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REPORTS ON ACHIEVEMENTS IN GEOGRAPHIC INFORMATION IN ADDRESSING NATIONAL, REGIONAL AND GLOBAL ISSUES, INCLUDING: GEOSPATIAL DATA COLLECTION, MANAGEMENT AND DISSEMINATION

The New Geodetic Reference System of Japan
- its adoption and application to our products –

(Submitted by Japan)**

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** Prepared by Geographical Survey Institute

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Geographical Survey Institute

1. Summary

The Geographical Survey Institute (GSI), the national surveying and mapping organization of Japan, holds jurisdiction of the Survey Act which was established in 1949. The amended Survey Act effective on Apr. 1st 2002 introduced a world geocentric reference system as the geodetic reference system, that is, "Japanese Geodetic Datum 2000 (JGD2000)" instead of the former Tokyo Datum in order to adapt the coordinate system to various high-tech tools using GPS/GIS technology more easily. After the amendment, GSI has changed all the coordinates of their products based on JGD2000 and make it known to public including governmental organizations and local governments.

2. Amendment of the Survey Act

2.1 Background of the amendment

The former Japanese geodetic reference system "Tokyo Datum" was basically established in early 20th century. This coordinate system had a large shift to the world geodetic system which amounts to 400-450m (Fig.1). The shift is mainly due to the astronomical determination of the origin of longitude and latitude for the Tokyo Datum. The old geodetic system was also distorted internally by several meters because of immature survey technology and accumulated crustal deformation for around 100 years.

Nowadays, development of space geodetic technology such as VLBI and GPS has revealed more precise feature of the earth, and the new geodetic reference system that can be used world-widely was established. Conversion of digital spatial data that are rapidly come into wide use in GPS/GIS needed more costs, if this amendment had delayed.

Japan had decided to amend the Survey Act to introduce the new survey standard JGD2000 for above reasons.

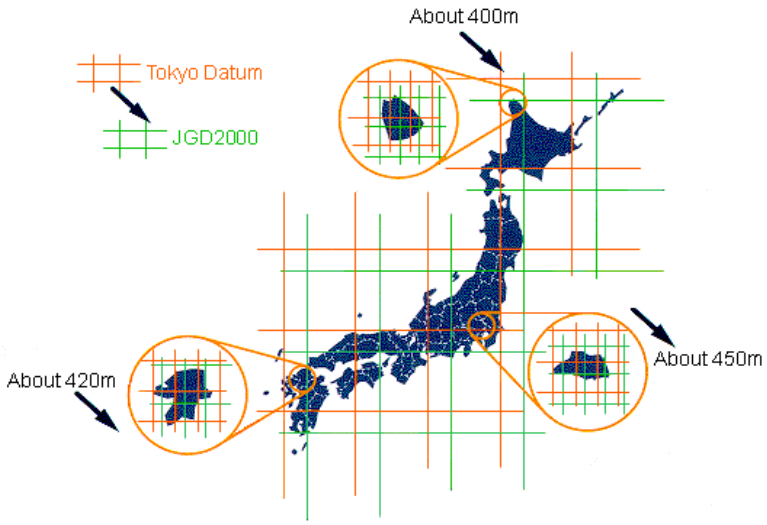

Figure 1 The difference between the Tokyo Datum and the JGD2000

2.2 Outline of the amendment

The amended Survey Act defined the world geodetic system as, “Approximating the figure of the earth to rotating ellipsoid”, “Corresponding the center of the datum to the gravity center of the earth”, and “Corresponding minor-axis of rotating ellipsoid to self-rotating axis of the earth”.

Additionally, amended act also defined that a position is expressed in geographical longitude and latitude, and height above the sea level using the new survey standard, JGD2000, and distance and area are reduced upon the surface of the rotating ellipsoid.

JGD2000 is based on the GRS80 ellipsoid that was defined by IUGG. Tokyo Datum, the former survey standard in Japan, was based on the Bessel ellipsoid which had been proposed in 1841, and the earth has come to a flatter one (Tab.1).

For JGD2000 the Japanese origin of longitude and latitude is based on ITRF94 that are determined by IERS using various space geodetic technologies. The re-calculated values for the Japanese origin of longitude and latitude are, (longitude) E139°44?28?8759, (latitude) N35°39?2 9?1572.

	Semi-major axis(meters)	Flattening of the ellipsoid of rotation
Tokyo Datum	6,377,397.155	1/299.152813
JGD2000	6,378,137	1/298.257222101

Table 1 The difference in shape and size of the globe between the Tokyo Datum and the JGD2000

3. JGD2000 and National Control Points

3.1 Redevelopment of the Geodetic Network and the new Japanese Geodetic Datum

At the transition of the geodetic system the geodetic network had to be reconstructed in order to adjust the coordinate data of all the control points (triangulation points) throughout the country to the JGD2000. As a first step the positions on a global base were determined by international connections through VLBI observations at the Kashima VLBI observation station (Ibaraki prefecture).

Then for the computations of the coordinates of the control points around Japan the network framework was constructed based on the VLBI and GPS observations. Starting from the Kashima VLBI station the coordinates of the Shintotsukawa VLBI station (Hokkaido) and Kainan VLBI station (Wakayama prefecture) were determined, upon which computations for all the GPS-based control points (GPS continuous observation points), about 600 points in total, were conducted for further computations of the geodetic network framework. (Fig2)

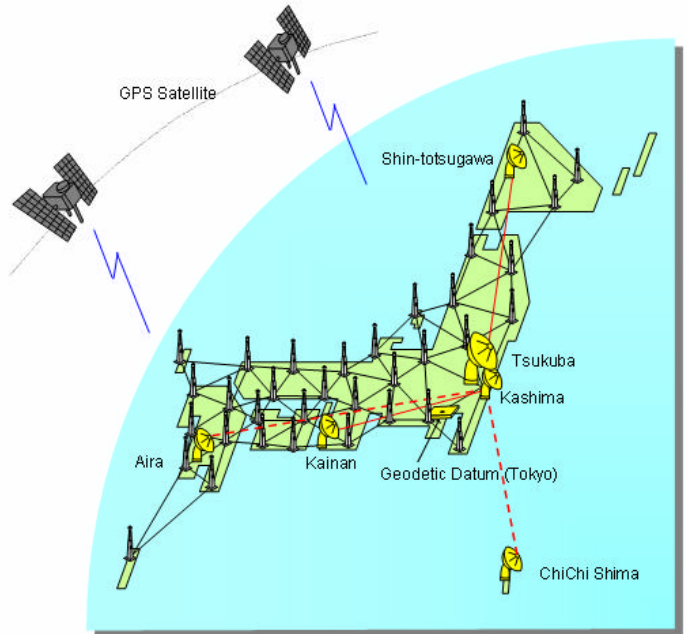

Figure 2 VLBI observation stations and GPS continuous observation network

With the values of the GPS-based control points thus fixed, positional data of the first, second, and third order triangulation points were revised adopting the latest observation data. The coordinates of the fourth order triangulation points of about 60,000 in place since 1950s were converted to the coordinates of the JGD2000 by the conversion program developed by the GSI. This conversion program named TKY2JGD together with the conversion parameters was made available on the internet for the general public and for public surveys as well. The newly established coordinates values from the computations with reference to the JGD2000 is called Geodetic Coordinates 2000.

3.2 The new geoid model of Japan: GSIGEO2000

At the same time as the amendment of the Survey Act, GSI published a new geoid model of Japan, GSIGEO2000, which provides the geoid height in accordance with JGD2000 on 1.0 min. by 1.5 min grid. The model was a "hybrid geoid model" and established by adopting the gravitational geoid model, JGEOID2000, to nationwide geoid undulation data by the GPS observation at more than 800 benchmarks. Now it is widely used in GPS surveys as the conversion parameters between ellipsoidal height by GPS and orthometric height by leveling.

3.3 Release of benchmark data

Elevation data of the nationwide benchmarks, the basis for precise heights, were fully revised after the previous revision in 1969.

The very objective of the revision of the elevation data is to remove the discrepancies accumulated over the years since 1969, due to crustal displacements due to earthquakes affecting many areas, volcanic activities, and ground subsidence.

4. JGD2000 and Maps of the Geographical Survey Institute

4.1 Revisions in the topographic maps of 1:25,000, 1:50,000 and regional maps of 1:200,000

4.1.1 Expression of longitudes and latitudes

The maps prepared by GSI indicates longitudes and latitudes at the four corners of the neatlines of each map sheet. After the introduction of JGD2000 they are given in two ways, in the old and the new system. For example in the topographic maps of 1:25,000 the new data of longitude and latitude (up to the order of first decimal) are given in brown color in two rows at the four corners of the neatlines, for which a special annotation is added at the right bottom under the legend, indicating the adoption of the JGD2000 on 1 April, 2002. For the topographic maps of 1:25,000 the map sheets will be gradually changed for data entry of less digits.

4.1.2 Preparation of comparison chart of coordinate values

A booklet for quick comparison of the new and old values has been made and attached to the maps already published, where the values of the four corners are given in two different systems as is shown in Table 2.

Table - 2 A Sample of the comparison chart

Map sheet number	Map name	Upper Left Old Latitude Upper Left Old Longitude Lower Left Old Latitude Lower Left Old Longitude	***Upper Left New Latitude*** ***Upper Left New Longitude*** ***Lower Left New Latitude*** ***Lower Left New Longitude***	Upper Right Old Latitude Upper Right Old Longitude Lower Right Old Latitude Lower Right Old Longitude	***Upper Right New Latitude*** ***Upper Right New Longitude*** ***Lower Right New Latitude*** ***Lower Right New Longitude***
Shiretoko Misaki 11-3	Shiretoko Misaki	44 20 00.0 145.15.00.0 44 15 00.0 145 15 00.0	***44 20 08.7*** ***145 14 45.3*** ***44 15 08.7*** ***145 14 45.3***	44 20 00.0 145 22 30.0 44 15 00.0 145 22 30.0	***44 20 08.7*** ***145 22 15.3*** ***44 15 08.8*** ***145 22 15.3***

The above is the example of the topographic map of 1:25,000. The value of the four corners of the neatlines are given in 0.1 second. Letters in bold indicate JGD2000, others indicate the Tokyo Datum. Numbers 44 20 08.7 means North latitude 44°20?8?7 (minutes and seconds by sexagesimal, first decimal of seconds by decimal).

4.2 Revisions in the digital maps

1) Digital map 25000 (Spatial Data Framework)

In the ones that have been published before the new Act went into force coordinate values of both the old and the new system are given, while the values according to JGD2000 are given in the ones released after the transfer took place.

2) Digital Map 2500 (Spatial Data Framework)

To the ones that have been published before the new Act went into force a notice is attached so that users can access to the conversion software through the GSI website, while for the ones after the revision the values newly obtained in accordance with JGD2000 are given.

3) Digital Map 25000,50000,200000 (Map Image), Digital Map 50 m, 250m, 1km Mesh (Elevation)

To the ones that have been published before the new Act went into force a notice is attached so that users can access to the conversion software through the GSI website, while a program is attached for display of the values of the both systems to the ones after the transfer.

5. Amendment of the Survey Act and Public Surveys

5.1 Definition of Public Surveys

When all or a part of the survey costs are covered or supported by the government departments other than GSI or by a public entity, they are called public surveys.

5.2 Gradual transfer to JGD2000 in Public Survey Works

5.2.1 Preparation of a Manual

For an efficient conversion of the survey data GSI has made a “Conversion manual for the public survey data”, where the conversion methods of control points, map products, and digital topographic map data are described.

5.2.2 Publicity of the new system

GSI launched a nationwide campaign and seminar for promotion of the new system in 62 major cities throughout Japan six months before the amendment of the Survey Act in order to well acquaint those concerned with survey planning and survey works with the new system and the necessary conversion process. At seminars lectures were given on the new Survey Act, Public Survey procedures, coordinates conversion methods, and the conversion manual for the public control point and such. Similar sessions were held for various government agencies and some written information on the conversion was distributed to the sectors concerned including schools, map manufacturers and map retail shops.

6. Concluding remark

As of April 1 of 2002 all the GSI survey works and public surveys are conducted based on the world geocentric reference system. Now three years since the introduction the conversions of the old data and surveyunder the new system are well underway. At the private level as well the JGD2000 is steadily gaining ground in response to and under the leadership of the national government.