Grids & Datums

The Republic of Korea

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 the Republic of Korea was originally printed in 1999 but contains updates to their coordinate system since then.

The ancient kingdom of Chosŏn was established in the northern part of the peninsula during the third millennium B.C. Buddhism was introduced in the fourth century A.D., which the Koreans then carried to Japan. The Yi dynasty ruled the kingdom from the capital at Seoul from 1392-1910. Korea was forced to grant a treaty opening its ports to Japan in 1876. In resisting Chinese control, Korea was the focus of the Chinese-Japanese War of 1894-95, and further rivalry over Korea resulted in the Russo-Japanese War of 1904-05. (Someday I'll write about some fascinating geodetic history from that latter war.) Korea became a Japanese protectorate in 1905 and was annexed as a province in 1910. In 1945, after World War II, Korea was brought under the temporary protection of the USSR and the United States. The two zones of occupation were divided at the 38th parallel, and that line continues to divide the peninsula's politics.

The first geodetic datum used in Korea was the Tokyo Datum of 1892 where: Φ_o = 35° 39´ 17.515˝ North, Λ_o = 139° 44´ 30.097˝ East of Greenwich. The defining azimuth was determined from the old Tokyo Observatory at Azabu to station Kanoyama (Kano Mountain) as: α_o = 156° 25´ 28.44˝. The Tokyo Datum of 1892 is 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. Geodetic surveys started in Korea in 1910, and 13 baseline measurements were completed by 1918. During this time, 400 first-order, 2,401 second-order, and 31,646 third-order triangulation stations were established in all of the Korean Peninsula. The number of stations in South Korea totaled 16,089. Five tide stations were used for the establishment of the vertical datum to local mean sea level, and 6,629 kilometers of leveling

were run. The original triangulation was the Datum for the Old Cadastral Grids based on the Gauss - Schreiber Transverse Mercator formulae. The three belts were East, Central, and West with Central Meridians (λ_o) = 129°, 127°, and 125° East of Greenwich, respectively. The False Northing Latitude of Origin was 38° North, the False Northing = 500 km., the False Easting = 200 km. For all three belts, the Scale Factor at Origin (m_o) = 1.0. Note that these narrow belts used the simpler Gauss - Schreiber formulae for the Transverse Mercator, the same as the U.S. Coast and Geodetic Survey later did in the 1930's for the NAD 1927 State Plane Coordinate Systems. The Tokyo Datum of 1918 was later adopted for use in Korea, but the Cadastral Grids were NOT changed to accommodate that new system. The only difference between the

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two datums is that the 1918 re-determination of longitude is: Λ_o = 139° 44′ 40.502″ East of Greenwich, which is an increase of 10.405". The latitude was the same for both years. In Korea, the geographic coordinates of the triangulation stations are on the Tokyo Datum of 1918, but the Grid coordinates are on the Tokyo Datum of 1898. This is a little-known fact of Korean mapping that has led some cartographers to question their own sanity!

The number of triangulation stations lost or destroyed during World War II and the Korean War was about 12,000, or approximately 80% of the marks in South Korea. The rearrangement and reconstruction of the triangulation stations were begun in 1957. Rearrangement in this context means that work is done to build the stone marker to coincide with the recovered footing of the original triangulation station. Reconstruction work refers to rebuilding the footing and marker at the original site, or nearby, and per-forming the triangulation observations anew. All of this work was completed by 1986. In 1975, electro-optical distance meters (EDM) were introduced to the observational techniques. The re-survey has been of 1,291 existing first- and second-or-der stations as well as 14,798 third-and fourth-order stations. This has resulted in a new geodetic network being established where the accuracy specification is ±3 cm horizontal, ±5 cm vertical.

The Korean Datum of 1985 origin is at station Suwon on the grounds of the National Geographic Institute (NGI) where: Φ_o = 37° 16′ 31.9034″ North, Λ_o = 127° 03′ 05.1451″ East of Greenwich. The defining azimuth to station Donghak-san is: α^o = 170° 58′ 18.190″. The ellipsoid of reference did not change. The 40 Laplace stations established for this new datum were planned for a density of one station per 5,000 km^2. By 1996, 37 Laplace station observations were completed. The civilian Cadastral Grid system will continue on the new datum with no change in parameters other than the ellipsoid.

The leveling net in Korea was initially established between 1910-15, but the Korean War virtually destroyed all existing marks in the south. Since 1960, NGI started the re-survey of its network and by 1986 completed the first-order net. This is composed of 16 loops and 38 routes with a total length of 3,400 km and 2,030 benchmarks spaced at 2-4 km intervals. The primary benchmark of the Republic of Korea is at Inha University in the city of Inchon. Second-order benchmarks total 4,035 points along 7,600 km of leveling routes.

NGI has used satellite surveying techniques since 1979. Two Magnavox 1502 receivers were employed at Pusan, Kyeonju, and Cheju-do through co-operation with Japan until 1982. Twenty islands have been occupied for Transit satellite observations as of 1991. Since 1991, NGI has been using GPS receivers to strengthen the classical network. Plans to establish 20 permanent GPS observation stations in a Continuously Operating Reference Station (CORS) network started with the first station called SUWN using a TurboRogue™ SNR-8000 receiver on March 15, 1995.

Gravity surveys have been con-ducted by NGI since 1975. The original design plan called for 25 first-order stations and 2,000 second-order stations. By 1996, 1,709 second-order relative gravity stations had been observed at existing bench marks. The initial point for the Korean gravimetric datum is also at station Suwon in connection with the international gravity datum at the Geographical Survey Institute of Japan. Auxiliary first-order stations are located at Seoul National University (ϕ = 37° 27.1′ N, λ = 126° 57.0′ E), at Kyeongbuk National University (ϕ = 35° 53.2′ N, λ = 128° 36.9′ E), at Pusan National University (ϕ = 35° 13.0′ N, λ = 129° 05.0' E), and at the Korean Standards Institute (ϕ = 36° 23.1′ N, λ = 127° 22.4′ E).

On August 20, 1888, Russia and Korea signed an agreement providing for freedom of navigation on the Tumen River for coasting-vessels of both nationalities. The treaty also spoke of the river as "their common frontier." However, since Japan annexed Korea in 1910 the status of that common boundary is not clear. By 1914, Japan submitted a plan for the delimitation of the boundary by using the Rule of the Thalweg, but World War I and the Russian Revolution prevented any action.

The Korea "Demarcation Line" at the 38th parallel represents the partitioning of Korea effected by the July 27, 1953 Panmunjom Agreement ending the Korean hostilities. Approximately 238 km long (148.5 miles), the line follows a sinuous path over rugged terrain.

The China-Korea boundary received attention in November of 1961 when magazines published in both countries carried features on the Ch'ang-pai mountain range and specifically "The Pond of Heaven" which is a volcanic lake. Both countries claimed the same lake. The first at-tempt by both countries to define their common border in this region dates back to 1713, but disputes and confusion obviously continue.

On January 30, 1974 the governments of Japan and Korea signed two maritime agreements that established a continental shelf boundary in the northern part of the maritime region adjacent to the countries. The boundary is defined by a series of ellipsoidal loxodromes (rhumb lines) be-tween points referenced to the Tokyo Datum of 1918. On September 20, 1978 the Republic of Korea promulgated a system of "straight baselines" by Presidential Decree No. 9162. These straight lines are also de-fined as loxodromes on the Tokyo Da-tum of 1918, and Korea defers its boundary claim of territorial waters in narrow water bodies such as the Korean Strait and Cheju Hachyop.

DMA/NIMA lists the three-parameter datum shift from Tokyo Datum of 1918 to WGS 84 Datum in the Republic of Korea as: DX = –147m ±2m, DY = +506m ±2m, DZ = +687m .2m, and is based on a 29-station solution. However, my solution for nine well distributed first-order points (N'pyong, Hainam, Namhai, Bangejin, Sokcho, Hansan, Sangju, Uljin, and Kangwha) is: DX = –323m ±2m, DY = +309m ±2m, DZ = +653m ±2m. The actual rms fit of my solution to test points is: Latitude = ±2.20m, Longitude = ±1.26m, and Height = ±7.87m. On the other hand, using a 7-parameter Molodensky model (with the Datum origin) with these co-located positions yields:

DX = –325.89m, DY = +324.13m, DZ = +664.51m, scale = –7.60 x 10^6, R_z = +01.75″, R_y = –9.20″, R_x = –7.39″. The actual rms fit of my 7-parameter solution to test points is: Latitude = ±1.69m, Longitude = ±0.84m, and Height = ±0.65m. For example, test point "N'pyong 21. On Tokyo 1918 Datum: X = 498,278.75, Y = 269,683.64, ϕ = 37° 58′ 54.538 N, λ = 127° 47′ 35.747 E, H = 784.65m. On WGS 84 Datum: ϕ = 37° 59′ 04.483 N, λ = 127° 47′ 38.404 E, h = 812.007m.

Thanks for the geodetic his-tory of Korea and data go to Mr. Heungmuk Cho of the Geodesy Division, National Geography Institute in Suwon-shi, Republic of Korea.

Update

"Korean Geodetic Datum 2002 (KGD2002), has been adopted since 1st January 2003, replacing the Tokyo datum which has been used in the country since early 20th century.

"The new datum is based on the International Terrestrial Reference System (ITRS) and uses the Geodetic Reference System 1980 (GRS80) ellipsoid. The KGD2002 uses International Terrestrial Reference Frame 2000 (ITRF2000) at epoch 1st January 2002, which has a geocentric origin. The datum origin of KGD 2002 is located at NGII and the coordinates are: φ_o = 37° 16′ 33.3659″ N, λ_o = 127° 03′ 14.8913″ E, h_o = 91.253 m. Subsequently, the 1st order geodetic control stations consisting of 14 GPS CORS stations were readjusted for determining the KGD2002 coordinates. All of the works had been completed by the end of 2002.

"The National Geographical Information Institute (NGII) of Korea together with a number of surveying contractors has held GPS observation campaigns over the geodetic network since 1996. During these campaigns, about 11,000 points were observed until the end of 2007."(*Implementation of the New Korean Geocentric Datum and GPS CORS Management, Young-Jin Lee, Hung-Kyu Lee, Chan-Oh Kwon and Jun-Ho Song, Integrating Generations, FIG Working Week 2008, Stockholm, Sweden 14-19 June 2008.*)

In Memoriam

James Boyce Case
1928 - 2017

Jim Case, 88, of Cedar City, UT, passed away May 8, 2017, in St. George, Utah. He was born October 26, 1928, in Lincoln, Illinois, to Richard Warren and Blanche Irene Boyce Case. He married Claire Criger, together they had a son James C. Case.

Jim grew up in Hanford, California where he graduated from Hanford High School, then graduated from Stanford University, and earned a doctorate degree from Ohio State University. He spent his career as a photogrammetrist for the federal government. He has lived in Cedar City, UT, since 1989.

Jim joined ASPRS IN 1952 and was an Emeritus and Honorary Member and the editor of *PE&RS* for many years.

Family and friends are invited to share condolences online at http://www.serenitystg.com/obituaries/James-Case-4/.

Comments from ASPRS members and friends of Jim Case:

> I'm deeply saddened by the news of Jim's passing. I worked closely with him as he engineered my passage through the ASPRS journal editorship many years ago. He was a good shepherd and I was in frequent contact with him during that apprenticeship. Please accept me among the list of mourners. Back in the day, he was my beacon as I endeavored to do my job for the Journal. His passage brings me to my knees and I will not never forget his impact on me!
>
> Stan Morain

> I fully agree with those who appreciated Jim's contribution to ASPRS and especially he was outstanding as the editor of PE&RS. We worked together at the TOPO Center after he left Autometric. Jim had visited Duane Brown and took notes on Duane's idea for Orbital Constraints on Block Adjustment Mathematics. Jim gave me a copy of his notes which I really appreciated. Later the DMA funded DBA to write the Fortran Program and we used the program on the Apollo Lunar imagery. Jim Case published an epic paper on using constraints in Photogrammetry. I had great respect for Jim and we have lost a great contributor and friend.
>
> Don Light

> I was first introduced to Jim Case by Frank Moffitt shortly after graduating. I learned then to use "micrometers" instead of "microns." Who would know that years later that I would become the technical editor for the Manual of Photogrammetry.
>
> George Lee

> Jim was an amazing person. I have fond memories of listening to how, as journal editor, he saw our profession changing and, later, how he was adapting to living in Utah. Good man.
>
> Peggy Harwood

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