& GRIDS & DATUMS

THE UKRAINE

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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 Ukraine was originally printed in 2004 but contains updates to their coordinate system since then.

Paleolithic remains have been found in the region, but the oldest dwelling in Kiev is from the 25th century B.C., about 4,500 years ago. "Ukraine was the center of the first Slavic state, Kievan Rus, which during the 10th and 11th centuries was the largest and most powerful state in Europe. Weakened by internecine quarrels and Mongol invasions, Kievan Rus was incorporated into the Grand Duchy of Lithuania and eventually into the Polish-Lithuanian Commonwealth. The cultural and religious legacy of Kievan Rus laid the foundation for Ukrainian nationalism through subsequent centuries. A new Ukrainian state, the Cossack Hetmanate, was established during the mid-17th century after an uprising against the Poles. Despite continuous Muscovite pressure, the Hetmanate managed to remain autonomous for well over 100 years. During the latter part of the 18th century, most Ukrainian ethnographic territory was absorbed by the Russian Empire. Following the collapse of czarist Russia in 1917, Ukraine was able to bring about a short-lived period of independence (1917-1920) but was reconquered and forced to endure a brutal Soviet rule that engineered two artificial famines (1921-22 and 1932-33) in which over 8 million died. In World War II, German and Soviet armies were responsible for some 7 to 8 million more deaths." (*World Factbook, 2004*). The republic achieved independence in 1991.

Ukraine is slightly smaller than Texas and borders Belarus (891 km), Hungary (103 km), Moldova (939 km), Poland (526 km), România (169 km), Russia (1,576 km), and Slovakia (97 km). The coastline is 2,782 km along the Black Sea and the Sea of Azov. The climate is temperate continental, and most of Ukraine is steppes and plateaus, with the Carpathian Mountains in the west and the southeastern coast of the Crimea from Sevastopol through Yalta and north to Feodosiya. The lowest point is the Black Sea (0 m), and the highest point is Hora Hoverla (2,061 m). The capital is Kiev, and according to legend, the city was founded in 482 *A.D.* by a royal family of three brothers and one sister.

The czarist Russians performed surveys and topographic mapping of Ukraine in the 19th and early 20th centuries, but these works were for military purposes only. They did nothing with respect to individual land ownership registration, and they preferred the sazhen for their unit of measurement. (Paraphrased from Poland, *PE&RS*, September 2000). The existing classical triangulation net is a dense mesh to the west along the border with Poland, Hungary, România, and Moldova, primarily in the mountainous region and extending as far east as Rivne, Ternopil', and Chernivtsi. A southern chain of figures reaches from the western city of

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Izmayil, through Odessa and Kherson to the Crimea where it includes Feodosiya and Kerch. There are seven other meridional arcs that are connected by three more-or-less continuous east-west chains. Although some first-order work is evident around Kiev, there is a very dense network about Yalta in the Crimea. There are a number of high-order local surveys evident in Ukraine, and I suspect that some of these locations may be coincident with now-empty underground silos; a once-favorite area for ICBM sites when the USSR had control of Ukraine.

The observations for the Horizontal State Geodetic Network (HSGN) of Ukraine began in 1923-25, but it took over 30 years to complete both horizontal and vertical leveling work. Completed in 1970, the first-order network has been maintained while densification has continued for third and fourth-order control. The HSGN consists of 19,538 points that include 547 first-order and 5,386 second-order points. The HSGN is on the "System 42" datum established (in 1942) by the USSR where the origin point is at Pulkovo Observatory where: 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″. System 42 is referenced to the Krassovsky 1940 ellipsoid where a = 6,378,245.0 meters, and $^1/_f$ = 298.3. The previously mentioned dense and continuous western network is entirely first-order in quality. The remainder of the first-order network of the Ukraine

is comprised of polygons: the lengths of each section being less than 200-250 km. There are 250 LaPlace (astronomic) stations in the HSGN which are located at each end of the first-order triangulation polygons and in the middle of each section. In continuous first-order chains, the LaPlace stations are spaced every 10 triangles, and the accuracy of the azimuths is ±1.2″. In second-order chains, LaPlace stations are located at baseline terminals. The accuracy of baseline distance measurements is not less than 4×10^{-6}. In general, a single Ukraine map sheet at a scale of 1:1,000,000 will contain about 35-70 LaPlace station points and about 20-30 baselines. The average density of HSGN points is 1 point in 30 km^2, but this varies in different regions. For instance, in the industrial region around Donbass, the density goes up to 1 point in 5-10 km^2, while in the rural region around Polissia the density goes down to about 1 point in 40-50 km^2. The grid system associated with the Ukraine HSGN is the same as with all former countries of the Soviet Union – the Russia Belts which are identical to the UTM grid except that the scale factor at origin (m_o) = unity. For large-scale mapping, the width of the belts reduces to 3° rather than the standard 6° belt.

The Vertical State Geodetic Network (VSGN) consists of almost 11,000 km of first-order leveling, plus12,600 km of second-or-der leveling, 6,000 km of third-order leveling, and about 300,000 km of ordinary leveling. The average distance from any site in Ukraine to a first- or second-order level line does not exceed 40 km. The first-order VSGN is tied to the vertical networks of Poland, Slovakia, România, Hungary, Russia, and Belarus. The vertical datum is referenced to the Kronstadt tide gauge located at the Baltic Sea, near St. Petersburg (Russia). Benchmark spacing in Ukraine is not in my files. The State Gravimetric Network is comprised of 80 first-order points and 20 second-order points with the fundamental point located in Poltava.

The NGA does not list datum transformation parameters from System 42 to WGS84 for Ukraine. My guess is that the parameters are pretty close to what they are for Moscow since the strategic importance of the country was so enormous to the USSR. Ukraine has now passed legislation that denotes WGS84 as the national datum of the republic.

Years ago, I sat in a hotel room in South America and watched "The Wall" being torn down. I was working on a U.S. A.I.D. project for land titlelization in which I designed the geodetic and photogrammetric aspects of the project for a canton in Ecuador. That process is a major project now in Ukraine, and GPS technology is an integral component of the social transformation. Those that read my columns are aware that I often grouse on "La Ley" – "The Law" as it exists in much of Latin America in which a branch of the federal government is given the exclusive monopoly for geodetic surveying and topographic mapping of a country. That is a custom derived from the European way of doing things back in the 19th century. I don't care for the concept because it frustrates private commercial mapping in favor of some federal groups, usually the military. Such an idea seems to be the current state of affairs in Ukraine, and their federal government appears to have passed a similar 19th-century era-type law. This may be a result of sociological/economic phenomena more than anything else, but it's disappointing to see such developments in new republics striving for excellence in a worldwide capitalistic environment. I wish them success in their endeavors to provide farmers with a title to the soil their forefathers have tilled for so many centuries; the geodetic and photogrammetric sciences will allow the technical aspects to flow smoothly.

I have to thank Dr. Momchil Minchev of Sofia, Bulgaria for his generous assistance in locating geodetic publications in English on the Ukraine for me. The reports of Dr. Michael Cheremshynsky of the Ukraine Main Administration of Geodesy, Cartography, and Cadastre of Ukraine in Kiev have made the technical details of the geodetic history possible for this article. Once again, Dr. Minchev has helped me unravel an enigma.

Ukraine Update

"2020 can be considered as the year of geospatial data in Ukraine with the Ukrainian geospatial community facing a historic moment of digitalization. We have introduced a 'single window' for natural resource management, which will help to save budget funds and develop territories, strengthen public control over the activities of state bodies and increase public confidence in the government.

"In April 2020, Ukraine's law on the National Spatial Data Infrastructure (NSDI) was finally adopted by the Ukrainian Parliament after more than 10 years and 4 attempts. Although Ukraine is not an EU Member State, the law is fully in line with INSPIRE and also reflects the main principles of EU open data policy" (*State Service of Ukraine for Geodesy, Cartography and Cadastre (StateGeoCadastre) 2022*).

The Ukranian government's geodetic website (https://dgm.gki.com.ua/pererahunok-po-gelmertu-(po-kljuchu)-na-ploschini) offers a Helmert-style datum conversion tool and appears to have a completely open access portal to the nation's geodetic network, as typical for a free republic. The website pages are in Ukrainian and in English.

This column was previously published in *PE&RS*.