GRIDS & DATUMS

ROMÂNIA

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 România was originally printed in 2001 but contains updates to their coordinate system since then.

România is situated in central Europe, in the northern part of the Balkan Peninsula. Its territory is marked by the Carpathian Mountains, the southern border is the Danube River, and the eastern border is the Black Sea. Bordering countries are Ukraine to the north, Moldova to the northeast, Bulgaria to the south, Yugoslavia to the southwest, and Hungary to the northwest. The highest point is Moldoveanu at 2543 m (8,343 ft), the lowest point is at sea level. Traces of human existence date back to the Lower Paleolithic Period (approximately two million years B.P.), and relatively stable populations in România were found beginning with the Neolithic Period (7000 to 8000 B.P.). Strabo, a famous geographer and historian in the age of Emperor Augustus, wrote that "the Dacians have the same language as the Getae;" the basic difference is that the former inhabited the mountains and Transylvania, while the latter settled in the Danube River valley. The Romanians are the only descendants of the Eastern Roman stock, and their language is one of the romance languages. România has been referred to as a "Latin island in a sea of Slavs." România, a Republic, is composed of the old principalities of Wallachia, Modovia, and Transylvania. Its latest constitution is dated December 8, 1991.

The Austro-Hungarian Empire was surveyed at a time when topographic surveys were based partially on geometry and partially on art. The topographer, more an artist than a surveyor, proudly made the map by himself. Therefore, the proverb: "There are plenty of surveyors, but few topographers." Maps are no longer produced by ingenious topographer-artists, but by a team of specialists like those

who are members of ASPRS. The Second Topographical Survey (in România) of the Austro-Hungarian Empire was the Franziszeische Aufnahme of 1806 to 1869 that utilized the Cassini-Soldner Grid of Vizakna, Sibiu (Hermannstadt) Observatory for Transylvania, România. The original coordinates of the Cassini Grid origin used from 1817-1904 were ϕ_o = 45° 50′ 25.430″ North and λ_o = 41° 46′ 32.713″ East of Ferro, geodetically determined from Vienna. As per the European geodetic convention of the time, no false origin was employed and coordinates were computed with quadrant signs. This Grid was cast on the von Zach 1812 ellipsoid where a = 6,376,385 m and $^1/_f$ = 310.

While still a part of the Austro-Hungarian Empire, Constantin Barozzi (1833 to 1921) helped in the Viennese measurement of the Slobozia geodetic base and in the triangulation chain that connected Dobrogea to Transylvania. By 1870,

Photogrammetric Engineering & Remote Sensing
Vol. 85, No. 4, April 2019, pp. 253–255.
0099-1112/18/253–255

doi: 10.14358/PERS.85.4.253

Barozzi was appointed as the chief (and founder) of the Scientific War Dépôt, the national military mapping department of România. The third topographic survey of the Austro-Hungarian Empire (Neue Aufnahme) was conducted from 1869 to 1896 and was based on the St. Anna Datum of 1840, located in Arad, România. The origin was at Arad South Base: $\Phi_o = 46° 18' 47.63''$ North and $\Lambda_o = 39° 06' 54.19''$ East of Ferro (geodetically determined from Vienna). This Datum was originally referenced to the Zach 1812 ellipsoid, but the Austrians introduced the Bessel 1841 ellipsoid as a new standard for the empire in 1869 where $a = 6{,}377{,}397.155$ m and $^1/_f = 299.1528$. The defining azimuth to Kurtics was determined astronomically, but the angular value was not published and is now lost. The Arad 1840 Base length was 8,767.578 m. The metric system was legally established in 1872, and the 1:25,000 mapping scale was introduced along with the polyeder (polyhedric) projection to eliminate inconsistencies in map sheet lines. Remember that in past columns I have pointed out that the polyhedric projection is mathematically equivalent to the local space rectangular (LSR) coordinate system that is commonly used in computational photogrammetry. Of course, back then they did not transform first to the Earth-centered Geo-centric Coordinate System and then perform a 3 by 3 rotation secant or tangent to the surface of the ellipsoid the way we do now. (It's trivial with Fortran or C, but mind-boggling with tables of logarithms).

A chain from St. Anna base line to Sibiu (Hermannstadt) Observatory was computed in 1846. The computations again were based on the Zach 1812 ellipsoid and St. Anna was used as a starting point. From these computations for Sibiu Observatory, the following values were obtained: $\phi = 45° 50' 28.95''$ North, $\lambda = 41° 46' 39.00''$ East of Ferro, and the azimuth to Presbe $\alpha = 359° 16' 33.78''$. If these values are compared with the values derived in 1870 from Vienna University using the Bessel 1841 ellipsoid: $\phi = 45° 50' 25.97''$ North, $\lambda = 41° 46' 31.66''$ East of Ferro, and the azimuth to Presbe $\alpha = 359° 16' 43.24''$. The result of this "bust" was that the cartographic adjustments were a nightmare for nearly a century when trying to fit other datums to Românian sheets.

Thanks to John W. Hager, the Constanta Datum established by the Russians in the 19th century originated at the minaret of the main mosque in Constanta where $\Phi_o = 44° 10' 31''$ North and $\Lambda_o = 29° 39' 30.55''$ East of Greenwich. The reference azimuth from East Pyramid to West Pyramid on the Kyustendyi (Constanta) Base was $\alpha_o = 305° 15' 01.7''$, and the ellipsoid used was the Walbeck where $a = 6{,}376{,}896$ m and $^1/_f = 302.78$.

The Austrians were at work in Bukovina and Transylvania through this time, and established the Kronstadt base in 1876 that measured 4,130.141 m ±1/2,000,000. A famous name in east European coordinate systems, Kronstadt is merely the Austrian name for the central Românian Alpine city of Brasov. Two ellipsoidal Bonne Grids were established in 1870, both cast on the Bessel 1841 ellipsoid, the West Românian Bonne where $\phi_o = 45° 00'$ North and $\lambda_o = 26° 06' 41.18''$ East of Greenwich, and the East Românian Bonne where $\phi_o = 46° 30'$ North and $\lambda_o = 27° 20' 13.35''$ East of Greenwich. Both of these Grids had a scale factor at origin equal to unity and had no false origin.

During World War I, the necessity for a conformal grid system became evident for artillery fire control, and Professor Cholesky developed a Lambert Conformal Conic Cadrilaj (Grid) for România. Cholesky imposed two conditions on the design:

(i) The projection distance between parallels 45^G and 50^G shall equal the distance between parallels 50^G and 55^G, and both these distances shall be 500 km.

(ii) The scale factor at the central parallel shall equal the reciprocal of the scale factors at the projection limits.

Thanks to Giles André of the Defence Geographic Centre in Middlesex, Placinteanu in 1940 and Negoescu in 1942 attempted to recreate and extend the original Lambert-Cholesky Tables. The closest computational cartographic fit yielded the following parameters: Clarke 1880 ellipsoid (modified for this Grid) $a = 6{,}378{,}249.2$ m, $e^2 = 0.00680348764$, $m_o = 0.99844674$, $\phi_o = 45° 02' 29.216''$ North, $\lambda_o = 24° 18' 44.99''$ East of Greenwich, False Easting = 500 km, and False Northing = 504,599.11 m. These parameters are not a reflection of a Lambert-Cholesky projection, but for a projection in sympathy with Cholesky's over România.

After WWI, the new origin point for the Bucharest Datum of 1920 was based on the Bucharest Military Observatory, and the astronomical coordinates were transferred to point Militari, situated at the end of the Bucharest baseline, where $\Phi_o = 44° 26' 07.2832''$ North and $\Lambda_o = 26° 01' 00.207984''$ East of Greenwich. The reference azimuth to Ciorogârla (west end of base) was $\alpha_o = 96° 43' 22.8''$ (measured from south), and the new ellipsoid used was the Hayford 1909 (later termed the International 1924) where $a = 6{,}378{,}388$ m and $^1/_f = 297$.

With ten years of triangulation progress, the New Românian Datum of 1930 was established and referenced to the International 1924 ellipsoid. The origin was at Observatorul Militar Astronomic din Dealul Piscului, Bucuresti, called "Dealul Piscului" in the West, where $\Phi_o = 44° 24' 34.20''$ North $\pm 0.06''$ (1895) and $\Lambda_o = 26° 06' 44.98''$ East of Greenwich $\pm 0.075''$ (1900.7). The reference azimuth to Cotroceni, originally observed in 1895, was $\alpha_o = 127° 01' 53.005''$. A Rousilhe Stereographic Grid was developed with its projection center near the geographic center of the country. The defining parameters are $\phi_o = 51^G = 45° 54'$ North, $\lambda_o = 28^G\ 2138.51 = 25° 23' 32.8772''$ East of Greenwich, FE = FN = 500 km, and $m_o = 0.9996666666$. Because the origin is near Kronstadt (now Brasov), it came to be known as the "Stereographic Projection with Kronstadt as Central Point."

After WWII, România was introduced to the Soviet "System 42" Datum with its origin at Pulkovo Observatory, where $\Phi_o = 59° 46' 18.55''$ North and $\Lambda_o = 30° 19' 42.09''$ East of Greenwich. The reference azimuth to Signal A is $\alpha_o = 317° 02' 50.62''$, and the new ellipsoid used is the Krassovsky 1940 where $a = 6{,}378{,}245$ m and $^1/_f = 298.3$. The standard grid used in the former U.S.S.R. and most former satellite countries is the Russia Belts Gauss-Krüger Transverse Mercator where the grid parameters are identical to the UTM except that the Russia Belts have a scale factor at origin on the Central Meridian equal to unity. However, România did not go along with that for its internal use, even though the Soviets used their Russia Belts for military topographic mapping of the country. The "Stereo 70" was developed for România based on the Hristow Oblique Stereographic projection. The projection center was selected as $\phi_o = 45°$ North and $\lambda_o = 25°$ East of Greenwich, and associated parameters were FE = FN = 500 km and $m_o = 0.999750$. Example computation point is $\phi = 44° 30' 30''$ N and $\lambda = 26° 03' 03''$ E such that, on the Stereo 70 Grid, Northing (X) = 334,794.541 m and Easting (Y) = 583,553.824 m. As a computational exercise using the identical geodetic coordinate but computing the Grid on the Kronstadt Stereo with its different ellipsoid, Northing (Y) = 345,588.461 m and Easting (X) = 552,344.592 m. Note that the Kronstadt Stereo unit of angular measurement is Grads ($100^G = 90°$) so that $\phi = 49^G\ 45^C\ 37^{CC}.037$ N and $\lambda = 28^G\ 94^C\ 53^{CC}.704$ E for the identical point. NIMA lists the transformation from System 42 in România to WGS 84 Datum as $\Delta X = +28$ m ±3 m, $\Delta Y = -121$ m ±5 m, and $\Delta Z = 177$ m ±3 m, and this is based on four collocated points computed in 1997. The U.S. National Geodetic Survey assisted the government of România with the establishment of the România High Accuracy Reference Network, and, for station Dealul Pisculci on System 42, $\phi = 44° 24' 22.383''$ N, $\lambda = 26° 06' 44.126''$ E, and H = 89.275 m; and, on EUREF89, $\phi = 44° 24' 22.71021''$ N, $\lambda = 26° 06' 38.74635''$ E, and h = 124.520 m.

The International Boundary Treaties of România indicate that the border of the country is largely monumented or along streams and rivers. Interestingly, the boundary with Hungary distinguishes between navigable streams that are defined by the thread of the main channel or thalweg, and non-navigable streams that are defined by the geographical center or medium filium acquae. Thanks for help go to Russell Fox of the Ordnance Survey, Giles André of the Defence Geographic Centre, Dave Doyle of the National Geodetic Survey, and John W. Hager.

The successful development of countries in the 21st century is going to be largely dependent on the free availability of spatial data. Although there is little difficulty in a national government charging fair market value for data, the total suppression of spatial data distribution for military purposes of security is quite out of date and futile. Military operations in the recent past have clearly demonstrated that existing native topographic maps and existing native geodetic control have absolutely nothing to do with successful coordination of fire support. Secrecy of positional data and topographic maps only hurts the local economy and discourages foreign investment. It is hoped that the formerly "closed societies" will move to a more enlightened philosophy regarding GIS technology.

Update

Transylvania had an unsettled history in the 20th century. As a result of the repeated changing of the region between Hungary and Romania and of the Soviet dominance between 1945-1990, several map grid systems have been introduced. Besides the old Hungarian 'Marosvásárhely' Stereographic system and the Romanian Stereo-70 system, the Soviet-type Gauss-Krüger projection was also introduced. These grids can be handled together with the world's quasi-standard, the UTM system, using this small MS Excel table, Viteaz.

Viteaz is a MS Excel table that allows you to convert UTM, Soviet-type Gauss-Krüger, Romanian Stereo-70 and old Hungarian ‹Marosvásárhely› Stereographic coordinates. You can enter your input in any of the listed projections and will be given the result in all the three other systems.[1] Viteaz can be downloaded from http://sas2.elte.hu/tg/viteaz2.xls.

Romania has 74 GPS RTK Continuously Operating Reference Stations at approximately 70 km spacing. The National (*relative – Ed*) Gravity Network of 1st and 2nd order (about 270 points) was observed by the Ministry of Defense – Topography and Cartography Directorate. The country has four points determined by Absolute Gravity.

Astrogeodetic leveling was part of a research project culminating in November of 2015. Results showed accuracies of (*xi,eta*) of ±0.500″ and ±0.745″, respectfully with a Topcon M505AX with a CCD chip.[2] (In comparison, LSU has issued a Purchase Order (2019) to the University of Latvia, Institute for Geodesy & GeoInformatics for a Digital Zenith Camera that has an accuracy of ±0.100″ in both components-after one hour's observation-automatically.)

The Romanian government has a transformation package it is TransDatRO and can be downloaded from http://www.ancpi.ro/index.php/en/download-2.

1 http://sas2.elte.hu/tg/viteaz_en.htm
2 https://iag.dgfi.tum.de/fileadmin/IAG-docs/NationalReports2015/IUGG_2011-2014_Final_Report_ROMANIA.pdf

This column was previously published in *PE&RS*.