. Insufficient Development of Based Data for Scientific Management in City

NGIS was begun and basic information such as topographic map, cadastral map and underground utility map was developed. GIS applied system of municipality was developed in management of utilities such as road, water and sewage pipelines, and management system for land information was developed. Besides management of these utilities, though the data necessary for environment-friendly and sustainable management in city raised concerns, it was not sufficient and the base for developing information system in terms of region which was outside of administrative boundary was not satisfactory.

In case of GIS, vector data was digitized a lot, but development of raster data such as aerial photograph and satellite data was insufficient. Municipality owned-aerial photograph was a data which showed the past records but the photographs were abandoned because of difficulty in managing data.

3.4 Plan for Maintenance and Management

3.4.1. Maintenance and Management of Database

Sustaining renewal, maintenance and management of database were necessary after development of system. Maintenance and management of up-to-date base map was the most important. Topographic figure is changing day by day and the affairs of department using this couldn't be carried out in case the renewal is not done timely.

Still, the subject of renewal, the way and period of database were not taken into consideration when GIS master plan was established.

3.4.2. Maintenance and Management of System

Hardware was a quick progressive part in a computer technology. The system with specific hardware could be useless along with the hardware. It costs a lot to transplant the system and to maintain and manage the existing computer.

3.5 Steering Organization

Six regional cities including Seoul metropolitan had GIS implement by the planning group for informationization or the planning division for informationization under the planning administration department.

Municipalities including city had been identified to have GIS implement by the section or subsection. According to the report of GIS international seminar by Korea Research Institute for Human Settlements, sixteen cities had the department in charge of geographic information, which was equivalent to 20.6%. Only Seoul had the section and fifteen other cities had the sub-sections in charge of geographic information. Six-two cities(79.4%) didn't have the department in charge, but they recently had them in 2 years. Those cities which didn't have the department in charge had GIS implement by the information planning department. On the average 2.1 people were in charge of GIS and twenty-two cities(27.8%) didn't have the manpower in charge. Nineteen cities(24.1%) had one person in charge, seventeen(21.5%) had two people and only eight (10.1%) had more than five people in charge of GIS.

Most of the municipalities were short of the manpower in charge. Due to the shortage of the professional manpower, it was hard to acquire related technology and to accumulate the experience and GIS was not implemented smoothly.

3.6 Establishment of the Law

System operation was conducted in case the related law was established according to GIS development and operation of each municipalities. There had been a lot of difficulties in system development and operation due to the insufficient law but "the Act on the Development and Operation of NGIS was established which paved the way for implementation. However, following measures including the operational regulations for GIS development was insufficient and the establishment of the law was not described clearly in the existing GIS master plan of each municipality. Especially institutional and technical measures were omitted in GIS master plan, which allowed the base map made by each municipality to be distributed to prevent waste of national resources for duplicate development of data.

4. THE REFORM DIRECTION OF GIS FOR MANAGEMENT OF CITY INFRASTRUCTURE

After analyzing GIS master plan and the state of implementation of each municipality, this research presented the reform direction for the problems and insufficient parts as follows.

4.1 Preliminary Research for GIS Development

When GIS is developed, preliminary research should be conducted to understand and identify GIS itself rather than to establish future objective and idea after municipality introduces GIS.

First of all, the research should be conducted thoroughly on special environment of each municipality, members' informationization mind about GIS and selection of the priority when GIS is introduced. And how to apply the technology should be presented by each municipality after the research on national and international technology.

4.2 Reform Direction for System Development

4.2.1. Setting the Objectives for Using System

It is not an objective to develop GIS. So even the small system is useful and cheap enough though it is not up-to-date. The objective to use GIS as a tool should be set concretely and in defined quantity about what the purpose to use system is and at what level to improve. When the objective is set clearly, necessary skill, certain data and limited system can be implemented. Ambiguous objective can't make a cheap and good system.

4.2.2. Integration and Introduction of System Focusing on Data

To accumulate quality data, it is needed to systemize from upper stream of data flow which creates data. For example of road data, the department of road construction or road management continues to get the information about the changes on the road for a renewal of road register. The work can be carried out efficiently and road data is changed into database when GIS is introduced in the renewal of register. The department of road management is in charge of inputting road data as work. As the users of the information are working with the same department, the road data can be renewed in the department of road management. Also the department of road management which knows the situation can find whether the data is right or not when the data is input. Consequently, users of lower department can use the road data easily.

When GIS project is implemented, municipality, affiliated institutions and departments are notified the schedule of implementation, implementation boundary of DB, H/W contents, S/W contents and the contents of development. After that, a relevant measure is taken for linking together, using, discussing and coordinating each other so that the project can be carried out after reaching an agreement or linking regulations.

4.3 The Plan for Maintaining, Managing and Developing Database

4.3.1. Sharing a Base Map

It is discussed that data should be integrated according to its kind in municipality, Korea. Although the situation that the institutions in charge in Japan are different is similar to that of Korea, Japanese institutions are using and sharing the basic data rather than integrating each utility map. Consequently, municipality in Korea should review professionalism of managing each utility, and consistency of existing affairs, maintenance of data, applicable objective and measure before it integrates the management system of each utility. That is, municipality should develop the system such as common affairs supporting system, formal affairs supporting system, integrated and non-formal affairs supporting system step by step in order through sharing a base map rather than integrate the management system of utility in haste. Also, duplicate development should be avoided within each municipality and it should develop Data Ware House so that data renewed in affairs can be distributed.

4.3.2. The Plan to Improve the Accuracy of Base Map

The digital map of 1/1,000 scale is a base map for investigating and excavating underground utility. As it can affect a lot on underground utility, the guide for inspection and production of digital map should be given the accuracy of layers related to survey of underground utility after it is improved to framework data rather than digital mapping of paper map. To secure the accuracy of digital map of 1/1,000, the error of digital map should be corrected not by field survey but by field-supplemented survey to supplement the error in the process of the inspection and survey of digital map as well as the production of topographic map with a photograph of large scale.

A series of work from drawing of base map to correction and renewal should be carried out consistently and systematically through introduction of minor control point in urban area. At the same time, accomplishment of unified minor control point should be applied in design, construction and maintenance of city based utility.

4.3.3. The Direction of Reform for Maintenance and Management

Consistent renewal and maintenance of database are necessary after system is developed, and maintenance and management of recent base map are the most important out of them. Topography and figure are changing day by day and the specific details should be presented in order that renewal can be conducted timely.

4.4 The Direction of Reform for Steering Organization

When the steering organization is formed, it should be initiative to lead the whole project. The department related to introducing geography information system actually use the system

in the affairs and should focus on accomplishing its affairs through horizontal organization. Besides, it should take into consideration to develop the useful system.

Above all, it is critical to establish GIS professional organization newly and to deploy the professional manpower for digitizing underground utility map and developing and using GIS in the Korean situation. First of all, it is important to secure the professional manpower and organization in charge through institutional law and incentive in budget.

Especially, effort and cooperation should be followed to get the whole members of municipality to understand through various publicity and education. Also, like ROADIC(road administration information center)in Japan, establishment of RFIC(road facility information center) by the third sector should be considered through sharing the cost by related institutions and public utilities for efficient integration and maintenance.

4.5 Clearing-House

It costs a lot to develop the data development of clearing-house. When institutions, organizations and private sector develop it independently, the cost can be social indirect capital which will result in waste of national resources owing to duplicate development of data. First of all, each municipality develops the clearing-house to distribute the produced base map and makes it possible for institutions, private sector and enterprise to use it. And the base should be developed not only for restoring and coping with disaster with affiliated institutions, but also for managing underground utility and improving service to people.

The Act on Development and Operation of NGIS enforced on July 1, 2000 allows the developed database to be copied and sold. So each municipality should sell the developed spatial database, secure the resources for implementing the project and have the private sector use it. The considerations for selling the spatial data are as follows: the object and the way of selling, anticipated customer, the procedure and media of selling, fixing the price and security. And the related regulations should be established and revised.

4.6 Establishment of the Act

The Act on Development and Operation of GIS in each municipality should be established so that operation of system may be activated. The concrete measure should be presented for establishing operational system in order that every municipality may establish and revise the applicable article of operational regulations of GIS defining plan for operating organization, plan for maintenance of system and database, clearing-house, security step by step.

5. CONCLUSION

As 21C has become highly informationized and knowledge-based community, each municipality is implementing UIS project in order to maximize administrative service to people, to accomplish efficient administrative affairs and management of city based utility and to deal with internal and external environmental changes. This research presented the

reform plan based on them after it found the problems through survey and analysis of the project for digitizing underground utility map in municipality of Korea.

1. The through research should be conducted to place the priority of affairs and member's informationization mind about GIS and specific environment during the establishment of GIS master plan in municipality. However, many municipals didn't conduct sufficient preliminary research and analysis so the strategy of implementing GIS developed in each municipality is unsatisfactory.
2. The project should be implemented so that flexible system and accurate data may be developed and minimum necessary skill be secured after defining the objective of GIS development. Moreover, the system or organization relevant to each step such as steps of plan, development and maintenance should be established. And it is reviewed that RFIC(road facility information center) should be established through sharing the cost for efficient integration and maintenance by the 3rd sector.
3. Phased development should be considered through sharing base map for developing the systems such as common affairs supporting system, formal affairs supporting system, integrated and non-formal affairs supporting system in order. Accurate underground utility map should be maintained and managed through applying uniformed minor control point in plan, construction and maintenance and management of the utility in urban area by introducing minor control point in urban area.
4. Unless there is effort for maintenance and repair after developing GIS for management of city infrastructure, it will result in losing confidence and expending lots of cost by inefficiency. Consequently, the maintenance, management and renewal of base map should be conducted timely and systematically according to the change of topography and figure.

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