YUGOSLAVIA

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This month's topic is about Eastern Europe and specifically the former country of Yugoslavia. Upon the collapse of Austria–Hungary the Kingdom of Serbs, Croats, and Slovenes was proclaimed in 1918. The name was changed in 1931 to Yugoslavia and divided into 9 republics not based on racial lines. The principal Yugoslav mapping agency became the 1920 Geografski Institut Jugoslovenske Narodne Armije (GIJNA) Geographic Institute of the Yugoslav Peoples' Army, formerly the 1888 Vojni Geografski Institut (VGI) Military Geographic Institute. Prior to that, the land survey had been carried out by the Viennese Military Geographic Institute (1851-1908) for Serbia and by the VGI in 1871 for Croatia and Slovenia.

Between the two World Wars, the Italian Istituto Geografico Militare produced topographic series of the then Italian territories of Venezia Guilia and Istria. During World War II both the German Generalstab des Heeres (General Staff of the Army) and the British Directorate of Military Survey, War Office (Geographical Section, General Staff) reprinted and revised many Yugoslav and Italian maps.

The coordinate systems that have been used for Yugoslavian lands have been quite diverse through history. Geographic coordinates have been based on the Prime Meridians of Paris, France; Ferro, Canary Islands; Greenwich, England; and also some temporary usage of the Vienna University Observatory where: ϕ = 48°12'35.50" N, λ = 16°22'49.98" E (later offset to Paris).

The names of the classical horizontal datums found in the former Yugoslavia include Hermannskogel 1871, K.U.K. VGI Vienna University System 1892, Pulkovo 1942, and European 1950. The Vienna University System 1892 used the now obsolete Zach 1812 ellipsoid and the Hermannskogel 1871 datum used 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 "Parisian" system of mapping (based on the Prime Meridian of Paris, where the offset from Greenwich is accepted as λ = 2°20'13.95"E) was cast on the polyhedric projection from 1878 to 1959.

The polyhedric projection is aphylactic in that it is not equal-area (authalic). Also, it is not azimuthal, and it is not conformal (orthomorphic). The aphylactics used for large scale topographic mapping (and grid systems) were adopted because of their ease of construction.

For a historical perspective of how maps were produced before photogrammetry, consider that a century ago, a mapping party would leave the capital city some weeks **after** the departure of the triangulation parties. Since the lay of the land to be mapped was largely unknown, there was little opportunity to plan where control would be established and mapping could proceed. Based on where triangulation stations were established, the topographer would then proceed to interpolate between those stations and map the topography with plane table and alidade. Since there was no prior knowledge of what and where mapping was to be accomplished, no graticules were prepared in advance. The result was that the manuscripts had to be prepared first at the base camp. Aphylactic projections were developed so that with a simple book of projection tables, the topographer could draft the graticule on a sheet of starched linen in a tent. Although we can be critical of such mathematical machinations nowadays, there was a valid and practical reason for such aphylactic projections back then.

Another aphylactic projection common in Europe is the Cassini-Soldner (rectangular spheroidal) while in the United States, the American Polyconic was used for decades by the U.S. Army Corps of Engineers for the World Polyconic Grid (predecessor of the Universal Transverse Mercator or UTM). Furthermore, the American Polyconic was also used by its originators, the U.S. Coast & Geodetic Survey as well as by the U.S. Geological Survey for the National Mapping Program.

The polyhedric projection can be characterized in a variety of ways; the easiest for the photogrammetrist to relate to is the Local Space Rectangular (LSR), a variant on the Geocentric Coordinate System. When we consider an analytical model for our photogrammetric computations, we usually need to take the ellipsoidal curvature of the earth into account. Our defining parameters are established by our datum, be it a classical horizontal geodetic datum such as the Hermannskogel 1871 and NAD 1927, or an inertial mass-centered datum, such as NAD 1983 and WGS 1984.

The LSR equations can be found in both the 3rd and 4th editions of the *Manual of Photogrammetry*. In aerotriangulation, we use the ellipsoid height (h) and the optionally-transformed LSR (Z_L) of our points as they are to compensate for ellipsoidal earth curvature. For the polyhedric projection, we force the LSR (Z_L) to be equal to zero. For a secant case, we merely assign the ellipsoid height of the point of origin (h_o) a value less than zero.

The most common classical datum (prior to the European 1950) found in the former Yugoslavia is the Hermannskogel 1871 Datum with ϕ_o = 48° 16' 15.29" N, λ_o = 33° 57' 41.06" East of Ferro, where Ferro = 17° 39' 46.02" East of Greenwich and azimuth to Hundsheimer is α = 107° 31'41.7". The most common grid found on that datum is the Yugoslavia Reduced Gauss-Krüger Transverse Mercator. The scale factor at origin (m_o = 0.9999), the central meridians of the belts (C.M. = λ_o = 15°, 18°, 21° East of Greenwich) and the False Easting at C.M. = 500 kilometers. The Ministry of Finance used the non-reduced version only between 1938-40 where m_o = 1.0.

About fifty years ago, the Army Map Service transformed Hermannskogel 1871 Datum to the European Datum 1950. However, large data sets still survive on that old datum. The author examined the relation between the two datums recently and computed new transformations. Twenty two points were used that are common to both datums in the former Yugoslavia and a simple three-parameter shift analysis yielded the following: ΔX = +770.417 meters, ΔY = -108.432 meters, ΔZ = +600.450 meters. The accuracy of this transformation when expressed in terms of actual geodetic coordinates is: Latitude change ($\Delta\phi$) = ± 3.74 meters, Longitude change ($\Delta\lambda$) = ± 4.54 meters, and Ellipsoid Height change (Δ h) = ± 12.70 meters. On the other hand, a seven-parameter shift analysis yielded the following: ΔX = +758.53 meters, ΔY = +259.52 meters, ΔZ = +542.18 meters, Scale = -6.0×10^{-6}, Z-rotation (ω) = +11.29 seconds, Y-rotation (ψ) = +2.06 seconds, and X-rotation (ξ) = -5.66 seconds. The accuracy of this transformation when expressed in terms of actual geodetic coordinates is: Latitude change ($\Delta\phi$) = ± 1.07 meters, Longitude change ($\Delta\lambda$) = ± 1.44 meters, and Ellipsoid Height change (Δ h) = ± 0.64 meters. For example, station Vel Gradiste has the following EU50 coordinates: 45° 09' 17.3501" N, 18° 42' 44.9479" E, 0.0 m. and the following Hermannskogel 1871 coordinates: 45° 09" 14.4675" N, 18° 43' 00.7696" E, 0.0 m. The Yugoslavian Reduced Grid coordinates are: Northing (X) = 5,001,303.81 m., Easting (Y) = 556,359.65 m.