Grids & Datums

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THE REPUBLIC OF HUNGARY

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 Hungary was originally printed in 1999 but contains updates to their coordinate system since then.

Vaik "came" to the Magyar Duchy in the year 997 AD through conquest. He applied for and received the title of Apostolic King of Hungary from Pope Sylvester II and was crowned in Budapest in 1000 AD under the Christian name of Stephan. He died in 1037, and was later canonized as Saint Stephan, becoming the Patron Saint of Hungary. A substantial amount of Hungarian folklore is based on St. Stephan. Private topographic and cartographic activities in the Austro-Hungarian Empire started in the middle of the 16th century. In 1763, Queen-Empress Maria Theresia ordered the survey and topographic mapping of all the Provinces of Hapsburg. There have been five separate and distinct topographic surveys of Hungary.

The first topographic survey of Hungary was performed from 1763 to 1787 and was termed the "Josephinishe Aufnahme." The Liesganig triangulation and attached supplemental surveys were executed graphically with plane table and alidade. There was no geodetic survey used as a foundation. The associated topographic survey was performed at a scale of 1:28,800 and was based on the Vienna Klafter System where 1 Zoll = 400 Klafters = 758.6 meters. Altogether there were about 4,500 sheets surveyed and all of them were kept secret for military purposes.

The second topographic survey of Northern Hungary (Franziszeische Aufnahme) was conducted from 1810 to 1866.

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The Vienna Datum of 1806 was established based on the origin of St. Stephan Turm (St. Stephan's Tower) where $\Phi_o = 48° 12′ 34.0″$ North, $\Lambda_o = 34° 02′ 15.0″$ East of Ferro. (Ferro is in the Canary Islands which is 17° 39′ 46.02″ West of Greenwich.) The defining azimuth of the Datum was from St. Stephan Turm to Leopoldsberg: $\alpha_o = 345° 55′ 22.0″$. Coordinates for the mapping were based on a Cassini-Soldner Grid centered at the Datum origin. The Bohnenberger ellipsoid was used from 1810-1845 where a = 6,376,602 meters and $^1/_f = 324$. The Zach ellipsoid was used from 1845-1863 where a = 6,376,602 meters and $^1/_f = 324$. From 1847-1851 the Walbeck ellipsoid was also used where a = 6,376,896 meters and $^1/_f = 302.78$.

An Austrian Cadastral triangulation was established in 1817 and the origin established for Hungary was in Budapest at the Gellérthegy Observatory ("hegy" is Hungarian for hill) for another Cassini-Soldner Grid. The Gellérthegy Grid origin used from 1817-1904 is: Latitude of Origin (φ_o) = 47° 29′ 15.97″ North, with a Central Meridian (λ_o) = 36° 42′ 51.57″ East of Ferro. The second military triangulation surveyed in 1806-1829 consisted of the main chains (of quadrilaterals) that covered the western part of the monarchy (west of the meridian of Budapest) and the chain that extended along the Carpathian Mountains to Transylvania. In 1863, the Bessel ellipsoid of 1841 was prescribed for use in the triangulation instructions.

The third topographic survey of Hungary (Neue Aufnahme) was conducted from 1869 to 1896 and was based on the Arad, St. Anna Datum of 1840, where the origin was: Φ_o = 46° 18′ 47.63″ North, (λ_o) = 39° 06′ 54.19″ East of Ferro (geodetically determined from Vienna). This Datum was referenced to the Zach ellipsoid and was used for the Third Topographic Survey of Hungary. The defining azimuth to Kurtics was determined astronomically, but the angular value was not published and is now lost. 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.

In 1874, the Budapest Stereographic Projection was defined at Gellérthegy where the Latitude of Origin (φ_o) = 47° 29′ 14.93″ North and the Central Meridian (λ_o) = 36° 42′ 51.69″ East of Ferro. The orientation of this system was defined as the azimuth to Széchényihegy, α_o = 100° 47′ 14.34″ which was in sympathy with the azimuth to Nagyszal, α_o = 191° 28′ 52.19″ derived from the Vienna University Observatory. (In the derivation carried out in 1861-63, the Walbeck ellipsoid was used.) The regions of Central and Southern Hungary were topographically surveyed from 1881-1884. Northern Hungary was surveyed from 1875-1878 and Western Hungary was surveyed from 1878-1880, the latter two by the use of cadastral planimetry.

The fourth topographic survey of Hungary was carried out in essentially the same manner as the third survey. All plane table sheets of the cadastral survey were reduced with a pantograph, and were published on the Polyhedric Projection at 1:75,000 scale. From 1896-1898, three trig points were required per plane table sheet. From 1898 to 1903, 10 trig points per sheet were required, and that was increased to 20 trig points thereafter. Tacheometry was introduced for this survey, and mapped distances could be estimated only if less than 100 meters from the instrument. In 1905, photogrammetry replaced the plane table with the stereo-comparator (sort of an un-digitized analytical plotter to you readers under 40).

In 1907, Dr. A. Fasching derived the position of the eastern tower of the former observatory at Gellérthegy where the Latitude of Origin (φ_o) = 47° 29′ 09.6380″ North and with a Central Meridian (λ_o) = 36° 42′ 53.5733″ East of Ferro and α_o = 100° 47′ 07.90″ to the Laplace station Széchényihegy. In 1908, a system of three cylindrical projections was introduced, all with the Central Meridian of Budapest. The oblique cylinders touch the Gaussian sphere along the great circles perpendicular to the meridian at the following origins: 48° 42′ 56.3180" N, 47° 08′ 46.7267″N, and 45° 34′ 6.5869″N. For the orientation, the azimuth Gellérthegy- Széchényihegy was used, hence the common X axis of the three cylindrical projections form an angle of 6.44 arc seconds with the Budapest Stereographic Grid of 1874. The stereo-graphic projection was used only for the computation of the First and Second- Order nets – the cylindrical projection was used for the actual mapping.

Also in 1908, the invention of the Stereoautograph by Captain von Orel of the Military Geographic Institute of Vienna allowed the compilation, including contours, to be done completely mechanically (as opposed to *insitu* field work). Note that this phenomenal breakthrough in mapping with photogrammetry used terrestrial photographs! The Zeiss 1911 Stereoautograph, the next wonder of photogrammetry, was used to compile the last sheets of the never completed Fourth Topographic survey of the Austro-Hungarian Empire. According to Andrew Glusic of Army Map Service, (from 40+ years ago):

> **Warfare and the Map**. The Armies have been using the maps for more than two centuries. The Napoleonic Wars gave a special impulse to the use of geographic maps in warfare; consequently, in the European Armies mapping services were created, of which many are known as Military Geographic Institutes. It was the military who through the XIX century in Europe as well as in the colonies was responsible for the largest part of the geodetic and topographic surveys. In these surveys the military aspects dominated; particularly at their outsets the scientific purposes were not considered and many times also technical requirements were ignored. There was solely one goal to produce a military map. This military map should include all such information of the area concerned which the military leaders need for the planning and execution of movement, combat, accommodation and supply. The enormous technical progress in the last century largely influenced the application of strategical and tactical principles in warfare; therefore, the nature of warfare changed and consequently the requirements for the military maps. In order to avoid the lack of adequate maps in any future war, the nature of the warfare together with the corresponding changes which would affect the standards of the mapping have to be considered in advance within limits of possibility and also proper measures should be undertaken at the time. The Austro-Hungarian military authorities passed up the proper time for such considerations; hence the single tactical map of the Monarch – 1:75,000 special map – trailed far behind the requirements imposed by the changes of warfare in World War I.

A new topographic survey of Hungary was started in 1927. The oblique stereographic projection was used for the "Budapest System" with the origin at the base point of the East Tower of the Astronomical Observatory of Budapest at

Gellérthegy. (The observatory was torn down and replaced by a stone fortress on Gellért hill. The old point was then later found to be on the rampart of that fortress, and a National Report to the IUGG portrayed a photograph of the point marked by a gazebolike canopy!) The origin of the coordinate system was defined where: Latitude of Origin (ϕ_o) = 47° 29′ 09.6380″ North, with a Central Meridian (λ_o) = 36° 42′ 53.5733″ East of Ferro (Ferro = 17° 39′ 46.02″ West of Greenwich as derived from astronomic observations in 1907). The defining azimuth was from Gellérthegy to Nagyszal where: α_o = 191° 28′ 52.19″ as retained from the 1874 datum values from Vienna University. The ellipsoid of reference was the Bessel 1841 where: the semi-major axis (a) = 6,377,397.155 meters and the reciprocal of flattening ($^1/_f$) = 299.1528128. The False Easting and False Northing were each 500 km.

The northern part of Transylvania, occupied by the Hungarian Army in WWII, was mapped with a system defined as the "Marosvásárhely Stereographic System" with a Datum Origin point at the cadastral triangulation station Keszteј where: Latitude of Origin (ϕ_o) = 46° 33′ 09.12″ North, and with a Central Meridian (λ_o) = 42° 03′ 20.955″ East of Ferro. The defining azimuth from Kesztej to Tiglamor was: α_o = 146° 57′ 41.052″. The False Easting and False Northing were each 600 km, and this local Datum and Grid was referenced on the Bessel 1841 ellipsoid.

The Hungarian surveying and mapping agencies went through a series of reorganizations after WWII through 1952-54 when the country began to follow the pattern established by the USSR. The Gauss-Krüger Transverse Mercator projection was adopted in 1957 with the Grid parameters of a scale factor at origin equal to unity, and false origin 500 km West and 5000 km North. Since 1954, the Krassovsky 1940 ellipsoid was used where: the semi-major axis (a) = 6,378,245 meters and the reciprocal of flattening ($^1/_f$) = 298.3. Prior to 1957, the Central Meridians (λ_o) for military mapping were 18° and 21°, and after 1957, 15° and 21° were used. For cadastral mapping since 1957, the Central Meridians of 17°, 19°, 21°, and 23° were used. The Hungarian Datum of 1957 with origin coordinates at Erdóhegy and associated parameters were kept secret for military purposes.

The new national Hungarian Datum of 1972 (HD 72), also known as the "Unified National Horizontal Network of 1972" (EOVA Datum of 1972), is defined with origin coordinates at Sztlthegy where: Φ_o = 47° 17′ 30.44″North, Λ_o = 19° 36′ 10.18″ East of Greenwich. The defining azimuth is from Sztlthegy to Erdthegy: α_o = 209° 55′ 27.79″. The corresponding geodetic parameters of this origin are: ϕ_o = 47° 17′ 32.6156″ North, λ_o = 19° 36′ 09.9865″ E. The defining geodetic azimuth is: α_o = 209° 55′ 26.64″ and the ellipsoid of reference is the Geodetic Reference System (GRS) 1980. For the origin, h_o = ellipsoid height, H_o = height above the Baltic Sea and N_o = geoid undulation. Therefore, h_o = 235.80 meters = H_o + N_o = 229.24 m. + 6.56 m. The published transformation parameters from HD-72 to WGS 84 are: ΔX = –5.3 m, ΔY = +157.77 m, ΔZ = +31.6 m, k = –2.11 ppm, R_z = –1.11", R_y = –0.50", R_x = –0.97".

Remember the Hungarian transverse cylindrical Grids of 1908 mentioned several paragraphs ago? Well, the new system is based on a new definition of that old Hungarian favorite.

The Egységes Orzágos Vethleti rendszer (Uniform National Projection system) "EOV Grid" is a conformal double transverse cylindrical projection. The Grid is defined at: ϕ_o = 47° 08′ 39.8174″ North, Central Meridian, λ_o = 91° 02′ 54.8584″ E. The false origin is 200 km east (+X), 650 km north (+Y), and the scale factor is = 0.99993. The national fundamental benchmark is at Nadap where H = +173.1638 meters above the Baltic Sea and H = +173.8388 meters above the Adriatic Sea.

Update

The Institute of Geodesy Cartography and Remote Sensing (FÖMI) according to the Hungarian Government's Decree No. 1312/2016 (13 June) by legal succession – with integration into the Government Office for the Capital, Budapest – will be dissolved. FÖMI will continue its professional activities within the organization framework of the Government Office for the Capital, Budapest from 1st January 2017.

The GNSS reference system is the 3-dimensional geocentric Cartesian system ETRS89 (realised in Hungary by the OGPSH). For practical surveying and mapping works, the local HG72 system has to be used. The transformation between the two independent systems is possible based on common points. The accuracy of the transformation cannot exceed the accuracy of the geodetic networks (or sub-networks). There are therefore many possible transformations within the limits. However, it is reasonable to apply the transformation in a standardised way. To this end, the EHT software was developed and released by the FÖMI SGO in 2002. Its method is based on a local transformation using OGPSH points and provides the best available accuracy. The program automatically selects the suitable nearby reference points from its data base. It works for the whole territory of the country. The new version released in 2008 is already capable of transforming the coordinates in both directions. The EHT is available free of charge from the gnssnet.hu web site.

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