& GRIDS & DATUMS

THE CZECH REPUBLIC

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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 Czech Republic was originally printed in 2000 but contains updates to their coordinate system since then.

Once part of the Holy Roman Empire, the first Czechoslovakian Republic (1918-1939) was formed by Czechs and Slovaks from territories that were formerly part of the Austro-Hungarian Empire. Those provinces were Bohemia, Moravia, Silesia and the northern part of Hungary settled by Slovaks and Ruthemians (Slovakia and Carpatho-Ukraine). Hitler supported the ethnic Germans living in the Sudeten region as an excuse to the German annexation, which reduced it to the Protectorate of Bohemia and Moravia (1939-1945). The remaining portions of the republic were broken up among neighboring countries dur-ing WWII. After the war, it emerged as the Second Czechoslovakian Republic, but without the Carpatho-Ukraine. The USSR gained control, and Czecho-slovakia became part of the Warsaw Pact in 1955. Consequently, in dis-cussing the surveying and mapping of this country, a differentiation is made with respect to the activities of four separate epochs, *i.e.* the First Czecho-slovakian Republic, the Protectorate, the Second Czechoslovakian Republic, and the Czech Republic. On 1 January 1993, the country peacefully split into its two ethnic components, the Czech Republic and Slovakia.

The Czech Republic is north of the Danube Valley and is largely mountainous. Bohemia, in the west, consists of rolling plains, hills, and plateaus surrounded by low mountains; Moravia, in the east, consists of very hilly country. The lowest point of the republic is along the Elbe River (115 meters), and the highest point is Snezka (1,602 meters) in the Carpathian Mountains.

The original triangulation of the region by first-order methods was by the III K. und k. military triangulation of the Austro-Hungarian Empire. The cadastral grids employed by

the Happsburgs were the Böhmen Soldner (Cassini-Soldner) with a ϕ_o = 48° 02′ 20.5″ N, λ_o = 14° 08′ 24.15″ East of Greenwich, and the Mähren Soldner with a ϕ_o = 48° 12′ 32.75″ N, λ_o = 16° 22′ 36.58″ East of Greenwich. No false origins were used according to the European convention of the time. However, the entire region was not covered by 1918 as published in the Ergebnisse der Triangulierungen (Triangulation Results). The responsibility for the survey activities in the First Republic was divided among the following agencies: Triangulačni Kancelař Ministerstva Financi (Triangulation Office of the Ministry of Finance); Katastralni Měřřické Uřady (Office of Cadaster); Nivelacni Uřad Ministerstva Veřejnych Praci (Leveling Office of the Ministry of Public Works); and Vojenský Semepisný Ústav (Military Geographic Institute). The duties of the civilian agencies had some overlap among themselves as well as with the military, but the records of all agencies could be utilized for military purposes. The territory was covered by the old cadastral triangulations with

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origins at Gusterberg, St. Stephan Tower (Vienna), Gellerthegy, Pschow, and coordinates referring to Vienna University Datum, St. Anna Datum, and Hermannskogel Datum. A new first-order net was started in 1936 and was completed in 1956. The basic cadastral trigonometric net was connected with the first-or-der nets of Austria, Germany, Po-land, and Romania (through the Carpatho-Ukraine and Slovakia). Be-tween 1918 and 1932, the Military Geographic Institute (MGI) applied the Lambert conformal conic projection for triangulation computations and mapping. This was based on the Hermannskogel Datum of 1871 referenced to the Bessel 1841 ellipsoid of revolution where the semi-major axis (a) = 6,377,397.155 meters and the reciprocal of flattening ($^1/_f$) = 299.1528128. The Hermannskogel 1871 Datum has its origin with ϕ_o = 48° 16′ 15.29″ N, λ_o = 33° 57′ 41.06″ Est de I'lle de Fer (East of Ferro Island in the Canaries), where Ferro = 17° 39′ 46.02″ East of Greenwich and azimuth to station Hundsheimer is α_o = 107° 31′ 41.7″. The secant Lambert Grid had the standard parallels of ϕ_N = 50° 15′ N and ϕ_S = 48° 30′ N, a Central Meridian (λ_o) = 35° 45′ East of Ferro, a False Easting = 1,000 km, and a False Northing = 500 km. This point corresponds to the center of the southern sheet line of the 1:75,000 sheet titled "4260 Vsetin."

Professor Ing. Josef Krøvák (commonly spelled Křovák or Krovak) prepared the Conformal Oblique Conic Projection of Czechoslovakia in 1922 for the preparation of cadastral (tax) maps and topographic maps of medium scales for the civil geodetic service of Czechoslovakia. The "starting meridian" was termed Ferro where the MGI usage differed from the civilian definition listed above. The MGI used the relation: Ferro = 17° 39′ 45.90″ East of Greenwich. The Krovak Projection is a double projection in that the oblique conic is projected from the Gaussian Sphere where the radius = 6,380,703.6105 meters. The Gaussian Sphere was "in-vented" by Carl Friederich Gauss, and is also commonly known as the "conformal sphere." It is simply the geometric mean of the ellipsoidal normal (at a point) terminated by the semi-minor axis and the radius of the ellipsoid (at the same point) in the plane of the meridian. To be succinct, it's $[\upsilon\rho]^{-1/2}$ evaluated in this case at ϕ = 49° 30′ N. For the Mapping Scientists and Photogrammetrists that do not live in South Louisiana, this is the same formula used in the commonly used radius of the earth for the "sea-level correction" in establishing ground control. For the Czech Republic, they used the Bessel 1841 ellipsoid at that latitude. Whenever one sees the term "double projection," the generating sphere is usually the Gaussian Sphere. The oblique cone has a pole centered at ϕ = 59° 42′ 42.6969″ N, λ = 42° 30′ East of Ferro (southwest of Helsinki, Finland). The spherical cartographic coordinates are trans-formed into the rectangular plane coordinates of the uniform cadastral system. For this purpose the reduced (0.9999) Gaussian Sphere is projected on the surface of an oblique cone touching the sphere around the central cartographic parallel, having a cartographic latitude of 78° 30′ N, with the vertex in the extended axis connecting the center of the sphere at the rotation angle of 30° 17′ 17.3031″. This is still in use as of 2000, and is known as Systém—Jednotné Trigonometrické Sítì Katastrální or S-JTSK (System of the Unified Czech/Slovak Trigonometrical Cadastral Net). The Czechs state (Prof. Ing. Bohuslav Veverka, DrSc., Prague, November 1997) that the "scale, location and orientation of the S-JTSK on the surface of the Bessel's ellipsoid was derived from the results of the historical Austro/Hungarian military surveys in the years 1862-98. There are 42 identical points on the Czech territory used for transformation computations. Astronomical orientation was measured only on the Hermannsko-gel trigonometrical point in Austria, scale factor was derived from the basis of the geodetic length in Josefov." Professor Veverka published a program written in the Pas-cal language that performs the direct and inverse transformations with the Krovak Projection. Note that the X-axis normally coincides with the meridian 42° 30′ East of Ferro increasing **South**, and the orthogonal Y-axis is increasing **West**. A test point provided lists: ϕ = 48° 07′ 46.2973, λ = 35° 42′ 35.2147″, Y = 504,691.675 m, X = 1,289,068.724 m. The Krovak Projection was officially adopted by the Czech military in 1932.

In 1939, the Germans found that during their occupation of the "Protectorate of Bohemia and Moravia," only 5% of the Protectorate's territory was covered by the new topo-graphic survey. The Landesvermes-sungsamt Böhmen und Mähren (Land Survey of Bohemia and Moravia) was formed. The subsequent triangulation was incorporated into the final Reichsdreieck-snetz (Triangulation Net of the Empire), with the datum origin being at Pottsdam where Φ_o = 52° 22′ 53.9540″ North, Λ_o = 13° 04′ 01.1527″ East of Greenwich. The defining azimuth to station Golmberg is: α_o = 154° 47′ 32.19″, and the ellipsoid of reference is the Bessel 1841. For the purpose of incorporation, the Reichsdreiecksnetz was ex-tended over the territory of the Protectorate, and 36 first-order stations were re-observed with two new base lines measured at Podébradý and Kroměřiž. The Grid system used was the Deutsche Herres Gitter (DHG) which had the exact same parameters of the UTM Grid except that the scale factor at origin was unity. The DHG is exactly the same as the USSR's Grid (Russia Belts) except for the ellipsoid.

After WWII, the agencies responsible for geodetic, topographic and cartographic activities in the Second Czechoslovakian Republic were in a stage of re-organization up to the end of 1953. During the years 1953-54, those agencies were subsequently organized according to the pattern established in the USSR. The Ustřední Správa Geodesie a Kartografie – USGK, (Central Ad-ministration of Geodesy and Cartography) was established. The Zakladni Trigonometrickasit – ZTS (Basic Trigonometric Net), included the first-order net of the Protectorate and the first-order net established in 1949-1955 in Slovakia. The adjustment of the net was carried out by the method of Pranis-Praniévitch on the Krassovsky 1940 ellipsoid where a = 6,378, 245 meters, and $^1/_f$ = 298.3. The Datum is defined as "System 42" where the origin is at Pulkovo Observatory: Φ_o = 59° 46′ 18.55″ North, Λ_o = 30° 19′ 42.09″

East of Greenwich. The defining azimuth at the point of origin to Signal A is: α_o = 317° 02′ 50.62″. The "Russia Belts" Grid System is used with the System 42 Datum; identical to UTM except that the scale factor at origin is unity.

A civilian version used since 1952 is a modification of the Russia Belts system in that the False Northing at origin was ϕ = 49° 30′ North, the False Northing = 200 km, the False Easting = 500 km, and the scale factor at origin (mo) = 0.99992001. Everything else remained the same as the standard Gauss-Krüger Transverse Mercator Grid. Boundary treaties with adjacent countries refer to ancient datums and grids that include the old double stereographic projections of the 19th and early 20th centuries. The S-JTSK Krovak Projection is alive and well in the Czech Republic for the 21st century.

Update

Applied research in the department is in the first place directed to the present needs of the branch of the Czech Office of Surveying, Mapping and Cadastre in the field of geodetic control networks, their update and integration within the modern European geodetic control. Recently the project of incorporation of the Czech and Slovak Astrogeodetic Network, together with the primary networks of Austria, Hungary and Germany, into the European terrestrial continental reference system ED87 has been accomplished. The department participated in the extension of the new European reference frame EUREF to the Czech and Slovak Republics, in the establishment of the Czech zero-order GPS reference network and in its densification to the average density 1 station/ 400 km^2 as well as in the direct connection of the Czech GPS reference network with reference networks of Germany and Austria. In the establishment of GPS reference networks the department takes part by both the observations and the processing by the scientific software package. The most topical task is the establishment and monitoring of the Czech National Geodynamical Network by GPS technique. The network consists of 32 stations at which GPS observations have been periodically repeated (twice a year) since the spring 1995. These observations are supplemented by levelling and gravity measurements. The objective of this project is a stability assessment of the horizontal control network and its integration with the vertical control network of the Czech Republic. The department takes an active part in the process of incorporation of the Czech national geodetic control into the continental European geodetic control by participation in the international projects EUREF and EUVN (its realization is now in its initial stage). With the help of the national GPS reference networks the present user terrestrial reference frame (S-JTSK/95) has been improved and is now passing through large scale disputations. For the cadastral offices the local networks, densified by themselves by GPS techniques, are tied to the national GPS reference network. A reference quasigeoid model was computed for the territory of the Czech Republic with an accuracy of about 5 cm which makes it possible to determine sea level heights from GPS observations at any place of the state territory. The stability of the reference frame is continuously monitored by evaluation of observations of a cluster of European IGS stations. For the calibration and processing of the GPS technology, the calibration network was established at Geodetic Observatory Pecny and Skalka. In the field of the geodetic control networks the department collaborates with the Land Survey Office and with the Department of Advanced Geodesy of the Faculty of Civil Engineering of the Czech University of Technology in Prague. Last updated: 17.10.2005

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