Grids & Datums

JAPAN

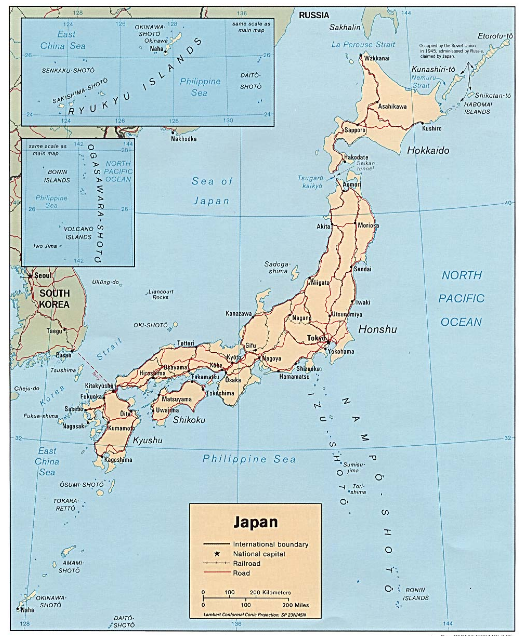
BY Clifford J. Mugnier, CP, CMS, FASPRS

The Grids & Datums column has completed an exploration of every country on the Earth. For those who did not get to enjoy this world tour the first time, *PE&RS* is reprinting prior articles from the column. This month's article on Japan was originally printed in 2002 but contains updates to their coordinate system since then.

Japan was inhabited by humans as early as 30,000 B.C. Its written history began in the 5th century A.D., after it adopted handwriting from the Chinese culture. Buddhism was introduced circa 552, and Japan closely imitated Chinese institutions during the sixth to ninth centuries. First visited by the Portuguese in 1542-43, European influences had little effect on religion; Shintoists and Buddhists rep-resent 84 percent of the current population and Christianity is practiced by less than one percent. For several hundred years, the Portuguese had far greater in-fluence than the later English and Dutch trading companies. Commodore Mathew Perry, USN, secured the first commercial treaty in 1853. The "Land of the Rising Sun" is a constitutional monarchy with a parliamentary government. There are 47 prefectures. Japan's independence dates back to 660 B.C. (traditional founding by Emperor Jimmu), and its constitution is dated 03 May 1947.

Comprised of four main islands—Honshū, Shikoku, Kyushu, and Hokkaidō—Japan also includes the Bonin Islands (Ogasawara-Guntō), Daitō-Shotō, Minami-Jima, Okino-tori-Shima, Ryukyu Islands (Nansei-Shotō), and Volcano Islands (Kazan-Rettō). Japan is mostly mountainous; the lowest point is Hachirō-Gata (lake) at –4 m, the highest is Fuji-Yama at 3,776 m, and both places are on the island of Honshū.

In 1869, the Survey Division of the Ministry of Civil Services was established. In 1888, the Imperial Land Survey of the Army General Staff absorbed the Survey Division and carried out the fundamental surveying and mapping of the entire Japanese Empire. The Tokyo Datum of 1892 was established at the Azabu origin where Φ_o = 35º 39´ 17.5148˝ North and Λ_o = 139° 44´ 30.097˝ East of Greenwich. The defining azimuth was deter-mined from the old Tokyo Observatory at Azabu to station Kanou-Yama (Kanou Mountain) as



α_o = 156° 25´ 28.442˝. The Tokyo Datum of 1892 was referenced to the Bessel 1841 ellipsoid where the semi-major axis (a) = 6,377,397.155 meters and the reciprocal of flattening ($^1/_f$) = 299.1528128. The pervasive Tokyo Datum of 1918 reflected a new determination of longitude at Azabu Observatory such that the origin was re-defined as Φ_o = 35º 39´ 17.5148˝ North and Λ_o = 139° 44´ 40.5020˝ East of Greenwich. The orientation was not changed, and the deflection of the vertical at the observatory was defined to be nil. The ellipsoid height of mean sea level in Tokyo Bay was defined to be –24.414 m. For military use, the Japanese Imperial Land Survey (JILS) used a conformal double transverse Mercator grid known as the Gauss-Schreiber Transverse Mercator grid from about 1892 to 1921. (That's the same formulae that the U.S. Coast & Geodetic Survey chose for the TM zones on the North American Datum of 1927.) The multiple belt system defined the East Belt origin as φ_o = 36º 03´ 34.9523˝ N and λ_o = 139° 44´ 40.5020˝ E,

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where the X axis began at the meridian crossing the transit circle at Tokyo Observatory. The East Belt covered the area south of the Tsugaru Kaikyō (Strait) and east of 135°, comprising all of Honshu east of Kobe to 142°. The West Belt origin was φ_o = 36º 03´ 34.9523˝ N and λ_o = 132° 04´ 42.9183˝ E, where the meridian crossing the Kammuri-Yama first-order station in Hiroshima-Ken was the X axis origin, and the limits of the West belt were from 126° to 135°. The North Belt origin was φ_o = 45º 00´ 00˝ N and λ_o = 142° 15´ 17.2085˝ E, where the meridian crossing the Yubari-Dake first-order station in Hokkaidō was the X axis origin, and was used for computation in Hokkaidō. This North Belt was also used in Karafutō, the southern half of Sakhalin Island, invaded during the Russo-Japanese War of 1904-1905 and occupied by the Japanese un-til after WWII. The southern belt covered the area south of 31° where the Formosa Belt origin was φ_o = 23º 40´ 00˝ N and λ_o = 120° 58´ 25.9750˝ E, where the meridian crossing the Koshizan first-order station (now called Hu-tzu-shan in Taiwan) was the X axis origin. These grids did not use false origins, and in all cases the scale factor at origin (mo) was equal to unity. The purpose of the JILS Grids was to compute the basic primary triangulations of these areas. Similar systems were implemented by the JILS in Manchuria, China (*PE&RS*, May 2000), and Korea (*PE&RS*, November 1999).

According to John W. Hager, "After 1921, the JILS Grids changed to the following: Latitude of Origin for Korea and zones 1 through 5 is 36º N, for Formosa 24º N. The Longitudes of Origin – Korea 128º, zone 1 132º, zone 2 136º, zone 3 140º, zone 4 144º, zone 5 148º, and Formosa 121º. All zones use a unity Scale Factor, and False coordinates were used, but the only one I have is for zone 2 where FN = 6,000 km, and FE = 3,600 km. Notes on the Japanese Artillery (JA) versus the JILS: where JILS X (northing) = 0 meters = JA Y = 250,000 meters, JILS Y (easting) = 0 meters = JA X = 200,000 meters. Further stated that Latitude of Origin = 28º N, Longitude of Origin = 129° 19´ 23.6028˝ E, (Yuwan-Dake). This is marked as the New Tokyo (1918) value and with a further remark to see also 129° 19´ 13.1978˝ E, which is the Old Tokyo (1892). Convenient in that the grid values are the same and only the geographic vary. The Korean National Geography Institute and National Construction Research Institute use the same gimmick by increasing the longitude of origins by 10.405˝."

After WWII, the duties of the JILS were transferred to the Geographical Survey Institute (GSI) in the Ministry of Home Affairs. In 1947, a new Surveying Law defined 13 zones for cadastral mapping ("Public Survey"), on the Gauss-Schreiber Transverse Mercator Grid with specific prefectures for each zone. For Zone 1, φ_o = 33º 00´ N and λ_o = 129° 30´ E, required for Nagasaki and Saga. For Zone 2, φ_o = 33º 00´ N and λ_o = 131° 00´ E, required for Fukuoka, Ōita, Kumamoto, Miyazaki, and Kagoshima. For Zone 3, φ_o = 36º 00´ N and λ_o = 132° 10´ E, re-quired for Yamaguchi, Shimane, and Hiroshima. For Zone 4, φ_o = 33º 00´ N and λ_o = 133° 30´ E, required for Kagawa, Ehime, Tokushima, and Kōchi. For Zone 5, φ_o = 36º 00´ N and λ_o = 134° 20´ E, required for Hyōgo, Tottore, and Okayama. For Zone 6, φ_o = 36º 00´ N and λ_o = 136° 00´ E, re-quired for Fukui, Shiga, Mie, Nara, Wakayama, Kyōto, and Ōsaka. For Zone 7, φ_o = 36º 00´ N and λ_o = 137° 10´ E, re-quired for Ishikawa, Toyama, Gifu, and Aichi. For Zone 8, φ_o = 36º 00´ N and λ_o = 138° 30´ E, required for Niigata, Nagano, Gumma, Yamanashi, and Shizuoka. For Zone 9, φ_o = 36º 00´ N and λ_o = 139° 50´ E, required for Fukushima, Tochigi, Ibaraki, Chiba, Saitama, Kanagawa, and Tōkyō. For Zone 10, φ_o = 40º 00´ N and λ_o = 140° 50´ E, required for Aomori, Akita, Yamagata, Iwate, and Miyagi. For Zone 11, φ_o = 45º 00´ N and λ_o = 140° 15´ 19´ 17.2085˝ E, where the central meridian is 2º west of the Longitude of the Yubari-dake first-order trig. station in Hokkaidō. Zone 11 is required for the following sub-prefectures of Hokkaidō: Iburi, Usu, Abuta, Hiyama, Shiribeshi, Otaru, Hakodate, and Ō-Shima. For Zone 12, φ_o = 45º 00´ N and λ_o = 142° 15´ 19´ 17.2085˝ E, where the central meridian is the longitude of the Yubari-dake first-order trig. station in Hokkaidō. Zone 12 is required for the fol-lowing sub-prefectures of Hokkaidō: Sapporo, Ishikari, Abashiri (Mombetsu), Asahigawa, Kamikawa, Soya, Urakawa, Muroran, Yūbari (excluding Usu and Abuta), Sorachi, and Rumoi. For Zone 13, φ_o = 45º 00´ N and λ_o = 144° 15´ 19´ 17.2085˝ E, where the central meridian is the longitude of the Yubari-dake first-order trig. station in Hokkaidō. Zone 13 is required for the following sub-prefectures of Hokkaidō: Nemuro, Kushiro, Abashiri (excluding Mombetsu), Kasai, and Kushiro. As usual, there was no false origin, and the scale factor at origin was equal to unity for all of these grids for the "Public Survey."

Thanks to Professor Kazuo Kobayashi of the Survey College of Kinki, there have been some new additions to the "Grids of the Public Survey." Hager later pored over some maps to identify the likely areas of coverage. For Zone 14, φ_o = 26º 00´ N and λ_o = 142° 00´ E, and appears to be for the Bonin Islands (Ogasawara-Guntō) and Volcano Islands (Kazan-Rettō). For Zone 15, φ_o = 26º 00´ N and λ_o = 127° 00´ E, and appears to be for Okinawa Guntō and Amami Guntō. For Zone 16, φ_o = 26º 00´ N and λ_o = 124° 00´ E, and appears to be for Sakishima Guntō. For Zone 17, φ_o = 26º 00´ N and λ_o = 131° 00´ E, and appears to be for the Daito Islands (Kita Daito Jima and Okino Daito Jima). For Zone 18, φ_o = 20º 00´ N and λ_o = 136° 00´ E, and appears to be for Parece Vela.). For Zone 19, φ_o = 26º 00´ N and λ_o = 154° 00´ E, and appears to be for Marcus (Minami Tori Shima).

In 1985, Toshiyuki Shiina, general manager of the Geodetic Surveying Department of the Aero Asahi Corporation wrote to me of the special grid he de-vised for the Seikan Tunnel Project. (The project was the longest tunnel under the seabed in the world at the time.) Because the tunnel spanned two Public coordinate grids between the Main Island of Honshu and the northern island of Hokkado, he chose to define his own special purpose grid for the project based on the Gauss-Krüger Transverse Mercator projection. Shiina also chose a scale factor at origin, mo = 0.9999 and the projection origin at φ_o = 41º 10´ N and λ_o = 140° 10´ E.

The GSI reports that it is moving the country to the Japanese Geodetic Datum 2000 (JGD2000). The National Imagery and Mapping Agency (NIMA) reports in Technical Report 8350.2 (January, 2000) that the transformation (for Japan) from Tokyo 1918 to WGS84 is $\Delta a = 739.845$, $\Delta f \times 10^4 = 0.10037483$, $\Delta X = -148m \pm 8m$, $\Delta Y = -507m \pm 5m$, and $\Delta Z = -685m \pm 8m$.

Update

Japan now has a GPS network established with a density of about 20 km used primarily for an earthquake warning system. The new published transformation parameters from Tokyo97 Datum to ITRF94 are: $\Delta X = +147.414$ m, $\Delta Y = -507.337$ m, $\Delta Z = -680.507$ m. Thanks to Prof. Kazuo Kobayashi, "the lowest point in Japan is the middle of the Seikan Tunnel at –256.5674m. The history of Japanese Datum leveling above Mean Sea Level at Tokyo Bay at "1-chome Nagatacho, Chiyokaku, Tokyo in 1894 = 24.5000m, in 1923 = 24.4140m and in 2011 = 24.3900m."

The Geospatial Information Authority of Japan (GSI) has published extensive information on their data in English: https://www.gsi.go.jp/ENGLISH/page_e30030.html

- There is a detailed preface: https://www.gsi.go.jp/common/000001194.pdf,
- Concept of the New Japanese Geodetic System: https://www.gsi.go.jp/common/000001195.pdf,
- The new Height System of Japan: https://www.gsi.go.jp/common/000001197.pdf,
- And Development of a new Geoid: https://www.gsi.go.jp/common/000001198.pdf.

The contents of this column reflect the views of the author, who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the American Society for Photogrammetry and Remote Sensing and/or the Louisiana State University Center for GeoInformatics (C^4G).

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share their data as analysis-ready data services, and as more online analytical tools are developed and made accessible for free, and more disruptive machine learning and other Artificial Intelligence (AI) approaches are leveraged, the future could be very different from the past. Simply stated, it will be much more inclusive – both in terms of the diversity of data sources and analysis techniques, and in terms of broadening the user base, including a range of non-technical users, although it will still require a great deal of technical expertise to produce the information and visualizations. These services can be made more global, providing economies of scale in development, facilitating partnerships, and expanding the user base beyond just a few with access to the data and tools to virtually anyone with a smartphone or similar device.

These kinds of platforms could move beyond being data/analytic service catalogs to become powerful customized decision support tools that leverage the services for use on any smartphone or tablet or other digital devices that even the poorest countries, institutions or people can leverage to make more information-based decisions and benefit from this rapidly-accelerating disruptive technology age.

The ASPRS community welcomes any feedback.

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