The Republic of Latvia

Between 2500 and 1500 BC, the Finno-Ugric and proto-Baltic tribes settled on Baltic shores. The closest ethnic relatives of the Latvians are the ancient Prussians, the Galinds, the Jatvings, and the Lithuanians. The first settlers in the territory of Latvia were the Livonians or "Libiesi." The Livonians were once concentrated in the northern part of Latvia, but today only about 100 individuals speak their ancient language which nevertheless has contributed to a prominent Latvian dialect. By the 12th century, the natives were split into a number of tribal groups, all practicing nature religions. The Knights of the Sword (Livonian Order) were crusaders that forcibly converted Latvia to Christianity in the 13th century. For centuries, Latvia has been under Swedish, Polish, German, and Russian rule. In 1918, Latvia proclaimed independence from Czarist Russia. By 1940, Latvia was occupied by the Soviet Union and was soon overrun by Nazi Germany. Soviet forces reoccupied the country in 1944-45, and Latvia remained under Soviet rule until 1991 when it was admitted into the United Nations. In May 1994, the Latvian National Independence Movement finished first in Latvia's first post-Soviet local elections; the ex-communists fared the worst.

Latvia shares borders with Estonia to the north (339 km), Russia to the east (217 km), and Belarus to the southeast (141 km), and the Baltic Sea and Gulf of Riga to the west comprises a coastline of 531 km. Slightly larger than West Virginia, the country is mostly low coastal plain with the highest point being Gaizinkalns at 312 meters.

Survey activities in Latvia began with Tenner's first-order network of 1820-32 in Semgallen and Courland, and were published by Czarist Russia in 1843 and 1847. Tenner later supplemented his primary net with lower-order stations. The Tenner chains were originally computed on the Walbeck 1819 ellipsoid where the semi-major axis (a) = 6,376,895 m and $1/f$ = 302.7821565; they were later recomputed on the Bessel 1841 ellipsoid. Between 1878 and 1884, Schulgin further increased the density of lower-order stations in the area originally surveyed by Tenner. However, the majority of these latter station monuments did not survive into the 20th century, and they were ignored by the Russians. The Tenner net in the east did not extend further north than the Sestukalns-Geisenkalns side, and the Struve primary net extended north from this side through Yuryev and over the Gulf of Finland. The Russian Western Frontier surveys were executed mainly by Yemel'yanov and Nikifirov between 1904 and 1912. These chains formed a major part of the modern (early) 20th century network of Eastern Latvia with some of the first-order stations being old Tenner or Struve stations. This Russian survey covered much of western and central Livonia in 1904-05, and eastern Livonia and Lettgallen were covered with the 1906 and 1912 nets. Lower-order nets to fourth order supplemented the primary chains. These Czarist Russian surveys were computed on the Pulkovo 1904 Datum or the Yuryev II Datum, both of which are referenced to the Bessel 1841 ellipsoid where a = 6,377,397.155 m and $1/f$ = 299.1528128.

After Latvia achieved Republic status, the new Latvian Survey Office began to unify these various nets in stages, before commencing with their own survey activities in 1924. The results of this program of unification are published in *Latvijas Valsts Trigonometrieskais*. The Pulkovo 1904 Datum points were recomputed into Yuryev II Datum based on 14 available first-order Scharmhorst points, and this was then put into the Senks Soldner Grid. The 1905 Russian net had already been computed on the Yuryev II Datum, and was accepted into the Old Gaisenkalns Soldner Grid where φ_o = 56° 52' 15.184" N and λ_o = 25° 57' 34.720" East of Greenwich. No false origin was used. Similarly, the 1906 and 1912 nets were already on the Yuryev II Datum, and those form the Old Vitoleieki Soldner Grid where φ_o = 56° 40' 08.64" N , λ_o = 27° 15' 11.79" East of Greenwich, and no false origin was used. Tenner's survey had been calculated on the Walbeck 1819 ellipsoid and was now recomputed on the Bessel 1841 ellipsoid and controlled by the Yemel'yanov-Nikifirov survey of the Puci-Sarmes side. This had the effect of introducing a slight swing to the orientation of the Tenner triangulation. The Latvian Kulkigan and Puci systems cover this net. For most of eastern Latvia, the earlier Russian surveys could be used to form the basis of the Latvian triangulation as the station centers could be found. In Courland and Semgallen the original triangulation dated back to 1820 and few of the old stations could be recovered. This necessitated a complete new survey, which was started in 1924 from the Liepaja-Paplaka base and extended in stages to the Puci-Sarmes side and thence to Riga and Jelgava. The origin of this system is the Yuryev II Datum value of Riga St. Petri Church "tower ball" which is the same station as the Tenner first-order point. The Yuryev II Datum azimuth to Jelgava Church was adopted for the orientation of the net. Although the Riga Church and Courland values are the same as Scharnhorst value and the azimuth is identical, the coordinates of Jelgava Church vary slightly by 0.002" in each axis. This was due to the scales of the Liepaja and Jelgava bases, which were adopted for the Courland System in preference to the less reliable Scharnhorst scale. This became known as the "Provisional Courland System (datum)." The Provisional Courland System was divided into two Cassini-Soldner Grids: The "Riga System" with its origin at Riga St. Petri Church where φ_o = 56° 56' 53.919" N and λ_o = 24° 06' 31.898" East of Greenwich, and the "Vardupe System" with its origin at the Provisional Courland station Vardupe where φ_o = 56° 51' 32.961" N and λ_o = 21° 52' 03.462" East of Greenwich. No false origin was used for either grid. The Provisional Courland System was immediately adjusted and computed before the triangulation of central and east Latvia was completed. This Provisional Courland System was first adjusted within itself and then adjusted to the Latvian part of the Baltic Ring. The lower-order control as far east as 24° 20' East of Greenwich was adjusted and computed in terms of this system.

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continued on page 882

continued from page 881

The General Latvian Triangulation Net of first-order stations covers practically all of Latvia, including Courland. The lower-order control east of 24° 20' East of Greenwich was computed in terms of the General Latvian Triangulation Net. Actually, there is a small overlap around 24° 20' East of Greenwich for which the coordinates of all stations, of all orders, were computed in both the Provisional Courland System and the General Latvian Triangulation Net. The 1924 net was adjusted in stages to fit the following eight bases: Puci-Sarmen Jelgava, Jekabpils-Dabarkalns, Garmaniski-Viski, Kangari-Jamilova, Kirbbisi-Akija, Duorno Sielo-Dziedzinka (Polish Base), Arula-Urkaste (Estonian Base), and Liepaja-Paplaka. The chain Puci-Sarmen to Jekabpils-Dabarkalns forms the backbone of the modern net from which the adjustment started. The origin of the General Latvian Triangulation Net is Riga Petrikirche (top of the Riga Church spire) where Φ_o = 56° 56' 53.919" N, Λ_o = 24° 06' 31.898" East of Greenwich, and the reference azimuth to Mitau German Church α_o = 215° 24' 04.38". The value for Riga Petrikirche approximates the Dorpat II System (datum). The Latvian control was computed in terms of four Cassini-Soldner Grids. The grid names and the coordinates of the respective origins are as follows: Vardupe Cassini-Soldner Grid where φ_o = 56° 51' 32.961" N and λ_o = 21° 52' 03.462" E; the Riga Cassini-Soldner Grid where φ_o = 56° 56' 53.919" N and λ_o = 24° 06' 31.898" E; the Gaisinkalns Cassini-Soldner Grid where φ_o = 56° 52' 15.031" N and λ_o = 25° 57' 34.920" E; and the Vitolnieki Cassini-Soldner Grid where φ_o = 56° 40' 08.447" N and λ_o = 27° 15' 12.252" E. These grid systems cover zones of about 1½° to 2° wide, and overlap slightly. The Vardupe Grid is computed from the geographics of the Provisional Courland System, while the Gaisinkalns and Vitolnieki Grid values correspond to the General Latvian Triangulation Net. The Riga Cassini-Soldner Grid coordinates are computed from both the Provisional Courland System geographics and the General Latvian Triangulation Net. However, care is taken in the Latvian "Trig" Lists to show from which geodetic system the Riga Cassini-Soldner coordinates are computed.

During these inter-war years, the Russians were also actively re-computing their survey information in the Baltic states. Prior to 1932 the Russian horizontal control of the Baltic States was always referenced to Dorpat Observatory at Tarbu in Estonia. In 1932 the Russians set up Pulkovo Observatory 1932 as their horizontal datum and origin reference to the Bessel 1841 ellipsoid, and later revised this to Pulkovo 1942, now properly termed "System 42" (datum) referenced to the Krassovsky 1940 ellipsoid.

Thanks to E.A. Early of the U.S. Army Map Service, "In 1942 the German Army undertook the conversion of the Latvian Soldner coordinates to DHG Pulkovo." (Deutches Heeres Gitter – German Army Grid) "The first phase of the conversion embodied the change of projection from Soldner to Gauss-Krüger. The Latvian Geodetic Engineer Mensin set up formulas and tables to convert the four Latvian Soldner systems to the German Gauss-Krüger system. However, upon checking these formulas at the boundaries of the Soldner systems, inadmissible gaps were discovered. Mensin's formulas were then abandoned and new ones were derived following the method given in Jordan-Eggert's *Handbuch der Vermessungskunde*. Since there were no reliable geodetic connections to the Pulkovo system available at that time, the conversion of the Latvian system to the Pulkovo 1932 system could only be approximated. The value of the datum point of the general Latvian triangulation net approximates the Dorpat II system value. The necessary formulas converting Dorpat II system values to the Pulkovo 1932 system were available in the official Russian work of Brigade Engineer O. A. Sergjew, *Making and Editing of Military Maps*, Moscow 1939. In the absence of better data, these formulas were taken as a basis for the conversion to Pulkovo 1932 datum. The German Preliminary DHG Pulkovo 1932 coordinates resulting from this conversion were published in the form of *Ausgabe Koordinatenkartei* by the Kriegs-Karten und Vermessungsamt Riga, in 1943.

In 1943 extensive surveys were executed along the Latvian-Russian border for the final connection of the Latvian triangulation with the Pulkovo system. At the conclusion of these surveys, the Latvian system (already in terms of the preliminary DHG Pulkovo 1932 system) was converted to the Pulkovo 1932 system by a rigid-field adjustment. The Russian Pulkovo 1932 system coordinates used in this adjustment were taken from Russian Catalogs. As a consequence of this adjustment, new conversion constants were computed to convert from the four

Latvian Soldner systems to the Final DHG Pulkovo 1932 system. As mentioned previously, the triangulation of Latvia is not completely uniform, since the triangulation in Courland is based on the Provisional Courland System adjustment. Only the first-order stations in Courland are available in terms of the General Latvian Triangulation Net. The lower-order trig in Courland was converted from the Provisional Courland System to the General Latvian Triangulation Net by a graphical adjustment (triangle by triangle) based on the comparison of first-order values. After the lower-order trig in Courland was converted to terms of the General Latvian Triangulation Net, the Final DHG Pulkovo 1932 coordinate for all Latvia were computed. These coordinates were published in 1943 as a second edition *Ausgabe Endwerte Koordinatenkartei* by the Kriegs-Karten und Vermessungsamt, Riga. In the Fall of 1944 the publication of the *Koordinaten-Verzeichnis* (trig books) was begun. The coverage of these books is scanty. Also, it is noted that there are differences of up to a meter, at some stations, between the *Koordinaten-Verzeichnis* values and those from the second edition *Koordnatenkartei*. Is appears that this difference is accounted for by the fact that some of the Latvian traverse points (as included in the second edition *Koordinatenkartei*) were resurveyed by the German Army and consequently were listed in the *Koordinaten-Verzeichnis* books by the German Survey values." To convert from DHG Pulkovo 1932 Datum Grid coordinates to European Datum 1950 coordinates on the UTM Grid, zone 34, use the following: (UTM Northing) = 0.9996056758 * (DHG Northing) + 0.0000176163 * (DHG Easting) + 828.01, and (UTM Easting) = 0.9996056758 * (DHG Easting) + 0.0000176163 * (DHG Northing) + 365.98. The NIMA published values for that general region of Europe from European Datum 1950 to WGS 84 are $\Delta X = -87m \pm 3m$, $\Delta Y = -95m \pm 3m$, and $\Delta Z = -120m \pm 3m$. The NIMA published values for System 42 Datum (in Latvia) to the WGS 84 Datum are $\Delta X = +24m \pm 2m$, $\Delta Y = -124m \pm 2m$, and $\Delta Z = -82m \pm 2m$.

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