“Survey” - Determining the Position of Japan -

Measuring the Accurate Position of Japan

Have you ever heard that Japan and Hawaii are getting closer by a few centimeters annually? Over a long period of time, our land is slowly drifting on the Earth’s surface.

The Geospatial Information Authority of Japan (GSI) has been continuously monitoring such land movements using a space geodetic technique called VLBII in cooperation with countries across the world. VLBII enables GSI to accurately measure the position of the Japanese Archipelago on the globe. Based on the accurate position obtained from VLBII, GSI provides the Japanese Geodetic Datum with 1300 GNSS*1 CORSs (Continuously Operating Reference Stations) throughout the country, which perform 24-hour GNSS observations to offer accurate reference positions.

This GSI’s activity allows us to know the precise positions (latitude, longitude, and elevation) of ourselves anywhere in Japan.

*1 VLBII (Very Long Baseline Interferometry): A technique to measure the distance between two or more parabolic antennas over thousands of km with a few-mm accuracy, by calculating the arrival time difference of received signals radiated from celestial bodies far away in the universe.

*2 GNSS (Global Navigation Satellite System): A collective term for satellite navigation systems that determine the position on the globe by using satellites, including the U.S. Global Positioning System (GPS), the Japanese Quasi-Zenith Satellite System (QZSS, nicknamed “MICHIBIKI”), the Russian Global Navigation Satellite System (GLONASS), and EU’s Galileo.

Determining the Reference of Japan’s Position

The Survey Act determines the “Origin of the Japanese Horizontal Control Network” and the “Origin of the Japanese Vertical Control Network” which furnish positions (longitudes/latitudes) and elevations in the Japanese Horizontal and Vertical Datum reference systems, respectively.

The positions of control points, including GNSS CORSs, triangulation points, and benchmarks, are all determined based on the origins. The position information of these control points is utilized in city planning, cadastral surveys, and construction surveys for roads and embankments.

Maintaining Control Points on Remote Islands

GSI places and maintains control points (triangulation points) on remote islands based on the Basic Plan on Ocean Policy, and has conducted surveys to determine longitude, latitude, and elevation as the basis for the accurate location information and mapping of the remote islands that authenticate the outer limits of the territorial seas and the Exclusive Economic Zone (EEZ).

Changes in Landform of Nishinoshima Island

Nishinoshima Island, about 950 km south of Tokyo, has dramatically changed its topography due to the eruption that started in November 2013. GSI, in cooperation with the Japan Coast Guard (JCG), dispatched staff members landing on Nishinoshima Island in October 2016 and placed control points to survey the new land and conducted field surveys to determine the longitude, latitude, and elevation.

Linking a Map to Compass - Geomagnetic Observation -

We use a magnetic compass to find directions, but the north indicated by a compass (hereafter called, “magnetic north”) differs from that on maps (hereafter called, “true north”).

The map on the left shows streets and blocks in Kyoto City. The city was established as a capital around the 8th century and the roads were arranged based on directions determined by solar observation, resulting in a good concordance of the direction of north-south roads and the true north. Conversely, Nijo Castle on the map was built based on the magnetic north direction determined by a compass in 1603. Hence, the outline of the castle is inclined about 3 degrees to the surrounding road. This tilt shows the difference between the magnetic north and the true north, which is called “magnetic declination”.

The magnetic declination varies depending on the place and the date. In Japan, which tilts about 9 degrees westward in Hokkaido and 5 degrees westward in Okinawa, GSI is currently conducting geomagnetic observation, including magnetic north directions and intensity of the geomagnetic field, throughout the country and providing information to help people use maps, such as for grasping directions in mountain climbing and determining aircraft routes.
GNSS CORS (Continuously Operating Reference Station) Network Supports the Society with a Highly Precise Satellite Positioning System!

**Support 1**
GNSS observation at CORS
Nationwide over 1,300 CORSs continuously observe signals from GNSS satellites.

**Support 2**
Management of location information
GSI monitors crustal deformations and manages the reference for the horizontal position (longitude and latitude) by calculating the daily solutions of CORS coordinates.

**Support 3**
Data provision
GSI provides observation data and coordinates values of CORSs for surveyors and the private sector.

**New Support**
Maintenance of Elevation Reference
- GSI Innovates the Elevation System in Japan
- GNSS enables us to easily and quickly obtain accurate horizontal positions (longitudes/latitudes), whereas elevations cannot be obtained so accurately yet.
- In order to obtain accurate elevations by using GNSS, it is required to measure gravity data densely nationwide to develop an elevation reference.
- GSI advances studies on establishing an elevation reference and will conduct airborne-gravity surveys as one method of grasping the underground structure. These activities enable GSI to develop a new elevation reference, allowing anyone to find an elevation anytime and anywhere by using GNSS.

Realization of a Society Where Highly Precise Positional Information Can Be “Surveyed” Anytime and Anywhere

**Highly Precise Satellite Positioning Using Quasi-Zenith Satellite System “MICHIBIKI”**
- GNSS CORS supports “MICHIBIKI” service!
- An official service of MICHIBIKI will start in the fiscal year 2018. From MICHIBIKI, positioning signals that are compatible with those of GPS, which are used by such navigation devices as smartphones and automobile navigation systems, are transmitted. In addition, centimeter-level augmentation service (CLAS) information, by which users can determine their position precisely in real time, is transmitted by MICHIBIKI.
- CORS observation data are calculated to produce augmentation information for CLAS. Hereafter the role of CORS will become even more important as it supports the positioning services of MICHIBIKI applied in the various fields.

**Highly precise satellite positioning is applicable in the wider field.**

**New Support**
Vehicle-mounted laser scanning
Digitized data for mapping are obtained efficiently by running a vehicle equipped with a laser scanner to measure ground surfaces.

**GNSS surveying**
Surveyors conduct surveys efficiently in real time.

**Promotion of i-Construction**
The application of location information including the information of construction machinery improves productivity in the field of construction.

Credit: Brochure of the Geospatial Project, Secretariat of the National Spatial Data Infrastructure (NSD) Committee

**See p.5 & 6 for further information**

GNSS CORS Contributes to Realizing the Society with Highly Precise Satellite Positioning in Three Dimensions.
GSI Innovates the Elevation System in Japan

"Survey" since the Meiji Period (late 19th century)

How to determine the elevation reference:
The elevation reference is determined by leveling survey measuring a height difference from that of the Origin of the Japanese Vertical Control Network and adding the gravity reduction.

How to observe and manage the elevation system:
GSI has conducted nationwide leveling survey covering a route of 20,000 km for about 10 years.

Leveling
Determine a height difference between two benchmarks by reading the scale of the rod placed on each benchmark using a level set up in between.

Terrestrial gravity survey
Observe gravity with a gravimeter on a benchmark.

User conducting a survey of elevation
Leveling
Steadily determine an elevation with labor and over time.

From Leveling to GNSS Surveying

A gravity anomaly creates undulation in the elevation reference.

The height from elevation reference to the surface is the elevation.

In other words, the elevation is determined by the undulation of topography and gravity anomalies.

GSI Is Realizing a Society Where Anyone Can Use Elevation Anytime and Anywhere by GNSS.

"Survey" in Near Future

How to determine the elevation reference:
The elevation reference is developed throughout the country according to gravitational data. (Leveling is still used in some parts of Japan including certain urban areas.)

How to observe and manage the elevation system:
More than 1,300 CORSs continuously monitor changes in elevation throughout the country.

Galileo
GLONASS
GPS

User conducting a survey of elevation
Airborne gravity survey
Grasp area-wide gravity anomalies on the surface with the onboard gravimeter.

GNSS CORS
More than 1,300 CORSs continuously monitor changes in their elevations.

Quick & simple
Manageable by a single person

What is an "elevation reference"?

The elevation reference in Japan is the mean sea level in Tokyo Bay (Tokyo Peil). The virtual surface made by extending Tokyo Peil towards the land serving as the reference of the elevation is called "geoid," the surface representing zero elevation. How do we determine the geoid, which is actually unseen and underground? The answer is that gravitational data enables calculation of the geoid! A highly precise survey of nationwide gravitational distribution determines the geoid with high precision.

Then, why is the geoid necessary? The geoid is necessary because it promptly reveals the elevation of a location with the Global Navigation Satellite System (GNSS). By newly developing a highly precise geoid, GSI realizes a society where anyone can find reliable elevation anytime and anywhere by GNSS promptly.

COLUMNS
Mystery of Height
Doesn’t water flow on a flat place --- ?
Water does not flow when there is no difference in gravity.

Elevation reference, the surface representing zero elevation (or geoid), calculated with leveling and gravity reduction.

Elevation reference
The height from elevation reference to the surface is the elevation.

Heavy substance
Elevation
Gravity small

Gravity large

Elevation

GSI is Making Effort to Realize Such Society in FY2024 as the Target Year.
Developing a Base Map for All Maps

The maps developed by GSI serve as a basis for all maps and play a key role in representing a national land. The maps are categorized into two types: basic maps developed with such basic features as roads, buildings, and rivers, throughout the country; and thematic maps with such thematic information as active faults, topography categories, land use, added to basic maps. Provided as digital media as well as on paper, these maps by GSI are used as base maps in creating such diverse maps as hazard maps by local government, and maps for smartphones and tourist maps by private companies. Moreover, the maps developed by GSI serve as base maps for many maps that you use in daily life.

Maps Developed by GSI

● Basic Maps – Maps Serving as the Base of the Country –
GSI develops the “Digital Japan Basic Map” as a basic map of Japan that is necessary for land management, specifying the territory, and other aspects. The Digital Japan Basic Map consists of map information, orthophoto imagery, and geographic name information, which collectively represent the national land of Japan.

Data on the locations and heights of roads, buildings, and contours being collected with equipment that produces 3D images based on pairs of aerial photographs at the same time.

● Thematic Maps – Maps Contributing to Disaster Mitigation by Helping Understand the Geographical Features

Thematic maps that represent certain themes according to the purpose of use are used for the prediction and mitigation of disasters, investigation, research, and education, etc. as fundamental materials. For example, 1,250,000 Active Fault Maps summarize information on active faults across the country, including detailed locations and fault-slip directions with related topographical conditions.

In addition, GSI develops maps that categorize the origins and characteristics of topographical structures and properties as well as colored elevation map.

Map information
Developed as map data covering the whole country, with information consisting of Fundamental Geospatial Data* and other feature items including structure and contours necessary for land management, etc.

Orthophoto imagery
Imagery converted from aerial photos to be displayed superimposed with the map. It is also available for materials used to prepare and update map information.

Geographic name information
Information including geographical names of residences as well as nature and public facilities is developed as basic information that serves as a key to finding a location.

* Fundamental Geospatial Data: Information including location information such as road edges and the peripheral lines of buildings that serve as the reference of locations on digital maps.

Big Data Used for Correcting Topographic Maps

Recently, many people have been climbing mountains and using smartphones and other devices to record their climbing information such as their climbing paths, and then post such records on an information-sharing site. As a result, information about many climbing routes is being disclosed on the Internet.

Cooperating with the information-sharing site operators, GSI is updating climbing routes on maps by using an enormous amount of climbing route information (big data). One day, your footsteps may be recorded on a topographic map of GSI.

Illustrated image of correcting a mountain climbing route as a red line by utilizing climbing records (green points)
To Provide Maps More Promptly and Efficiently

While taking aerial photographs was almost the only conventional way to update maps, in order to provide updated maps more efficiently, GSI is now collecting materials for map updates in various ways, including getting information from collaborating local governments and public facility administrators, in addition to aerial photography.

GSI staff members conduct field survey to clarify the information that cannot be clearly identified only from the collected materials, such as road, building, and contour route under a tree canopy that cannot be identified through aerial photographs.

With a device that develops 3D images from two aerial photographs, the locations and heights of features such as road, building, and contour are traced and plotted, or drawn as a map. Map features are also plotted from a drawing displayed as background when plotted in map editing software.

To clarify what the plotted data show, such necessary information as the types of railways and roads is added to the data. Then, map symbols and annotation information, such as city name, are added to the data so that it is easily understandable.

GSI provides various maps in different scales on paper or in digital format, such as the "1:25,000 scale topographic map" and "1:5,000,000 Japan and Its Surroundings."

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1. Collecting Materials
   - Taking aerial photographs
     - Completeness
     - Efficiency
     - Promptness
   - Cooperation with local governments
   - Cooperation with public facility administrators

2. Field Surveying
   - Aerial camera
   - Urban planning base map
   - Construction drawing

3. Plotting
   - By obtaining construction drawings and relevant materials from developers and administrators of roads and other public facilities prior to their completion, GSI promptly updates the major roads shown on maps as soon as the roads are in service.
   - With a device that develops 3D images from two aerial photographs, the locations and heights of features such as road, building, and contour are traced and plotted, or drawn as a map. Map features are also plotted from a drawing displayed as background when plotted in map editing software.

4. Map Editing
   - Mapping with a digital plotter
   - Editing with a editing software

5. Map Distribution
   - Map of City
   - Road classification: Prefectural road, National road, Local road
   - Utilizing FGD...
     - Geospatial datasets from different organizations do not match.
     - Geospatial datasets overlap exactly!
   - Example of FGD utilization
     - Disaster prevention map prepared by local government uses FGD as background

A Decade Has Passed Since the Creation of Fundamental Geospatial Data (FDG)! The Role of FGD

Ten years have passed since the initial release of the Fundamental Geospatial Data (FDG), the reference of locations shown on digital maps. Continuous update of FDG and its provision to the public by GSI, and the active use of FDG in relevant organizations prevent redundant surveys and enhance work and services in the administrative sector, including facility management, disaster prevention, and city development, along with the related services.

In the private sector, FGD also promotes the creation of new industries, including a digital content distribution service using geospatial data.
“Safeguard” – Preparing to Fulfill the Mission at the Time of Disaster -

No one can tell when a disaster occurs. In preparation for disaster, GSI maintains equipment and conducts disaster response drills and related monitoring as its daily activities.

- **GSI Land-Bird (GSI-LB)**

  GSI Land-Bird (GSI-LB) is an organization established in GSI, consisting of personnel familiar with Unmanned Aerial Vehicle (UAV). Normally, GSI-LB members work on new technology to contribute to improving productivity in the field of surveying, while in case of a disaster, they take images and videos, operating the UAV by themselves at the forefront of the site to provide useful information for rescue, restoration, and reconstruction. In preparation for a disaster that could occur at any time, by being able to respond to the site with the latest technology while securing safety, GSI is keenly working on developing personnel with excellent expertise in safety and skills every day through its training program and the licensing system.

- **GSI-LB logo**

  (The ochre-colored part represents “the land”, as target of photographing, and the blue part represents “the sky” where UAVs are flying.)

### Safeguard by “Humans”

- **Kunikaze Operations**

  GSI strives to secure the operation system of survey airplane (Kunikaze III) that is used to expeditiously gather information about disaster-stricken areas.

  - **Kunikaze III standing by**
  - **Inside Kunikaze III during disaster response**
  - **Aerial photo of disaster-hit area (the 2016 Kumamoto Earthquake)**

### Safeguard with “Technology”

- **REGMOS (Remote GNSS Monitoring System)**

  Using REGMOS, GSI conducts GNSS observation in active volcanoes even without power lines or communication lines and detects crustal movement in detail by supplementing the existing CORS network.

- **InSAR Analysis (Interferometric Synthetic Aperture Radar: InSAR)**

  Analysis example (crustal movement caused by volcanic activity on Sakurajima Island)

### Safeguard with “Map”

- **Data on Designated Emergency Evacuation Sites – To Safeguard Oneself from Disaster –**

  Regarding the designated emergency evacuation sites and designated evacuation sites provided by the Disaster Countermeasures Basic Act, GSI has developed and now maintains a location database containing location information based on facility names and their addresses, with about 110,000 items of data prepared in total in cooperation with municipalities, etc., across Japan. Since February 2017, GSI has released the data on the designated emergency evacuation sites on its web maps (GSI Maps). By overlaying with various kinds of GIS data, these data can be utilized in formulating evacuation plans and taking other actions.

  “Where should you evacuate when the risk of disaster is imminent?” Check your commuting or school route and evacuation sites near your home.

  (* As of November 2017)

- **Designated emergency evacuation sites shown in GIS Maps (Takamatsu City, Kagawa Pref.)**

- **Disaster response for the Northern Kyushu Heavy Rainfall in July 2017 (UAV video capture)**

- **Background: Flood response drill along Tone River**
Response to Frequently Occurring Disasters

Promptly Acquiring and Disseminating the Latest Geospatial Information on Disaster Situations by Using Various Technologies Including Unmanned Aerial Vehicle (UAV)

GSI, as a Designated Government Organization in the Disaster Countermeasures Basic Act, promotes disaster response-related measures against frequently occurring disasters by employing the latest geospatial technology to protect national land and people’s lives and assets. GSI acquires geospatial information necessary for grasping the disaster situation by emergently taking aerial photographs and conducting surveys and then promptly disseminating the information. The provided information is utilized by the national and local governments for disaster response, restoration and reconstruction, as well as by citizens for disaster prevention.

- **Flooding**

  - **Northern Kyushu Heavy Rainfall in July 2017**
  
  The Northern Kyushu Heavy Rainfall in July 2017 caused not only the flooding of rivers and natural damming but also sediment disasters such as debris flow and landslide, resulting in enormous damage, including washouts of bridges and the collapse of road shoulders. GSI emergently took photographs with survey aircraft and Unmanned Aerial Vehicle (UAV), and provided the aerial photographs and videos, while making a disaster situation map covering the estimated flood area and the sites of landslide and accumulated driftwood.

  - **Heavy Rainfall Associated with the Seasonal Rain Front since July 22 (July 2017)**
  
  The heavy rainfall associated with the seasonal rain front since July 22, 2017 caused embankment to collapse and inundation damage around the Omono River. GSI emergently took photographs with survey aircraft and provided the aerial photographs, while conducting a damage survey and making an estimated map of the flooded area.

- **Volcano**

  - **Volcanic Eruption of Mt Kirishima (Shinmoedake) (October 2017)**

  On October 11, 2017, Mt Kirishima (Shinmoedake) erupted for the first time in about six years. GSI immediately conducted SAR observation with a survey aircraft, which observed the detailed topography around the post-eruption crater that was not visible due to the volume of ash. GSI has also enhanced the monitoring of crustal movements around Mt Kirishima using REGMOS newly installed (see p. 12) around the crater and the existing CORS nearby.

- **Earthquake**

  - **The 2016 Kumamoto Earthquake (April 2016)**

  Significant crustal deformation was observed at CORS in a wide area around the Kumamoto district. GSI provided the observation results to the government’s Earthquake Investigation Committee and other relevant organizations for their investigation and analysis, such as estimating the fault that caused the earthquake. GSI also conducted surveys with an Unmanned Aerial Vehicle (UAV) and a terrestrial laser scanner to support the restoration of Kumamoto Castle at the request of Kumamoto City.
Providing Geospatial Information

Offering the Environment Where Users Can Easily Search, View, and Obtain Necessary Information

Information in our daily lives related to locations is generally called “geospatial information.” The elevations of mountains and land use conditions, such as farmland and commercial areas, are part of the geospatial information. While the geospatial information is useful in various situations, users need to spend much time and effort to find the information fit for their purposes if it is scattered around. As a solution, GSI runs the “Geospatial Information Library” that provides an environment where people can easily search for, view, and obtain geospatial information through the Internet.

GSI Maps <https://maps.gsi.go.jp/>

GSI Maps are free Web maps available for personal computers, smartphones and tablets, which are always updated. Users can overlay various information from more than 2,000 layers of information, including landform classification, disaster information, and old aerial photographs, whatever, on the basic information, such as topographic maps and aerial photographs. 3D map display using elevation data and data downloaded for 3D printer is also available.

GSI Globe (Sakurajima Island)

Browsing of Control Point Survey Results <https://sokuseikagis1.gsi.go.jp/>

Information on triangulation points, control points, and GSI CORS across Japan can be searched, viewed and obtained on this site.

Fundamental Geospatial Data (FGD) Download <https://fgd.gsi.go.jp/download/>

The nationwide Fundamental Geospatial Data (FGD) location information that serves as a base on digital maps can be searched, viewed and obtained on this site.

Introduction of Published and Offered Materials, Including Maps and Aerial Photographs <http://www.gsi.go.jp/MAP/>

GSI provides geospatial information not only online via the Internet, but also by other media such as paper, DVD, and CD-ROM. Information on GSI’s products such as price, size, and purchasing method can be found in this website.

Old Map Collection <https://kochizu.gsi.go.jp/>

GSI owns a wide variety of old maps as historical, cultural and academic research materials, including Ino’s maps (maps prepared by a survey team led by Ino Tadataka in the early 19th century). As this year, 2018, marks the 150th anniversary since the beginning of the Meiji era (1868), GSI is also working on various MEUI150th anniversary projects. As a part of these projects, maps of the Meiji era owned by GSI are posted on the website called “Old Map Collection.”

Figure on the left: Ino’s Map covering “Suruga, Izu, Sagami, Odaawara, and Oyama”
Advancing the Utilization of Geospatial Information

The Basic Act on the Advancement of Utilizing Geospatial Information (hereinafter "NSDI Act") is a law that aims to advance the high-level utilization of geospatial information and realize a society where people can live a safe and prosperous life. To realize such a society through industry-academia-government cooperation, the government established the National Spatial Data Infrastructure (NSDI) committee. GSI works as a secretariat member of the committee, being in charge of liaison and coordination.

Furthermore, GSI seeks to enhance geography education that conveys the importance and interest of geospatial information by sending staff to elementary, junior high, and high schools to deepen students’ understanding.

The Basic Act on the Advancement of Utilizing Geospatial Information (NSDI Act)
(Enacted in May 2007)

This plan was established by the Cabinet Decision, aiming to advance high-level utilization of geospatial information comprehensively and systematically. The plan aims to promote policies and measures to realize the world's highest level of "Advanced Geospatial Information Utilization Society" (Geospatial Society) that makes use of advanced technologies such as IoT, big data, and AI in various scenes including the 2020 Tokyo Olympic and Paralympic Games.

The Basic Plan for the Advancement of Utilizing Geospatial Information
(3rd term: five years since 2017)

Industry-academia-government Cooperation to Advance the Utilization of Geospatial Information

The “Cross-sectoral conference for NSDI” was established to share information on issues related to geospatial information among industry, academia and government, and to advance the utilization of geospatial information. As a Secretariat member of the Committee, GSI plays a leading role in the tasks by industry, academia and government.

Geospatial EXPO

"Geospatial EXPO" is an event where experts from industry-academia-government get together and introduce their services, products and the latest techniques related to geospatial information to the public through exhibitions, talks, symposiums, and hands-on activities. GSI organizes and manages the whole Geospatial EXPO as the host secretariat, and also exhibits its measures and holds the Geospatial Activity Competition.

Poster exhibition in the Geospatial Activity Competition

Presentation being delivered at the Geospatial Activity Competition

GSI Maps Partners Network <https://maps.gsi.go.jp/pn/>

GSI Tiles, map data accessible at GSI Maps, can be used on other systems and software. To support the creation of open-to-public innovations using the GSI Tiles, GSI established the GSI Maps Partners Network composed of groups and individuals that develop systems using GSI Tiles. Those groups and individuals exchange information and ideas with GSI regarding the utilization of GSI Tiles. These efforts have brought about new utilization of GSI Tiles in various fields, such as disaster prevention, meteorology, and GIS in local governments.

Activities for Supporting Geography Education to Promote Geospatial Information Utilization

As activities for supporting geography education, GSI holds events for students and briefings for companies that publish textbooks and educational materials, and delivers lectures for the general public.

- Summer school
- Briefing to textbook publishing company
- Lecture delivery

Experience of mapping
UAV demonstration flight
Introduction of GSI Maps
Research and Technology Development

- Unveiling the Mechanism of the Nankai Trough Earthquake
  Previous studies have revealed that there are areas stuck on a fault (asperities) and areas that move slowly without generating seismic waves (sliding zones) on a plate boundary which is the source of the occurrence of subduction-zone megathrust earthquakes, and their ranges change with time. GSI is working on a research for estimating temporal changes of asperities and sliding zones by combining GNSS CORSs on land and control points on the sea bottom, established by the Japan Coast Guard, to unveil the mechanism of occurrence of the megathrust earthquakes.

- Determining Accurate Positions of GNSS CORSs in More Detail
  The crustal movement has been monitored by calculating positional relationship among GNSS CORSs with high-precision. This method, called relative positioning, requires an enormous amount of calculation as the analysis is based on the combination of GNSS CORSs. Moreover, once a trouble occurs in a part of GNSS CORSs, the continuous crustal monitoring may not be possible.
  To overcome this weakness, GSI has been studying precise and rapid crustal movement monitoring technique based on directly calculating the position of each GNSS CORSs net relative position using the data of worldwide GNSS observation stations (Precise Point Positioning (PPP)).

- Grasp What Is Happening Now
  The prompt and efficient grasping of the disaster situations is the key to disaster response. To speed up grasping of a flood-caused inundation condition, GSI is developing a system that enables real-time estimation of the volume of inundation water using the automatically measured inundation range and area based on video images taken by disaster-prevention helicopters of Regional Development Bureaus of MEXT and other agencies. GSI is also examining ways to identify an inundation range by using AI technology.
Promoting the Administration of Land Surveys

Giving Advise on Public Surveys as the Competent Governmental Authority under the Survey Act

Public works such as road constructions and river improvement for disaster prevention are conducted in many places around us. Planning and designing these public works always accompany survey works that develop maps and that determine the reference of locations. GSI, as the competent governmental authority under the Survey Act that aims at ensuring accurate and efficient surveys, offers advice on survey works and examines the survey results so that survey works can be conducted smoothly in Japan.

Improving Productivity by Introducing New Technology - Using Unmanned Aerial Vehicle -

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is promoting a program called ‘Construction’, which aims to enhance the appeal of work at construction sites with improved productivity by introducing Information and Communication Technology (ICT) and other tools. As drawing elevation profiles from 3D model helps to understand a landform in detail, the application of 3D model and further use of the latest survey technology including UAV that can develop a 3D model is expected in various processes at construction sites. In this context, GSI has developed the “Public Survey Manual using UAV (Tentative),” which describes how to make a 3D model by analyzing aerial photographs taken from UAV and released it from its website. The manual is now widely referred in survey works because 3D models can be efficiently developed with a certain quality. In addition, GSI staff members are striving to improve their skills and accumulate know-how on operating UAV to properly respond to inquiries about such technology.

Photographing by UAV and developing a 3D model

Efforts in Public Surveys

Surveys are classified into Basic Surveys conducted by GSI, Public Surveys conducted by the national and local governments, and others.

“Operating Specification” that stipulate the type of survey machinery, survey and calculating methods, and methods of map making must be made when national and local governments conduct Public Survey (Article 33, the Survey Act). GSI stipulates the “rules for Operating Specifications”, setting the standard work method and other aspects, as an example of Operating Specifications (Article 34, the Survey Act), and also developed manuals for surveys using new technology including vehicle-mounted, UAV-mounted, and terrestrial laser scanners to respond to new technologies. GSI has released these manuals on its website. The “rules for Operating Specifications” are updated appropriately by incorporating a survey method in accordance with the manual for new technology. GSI gives technical advice on Public Surveys and examines the results. When the national and local governments submit a plan for conducting a survey, GSI examines the content, such as appropriateness of the method in view of its purpose, the accuracy, and possibility of duplication with past surveys, and then provides technical advice (Article 36, the Survey Act). Once a Public Survey is completed, GSI examines the results submitted by the national and local governments (Article 41, the Survey Act); Public Survey results considered as fully accurate in this examination are widely used, for example, to develop maps for daily use.

Japan Profile for Geographic Information Standards (JGPGIS)

Geospatial standards include International standards (ISO standards) and Japanese Industrial Standards (JIS). However, these standards include many rules that are not generally used in Public Surveys. Therefore, GSI has compiled minimum sets of necessary rules for Public Surveys as the Japan Profile for Geographic Information Standards (JGPGIS) and keeps them updated. By following JGPGIS, Public Survey results are consequently compliant with the latest international standards.

Examination and Registration of Surveyors and Assistant Surveyors

Surveyor and Assistant Surveyor are national certifications required to engage in Basic Surveys and Public Surveys. Surveyors make survey plans and conduct survey work, while Assistant surveyors are in charge of the survey in accordance with the plan made by surveyors (Article 48, the Survey Act). GSI conducts examinations and registration of surveyors and assistant surveyors.

Eligibility Requirements (Articles 50 and 51, the Survey Act)

<table>
<thead>
<tr>
<th>Surveyor</th>
<th>Academic background and work experience</th>
<th>To acquire credits for subjects concerning the survey at a university, junior college or national institute of technology; to graduate from the above-mentioned school and to have the prescribed practical experience; To obtain professional knowledge and skills at a survey technical training school and to have prescribed practical experience in surveying; To be an assistant surveyor who has acquired advanced knowledge and skills in surveying at a survey technical training school; or</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam</td>
<td></td>
<td>To pass the surveyor examination held by GSI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assistant Surveyor</th>
<th>Academic background</th>
<th>To acquire credits for the subjects concerning the survey at a university, junior college or national institute of technology and to graduate from the above-mentioned school; To obtain professional knowledge and skills at a survey technical training school; or</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam</td>
<td></td>
<td>To pass the assistant surveyor examination held by GSI</td>
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</table>
Global Activities

Geospatial Infrastructure to the Globe

The United Nations General Assembly in February 2015 adopted the first resolution in the survey field, recognizing the importance of the accurate positioning (latitude/longitude) in the people's lives and economic activities. GSI cooperates with the countries around the world in an activity to set the precise reference for locations. Furthermore, based on the governmental policy to push exports of Japan's quality infrastructure, GSI provides technical support to internationally achieve widespread use of CORS network with Japan's good practices by dispatching its staff to Thailand, etc. GSI contributes to realizing a world in which anyone can take full advantage of geospatial information through such efforts.

UN-GGIW-AP: the Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific

International Collaborative Observation

GSI is participating in the International VLBI Service for Geodesy and Astrometry (IVS), an international organization of VLBI, to conduct observation in cooperation with foreign countries. In addition, GSI is actively involved in the international collaboration, such as serving as Chair of the Asia-Oceania VLBI Group for Geodesy and Astrometry (AOV), and hosting of the Second AOV General Meeting in Kobe, Japan in 2017. GSI also participates in the International GNSS Service (IGS) to ensure the precision of GNSS surveying and positioning.

Technical Cooperation to Developing Countries

GSI provides technical cooperation to developing countries through Japan International Cooperation Agency (JICA) for developing maps and improving survey skills in developing countries. GSI has been carrying out training programs on survey and accepting participants every year since 1959. GSI has also been dispatching staff to many countries for sharing survey skills since 1964. In addition to such technical cooperation, GSI has been working to export Japan's survey technologies such as CORS air fundamental infrastructure to achieve high precision positioning society.

Antarctic Research Expeditions

GSI has dispatched staff to the Antarctic research expeditions to conduct geodetic survey and map creation since the first mission in 1956. (In 2017, a staff member from GSI joined in the 59th mission.) Furthermore, as part of the IGS activities, GSI is carrying out continuous GNSS observation in East Ongul Island, in which the Syowa Station is situated.

Contribution to the United Nations operations in the field of geospatial information (Expert sent to the United Nations Geospatial Information Section; Mr. Hidenori Fujimura)

United Nations Geospatial Information Section is responsible to provide geospatial information and services to the full range of United Nations operations, including the Security Council, the Secretariat, and the United Nations Peacekeeping Operations. Taking advantage of my experience in GSI such as GSI Maps, I am providing substantive professional expertise on integration of geospatial information with various new web technologies. This will support the decision-making and operational needs for the United Nations operations. I am also participating in the Joint Secretariat activities of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) to support discussions.

Report on the GSI activity at the Second AOV General Meeting (Kobe, August 2017)

Guided tour to CORS in GSI for an overseas delegation

Technical training program in Japan

Surveying on an ice sheet with a thickness of approximately 500 meters (shot by the 59th mission)

Surveying on an exposed rock without ice (shot by the 59th mission)

Working in the UN Secretariat
Science Museum of Map and Survey

The “Science Museum of Map and Survey” is a facility where both the young and old can have fun learning and experiencing the roles of map and survey. Other than displaying various exhibits concerning maps and surveys, the facility holds special exhibitions, and hands-on events for surveying and mapping events for children and students.

Open: 9:30 - 16:30
Closed: Mondays (The next day when Monday falls on a holiday) and the New Year holidays
<http://www.gsi.go.jp/MUSEUM/>

Introduction of the Museum

- Japanese Archipelago Skywalk Map
  The entire Japanese archipelago is drawn on the floor at a scale of 1:100,000. When seen with 3D glasses, it appears in three dimensions, giving you a glimpse of the actual topography of Japan’s land and sea areas.

- Permanent Exhibition Room
  You can have fun learning about maps and surveys through their history, old maps and quizzes.

- Earth Plaza
  A sphere model of Japanese Archipelago represented at a scale of 1:200,000. You can climb the sphere and experience the expanse of the country and the roundness of the globe. The retired survey aircraft Kuni-kaze is also on display.

Hands-on Event

GSI holds hands-on events such as the Surveying Experience Class and Map & Survey Workshops for elementary school students.

Surveying Experience Class
Map & Survey Workshop