

# Grids & Datums

## REPUBLIC OF MACEDONIA

by Clifford J. Mugnier, C.P., C.M.S.

Macedonia is the birthplace of Alexander III the Great (356-323 BC). "The history of the ancient Macedonian kingdom begins with Caranus, who was the first known king (808-778 BC). The Macedonian dynasty Argeadae originated from Argos Orestikon, a city located in the south western Macedonia region of Orestis. By 65 BC Rome conquered the Seleucid Macedonian kingdom in Asia under its last king Antiochus VII. Finally, the defeat of Cleopatra VII in 30 BC, brought an end to the last of the Macedonian descendants in Egypt, and with it, the last remains of the Macedonian Empire that was once the mightiest in the world disappeared from the face of the earth. In the 9<sup>th</sup> century (AD – Ed.), while the Byzantine Empire was ruled by the Macedonians Emperors of the Macedonian Dynasty, the Macedonian brothers Cyril and Methodius from the largest Macedonian city of Salonica, created the first Slavonic alphabet, founded the Slavic literacy, and promoted Christianity among the Slavic peoples. Macedonia remained a Byzantine territory until the Ottoman Turks conquered it in 1389. In the 19<sup>th</sup> century, Greece, Serbia, and Bulgaria freed themselves from the Turkish rule and actively began conspiring against the Macedonians displaying territorial aspirations on their land. In 1912, Greece, Serbia, and Bulgaria joined forces and defeated the Turkish army in Macedonia. 100,000 Macedonians also participated and helped in the Turkish evacuation but the victors did not reward them. The Treaty of

London (May 1913), which concluded the First Balkan War, left Bulgaria dissatisfied with the partition of Macedonia among the allies which resulted after the war. Bulgaria's attempt to enforce a new partition in a Second Balkan War failed, and the Treaty of Bucharest (August 1913) confirmed a pattern of boundaries that (with small variations) has remained in force ever since" (*historyofmacedonia.org*, 2012).

"In the wake of the First World War, Vardar Macedonia (the present-day area of the Republic of Macedonia) was incorporated into the newly formed Kingdom of Serbs, Croats, and Slovenes. Throughout much of the Second World War, Bulgaria and Italy occupied Macedonia. Many citizens joined partisan movements during this time and succeeded in liberating the region in late 1944. Following the war, Macedonia became one of the constituent republics of the new Socialist Federal Republic of Yugoslavia (PE&RS, September 1997) under Marshall Tito. During this period, Macedonian culture and language flourished. As communism fell throughout Eastern Europe in the late 20<sup>th</sup> century, Macedonia followed its other federation partners and declared its

independence from Yugoslavia in late 1991" (*Background Notes, U.S. Dept. of State*, 2011).

Slightly larger than Vermont, Macedonia is bordered by Albania (151 km) (PE&RS, January 2012), Bulgaria (148 km) (PE&RS, January 2002), Greece (246 km) (PE&RS, December 2002), and Kosovo (159 km). Macedonia is a mountainous territory covered with deep basins and valleys; three large lakes, each divided by a frontier line; country bisected by the Vardar River which is the lowest point (50 m), and the highest point is Golem Korab (*Maja e Korabit*) (2,764 m) (*World FactBook, 2012 and NGA GeoNames Server, 2012*).

"In the epoch between the two World Wars (1918-1941), the Military Geographic Institute (MGI) of the Kingdom of Yugoslavia (*Vojni Geografski Institut Kraljevine Jugoslavije*), the agency responsible for geodetic survey and mapping, made a great effort towards unification of the triangulation and production of a uniform map covering

the entire national territory, a considerable part of which never was surveyed. WWII prevented the completion of this project. After WWII, under different circumstances, the Geographic Institute of the Yugoslav People's Army (*Geografski Institut Jugoslovenske Narodne Armije-GI/JNA*) has been quite successfully proceeding with the work initiated by its predecessor.

From 1917-1924, the Clarke

1880 ellipsoid ( $a = 6,378,249.145$ ,  $1/f = 293.465$  – Ed.) was used by the Military Geographic Institute. In order to obtain geographic coordinates uniform with the geographic coordinates of the Austro-Hungarian Military Triangulation which covers the western part of Yugoslavia and because the Direction General of Cadaster and State Domains (*Generalna Direkcija Katastra i Državnih Dobra*) already had adopted the Bessel ellipsoid, the geographic coordinates of Serbian triangulation referring to Clarke 1880 ellipsoid were transformed to (the) Bessel (1841) ellipsoid ( $a = 6,377,397.155$ ,  $1/f = 299.1528128$  – Ed.). The degree survey which includes the arc along the 22° meridian observed in 1927-1930 was computed on the International (Hayford 1909) ellipsoid ( $a = 6,378,388$ ,  $1/f = 297$  – Ed.) for the purposes of the International Geodetic Association.

"The Military Geographic Institute of the Yugoslav People's Army adopted for its new topographical survey and map compilation the Gauss-Krüger (Transverse Mercator) projection, but the maps compiled prior to WWII, still reproduced and predominantly used, are

**After a careful analysis of the Strumica base line the Federal Geodetic Administration published the following mean total relative error: Strumica base line  $E_r = \pm 9.4 \text{ mm} / 6623.806 \text{ km} = \pm 1/7,000,000$  or  $\pm 1.4 \text{ mm/km}$ . The density of triangulation in Macedonia is 1 trig point to 1.6 km<sup>2</sup>.**

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constructed in the polyhedric projection. (*Identical to the Local Space Rectangular projection discussed in the Manual of Photogrammetry, 5<sup>th</sup> edition, Chapter 3 – Ed.*)

1. The Gauss-Krüger (Transverse Mercator) projection of 3° zones with starting meridian Greenwich, central meridian 15°, 18°, 21° (*only 21° for Macedonia – Ed.*) East of Greenwich and scale factor 0.9999, used since 1924 in the Yugoslav Cadastral survey, was in 1949 introduced in the construction of sheets of the Yugoslav military maps. (*False Easting = 500 km. – Ed.*) The sheets are cut in the graticule system of the International map. The I33, L34, K33 and K34 sheets at 1:1,000,000 scale with dimensions  $4^{\circ}_{\phi} \times 6^{\circ}_{\lambda}$  cover the area of Yugoslavia.
2. The polyhedric projection. In an attempt to assure continuity with the Austro-Hungarian mapping the Military Geographic Institute of the Kingdom of Yugoslavia in the construction of the plane table sheets and maps used the polyhedric projection with starting meridian of Paris (20° East of Ferro or 2° 20' 13.98" East of Greenwich). The sheets were cut along the meridians and parallels.

"In 1922, baselines were observed at Strumica (6,623.806 m  $\pm$  1/2,158,000) and at Prilep (5,982.555 m  $\pm$  1/5,489,000) with Jäderin base apparatus. Concerning the accuracy of measurement of base lines it should be mentioned that the  $\pm \Delta s/s$  fraction given with the lengths of base line represent so-called internal accuracy of the base line derived from the difference between the forward and backward measurements. This internal error does not include systematical errors caused by the apparatus and its constants (calibration of invar wires by the *Bureau International des poids et mesures* Sevres, France is carried out by a mean error up to  $\pm 22$  microns which would produce an accumulation of systematical error up to 0.92mm/km). After a careful analysis of the Strumica base line the Federal Geodetic Administration

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"The vertical control of Macedonia refers to the leveling datum Trieste, Molo Sartorio of which the elevation of starting benchmark within one year (1875) of observations of tidal gauge was dened to be +3.352 meters above the mean sea level of the Adriatic Sea" (*Mapping of the Countries in Danubian and Adriatic Basins, Andrew M. Glusic, Army Map Service Technical Report No. 25, June 1959*).

The Hermannskogel 1871 Datum origin is at:  $\Phi_0 = 48^{\circ} 16' 15.29'' \text{ N}$ ,  $\Lambda_0 = 33^{\circ} 57' 41.06'' \text{ East of Ferro}$ , where Ferro =  $17^{\circ} 39' 46.02'' \text{ East of Greenwich}$  and azimuth to Hundsheimer is  $a_0 = 107^{\circ} 31' 41.7''$ , and is referenced to the Bessel 1841 ellipsoid. Technical Report 8350.8 lists three-parameter transformation values for Yugoslavia (prior to 1990) for Slovenia, Croatia, Bosnia and Herzegovina and Serbia but not for Macedonia. Nevertheless, the consistency of the triangulation per Andrew M. Glusic's analysis leads me to believe that the transformation is valid for Macedonia from Hermannskogel 1871 Datum to WGS84 Datum:  $\Delta X = +682 \text{ m}$ ,  $\Delta Y = -203 \text{ m}$ ,  $\Delta Z = +480 \text{ m}$ . Note that these are "Non-Satellite Derived Transformation Parameters."



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