Grids & Datums

Slovak Republic

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"Slovakia's roots can be traced to the 9th century state of Great Moravia. Subsequently, the Slovaks became part of the Hungarian Kingdom, where they remained for the next 1,000 years. Following the formation of the dual Austro-Hungarian monarchy in 1867, language and education policies favoring the use of Hungarian (Magyarization) resulted in a strengthening of Slovak nationalism and a cultivation of cultural ties with the closely related Czechs, who were themselves ruled by the Austrians. After the dissolution of the Austro-Hungarian Empire at the close of World War I, the Slovaks joined the Czechs to form Czechoslovakia. Following the chaos of World War II, Czechoslovakia became a Communist nation within Soviet-dominated Eastern Europe. Soviet influence collapsed in 1989 and Czechoslovakia once more became free. The Slovaks and the Czechs agreed to separate peacefully on 1 January 1993.

About twice the size of New Hampshire, Slovakia is bordered by: Austria (91 km)(*PE&RS*, March 2004), Czech Republic (197 km) (*PE&RS*, January 2000), Hungary (676 km)(*PE&RS*, April 1999), Poland (420 km)(*PE&RS*, September 2000), and Ukraine (90 km) (*PE&RS*, June 2004). The terrain consists of rugged mountains in the central and northern part and lowlands in the south; the lowest point is the Bodrok River (94 m), the highest point is Gerlachovsky Štít (2,655 m)" (*World Factbook, 2011*).

The S-JTSK Krovak Projection is alive and well in the Slovak Republic for the 21st century. "Differences between S-42 and S-52 are max. 2 meters" (*op. cit., Veverka, 2003*).

The territory was covered by the old cadastral triangulations with 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-order nets of Austria, Germany, Poland, and Romania (through the Carpatho-Ukraine and Slovakia). Between 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 l'Ile 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." "Only 3% of the state territory was mapped. The author of this projection was Captain Benes, and this projection is practically Lambert" (*Prof. Bohuslav Veverka, personal communication, February 2003*).

Ing. Josef Krøvák (commonly spelled Krovák 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 *in Slovakia* used the relation: Ferro = 17° 40' East of Greenwich (*op. cit., Veverka, 2003*). 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 "invented" 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 [$\sqrt{\nu\rho}$] evaluated in this case at φ = 49° 30' N. For the Slovak 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_o = 59° 42' 42.6969" N, λ_o = 42° 30' East of Ferro (southwest of Helsinki, Finland). The spherical cartographic coordinates are transformed 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 Slovak Trigonometrical Cadastral Net). The Czechs state (*Prof. Ing. Bohuslav Veverka, 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."

"The average density of control points of first- through fifth-order is 1 per 2.7 km². The State Astronomic and Geodetic Network contains 66 points in S-JTSK and in S-42/83. The State Astronomic and Geodetic Network in S-42/83 has been adjusted together with the

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astronomic and geodetic networks of the East European Countries" (*Geodesy, Cartography and the Cadastre of the Real Estates in the Slovak Republic, 2000*).

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 *Ustrední Správa Geodesie a Kartografie* – USGK, (Central Administration of Geodesy and Cartography) was established. The Zakladni Trigonometricka Sit – ZTS (Basic Trigonometric Net) (*op. cit., Veverka, 2003*), included the first-order net of the Protectorate and the first-order net established in 1949-1953 in Slovakia (*op. cit., Veverka, 2003*). 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 provisional military version used since 1952 for 1:25,000 scale mapping (Gauss-Krüger – since 1953) (*op. cit., Veverka, 2003*) 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 (m_o) = 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 Slovak Republic for the 21st century. "Differences between S-42 and S-52 are max .2 meters" (*op. cit., Veverka, 2003*).

TR 8350.2 provides two 3-parameter transformations for all of the former Czechoslovakia. **From** S-42 (referenced to the Krassovsky 1940 ellipsoid) **to** WGS84: ΔX = +26 m ±3 m, ΔY = −121 m ±3 m, ΔZ = −78 m ±2 m, and **from** S-JTSK (referenced to the Bessel 1841 ellipsoid) **to** WGS84: ΔX = +589 m ±4 m, ΔY = +76 m ±2 m, ΔZ = +480 m ±3 m.

The Slovak Republic has published (*BKG 2001-2003*) a full 7-parameter Molodensky transformation **from** S-JTSK **to** ETRS89: ΔX = +559.0 m, ΔY = +68.7 m, ΔZ = +451.5 m, R_x = +7.920", R_y = +4.073", R_z = 4.251", δs = +5.71", X_o = 3,980,912.082 m, Y_o = 1,392,955.999 m, Z_o = 4,767,344.572 m. The Molodensky offset origin point appears to be southeast of Banská, in a geometrically central part of the republic. A newer version using the Bursa-Wolfe 7-parameter transformation **from** S-JTSK **to** ETRS89: ΔX = +485.0 m, ΔY = +169.5 m, ΔZ = +483.8 m, R_x = +7.786", R_y = +4.398", R_z = 4.103", δs = 0. This was computed in 2006 with about 700 identical points and when checked with 3 test points, the transformation accuracy was about 1 meter.

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