Guideline of Technical Transfer

on

Geographic Information System

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Preface

Geographic Information System (GIS) technology is an information technology dealing with geographic information, has been beneficial in increasing efficiency in the planning and daily works of central and local governments mainly in developed countries. Recent benefits also include more efficient policy making through sharing of information, the provision of government information and other civil services.

On the other hand, development plans in some developing countries have to be formulated with insufficient information and few facts because of limited financial resources and/or personnel. This may have led to inappropriate political intervention. Therefore, efficient, scientific and appropriate planning using GIS applications with necessary information is greatly anticipated especially in some developing countries.

The necessary technologies in dealing with GIS are numerous and diverse. However, most of available materials on GIS are technical manuals and application examples that are intended for developed countries. GIS is now expanding into many application fields in many developing countries. However, there are still a lack of materials on GIS targeted for developing countries.

Secretariats of Japanese embassies, staffs of Japan International Cooperation Agencies (JICA) and Japanese experts have come to design and/or implement projects using GIS. Although they are not GIS experts, they are required to have an understanding general concepts of GIS.

When submitting budget request on project, mapping organizations are required to explain the benefits of GIS. Unfortunately, these organizations have a limited number of materials explaining these benefits.

This manual has been prepared to meet these needs. Special technical words are excluded as much as possible. Technical elements are described easily and simply. The manual focuses on benefits of using GIS in developing countries.

Outline of a GIS and its Benefits

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Summary

The following is an outline of GIS including background information, basic functions, various fields of applications, and the benefits of using GIS, such as information management, the visualization of information, information sharing and prompt and accurate decision-making.

1. What is a GIS?

A **geographic information system** (GIS) is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information (i.e. data identified according to their location).

It can present information in map form for easy interpretation and includes application software that can perform a variety of individual functions.

Geographic information can be classified into two categories: graphic information indicating positions of objects and attribute information including textual data, numerical values, and image data (geographic names and properties of roads, buildings, etc.). Since a GIS makes it possible to link graphic and attribute information, one can find an attribute of an object on a map, such as a road, building, etc. or display objects having a specific attribute on a computer screen.

2. History and Development of GIS

GIS was first developed in Canada in the 1970s. In the beginning, the development of GIS was hindered due to the fact that information technology was still in its infancy and the production of geographic information was costly. Today, however, the sophistication of peripheral information technology, the development of high-performance computers and software, the production of key digital data and the establishment of information and telecommunication infrastructure have enabled easy access and simple management of geographic information, which in turn have resulted in a rapid popularization of GIS. Today, GIS are being widely used in government offices, private businesses and a variety of situations in the lives of the general public.

3. Fields of Application of GIS

The most basic function of GIS is to record geographic data in layers according to categories, such as roads, buildings, drainage systems and so on. This makes it possible to display and map only certain data that is required.

A GIS is also capable of performing other manipulations such as overlaying different kinds of geographic information, retrieving objects that exist within a fixed distance from a road, determining the shortest route to a destination in a navigation system and so on.

As GIS are multi-functional, they can be applied to a wide range of fields. The fields of application vary between developed and developing countries. The following list shows possible areas of application in public administration that GIS may be useful.

- National and regional development planning
- Urban planning and regulations
- Planning for road construction and environmental assessment
- River system management and drainage basin management planning
- Planning for transportation systems and inland water management
- Irrigation planning and selection of crop plants suitable to a specific locality
- Forest management planning
- Disaster measures utilizing hazard maps
- Prompt responses to disasters such as fires
- Regional education planning such as distribution of elementary schools
- Regional medical-care planning such as distribution

of health care centers

4. Benefits of GIS

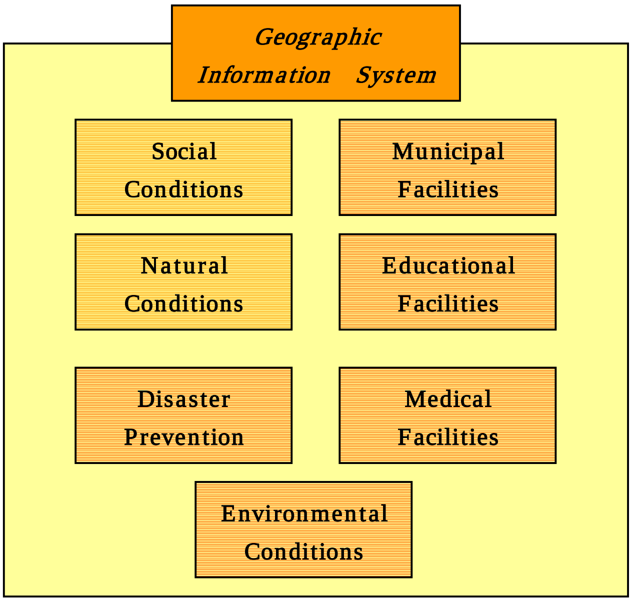
At present, a great number of international aid organizations are introducing GIS to their counterpart agencies and GIS is being widely used in a variety of fields. GIS may be considered a mere analytical tool, but because it can simultaneously handle cartographic data and attribute data by computer, it has benefits in areas such as the following:

(1) Information Management
(2) Visualization of Information
(3) Information Sharing
(4) Prompt and Accurate Decision-making

4.1 Information Management

A GIS makes it is possible to manage information with unprecedented efficiency. It has a database function within so that information can be updated and added to from a single point of access to provide the latest and most up-to-date information.

Take the field of agricultural development for example. In addition to cartographic data, various other kinds of information, such as present land use conditions, soil conditions, water systems, and population statistics are necessary. By using a GIS, it is possible to efficiently manage all this information from one location by storing it on the database.

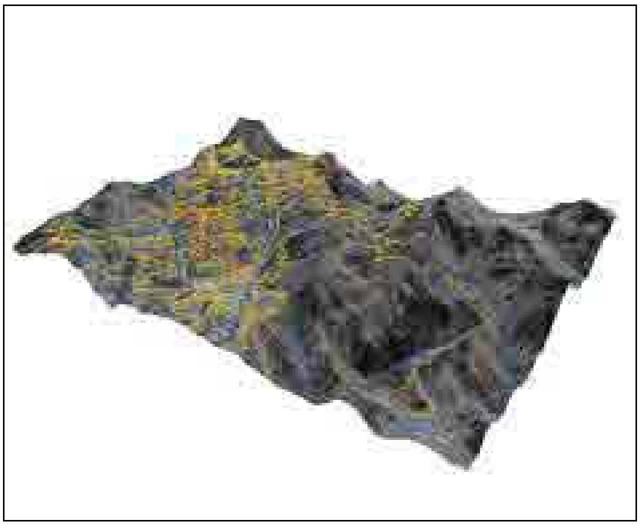


4.2 Visualization of Information

The second advantage is that by applying GIS technology, various types of information can be displayed in two-dimensional and three-dimensional forms.

Traditional topographical maps show the shape of the land's surface with contour lines but with only that it is difficult to grasp the actual shape of the area. However, by using the 3-D analysis of a GIS, you can create a DEM (Digital Elevation Model), compound it with an aerial photograph and prepare a bird's eye view map. This enables one to visibly grasp the topographic conditions. In addition, a GIS has an overlay function with which various kinds of other information can be superimposed making it possible to understand the cause-and-effect relationships among the different elements in the target area. Furthermore, statistical data, such as population and observation data, are usually kept in registrars but with GIS you can graphically display this information.

By applying GIS in such a way, it is possible to transform ordinary maps and statistical data into information that can be visualized.



3-D visualization of an image using a DEM

4.3 Information Sharing

The third advantage is that you can share the information in a database that is constructed.

For example, a department in a ministry or agency can effectively use a database it constructs by storing it on servers making it available to other departments through the network. However, as there is a problem of security, the system should be set up so that only the department that constructed the database can control the data (updating, deleting, etc.) while the other departments simply have access to the information.

In addition, databases can be used effectively in a variety of fields, such as education, by making them accessible to ordinary citizens through the Internet. It is particularly useful in the environmental field, as it is possible to create a GIS database for regional environmental conditions so that the public can have access to information such as how different areas are affected by pollution, and what policies are being implemented to cope with these problems.

4.4 Prompt and Accurate Decision-making

Finally, with a GIS, information can be interpreted quickly and accurately, when important decisions need to be made. For example, in the event of a disaster, (i.e. fire, flood, earthquake, volcanic eruption, etc.), the danger areas and where they are going to spread to have to be instantaneously analyzed and interpreted so that the public can be notified of escape routes and places of refuge. Without a GIS, it takes a considerable amount of time to speculate about the danger areas while overlaying various kinds of information on ordinary maps in order to work out the best routes of escape. However, with a GIS, information can be linked, or integrated to geographical locations so that present conditions can be grasped with precision. In addition, information that is gathered in the form of numerical values can be used to simulate the extent of the disaster, and if you go one step further and layer on road network data you can add in various other elements to determine the shortest and safest escape route.

By using GIS functions in such a way, it is possible to make prompt and accurate decisions.

Reference: Utilization of GIS in the near future, Japan Construction Information Center, April 1998.

The Development of National Spatial Database Infrastructure in Japan

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Abstract

Geographic information data used for GIS is called "spatial data", which has information of geographic locations such as latitude/longitude, place name, and address. In Japan, National Spatial Data Infrastructure is designated as fundamental information, which describes characteristics of the national land, selected from various kinds of spatial data. National Spatial Data Infrastructure is categorized as spatial data framework, basic spatial data, and digital image data. Particularly spatial data framework is geographic data, which is considered as the framework for information used in GIS and can be utilized by linking to basic spatial data such as statistics and inventories. The Japanese government announced that National Spatial Data Infrastructure would be an infrastructure supporting higher information-oriented society in the 21st century and has made an effort primarily to develop spatial data framework as a part of the establishment of the environment to diffuse GIS in the entire society in general as well as government bodies. In addition, the improvement of data distribution and the environment for users have a very important aspect. Thus, the government has also been promote to achieve an effort to develop the environment for users, such as the standardization of geographic information, the establishment of clearinghouse, the provision of geographic information on the web.

1. Background

The Great Hanshin-Awaji Earthquake in January 1995 raised a substantial issue that associated organizations couldn't share various types of information needed for the rehabilitation of the cities. Exchanging information among others was necessary to identify the condition of damages by the earthquake quickly, rescue casualties right after the disaster, propose the rehabilitation plan, and so forth.

Most information they needed was required to confirm geographic locations on the map. For example, it was essential to know what kind of damages and where they are, which shelter who stays, which building is destroyed and has to be removed, and where those buildings are located, how the rehabilitation of the cities should be geographically carried out in urban planning.

The national government recognized a lesson from above and the effort to develop National Spatial Data Infrastructure (NSDI) in the United States. "A Liaison Committee of Ministries and Agencies Concerned with Geographic Information Systems" was established in September 1995 so that government bodies could collaborate in terms of the diffusion of GIS. Two task force groups, i.e. Spatial Data Framework Task Force Group and Basic Spatial Data Task Force Group were formed, each of which had a few working groups to discuss more specific topics in detail.

The Liaison Committee formulated a Long-term Plan in 1996 for the development of NSDI in Japan. The Plan specifies actions to be taken by the Government during the two-phase period starting in 1996 up to the beginning of the 21st Century. The first phase focuses on development of the definition of the NSDI in Japan as well as standardization of metadata and clarification of the roles of the Government, local governments and the private sector, rather than actual spatial data development. The implementation of NSDI including spatial data set development for NSDI is expected in the second phase. Approximately three years are assigned to each phase, i.e. the first phase (1996-99) and second phase (1999-2001).

In accordance with the Long-term Plan, Geographical Survey Institute (GSI), a national mapping organization in Japan, started research on GIS standard of Japan in 1996. This study was intended to provide a technological backbone to the Japanese SDI standard discussed in the Liaison Committee. 53 private companies are involved in this three-year research project funded by the Ministry of Construction, now the Ministry of Land, Infrastructure and Transport, as one of the collaborative research project with private sector. Two kinds of standards were developed through this research: spatial data exchange standard and spatial data development standard. 6 working groups were established to discuss 8 work items including data structure, data quality, georeferencing, metadata, and cataloguing. Spatial data development standard includes a guideline to develop specifications for spatial data development contracts. The final drafts of these standards were completed at the end of FY 1998.

The Committee adopted Final Report of the First Phase of the Long-term Plan on March 30, 1999. The Final Report entitled "Standards and Development Plan of National Spatial Data Infrastructure" includes two standards of Japanese NSDI (i.e. a technical standard that is based on ISO/TC211 standard drafts, and a list of data items adopted as the framework data) and a development plan for the second phase of the Long-term Plan. The technical standard included in the Final Report was developed through collaborative research mentioned above.

2. The Concept of National Spatial Data Infrastructure

The Liaison Committee designates National Spatial Data Infrastructure as a basic data out of various kinds of spatial data and categorizes them into three, spatial data framework, basic spatial data, and digital image data.

2.1 Spatial data framework

Spatial data framework is fundamental geographic data that is applicable to GIS, such as data of topography, place names, political boundaries, and transportation network in the nation, and can be utilized by linking them to statistic data or information of inventories. It corresponds to national digital geospatial data framework in the concept of U.S. NSDI

Moreover, spatial data framework has the most frequent use of data than other types of data and gives a large impact on the society and economy. Therefore, the nation, local governments, and private corporations have to be cooperating together in order to develop items of data primarily, which are selected as "spatial data framework standard" (shown in table 1).

The governmental organizations have been developing geographic information, which is to be elements of the framework of data required to operate GIS, and begun providing them via online media like internet and electronic media like CD-ROM. The data of geographic information includes geodetic control points, road/railroad network, coastlines, public buildings, place names, administrative boundaries and so on.

Table 1. List of Data Items Identified as Spatial Data Framework

Categories	Items of data
Geodetic Control Points	National and Public GCPs
Elevation	DEMs
Transportation	Road Network, Road Boundary, Railroad Network,
Rivers, Coastlines	River Network, River Boundary, Coastlines, Low Tide
Land	Parcel Boundary, Forest Boundary
Building	Public Building, Privately Owned Building
Georeference	Geographic Names, Address, Administration Boundary, Census Boundary, Standard Cells

2.2 Basic spatial data

Basic spatial data is primary data from the public aspect, which can be open to public and link or overlay spatial data infrastructure. This type of data includes data of statistics and inventories described about the nation and thematic geographic maps. Data of statistics and inventories is what is associated with population, social/economic activities, the prevention for disasters, environment, while thematic geographic maps is what illustrates the distributions of native plants, land use, geology, topography, and etc.

Besides, items of data about basic spatial data is not selected unlike spatial data framework because it is expected that the items of data considered as basic spatial data will change according to the transformation in the society and economy.

2.3 Digital image data

Digital image data is designated mainly digital images obtained by aerial photos or image data by artificial satellite. These digital image data are not only utilized in obtaining and updating data for spatial data framework but also presumably applied to a background image in GIS by transferring into orthophotos.

It is expected that particularly satellite images will be utilized as a background image in GIS, since images from artificial satellite have been produced with high-resolution in the market, can be obtained data by digital type generally, and can be covered a larger extent than aerial photo can cover.

3. Perspective of the Development of National Spatial Data Infrastructure

As mentioned above, national spatial data includes maps, statistics and inventories, images and etc. In this context, the central government should not develop data independently but direct local governments and private firms to developing and providing data by assigning a part of role respectively. The goal is to share data among organizations as an infrastructure of the entire society.

Therefore, the central government not establishes a whole new database but compiles basic data out of the existing data already developed individually by other organizations. Since most data are provided on the web as a general role, users can obtain data they needed from database online network by downloading and apply these data by linking or overlaying depending on their purpose.

4. The Environment for Users of National Spatial Data Infrastructure

It is essential to allow users easily to pull out data they need so that users can obtain and apply data they need from database online network by downloading. In addition, all data are standardized and compatible to use among others. Therefore, in terms of the provision of data, it is ideally requested that everyone can obtain them without charge or for reasonable price and it has to be minimized constrains on the usage of data.

Above mentioned, it is important to arrange the environment to distribute data since spatial data are produced individually by different organizations. There is a reason why the government has made an effort developing the environment for these users. The environment for users of GIS is progressed surely by the efforts, such as the establishment of data clearinghouse to search the existing GIS data, standardization of GIS to promote data sharing with others, and the provision of data owned by the nation on Internet.

In a broad sense, the concept of National Spatial Data Infrastructure might include the environment for users.

5. Agreement on the Targets and Specific Actions

The Liaison Committee agreed upon the targets and specific actions of the members to facilitated development and utilization of GIS in October 2000. The first target is a digitalization of geographic information and its provision service through Internet. GSI develops Digital Map 2500 (Spatial Data Framework) by FY 2000 for urban planning area and Digital Map 25000 (Spatial Data Framework) by FY 2001. The National Land Agency (now the Ministry of Land, Infrastructure and Transport) develops georeferencing data for districts. The target year for starting Internet service is FY 2000 for georeferencing data, FY 2001 for Digital Map 2500 and FY 2002 for Digital Map 25000. The second goal is to develop metadata in parallel with basic geographic information and establish clearinghouse for data-sharing within the government to minimize redundancy and also enable an easy access from private sectors. The government clearinghouse operated by GSI was released in March 2001. The third point agreed upon is standardization of geographic information developed by GSI and privatre sector in accordance with the Japanese Industrial Standard.

6. Clearinghouse

The Long-term Plan also specifies the need of establishing a clearinghouse system for spatial data. In this context, GSI has been engaged in a Geographic Information Directory Database (GIDD) as a five-year project since April 1994. This database was designed to provide directory information (i.e., metadata) of spatial data through computer networks, and to function as a clearinghouse node by developing a search environment of distributed databases. The metadata standard, which was used in the GIDD, was developed as one of the work items of Spatial Data Exchange Standard of "Research on GIS Standardization" described above. This standard was determined as Japan Metadata Profile (JMP) after additional necessary modifications. A prototype of GIDD with limited search capability was developed and examined practically. It was followed by the development of the second-generation system by GSI, to enable users to place requests to multiple database servers on the global network using ISO 23950. It has been available since March 2000. ISO 23950 is a client/server type protocol and was incorporated into the Japanese Industrial Standard (JIS X 0806: 1999). The URL of this clearinghouse gateway is:
http://zgate.gsi.go.jp/

At the same time, GSI added a clearinghouse node server to the international geographic clearinghouse coordinated by the U.S. Federal Geographic Data Committee. Up to the end of September 2001, over 900 metadata are registered in the GSI node. In addition, GSI asked the other government ministries and agencies concerned with geographic information to prepare metadata and clearinghouse node servers. As a result, as of January 2002, 12 node servers were developed by government ministries and agencies, as well as relevant organizations, and 20 node servers including by the foreign and international organizations has been registered in the clearinghouse gateway managed by GSI.

7. Future Efforts

Although the effort to develop GIS in Japan has begun later than other nations, it is clearly seen the steady progress by that the Liaison Committee established in 1995 has organized the concept of National Spatial Data Infrastructure and has been developing basic data of GIS and the environment for users.

In the future, it is necessary to develop the present infrastructure further and achieve the effort to increase the use of GIS substantially by applying data and the environment of GIS to different fields.

In order to respond to these needs, the Committee has drawn up a new four-year Long-Term Plan starting from FY 2002 to promote further dissemination of GIS in Japan, aiming at realizing to: streamline office work and improve civil services in the governmental organizations; create a new business model and produce new employment in the industry; and have the people enjoy quality service in their general life.

NSDI, RSDI, GSDI and Global Mapping

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Abstract

The concept of SDI (spatial data infrastructure) has become popular since the middle of 1990s. It is that spatial data can be viewed as an infrastructure with the same rationale as roads, communication networks etc., which is needed to support the economic, social and environmental objectives. SDI includes the technology, policies, data, standards, human and financial resources necessary to acquire, process, store, distribute and use spatial data. The core components of SDI are: clearinghouse; metadata; standards; and framework data. There are three levels of SDI: national (NSDI); regional (RSDI); and global (GSDI). United States started the development of NSDI in 1994 under the coordination of the Federal Geographic Data Committee (FGDC). To date, more than 30 countries have or plan to have NSDI initiatives. In 1995, the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) was formed, and published a paper on the vision of the Asia-Pacific Spatial Data Infrastructure (APSDI) in 1998. Europe and the Americas are making similar efforts for RSDI. GSDI initiative is lead by GSDI Steering Committee. In 2000, it published SDI Cookbook for sharing the experiences in building SDI implementations. Global Mapping is an international collaborative initiative through voluntary participation of national mapping organizations, aiming to develop globally homogeneous geographic dataset at the ground resolution of 1 km. Currently, 10 countries have released their Global Map version 1.0, which are available via Internet at no cost.

1. National Spatial Data Infrastructure (NSDI)

The concept of national infrastructures is not new. In all nations, the major road and telecommunication networks, and basic health and education facilities, have been funded by governments. The rationale is that it is a legitimate role of government, on behalf of the community, to provide a common, consistent infrastructure upon which a variety of government, private sector and community activities can take place. Spatial data can also be viewed as an infrastructure, with the same rationale and characteristics as roads, communication networks and other infrastructure. A spatial data infrastructure (SDI) is needed to support the nation's economic growth, and its social and environmental objectives, underpinned by international standards, guidelines, and policies on access to those data.

The concept of National Spatial Data Infrastructure (NSDI) was firstly proposed in the Executive Order 12906 of the U.S. President Bill Clinton titled "*Coordinating Geographic Data Acquisition and Access: the National Spatial Data Infrastructure*" published in 13 April, 1994.

According to the document, NSDI is defined as "*the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilization of geospatial data*".

An executive branch in the Federal Government was ordered to develop a coordinated National Spatial Data Infrastructure to support applications of geospatial data for public and private sector, in cooperation with State, local, and tribal governments, and the Information Infrastructure, avoid redundancy and promote effective and economical management of resources by Federal, State, local, and tribal governments.

Thereby, the Federal Geographic Data Committee (FGDC) chaired by the Secretary of the Department of the Interior and composed of 14 federal agencies that produce and use geographic data, was nominated as the coordinating body for the Federal Government's development of the NSDI.

The FGDC developed Strategic Plan for the NSDI in 1994, which was revised in 1997, setting out the vision for the NSDI as: *Current and accurate geospatial data will be readily available to contribute locally, nationally, and globally to economic growth, environmental quality and stability, and social progress.*(Fig.1)

Major initiatives were undertaken by federal agencies and by organizations outside the federal government to develop the NSDI:

- Creation of a distributed electronic network of data producers and users, known as the National Geospatial Data **Clearinghouse**;
- Development of **standards** for data documentation, collection, and exchange;
- Formulation of procedures and partnerships to create a national digital geospatial data **framework** that would include important basic categories of data significant to a broad variety of users;
- Development of new **relationships** that allow organizations and individuals from all sectors to work together to share geogeospatial data.

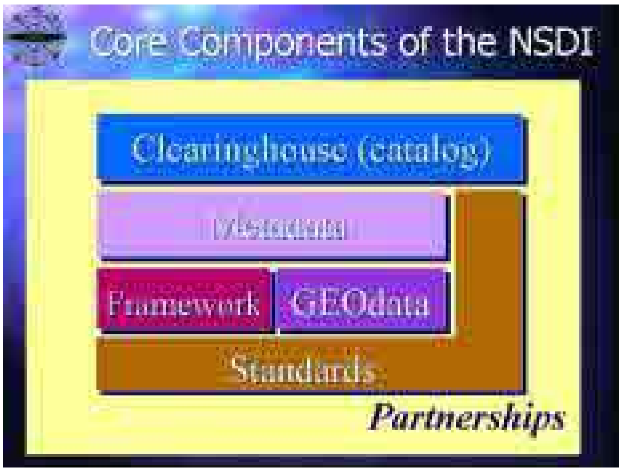

Fig.1 FGDC's Concept on Core Components of the U.S. NSDI.

National Geospatial Data Clearinghouse is a distributed network of geospatial data producers, managers, and users linked electronically. The clearinghouse was established by FGDC in 1994. Each federal agency was ordered to produce the document of all geospatial data ("metadata") which was stored, collected or produced, using the standard developed by the FGDC, and make that standardized documentation electronically accessible through the Clearinghouse network. The FGDC is also responsible for the establishment of the standards of geospatial data and promotion of use of the standards in the federal agencies.

Another important concept that this order firstly introduced was the implementation of a national digital geospatial data framework. The framework includes geospatial data that are significant to a wide variety of users within any geographic area or nationwide. The framework is a collaborative effort to create a widely available source of basic geographic data. It provides the most common data themes geographic data users need, as well as an environment to support the development and use of these data. The framework represents the best available data for an area, certified, standardized, and described according to a common standard. It provides a foundation on which organizations can build by adding their own detail and compiling other data sets. The framework's key aspects are:

- seven themes of digital geographic data that are commonly used, i.e. geodetic control, orthoimagery, elevation, transportation, hydrography, governmental units, and cadastral information;
- procedures, technology, and guidelines that provide for integration, sharing, and use of these data; and
- institutional relationships and business practices that encourage the maintenance and use of data.

Stimulated by the success story of NSDI in the U.S., many countries have started the development of respective NSDI. To date, more than 30 countries have or are planning NSDI initiatives. Some examples of NSDI development are introduced in the "SDI Cookbook".

2. Regional Spatial Data Infrastructure (RSDI)

At the 13th United Nations Regional Cartographic Conference for Asia and the Pacific, held in Beijing in May 1994, it was resolved that "*...directorates of national survey and mapping organisations in the region form a permanent committee to discuss and agree on, inter alia, geographical information system standards, geographical information system infrastructure and institutional development, and linkage of the prospective committee with related bodies in the world.* As a result of that Resolution, the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) was formally established at its inaugural meeting in Kuala Lumpur, Malaysia in July 1995. The aims of the PCGIAP are "*to maximise the economic, social and environmental benefits of geographic information in accordance with Agenda 21 by providing a forum for nations from Asia and the Pacific to:*

- *co-operate in the development of a regional geographic information infrastructure,*
- *contribute to the development of the global geographic information infrastructure, and*
- *share experiences and consult on matters of common interest.*

As a first outcome of the committee's activity, PCGIAP published a paper on the vision of the Asia-Pacific Spatial Data Infrastructure (APSDI) in 1998. PCGIAP's vision for APSDI is of a network of databases, located throughout the region, that together provide the fundamental data needed to achieve the region's economic, social, human resources development and environmental objectives. Those distributed databases include geodetic, topographic, hydrographic, administrative and environmental data. They may, in the future, be linked electronically so that they appear, to the users, as a virtual database, but they will also be linked together in a number of other important ways such as:

- an intra-regional institutional framework;
- the use of common technical standards;
- the adoption of common policies and inter-governmental agreements; and
- a comprehensive and freely accessible directory.

It is this suite of administrative and technical linkages that distinguishes the APSDI from a collection of uncoordinated datasets, and which will make it such a powerful tool for the region's economic and social development. If all nations adopt a regional perspective they will not only avoid waste of resources but will be able to provide users with consistent, reliable data that can be used to address issues such as land use conflict, environmental issues and locating mineral deposits. The APSDI will build upon national spatial data infrastructure initiatives in the region and will be closely linked to other relevant international initiatives including Agenda 21, Global Map and the Global Spatial Data Infrastructure.

Similar efforts aiming to develop RSDIs are being made in Europe by EuroGeographics and European Umbrella Organisation for Geographic Information (EUROGI), and in American Continent by the Permanent Committee on Spatial Data Infrastructure for the Americas (PCIDEA) respectively.

3. Global Spatial Data Infrastructure (GSDI)

The definition of Global Spatial Data Infrastructure (GSDI) is the broad political, organizational, technical and financial arrangements necessary for global access to geographic information. This is achieved through the coordinated actions of nations and organizations that promote the development and availability of interoperable digital geographic data and technologies to support decision making at all scales for multiple purposes. These actions encompass the policies, organizational remits, data, technologies, standards, delivery mechanisms, and financial and human resources.

To date, GSDI activity has been principally comprised of a group of individuals representing national mapping agencies, international organizations, and standards organizations. Five GSDI Conferences have been held since 1996. In the early stage, GSDI activity was only the voluntary talk by the participants in the ad-hoc conferences. However recently, GSDI community is seeking to form a permanent non-profit legal organization. The organizational model for GSDI in the long term is a global umbrella organization, which brings together national and regional committees and other relevant international institutions. GSDI is being advanced through the leadership of many nations and organizations represented by a GSDI Steering Committee. This multi-national Steering Committee includes representatives from all continents, and all sectors – government, academia, and the private sector.

The GSDI Steering Committee has identified a set of core goals to help advance awareness, acceptance and implementation of globally compatible spatial data infrastructures at the local, national, and regional levels:

- Articulate the operational environment needed to achieve Global SDI compatibility;
- Help build globally compatible SDI capacity around the world;
- Educate decision-makers on the benefits of GSDI inside and outside their borders;
- Assure that different SDI related policies can be facilitated by the GSDI;
- Advance the GSDI mission until a global SDI is achieved.

In July 2000, GSDI published "the SDI Cookbook (SDI Implementation Guide)" to clarify the SDI definition and to share the current experiences in building SDI implementations that are compatible at many scales of endeavor. To enable builders of SDI to make use of and build on existing SDI components in a way which makes their endeavors compatible with the efforts of other SDI builders, the SDI Cookbook identifies existing and emerging standards, free and commercial standards-based software solutions, supportive rganizational strategies and policies and best practices. Version 1.1 of the SDI Cookbook is available from GSDI webpage:
http://www.gsdi.org/pubs/cookbook/
cookbook0515.pdf

4. Global Mapping

Global Mapping project is an international collaborative initiative through voluntary participation of national mapping organizations of the world, aiming to develop globally homogeneous geographic data set at the ground resolution of 1km.

Primary objective of the Global Mapping project is to contribute to the sustainable development through the provision of base framework geographic dataset. At the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992, Agenda 21, an action program for addressing global environment challenges while continuing to support sustainable economic development, was adopted. Agenda 21 clearly mentions that there is need for improved coordination among environmental data and information activities, and it emphasized the transformation of existing information into forms more useful for decision-making. In particular, geographically specific spatial information is critical. Spatial information enables us to enhance our understanding of global and regional relationships inherent in present status and processes that lead to changes in key components of global environment. To this end, in 1992, then Ministry of Construction (presently Ministry of Land, Infrastructure and Transport) of Japan advocated the Global Map concept.

As the first international meeting on the Global Mapping, International Workshop on Global Mapping was held in Izumo, Japan in November 1994. As a result of the workshop, "The Resolution of Izumo Conference" was adopted, which consists of eleven items. Among them are: (1) promoting the preparation of Global Map by the year of 2000; (2) periodical updating of Global Map; (3) promoting technical cooperation for realization of Global Map; (4) establishing the Steering Committee for promotion and coordination of Global Mapping.

The Second International Workshop on Global Mapping was held in Tsukuba, Japan in February 1996. The main objective of the workshop was to establish the International Steering Committee for Global Mapping (ISCGM). Consequently, it was resolved to establish ISCGM chaired by Prof. Estes consisting of 14 directorates from 13 national mapping organizations (NMOs), to set the secretariat of ISCGM in GSI and to appoint 4 advisors. Number has increased to 18 members and 7 advisors now. Members are the heads of NMOs of Australia, Bangladesh, Canada, China, Colombia, France, Iran, Japan, Kenya, Republic of Korea, Malaysia, New Zealand, Niger, South Africa, United Kingdom and U.S.A. and representatives from SCAR and EuroGeographics. Advisors are representatives from international organizations and academic institutions such as UN, UNEP, UNU and ICA. ISCGM has three working groups to discuss more detailed plans. WG1 works for development of strategic action plan, WG2 for specifications, and WG3 works for data policy. ISCGM has held 8 meetings since its establishment to discuss action plan, specifications, data policy etc. for smooth implementation of Global Mapping Project.

ISCGM defined the Global Map as “a group of global geographic data sets of known and verified quality with consistent specifications, which is a common asset of mankind with scientific quality for world-wide distribution at marginal cost.” This definition clarifies three basic and important ideas about Global Map: i) global coverage; ii) consistent specifications; and iii) easy accessibility.

(1) Global coverage

Most countries have national mapping organizations for mapping programs to ensure base map coverage of their own countries. Likewise, it is necessary to have global coverage of geo-spatial information to provide baseline data sets of our planet. To detect changes of the earth, frequent update of the data is also important. As for spatial resolution, Global Map has one-kilometer resolution on the ground.

(2) Consistent specifications

Better understanding of the earth sometimes requires direct comparison between one part to the other part of the world. However, if the geodetic datum, mapping accuracy, classification criteria etc. are not consistent worldwide, accurate understanding of the state of the earth may not be realized. For example, total area of forest or desert would be different if the classification criteria are not consistent between countries or regions.

(3) Easy accessibility

Even though global geo-spatial information is developed with consistent specifications, it would be almost useless unless it is made widely available to the international community and used among different sectors of the society. There exist a few data sets whose distribution is prohibited or limited to a specific community due to national security, political sensitivities and other reasons. Similar to the idea of national digital geo-spatial data framework, the Global Map should be open to the public and distributed at marginal cost. The spatial resolution of one kilometer on the ground would cause little concern for national security, as we are anticipating sub-meter pixel resolution imagery from commercial high-resolution satellites.

Complete coverage of the Global Map will only be realized by the participation of all the national mapping organizations of the world. In November 1998, the UN sent a letter of Prof. Estes, Chairperson of ISCGM, inviting NMOs of respective countries and regions to Global Mapping Project with a recommendatory letter of Mr. Habermann, Director of The UN Statistics Division, to heads of NMOs. The Global Mapping Initiative is a voluntarily based international collaboration activity. There are three levels of participation. Level A country will develop Global Map(GM) of her and other countries. Level B country will develop GM of her country. Level C country will provide data needed for development of GM. Currently, 89 countries and regions have participated in the project and 32 are now positively considering. The area covered by participated countries and regions exceeds 72% of the whole land mass and more than 80% are covered by including considering countries and regions. Member organizations participated in the project are mainly National Mapping Agencies because they have source of information of core geographical data as a result of their original duty. The Scientific Committee on Antarctic Research (SCAR) participates in the project and is developing GM of the Antarctica.

ISCGM sets the period of the first phase of the GM development to the year 2000, whose target is to make the Global Map version 1.0 available. Member organizations have been producing GM of their own territories, while GSI and USGS EROS Data Center have created global data set by converting existing global data, V-map Level 0, GLCC and GTOPO30. GSI, as a level A country, has also been developing GM of Asian countries collaborated with National Mapping Agencies of respective countries. As a result, Global Map version 1.0 for ten countries have been released at present. It is expected that some forty countries will complete development of GM by the time of Rio+10 conference(Fig.2).

Fig.2 Status of Participation and Development of the Global Mapping Project

Global Map Specifications was firstly adopted at the Fifth ISCGM Meeting in 1998 and a minor amendment was made at the Seventh ISCGM Meeting in 2000. Full text of the Global Map Specifications is available at:

http://www.iscgm.org/gm-specifications11.pdf

Format for vector data shall be Vector Product Format (VPF) by United States National Imagery and Mapping Agency, and for raster data, Band Interleaved by Line (BIL) with separate header be used. The vector data consists of four layers such as transportation, boundaries, drainage and population centers, and raster data consists of elevation, vegetation, land cover and land use as well. Concerning the geodetic datum and ellipsoid, Global Map Specifications adopts combination of International Terrestrial Reference Frame 1994 (ITRF94) and the Geodetic Reference System 1980 (GRS80) ellipsoid as current world geodetic system. Besides, in order to manage the large amount of data, the Specifications adopts tiling system. Size of one tile is five degrees in latitude by five degrees in longitude in case the tile is located between zero degrees and forty degrees in latitude. There is no overlap or gap between tiles.

On 28 November 2000, release of Global Map Version 1.0 was declared at the Global Mapping Forum 2000 in Hiroshima, Japan. At the same time, WWW server of the ISCGM became operative and provision of the Global Map data was officially started.

Data firstly released were the Global Map Version 1.0 of 5 countries: **Japan**, **Lao P. D. R.**, **Nepal**, **Sri Lanka** and **Thailand. Philippines** followed in December 2000, **Colombia** in May 2001, **Australia** in June, **Bangladesh** in July and **Mongolia** in December. Global Map Version 0 data, which had been converted from existing global geographic information (GTOPO30, GLCC) according to Global Map Specifications, were also released.

Fig.3 Bird's-eye view processed from "Global Map Sri Lanka". Land Use and Transportation are overlaid and Elevation data are used for processing.

Non-commercial users, such as governmental institutions, research organizations as well as private researchers can

Fig.4 Land Cover, Transportation, Drainage, Administrative Boundaries and Population Centers of Bangkok and its Vicinity. Processed from "Global Map Thailand."

download these data free of charge via Internet. In addition, more than 10 countries are nearly to complete their data for the Global Map Version 1.0. More than 2,500 users have registered with the download page of ISCGM and data have been downloaded nearly 18,000 times since its release. Global Map Homepage is at:

http://www.iscgm.org/

Thus, Phase I of the Global Mapping Project was successfully completed in 2000. Global Map will be updated and upgraded in the next phase. One of the advantages of Global Mapping initiative is the big number of its participating organizations. This advantage makes it possible to assure reliability of the final product through proper verification implemented by each NMO in the world. Recent progress in space technology gives us opportunity to revise global scale geographic datasets in more consistent way. Currently, ISCGM is discussing the practical plan for updating and upgrading of Global Map, making the best use of these benefits.