United Nations E/CONF.93/L.9

Economic and Social Council

Distr.: Limited
24 November 2000

English only

Seventh United Nations Regional Cartographic Conference for the Americas
New York, 22-26 January 2001
Item 7 (b) of the provisional agenda*
Reports on achievements in surveying, mapping and charting in addressing national, subregional, regional and global issues, including technical issues

Cartographic Work in Japan from 1997 to 1999

Paper submitted by Japan

1. Geodetic Work

Fundamental geodetic works in Japan are principally executed by the Geographical Survey Institute (GSI) and the Hydrographic Department (HD).

The Japanese national geodetic network consists of 1,000 first order triangulation points, 5,000 second order triangulation points, 32,700 third order triangulation points and 61,000 fourth order triangulation points, and 20,000 km of precise leveling routes. Fourth order triangulation points are still being added mainly for cadastral surveys.

The establishment of a nationwide GPS observation network has started in 1992, and the operation started in 1994.

GSI is preparing for adoption of world geodetic system as national geodetic datum, i.e., Japanese Geodetic Datum 2000. New datum will be provided after amendment of Survey Act.

1.1 Precise Geodetic Network Surveying Project

GSI started the Precise Geodetic Network Surveying Projects in 1974 in order to switch over from old geodetic data obtained by conventional method (such as triangulation) to more precise new data by trilateration, using optical EDMs (Electro-optical Distance Measuring instruments). The geodetic framework of the project is classified into two networks. One is the Primary Precise Geodetic Network composed of 6,000 first and second order triangulation points, and the other is the Secondary Precise Geodetic Network composed of 32,700 third order triangulation points. Currently instruments used for this survey are being changed from EDM to GPS (Global Positioning System). GSI started the operation of the nationwide GPS observation network composed of 210 GPS observation stations called GPS-based Control Stations in 1994. Additionally, 737 GPS-based Control Stations had been added by March 2000. The network is operated continuously and the data are processed once a day.

The data of Precise Geodetic Network can serve not only as revised framework for mapping, but also for earthquake prediction and research on crustal deformation in Japan.

* E/CONF.93/1.

00-77849 (E) 081200

1.2 Leveling

GSI accomplished the eighth revision leveling survey along the first order leveling routes throughout Japan in March 1997. The ninth revision leveling survey has been carrying out from April 1997. About 2,000 km of revision surveys are carried out every year.

In addition to the revision survey, GSI is conducting 2,000 km of re-leveling annually in the Specified Observation Areas and the Intensified Observation Areas designated in the National Earthquake Prediction Program; furthermore, 14,000 km of re-leveling is performed annually in and around ground subsidence areas by GSI, in cooperation with local governments.

138 tidal stations are registered with the Coastal Movement Data Center and all the tidal data obtained at these stations are compiled and published every year.

1.3 Satellite Positioning

GPS observation shares a large part of satellite positioning of GSI. GSI is carrying out Precise Ephemeris Estimation of GPS satellites, data supply to IGS (International GPS Service), IGS data distribution as a regional data center, IGS data analysis as an Associate Analysis Center of IGS, continuous GPS observation at 947 fixed observation sites for the crustal deformation monitoring (GEONET: GPS Earth Observation Network System), and positioning of isolated islands by GPS.

GSI has been carrying out EGS (Experimental Geodetic Satellite, nicknamed "AJISAI") observation since 1986. Observation of EGS are carried out also by NASDA (National Space Development Agency of Japan) and HD. GSI is carrying out positioning of the satellite by telescopic photograph and spin rate estimation by photoelectric observation.

In order to measure the precise position of the mainland and islands of Japan in the World Geodetic System, HD has been conducting a series of satellite laser ranging (SLR) observation of LAGEOS at the Shimosato Hydrographic Observatory since 1982, and has constantly determined the positions of more than 70 off-lying islands using differential techniques of NNSS since 1974 and GPS since 1994.

HD started a marine geodetic control project in 1988 to determine the precise position of 15 major islands of Japan by the simultaneous SLR observation of AJISAI, and has already determined the precise position of 9 islands (all islands but Etrofu Shima). Now HD starts to study the plate movement around Japan Islands by continuing observation off our geodetic control points which includes Chichi Shima, Ishigaki Shima, Minami Tori Shima, and Wakkanai. The observations were performed at Chichi Shima in 1996, and Ishigaki Shima from 1997 to1999, and Wakkanai in 2000.

Both of these SLR observations are supported by the cooperative research provided by the U.S.A-Japan cooperation in the field of space development. The cooperative research is also related to the Crustal Dynamics Project conducted by NASA.

The obtained data were previously analyzed by the method SPORT (Successive Passes Orbit Revising Technique) developed at HD to determine the relative positions of these major islands referred to Shimosato as precisely as the uncertainty of 7mm for the baselinelength of about 2,000km in the case of Minami Tori Shima.

Since 1997, HD changed the analytical procedure from SPORT to Global Data Analysis which utilizes SLR observation data from all over the world with the help of the software GEODYN-II developed by NASA.

In order to watch the middle size crustal deformation (about 50km), HD continuously monitors the baselines in the Minami Kanto area, known as the nest of big earthquakes, by GPS geodetic survey in Izu Oshima, Manazuru, Yokosuka, Minami Izu, Kozu Shima, and Miyake Shima.

HD started continuous monitoring of GPS geodetic survey to detect the crustal deformation at the Japanese coastal area from 2000.

1.4 Astronomical Observation

GSI has carried out GPS/Leveling survey at about bench marks along the first order precise leveling routes in Japan to obtain geoidal heights.

HD is carrying out the observations of occultation of stars by the moon, including grazing occultations at the hydrographic observatories located at Tokyo, Shirahama, Shimosato, and Bisei. These observations are for preparing the Japanese Ephemeris (the most precise almanac in Japan), nautical almanac, abridged nautical almanac, and so on.

For the purpose of preparing the Japanese Ephemeris (the most precise almanac in Japan), nautical almanac, abridged nautical almanac, etc., HD has been conducting observation of occultation of stars by the moon at the hydrographic observatories at Tokyo, Sirahama, Simosato and Bisei, and grazing occultation at two places in Japan.

1.5 Very Long Baseline Interferometry (VLBI)

GSI has been operating five permanent stations at Shintotsukawa with 3.8 m, at Aira with 10 m, at Chichijima with 10 m, at Kashima with 26 m and at Tsukuba with 32 m diameter antenna GSI has carried out domestic VLBI experiments with five stations four times per year. Tsukuba and Kashima stations have been participating in international VLBI projects of VLBI global network for a deeper understanding of inter/intra-plate crustal deformation and Earth orientation changes. The projects are Continuous Observation of the Rotation of Earth (CORE), Research and Development (VLBI), The NAVnet

Experimental session (NAVEX), The Celestial Reference Frame sessions (CRF), The National Earth Orientation Service sessions (NEOS), and Asis-Pacific Space Geodynamics (APSG). The major purposes of GSI' s VLBI activities are below.

a) Connecting Japanese geodetic reference frame referred to International Terrestrial Reference Frame (ITRF) to participate in the International VLBI Service (IVS).

b) Precisely finding the movement of continents or the variability of the earth rotation to carry out VLBI experiments repeatedly.

c) The monitoring of mean sea level change to measure the position of tidal stations by VLBI and GPS repeatedly.

d) Establishment of a terrestrial reference frame in Asia and the pacific area by space geodetic survey techniques in cooperation with the related countries.

1.6 Gravity Survey

Gravity Surveys are executed on land by GSI and at sea by HD. GSI is repeating fundamental and 1st order gravity surveys at fundamental and 1st order gravity stations to detect gravity changes associated with crustal movements. Since 1984, an absolute gravity measuring system has been operated for fundamental gravity survey. Since 1992, GSI has introduced FG-5 absolute gravimeters and measured absolute gravity at the fundamental gravity stations. Using the fundamental and 1st order gravity data, GSI built Japanese Gravity Standardization Network 96 (JGSN96).

GSI also continues 2nd order gravity surveys at leveling and triangulation points. These data are concentrated on the preparation of Bouguer anomaly and free air anomaly charts and are provided for the study of underground structures.

In 1998, GSI published a geoid model in and around Japan as one of its digital data series, "Digital Data 5km Grid (geoidal height)" stored in a 1.44MB floppy disk, which is based on a gravitational geoid "JGEOID93" and results of GPS/leveling. The data is widely available to GPS surveyors and anyone else.

HD has been conducting gravity measurements in the Izu Syoto every year. These observation data are used to delineate vertical crustal movements related with earthquakes and volcanic eruptions.

HD has also been conducting the gravity surveys at sea area using survey vessels for prediction of earthquake and volcanic eruptions.

Geological Survey of Japan (GSJ) is compiling Bouguer anomaly data of Hokkaido and Kyushu districts by filling in data gaps with their own new measurements. The results are being published as Gravity maps (Bouguer Anomalies) at 1:200,000 scale. GSJ also compiled "Gravity Map of Japan (Bouguer Anomalies)" using total of about 350,000 land data and about 1,000,000 marine data in 1999. The Japanese Islands and their adjacent sea areas are covered by these sheets of the map at 1:1,000,000 scale. The digital data for the map will be published in 2000.

1.7 Geomagnetic Survey

GSI has been conducting land geomagnetic and aeromagnetic surveys. The former surveys are conducted at 105 1st order geomagnetic stations at about two or five year intervals. GSI also set up 11 fundamental geomagnetic stations throughout Japan for continuous geomagnetic observation and has started observation since 1996.

The data obtained by GSI are used for compilation of magnetic charts on the scale of 1:4,000,000 for D (declination), H (horizontal intensity), I (inclination), Z (vertical intensity) and F (total intensity) components. GSI revised each component chart in 1992, using the data obtained from the period between 1980 and 1990 which were reduced to the common epoch 1990.0.

In addition to these, GSI is carrying out an aeromagnetic survey to revise aeromagnetic total intensity chart at an altitude of 5,000 meters for the epoch 1995.0.

GSI started a precise aeromagnetic survey in and around volcanic area. In 1999, aeromagnetic survey was carried out in Mt. Iwate area.

HD conducted landmagnetic and aeromagnetic surveys on and over the Japanese islands and its surrounding waters. In order to maintain the safety of a vessel or an aircraft using a magnetic compass, magnetic variations and annual changes must be shown on the nautical and aeronautical charts. For that, HD is regularly conducting geomagnetic observations and measures magnetism and annual variations by means of airborne magnetic surveys on and around Japan and land magnetic surveys at the repeated observation points every five years.

HD has been conducting the magnetic surveys at sea area using survey vessels for prediction of earthquake and volcanic eruptions. HD carries out the land and aeromagnetic surveys to predict volcano eruptions.

GSJ has been conducting high-resolution aeromagnetic surveys over the Japanese islands and adjoining sea areas, using an airborne magnetometer of Cesium optical pumping type or proton precession type with high repetition rate. Total intensities (F) of magnetic field in the air are observed along with the precise position-fix data acquisition. Data obtained are processed and magnetic anomaly field is extracted after removing the International Geomagnetic Reference Field (IGRF), which are published as aeromagnetic anomaly maps at the scale of 1:25,000 to 1:200,000.

Recent target areas of high-resolution aeromagnetic survey are mostly related to the elucidation of active fault system. A survey in Kobe-Kyoto area was conducted in 1995 in relation to the 1995 Kobe earthquake and the data analyses concerned with Arima-Takatsuki tectonic line were performed in 1996. In 1997, the Yoro Fault area was surveyed as one

of geophysical studies under the earthquake potential evaluation program, and another survey was conducted in 1998 in the Fukui Plain in use of a helicopter mounted observation system, while the former were done using a fixed-wing airplane.

1.8 Synthetic Aperture Radar Interferometry

In order to obtain detailed spatial distribution of surface displacement over a large area, GSI studies synthetic aperture radar (SAR) interferometry. One of its achievements is the detection of surface displacement caused by using JERS-1 (Japanese Earth Resources Satellite-1) SAR data.

1.9 Precise distance measurements

GSI has carried out precise distance measurements using precise short-range EDM (ME-5000) with resolution of 0.5 mm for the purpose of observing crustal movements in swarm earthquakes area and active faults.

1.10 Mobile Observation

GSI has carried out observation of crustal movements in Mt. Iwate volcanic area with a mobile GPS continuous station and an automated polar system (APS) since 1998, when the volcanic activities of Mt. Iwate started. It is possible to set a mobile GPS continuous station, which was newly developed, "REGMOS 1", in not-electrified areas such as mountainous area or isolated islands with its solar-battery system and satellite communication system.

1.11 Unmanned Survey Craft

HD is developing an unmanned survey craft. In order to make it possible to carry out hydrographic surveys in a dangerous area, where for example submarine volcanic eruption is likely to occur, HD developed a remote-controlled unmanned survey craft in 1988. The craft, nicknamed "MANBO", well proved its practical capability of hydrographic survey, when a submarine volcano erupted off the Izu Hanto (Peninsula) in July 1989.

For the earthquake prediction program, one of the most important objectives is to make geophysical observations at sea-bottom. In response to this demand, some development schemes using the Sea Floor Acoustic Ranging (Sea FAR) system to observe crustal deformation at sea-bottom were launched in 1989, in cooperation with Japan Hydrographic Association. The operation and improvement of the unmanned survey craft was also conducted in relation with this project.

1.12 Crustal Dynamics Research

GSI has been participating in the National Earthquake Prediction Program. In order to monitor the crustal activity in and around the Japanese islands, GSI has been conducting several kinds of geodetic surveys and researches on measurement techniques and crustal movements.

In 1995 the Headquarters for Earthquake Research Promotion (HERP) was established in the Prime Minister's Office based on newly-enacted Special Measures Law on Earthquake Disaster Prevention. According to the Fundamental Seismic Survey and Observation Plan decided by HERP In 1997, GSI is responsible for the continuous observation of crustal movement by GPS station installed with intervals of 20-25 km and detailed active fault mapping in urban area. UP to now GSI has established a large nationwide array of about 1,000 continuous GPS observation station called GEONET (GPS Earth Observation Network).

GEONET has detected a number of coseismic crustal deformations. In April to may, 1998, the GPS observation showed that the crustal deformation was closely related to the earthquake swarm in Izu peninsula. GEONET also detected the deformation of Mt. Iwate associated with Volcanic activity in 1998.

GSI has conducted satellite SAR interferometry to reveal the spatial distribution of crustal deformation. Based on JERS-1 SAR interferometry and GPS data a model was proposed for the causative fault of Northwestern Kagoshima Prefecture Earthquake of May 26, 1997.

Data and relevant information of crustal movement are compiled and reported to related committees and organization such as the Earthquake Research Committee of HERP, the Coordinating Committee for Earthquake Prediction, the Japan Meteorological Agency, etc. on a regular basis. In case of emergency the data are provided immediately.

HD surveys for the earthquake prediction program. In order to obtain basic data and information necessary for researches of earthquakes, HD has been carrying out surveys and investigations for submarine topography and active sea-bottom structures in specific areas off Fukushima in which large-scale earthquakes have occurred before, as well as on Sagami-Nankai Trough (Fukushima) which is designated as the Intensive Observation Areas for earthquakes.

For this purpose, magnetic and gravity surveys were also conducted in offing Akita and Yamagata and other plate boundaries. Total intensity magnetic anomaly and free-air gravity anomaly maps were made for elucidation of sea-bottom structure. Free-air gravity anomaly is also used to calculate precise geoid.

Table 1. Geodetic Work for the Period from 1997-1999

		1997	1998	1999	Total
Primary Precise Geodetic Network		90	88	71	249
Secondary Precise Geodetic Network		65	27	44	136
Fourth Order Triangulation		940	945	955	2,840
First Order Revision Leveling		2,887	2,716	3,439	9,042km
Satellite Laser Ranging(HD)	Mainland	Since 1982			1
	Islands	1	1	1	3
GPS	GPS-based Control Stations	GSI			947
	Islands	HD 7	2	2	11
VLBI	Stations	4	5	5	14
Geoid observation(GPS/Leveling)		39	40	41	120
Gravity Survey	Fundamental (GSI)	14	6	5	25
	1st Order (GSI)	11	11	10	32
	2nd Order (GSI)	0	9	44	53
	Island/Harbors (HD)	4	5	5	14
	Sea (HD)	5	3	3	11
	Others (GSI)	-	-	1 in Korea	1
Geomagnetic Survey	Fundamental Magnetic Stations (GSI)	11	11	11	33
	1st Order (GSI)	0	2	2	4
	Island (HD)	1	1	1	3
	Sea (HD)	4	2	2	8
Aeromagnetic Survey	Volcanic area (GSI)	-	-	4,650	4,650km
	In and around Japan (GSI)	7,000	6,500	-	13,500km
	Land/Sea (HD)	2,100	3,400	3,600	9,100km

*In all tables in this report, year represents Japanese fiscal year which starts from April of the year and ends in March of the next year.

*Numbers in the table mean the number of surveyed points unless otherwise specified.

*NGI : National Geography Institute of Korea

2. Topographic Mapping

2.1 Medium Scale Topographic Maps

The first national base map series covering the entire country of Japan was 1:50,000 scale topographic map. The preparation of it began in 1895 and was completed in 1925.

In 1964 GSI adopted 1:25,000 scale topographic map as the national base map replacing the 1:50,000 scale map. The 1:25,000 scale map encompassing the whole country of Japan was almost completed in 1983.

In 1993, GSI adopted raster-based revision method for the 1:25,000 topographic maps, and plans to replace the conventional method completely with the new digital method by 1997. GSI also began to apply this new method to the 1:10,000 and the 1:50,000 topographic map revision.

GSI has been conducting revision surveys for and recompilation of these maps with the following principles:

a) The 1:25,000 scale maps are revised every three years for urban areas, five years for suburban areas or ten years for mountainous areas depending on the amount of changes in each map sheet. In addition to the above principle the revision is carried out at the same time when new highways, etc., are begun their function.

b) The 1:50,000 scale maps are revised with the revision of the corresponding 1:25,000 scale topographic maps.

c) The amount of changes is assessed by Regional Survey Departments of GSI, which are located at ten major cities throughout the country.

GSI began an experiment in perusal service of 1:25,000 scale maps using the internet in 2000.

2.2 Large Scale Topographic Maps

GSI initiated the National Large Scale Topographic Mapping Project in 1960, in order to cover 190,000 km^2 of flat areas of the country. The Forestry Agency also began promoting a similar project in mountainous areas, for the purpose of producing a Basic Forest Map (BFM) as the basis for surveying forests. The project covering mountainous areas was completed in 1980. Currently the Forestry Agency is promoting revision work of the existing Basic Forest Map.

Until 1974, local governments had been producing large scale urban planning base maps with their own standards. Since 1975, GSI and the City Bureau of the Ministry of Construction had standardized 1:2,500 urban planning mapping process by promoting the 1:2,500 scale map cooperative mapping project. In the project, GSI took aerial photographs and executed aerial triangulation and local governments undertook mapping processes such as stereo plotting, map compilation and drafting. Around 50,000 km² of urban planning areas were mapped according to the standard until the end of 1996. These maps are in principle revised every five years by local governments.

In 1983, GSI began to compile 1:10,000 scale topographic maps for urban areas compiling existing 1:2,500 scale maps.

Table 2 shows the amount of large and medium scale topographic mapping work undertaken during the past three years.

Table 2. Large and Medium Scale Topographic Mapping

		1997	1998	1999
1: 5,000	Revision	51.12 km²	79.03 km²	-
1:10,000	New edition	1 sheet	2 sheets	6 sheets
	Revision	41 sheets	30 sheets	53 sheets
1:25,000	Revision	706 sheets	722 sheets	591 sheets
	Recompilation	4 sheets	9 sheets	8 sheets
1:50,000	Revision	96 sheets	53 sheets	41 sheets
	Recompilation	4 sheets	-	1 sheet

Table 3 shows the basic forest mapping work during the same period.

Table 3. Basic Forest Mapping

		1997	1998	1999
1:5,000	Photomaps	915 km²	873 km²	367 km²
1:5,000	BFM Revision	1,175 km²	1,270 km²	936 km²

* planned at the beginning of the fiscal year

2.3 Small Scale Maps

Small scale maps published by GSI as of the end of 1999 are shown in Table 4.

The International Map of the World on the one millionth scale (IMW) is compiled utilizing standard international map symbols. Preparation of this map requires close international cooperation with various countries of the world, so that the map symbols, method of preparation, etc., are in compliance with the requests of the United Nations.

Table 4. Status of Small Scale Map Preparation

Title	Number of sheets	Size	Number of colors	Remarks
1:200,000 Regional Map	130	46 X 58 cm	6	Hill Shading
1:500,000 District Map	8	78.8 X 109.1 cm	9	Layer tints
1:500,000 District Map	8	do.	4	
1:1,000,000 IMW	3	do.	12	Layer tints and hill shading
1:1,000,000 NIPPON	3	do.	4	
1:3,000,000 Japan and Her Surroundings	1	do.	12	Layer tints and hill shading
1:100,000 Composite Map	6	63.6 X 93.9 cm 78.8 X 109.1cm	4 ,5 or 16	
1:300,000 Composite Map	1	78.8 X 109.1cm	6	Hill Shading

2.4 Geographical Information and Digital Mapping

a) Publication of Digital Maps

In 1993, GSI has published Digital Maps as results of basic survey for the first time. The media of the digital data are FDs (Floppy Disks) and CD-ROMs. The products are as follows:

(i) Digital Map 2,500 (Spatial Data Framework)

The coverage areas are urban planning area of major cities. These data are offered via CD-ROM.

(ii) Digital Map 25,000 (Map Image)

These are the image data of 1:25,000 topographic maps. One CD-ROM covers 1 degree in longitude and 40 minutes latitude area.

(iii) Digital Map 25,000 (Administrative Boundaries and Shorelines)
The original data are "Digital Cartographic Data from a 1:25,000 Scale Map" (see 2.4 b). One CD-ROM covers all Japan. These data are updated every year.

(iv) Digital Map 200,000 (Administrative Boundaries and Coastal Lines)
These are derived from (iii). One FD covers all Japan.

(v) Digital Map 200,000(Map Image)
These are the image data of 1:200,000 regional maps. Three CD-ROMs cover all Japan.

(vi) Digital Map 10,000 (General)
The original data are "KDB" (see 2.4 f)). The coverage areas are major big cities. Currently 235 FDs and one CD-ROM are released.

(vii) Digital Map 10m Mesh (DEM/Volcano)
The original data are "Basic volcano maps". The grid size is nearly 10m x 10m on the ground.
The EDM data of 13 active volcanoes in Japan are included in a CD-ROM.

(viii) Digital Map 50m Mesh (DEM)
The original data are "Digital Cartographic Data from a 1:25,000 Scale Map" (see 2.4 b). The grid size is nearly 50m x 50m on the ground. Three CD-ROMs cover all Japan.

(ix) Digital Map 250m Mesh (DEM)
The grid size is nearly 250m x 250m on the ground. One CD-ROM covers all Japan.

(x) Detailed Digital Information 10m Mesh (Land Use)
The grid size is nearly 10m x 10m on the ground.
The coverage areas are urban areas of Tokyo, Osaka and Nagoya. These data are offered via CD-ROM.

(xi) Digital Map 1 km Mesh (DEM/Average Elevation)
The grid size is almost 1 km × 1 km. These data are included in the above CD-ROM.

b) Digital Cartographic Data from a 1:25,000 Scale Map

In 1984, GSI started a new digital map information collection project and has been collecting the data for fundamental categories of 1:25,000 scale cartographic maps, namely, contour lines, administrative boundaries, roads, railways and shorelines.

The objective of the project is to prepare a digital cartographic data base from a 1:25,000 scale map for automated map compilation and production, and for providing basic data for Geographic Information Systems and digital data services.

c) Detailed Digital Information (10m Grid Land Use)

GSI has been collecting Detailed Digital Information (10m Grid Land Use) since 1981 under a Project of the Survey on the Trend of Housing Land Use, the objective of which is to prepare detailed information on present housing lots and possible future housing lots in the urban areas of Tokyo, Osaka and Nagoya.

Ten meter grid interval land use data taken from different periods, along with associated data, have been collected in order to classify and analyze the present and possible future state of change of housing land use.

These land use data are useful not only for making housing policy but also for various purposes such as urban planning and business. Therefore, these data have been opened to the public since 1999.

d) Digital National Land Information

In order to promote effective use of land resources, GSI started data collection of Digital National Land Information in cooperation with the National Land Agency in 1974. Various categories of information, such as elevation, coast lines, rivers, roads, railways, administrative boundaries, land use, etc., have been collected from 1:25,000, 1:50,000 and other smaller scale maps and filed onto magnetic tapes under each category.

The information has been used not only for the planning of national land, but also for city planning, water use planning, environmental assessment planning and other various applied fields.

e) Digital Mapping

GSI proposed a standard for large scale mapping with digital processes in 1988. Since then, most large scale maps have been produced in conformity to the proposed standard. Most of local governments that have urban planning area have mapped by digital mapping with this standard.

f) KDB

In Japan, digital map data have been produced and used for urban planning, utility management, navigation, etc. by public organizations and private companies. Under these circumstances, the effective and proper use of survey data of

digital maps is indispensable.

To avoid duplication of mapping and to maintain accuracy, GSI initiated the Kokudokihonzu (Japanese expression of National Large Scale Map) Data Base (KDB) project in 1989. In this project, digital map data, scaled from 1:500 to 1:10,000, produced by fundamental and public surveys have been compiled and stored in KDB, which was opened to the public in 1993.

g) SDF(Spatial Data Framework)

Since 1995, GSI has been producing spatial data framework (SDF) for GIS whose components are road network, administrative boundaries, inland water area, etc., on the scale level of 1:2,500. SDF will be prepared in the main urban area of approximately 96,000 km² area that belongs to urban planning area within several years. Preparation of SDF of scale level of 1:25,000 has been started entire national land as a target in 2000.

Table 5. Spatial Data Framework for GIS

	1997	1998	1999
SDF	8,850 km²	7,383 km²	32,829 km²

h)Thematic Digital Map Information for GIS

In 1999 GSI started to digitize thematic information of existing thematic maps in order to display and analyze with other information on GIS (Geographic Information System). Digitization of the land condition maps and active fault maps in urban area are on going, and other thematic maps are planned to be digitized in due course.

i)Digital Map 25,000

A large number of Geographical names are used in Japan. GSI collects geographical names and public facilities data from 1:25,000 topographical maps whole country. This Digital Map 25,000 was produced in this January. This data includes variety of geographical information and coding. And this data shows the position with latitude and longitude. This data will facilitate not only economic and social activities but also using environmental conservation, disaster prevention/disaster counter-measures and cultural heritage preservation.

3. Metadata and clearinghouse

In order to promote interoperability of geographic information, it is quite important to create metadata of geographic information and make them open to the public through a metadata search system, i.e. clearinghouse. Some government agencies, universities, and other agencies in Japan have started to create their metadata, and operate their clearinghouse. GSI also created metadata of its own geographic data products, and established a metadata search system - clearinghouse - in the Japanese language environment, named "gateway", which can deal with multibytes character code sets include Japanese characters as well as being compliant with International Standard for information retrieval -ISO 23950 -. By using the gateway, users can search not only GSI's metadata, but also many other metadata of other agencies all at once. The GSI's gateway is also harmonized with FGDC clearinghouse in United States, so that users can search both clearinghouses at the same time.

4. Thematic Mapping

GSI is engaged in various kinds of thematic mapping in cooperation with other governmental organizations for the purpose of providing basic geographic information for regional development, disaster prevention, etc. Table 7 shows some typical thematic maps prepared and published by GSI during April 1997 - March 1999.

From 1994, GSI plans to generate digital basic volcano maps by both digital mapping method and digitization from existing maps.

Table 7. Thematic Mapping by GSI (1997 – 1999)

Type of Map	Scale	Number of sheets
Basic volcano map	1: 5,000, 1:10,000	3
Land condition map	1:25,000	1
Land condition map of volcano	1:25,000, 1:30,000	3
Topographic map of costal areas	1:25,000	2
Land condition map of coastal areas Lake chart	1:25,000	2
	1:10,000	6
Active fault map in urban area	1:25,000	22
Land condition map of the landslide disaster in Hachimantai-Sumikawa in 1997	1:2,000	1

Besides these maps, GSI has compiled various thematic maps as the results of the geographic surveys and researches, for example maps related to some particular natural disasters.

5. The National Atlas of Japan

The first edition of the National Atlas of Japan compiled by GSI was published in 1977. It has been widely acclaimed. GSI continued to revise this by using the latest statistics and other source materials, and completed the National Atlas of Japan, Revised Edition, which was published in 1990. Furthermore, GSI has developed an Electronic Atlas System for the computer use, and a CD-ROM Atlas was published in 1997.

6. National Land Survey

The National Land Survey of Japan has been carried out under the direction and guidance of the National Land Agency (NLA). The objective of the survey is to contribute to the promotion of effective use and conservation of national land. To reveal the present condition of national land, such as land ownership and its utilization, is another objective of this survey. It is expected to be based on the National Land Survey Act which was enacted in 1951, when the survey was initiated. Three major items form the core of this survey; the land classification survey, the water use survey and cadastral survey.

6.1 Land classification Survey and Water Use Survey

A land classification survey is the survey of the topographical and geological features, soil, and present land use. The results are compiled into atlases and books. A water use survey aims at investigating the basic statistics of a river, such as annual rainfall, discharge, present water utilization for farming or drinking and groundwater.

In the land classification survey, NLA has developed a computerized mapping method in which a specific device, controlled by computer, can draw a colored map. By this method, one can easily identify various kinds of data related to land classification.

The above mentioned surveys are compiled into atlases and books as follows:

a) Land classification maps (Geomorphological map, Surface geology map, Soil map, Present land use map, Land use capability classification map), overlays (such as slope map) and an Explanatory data book.
b) Land conservation maps (Natural condition map, Present land use and vegetation map, Natural disasters map, Land use tendency and designated areas map, Control and designated area for disaster prevention map, Valuable natural and cultural assets distribution map, Basic conservation map) and Explanatory data book.
c) Water use maps and a descriptive catalogue of available information on major river system.
d) Groundwater maps and Explanatory data book.
e) Groundwater data ledger.

Table 8. Land Classification and Water Use Maps (1951-1999)

	Scale	Coverage
Land classification map	1:200,000 1:50,000 (c.m.m.) 1:2,500 - 1:5,000 (c.m.m.)	377,829 km² 296,515 km² 7,024 km²
Land conservation map	1:200,000 (c.m.m.) 1:50,000	151,637 km² 13 regions
Water use map	1:50,000 1:25,000 - 1:50,000	106 river systems 10 regions
Ground water map	1:15,000 - 1:50,000	5 regions

*c.m.m. : computerized mapping method

6.2 Cadastral Survey

The cadastral survey aims at clarifying the location, boundary, ownership, lot number, acreage, and current status of land use of each parcel. Local governments, such as prefectural and municipal governments, carry out the survey. They transact such affairs as planning the survey project, making contact with a surveying company, and supervising. NLA plays a role in the survey by giving local governments a 50% subsidy of the total cost and some technical guidance as well. The executive body only has to share 1/20 to 1/30 of the total cost, since a special grant is given to the survey by the Japanese government. Because of present austere budget conditions, the progress of the survey have suffered a sharp curb. 2,000 km² or more is the acreage that the cadastral survey has completed annually over the past five years. The progress of this survey at the end of F.Y.1996 is as follows:

Completed cadastral survey: 118,736 km² (1951-1999)
Progress ratio : 41.6% (Target acreage of the survey: 285,511 km²)

The cadastral survey consists of the following stages; supplementary survey, detailed on-the-spot survey, measuring the

acreage of each parcel, and making atlases and books. The supplementary survey comprises the control point survey which is to set up control points for cadastral surveying. The establishment of these control points is carried out by GSI. Scales of cadastral atlases differ from case to case depending on the mean acreage of a parcel. Scales of 1:250, 1:1,000, 1:2,500, or 1:5,000 are used. Of these, the scales of 1:500 and 1:1,000 are the most commonly used. The required accuracy of measurement is classified into six types depending on the land use pattern. For a residential area, for example, the highest degree of accuracy is demanded. On the other hand, the accuracy level for a forest area is the lowest.

Copies of cadastral maps and books are bound to be sent to registry offices after having been checked for accuracy and obtaining the legal approval of the National Land Survey, from the Minister of the National Land Agency, or, in some cases, from the prefectural governor, to replace the old maps which were prepared about 100 years ago and are still used for levy and land registration.

The cadastral survey had not been promoted well, and in an attempt to do so, the acceleration Act, named The Act on Special Measures for Promotion of the National Land Survey was enacted in 1962. Under this Act, a target acreage for the survey for a period of 10 years was clearly established. Now the survey has being carried out based on its fourth, the Ten-year National Land Survey Plan stage (1990-1999). According to the Plan, the target acreage is 49,200 km².

7. Soil Maps

Soil maps in Japan are roughly divided into two categories; for cultivated lands and for forest lands. They are prepared by the Ministry of Agriculture, Forestry and Fisheries.

A 1:50,000 scale map series of soil types and productivity of cultivated lands has been prepared by the Agricultural Production Bureau since 1959, and the entire area of cultivated land, 51,000 km² in all, is covered.

A 1:20,000 or a 1:50,000 scale map series of soil types in national forests has been prepared by the Forestry Agency since 1947. 65,000 km² were covered by this series. This agency has also prepared a 1:50,000 scale map series of soil types for many private forests.

8. Geological Maps

The Geological Survey of Japan (GSJ) has published most of geologic maps which cover the Japanese islands on scales of 1:50,000, 1:20,000, 1:1,000,000, 1:2,000,000 and 1:500,000.

A series of basic geologic maps published by GSJ is prepared on the scale of 1:50,000. This basic series was once prepared on the scale of 1:75,000 and the scale was changed to 1:50,000 in 1952. The number of publication of 1:50,000 scale geologic maps reached 615 sheets with explanatory texts at the end of 1999. This implies that the basic map series including those maps prepared on the scale of 1:75,000 covers 70% of the Japanese islands. Compiling these basic geologic maps and other geologic information, GSJ published smaller scale maps. At the end of 1999, 1:200,000 scale geologic maps cover 78% of the islands. Digital geoscience map series were also published as CD-ROM.

9. Marine Geology

GSJ has been engaged in marine geological and geophysical investigation of the sea around the Japanese Islands, the western and central Pacific Ocean and the Antarctic sea, chartering the geological survey vessel R/V Hakurei-maru and others. The investigation comprises basic studies of marine geology, mineral resources and geophysical prospecting, including sedimentological and environmental study of lacustrine and coastal areas. Marine geological maps on the scale of 1,000,000 covering the Japanese islands were published and a series of marine geological maps on the scale of 200,000 has been published around the main Japanese Islands. International cooperation is actively promoted in the fields of marine geology, mineral resources and environmental study of coastal seas.

10. Hydrographic Work

10.1 Hydrographic Surveying and Charting

a) The number of various hydrographic surveys carried out are as follows:

Table 9. Hydrographic Surveys

Type of survey	1997	1998	1999
Harbor	4	3	1
Updating	189	160	210
Passage	0	1	1
Coastal	9	11	13
Basic Maps of the Sea	6	7	6
Earthquake prediction	6	7	6

b) The results of these surveys were used for production of nautical and other charts, as shown in Table 10:

Table 10. Nautical and Other Charts

Type of chart		1997	1998	1999
New Charts	Nautical charts	10	5	6
	Miscellaneous charts	0	1	1
	Basic Maps of the Sea	14	13	12
	Aeronautical charts	0	0	0
New Editions	Nautical charts	31	42	45
	Miscellaneous charts	4	0	18
	Basic Maps of the Sea	0	0	1
	Aeronautical charts	0	3	3
Reprints		0	0	0
Total		59	64	86

Note: The Basic Maps of the Sea (BMS) currently produced are classified as follows:

Table 11. Classification of the Base Maps of the Sea

Series	Scale	Coverage	Size	Type
BMS in Coastal Waters	1:10,000 1:50,000	Within 12M of the coast	Full 1/2.	Bathymetry; Submarine structure
BMS on Continental Shelf Areas	1:200,000	Continental margin	1/2	Bathymetry; Submarine structure; Total magnetic intensity; Gravity anomaly
BMS in Ocean Areas	1:3,000,000	Ocean Area	Full	do. (except Submarine structure;)

c) The number of paper charts issued as of March 2000 is shown below:

Table 12. Number of Paper Charts Issued

Type of Chart	Number of Issues
Nautical charts	876
Miscellaneous charts	96
Basic Maps of The Sea	860
Aeronautical charts	25
Total	1,857

Note: The International Charts of the IHO under the responsibility of Japan as the produce nation, i.e. six of the 1:3,500,000 series and two of the 1:10,000,000 series have been published.

d) Electronic Navigational Charts (ENCs)

Table 13. Number of ENCs Issued as of March 2000

Type of Chart	Number of Issues
Electronic Navigational Charts	12

10.2 Other Publication Activities

Table 14. Other Publications of HD

Type of publication		1997	1998	1999
New publications	Sailing Directions	1	1	2
	Special publications	5	5	6
New Editions	Sailing Directions	6	6	6
	Special publications	3	4	4
Notices to Mariners	(Japanese)	5,133	5,150	4,925
	(English)	5,085	4,877	4,642
Japan Navigational Warnings	(Japanese)	2,052	2,004	2,366
NAVAREA XI navigational warnings (English)		757	700	788
NAVTEX navigation warnings (Japanese)		2,529	2,546	2,383

NAVTEX navigational warnings (English)		2,529	2,546	2,383
Information of Ocean Conditions	Quick Bulletin of Ocean Condition	24	24	24
	Ocean Current Forecasting	51	51	51

10.3 Marine Survey

a) Survey of coastal Area

In order to cope with the establishment of 200-mile exclusive economic zone (EEZ) in accordance with the United Nations Convention on the Law of the Sea(UNCLOS), HD is carrying out detailed surveys of low-water lines, topography and geological structure of the sea-bed in coastal area, particularly in those important areas around baseline defining the Japanese territorial sea. Japan concluded UNCLOS in 1996. Charts are indispensable for safe and efficient navigation. And information for charts, such as depth, coastline, hazardous obstructions and so forth, should be current. Conducting port, harbor, coastline and passage surveys, the Hydrographic Department has been trying to keep charts up-to-date.

b) Survey of Continental Shelf Areas

HD is carrying out hydrographic surveys south of Japan by using the large-type survey vessel "TAKUYO and SHOYO" equipped with modern survey instruments such as multi-beam echo sounder in order to obtain basic data required for utilization and development of the continental shelf of Japan.

c) Promotion of Marine Geodetic Survey

Nautical charts of each country are constructed to its own geodetic system. With the recent development of the geodetic satellite survey technique, however, a difference in geodetic systems becomes a problem. Accordingly, the IHO recommends that the meridians and parallels given on the chart should be shown on the basis of the World Geodetic System. Therefore, in Japan also, it becomes necessary to locate the mainland and remote islands on the basis of the World Geodetic System, and HD has been conducting geodetic satellite observations by laser ranging to the geodetic satellite LAGEOS, in conjunction with the United States National Aeronautics and Space Administration (NASA) to obtain the precise location of the mainland on the basis of the World Geodetic System.

10.4 Provision and Supply of Oceanographic Data and Information

Since the acquisition of oceanographic data and information required for the utilization and development of the ocean costs much money and time, it should be further promoted to utilize such data and information not only for the primary purpose but also for the secondary and tertiary purpose. From this point of view, HD has been engaged in collecting, managing and supplying such oceanographic data and information for 35 years as a comprehensive oceanographic data bank established in accordance with a resolution adopted by the Intergovernmental Oceanographic Commission (IOC) of UNESCO and a report made by the Council for Ocean Development of Japan. The Oceanographic Data and Information Division of HD is registered as the Japan Oceanographic Data Center (JODC) at the IOC under the International Oceanographic Data and Information Exchange (IODE) project promoted by the IOC, and is taking active part in internationally exchanging oceanographic data and information for their effective utilization as the Japanese representative in the field of oceanographic data exchange.

JODC provides oceanographic data collected from various organizations.

J-DOSS is the system that allows those people to search and retrieve the data and information.

11. International Activities

11.1 GSI's International Activities in Geodesy

As written in previous sections, GSI is actively participating in international cooperative projects in the field of geodesy, such as IGS (International GPS Service), DOSE (Dynamics of Solid Earth) and IAGBN (International Absolute Gravity Basestation Network), in order to determine precise positions in global coordinate system and to contribute to the progress of geodesy and earth sciences. The IGS provides precise orbits of the GPS satellites. It is one of the most important information for precise GPS observation. GSI participates in the IGS as one of the Regional Data Centers and the Associate Analysis Centers.

DOSE is an international research project of NASA and GSI participates in it through intercontinental joint VLBI observation. GSI also participates in the international research of NASDA on Japanese Earth Resources Satellite-interferometric SAR.

Japan has four absolute gravity stations of IAGBN, Esashi, Kyoto, Tsukuba and one in Syowa station in Antarctic. Absolute determination of gravity in Australia in 1996, including IAGBN(A) station, was carried out for the purpose of establishment for mean sea level change monitoring in southwestern pacific. Absolute determination of gravity in Korea in 1999 was carried out for providing precise gravity standard value.

11.2 Global Mapping Project

Since Ministry of Construction of Japan proposed Global Mapping concept in 1992, Global Mapping Project has been promoted through International Steering Committee for Global Mapping (ISCGM) which was established in 1996. The need of the Global Map for addressing global environmental problems has been well confirmed at the United Nations. The report of Special Session of the United Nations General Assembly on the Implementation of Agenda 21, held in June 1997, includes a section on the development of an information infrastructure accessible to anybody, using technology of geographic information systems including the Global Map.

In November 1998, the UN sent a letter of Prof. Estes, Chairperson of ISCGM, inviting National Mapping Organizations (NMOs) to Global Mapping Project and recommendatory letter of Mr. Habermann, Director of the UN Statistics Division, to heads of NMOs. There has been remarkable increase of participation in the Project. As of 31 August 2000, eighty countries and regions have participated in the project, and more than thirty-five countries and regions are waiting approval from their governments.

GSI is producing not only the Global map of Japan but also the Global Map of Bangladesh, Kazakhstan, Philippines, Mongolia, Thailand, Vietnam, Kyrgyz, Laos and Nepal in cooperation with respective NMOs. Data of the Global Map are distributed now. GSI will continue to make efforts to implement Global Mapping Project as ISCGM Secretariat.

11.3 International Hydrographic Organization (IHO)

IHO Commissions, Committees and Working Groups in which Japan (HD) has been participating are as follows:

a) Finance Committee (FC)
b) IHO Chart Standardization Committee (CSC)
c) IHO Committee on Hydrographic Requirements for Information Systems (CHRIS)
d) CHRIS Working Group on Updating the ENC (UWG)
e) IHO Commission on Promulgation of Radio Navigational Warnings (CPRNW)
f) Joint IHO-IOC Guiding Committee for the General Bathymetric Chart of the Oceans (GEBCO)
g) GEBCO Sub-Committee on Undersea Feature Names (SCUFN)
h) GEBCO Sub-Committee on digital Bathymetry (SCDB)
i) CHRIS Transfer Standard Maintenance and Data Base Working Group (TSMAD)
j) IHO Tidal Committee (TC)
k) FIG-IHO Technical Assistance Coordination Committee (TACC)
l) IHO-IAG Advisory Board on the Law of the Sea (ABLOS)
m) IHO Hydrographic Committee on Antarctica
n) IHO Working Group on Standards for Hydrographic Survey - S-44
o) IHO Worldwide Electronic Navigational Chart Data Base Committee (WEND)
p) IHO Working Group on Standardization of Nautical Publications
q) IHO Working Group on S-23, Limits of Ocean and seas
r) IHO Working Group on Copyright of Charts and other Nautical Publications
s) CHRIS Data Base Working Group (DBWG)
t) CHRIS Data Quality Working Group (DQWG)
u) Task Group on Gridding of the GEBCO SCDD

11.4 Intergovernmental Oceanographic Commission (IOC) of the UNESCO

HD participates in international conferences held by the IOC as one of the Japanese technical organizations. The Oceanographic Data and Information Division (Japan Oceanographic Data Center (JODC)) of HD is designated as the National Oceanographic Data Center of Japan under the system of IODE/IOC, and is also in charge of the Responsible National Oceanographic Data Center (RNODC), which manages the data from international projects such as the IOC Subcommission for the WESTPAC programme and Joint IOC-WMO Working Committee for Integrated Global Ocean Services System (IGOSS) programme and the IOC Marine Pollution Monitoring Network (MARPOLMON) in the WESTPAC region and Acoustic Doppler Current Profiler (ADCP).

11.5 International Lunar Occultation Centre

HD conducts astronomical observation under international cooperation and makes efforts to improve the accuracy of ephemeris. Particularly from April 1981, upon the request of the International Astronomical Union (IAU), HD took over the activities performed by the Royal Greenwich Observatory as the International Lunar Occultation Centre and started to collect and analyze observations all over the world in a homogeneous manner.