

Preface

In Japan the geodetic datum was first determined about a hundred years ago in the Meiji era when the modern survey was inaugurated for making topographic maps all over Japan. The earth was represented by the Bessel ellipsoid of revolution, and at the origin in Tokyo the astronomical latitude, longitude, and azimuth to the neighboring first order triangulation point were determined. Furthermore, the height of the vertical origin was given with reference to the level surface, the mean sea-level of Tokyo Bay. Based on the datum values horizontal coordinates of triangulation points and heights of benchmarks were determined by triangulation and leveling, respectively. The survey law regulated in 1949 fundamentally succeeded the original survey standard.

However, with the development of space geodetic techniques such as VLBI (Very Long Baseline Interferometry) and international observations using such techniques, the flattening and equatorial semi-axis of the ellipsoid which approximates the earth have become accurately known, and the coordinates of the Tokyo origin have been precisely determined in the geocentric geodetic system. Moreover, the prevailing utilization of GPS (Global Positioning System) has revealed problems caused by the difference between the old Japanese geodetic system and the world geodetic system. Thus, the survey law was amended in June 2001 so that the Japanese geodetic system will coincide with the world geodetic system. The amended survey law has been effective since April 2002.

With enforcement of the amended survey law new coordinates of the horizontal control points such as triangulation points in the world geodetic system have been provided for public use. The horizontal control points include electronic control points, which were permanently established for continuous GPS observations. Concurrently, heights of benchmarks in Japan were also revised with the data of the latest leveling and gravity survey. However, the level surface for height determination and the height of the vertical origin were not changed. Moreover, a new Japanese geoid model has been developed. The geoidal height is essential for conversion between the ellipsoidal height obtained by GPS surveys and orthometric height. These new coordinates of horizontal control points, new orthometric heights of benchmarks and the geoid model are generally referred to as the “Geodetic Coordinates 2000”.

On the other hand, as the Japanese Islands are located in a region where several plates collide, the crust is constantly being deformed and crustal movement associated with earthquakes and volcanic eruptions is remarkable. Therefore, the old geodetic system had strains due to accumulated crustal movements in addition to its inherent systematic errors. Accordingly, the purpose of establishment of the new Japanese geodetic system was to rid the strains of the old geodetic coordinates to meet recent social requirements accompanying the improvement of survey accuracy as well as the adoption of the world geodetic system.

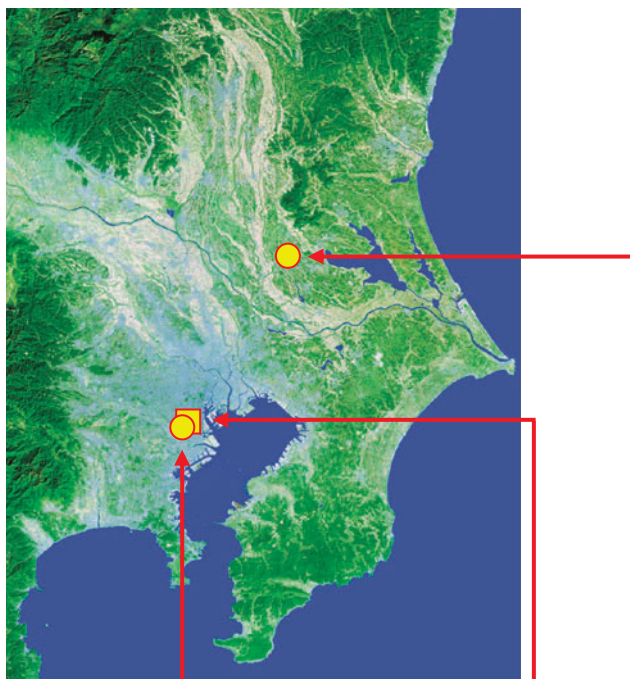
Establishment of the new Japanese geodetic system was not accomplished in a day. The establishment took a long period of data accumulation, research and development of geodetic technique and an enormous amount of computations. Though the frame of the new horizontal geodetic system consists of networks of VLBI stations and electronic control points, the main part is composed of networks of the first, second and third order triangulation points which have been resurveyed since the 1970s in the project of “Precise Geodetic Survey of the Japanese Islands” for crustal movement study and whole revision of coordinates of geodetic control points. The resurvey was carried out mainly by laser ranging in an early phase, and then by GPS survey in the 1990s. New heights of benchmarks have been calculated using repeated nationwide leveling data. The geoid model was developed in a hybrid mode using the data of gravity survey and GPS survey on benchmarks. Therefore, the Geodetic Coordinates 2000 is a synthetic result of geodetic surveys conducted until recently in Japan.

This issue of the Bulletin of the Geographical Survey Institute, vol. 51 is intended to show the process of establishment of the new Japanese geodetic system as a whole and the bulletin consists of four papers on “geodetic system”, “horizontal control points”, “vertical control points” and “geoid model”. The paper on the geoid model is a reprint from the Bulletin of the GSI, vol. 49, 2003.

The Geodetic Coordinates 2000 has been open to the public since April 2002 and is widely used for public survey and other purposes. However, crustal movement is incessant and conspicuous in Japan as stated above. Thus, it is necessary to continue nationwide geodetic surveys and observations to maintain the accuracy of the geodetic coordinate system. Furthermore, in the forthcoming information society it is expected that location information based on the national geodetic system will play an important role in the field of location-based services. In this sense the establishment of the new Japanese geodetic system is not a goal, but only the starting point to establish the GRID-Japan, Geo-Referencing Infrastructure for Dynamic Japan.

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Full view of Tsukuba VLBI Observation point:
the Target of Azimuth at the Horizontal Origin
Point and its metal marker



Vertical Origin and its crystal plate in Tokyo



Full view of Horizontal Origin Point of JGD2000 and its metal marker in Tokyo

Plate 1 Horizontal and Vertical Origin Points of JGD2000
and Tsukuba VLBI observation point



Plate 2 Kashima VLBI station (26m antenna)

The Kashima VLBI station, constructed in 1968 by the Radio Research Laboratory (now the Communications Research Laboratory) participated in international VLBI experiments since 1984. It continued to be active in international experiments after the ownership transfer to GSI in 1992 as a core station in Japan. In JGD2000, Kashima station's position and velocity in the ITRF were used as the reference.

It was dismantled in 2003 due to decrepitude, and its role in international experiments has been succeeded by Tsukuba VLBI station (32m antenna) built in 1998 at GSI.



- : Fixed in the framework adjustment
- : Adjusted in the framework adjustment
- : Used for evaluation
- ※ Chichijima (mobile) was held fixed in the adjustment in the Ogasawara islands

Plate 3 VLBI stations that define the framework of JGD2000

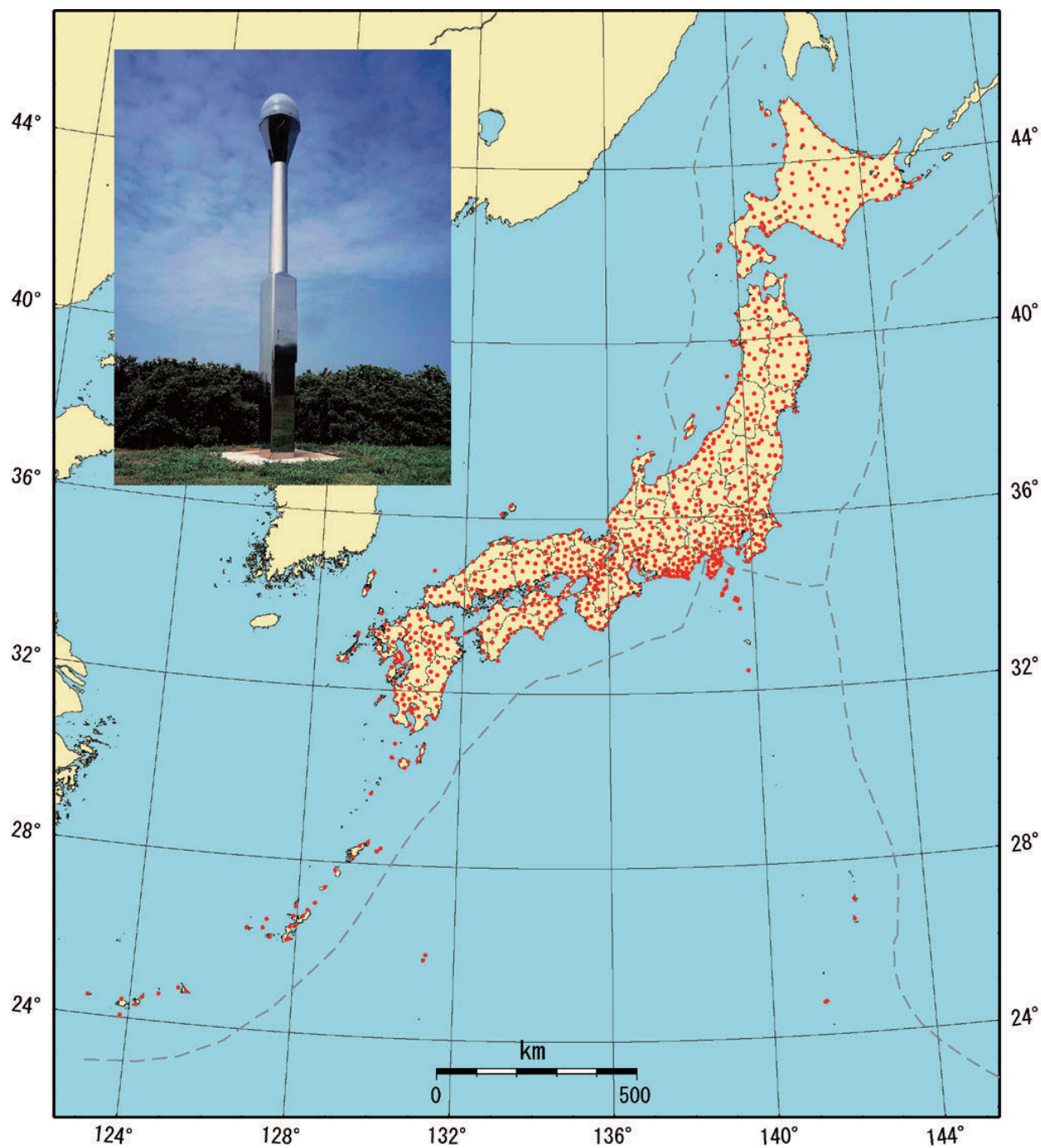
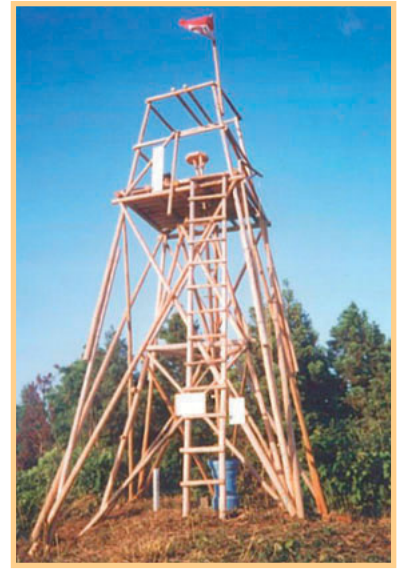


Plate 4 Distribution of GEONET stations



Electro-optical
Distance Meter (EDM)



Wooden Observation Tower
(EDM)



Steel Observation Tower
(height: 25m)

Primary Precise Geodetic
Network Survey (PPGN)

Highly Precise Geodetic
Network Survey (HPGN)



GPS Observation



GPS Observation using an antenna tower

Plate 5 Primary Precise Geodetic Network (PPGN) Survey and
Highly Precise Geodetic Network (HPGN) Survey

Plate 6-1 Displacement vectors of the
1st-order triangulation points

Data used: Primary Precise Geodetic Network
(PPGN) Surveys
Fixed points: PPGN points that are connected to
GEONET
Vector: Tokyo97 - Tokyo Datum

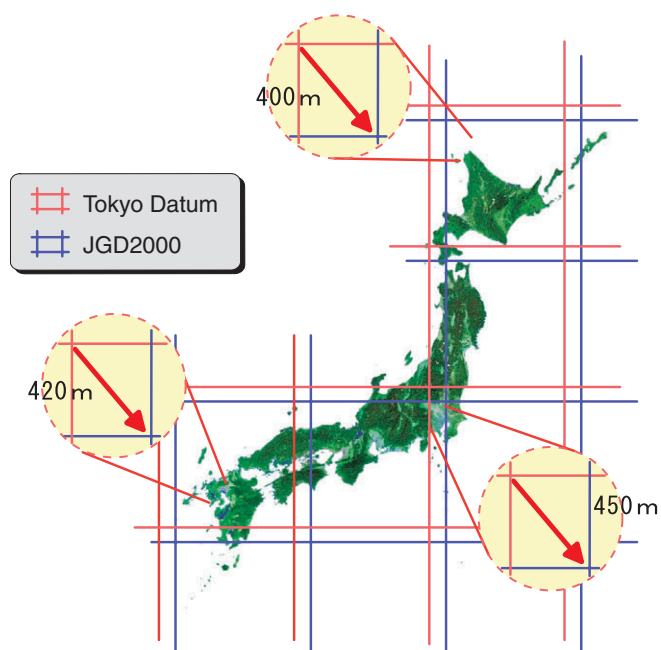
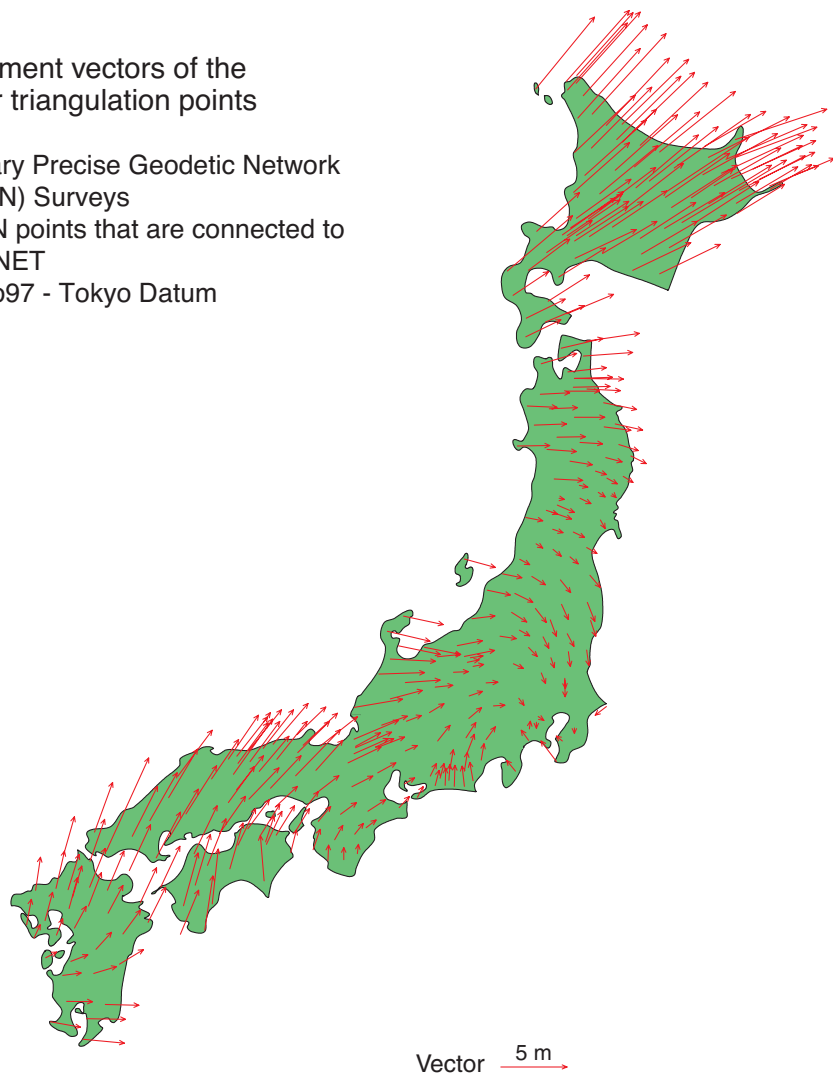


Plate 6-2 Relationship between Tokyo
Datum and JGD2000

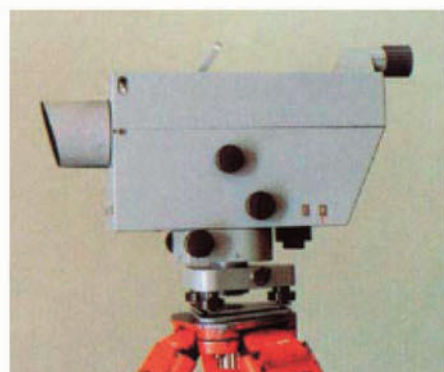
If the longitude and latitude of a point in Tokyo Datum are transformed into those in JGD2000, the longitude will decrease by about 12 arcsec, and latitude increase by about 12 arcsec. These differences vary slightly by regions.



Plate 7-1 First-order leveling survey



First-class level N3 (tilting level)



NI002 (automatic level)



DiNi11 (digital level)



NA3003 (digital level)

Plate 7-2 Levels used for leveling surveys