Grids & Datums

Republic of Finland

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According to the Library of Congress *Country Study of Finland*, "present-day Finland became habitable in about 8,000 *B.C.*, following the northward retreat of the glaciers, and at about that time Neolithic peoples migrated into the country. According to the legends found in the Finnish folk epic, the *Kalevala*, those early inhabitants included the people of the mythical land Pohjola, against whom the Kalevala people-- identified with the Finns—struggled … Both the traditional and modern theories agree that in referring to this prehistoric age one should not speak of a Finnish people, but rather of Finnic tribes that established themselves in present-day southern Finland, gradually expanded along the coast and inland, and eventually merged with one another, absorbing the indigenous population. Among those tribes were the Suomalaiset, who inhabited southwestern Finland and from whom was derived Suomi, the Finnish word for Finland. The Tavastians, another Finnic tribe, lived inland in southern Finland; the Karelians lived farther east in the area of the present-day Karelian Isthmus and Lake Ladoga. On the southern coast of the Gulf of Finland were the Estonians, who spoke a Finno-Ugric language closely related to Finnish. North of the Finns were the Lapps (or Sami), who also spoke a Finno-Ugric language, but who resisted assimilation with the Finns."

Finland is located in northern Europe, and has a 1,126 km coastline on the Baltic Sea, the Gulf of Bothnia, and the Gulf of Finland, excluding islands and coastal indentations. Bordered by Norway, 729 km (*PE&RS*, October 1999), Sweden 586 km (*PE&RS*, August 2004), and Russia, 1,313 km, Finland is slightly smaller than Montana. The lowest point is the Baltic Sea (0 m), and the highest point is Haltiatunturi (1,328 m). Note that the southwestern border of Finland with Sweden is the Tornio River where the French Royal Academy of Sciences performed one of their triangulations in the 18th century in an attempt (by Pierre-Louis Moreau de Maupertuis) to prove that Sir Isaac Newton was incorrect in his theory on the shape of the earth being an oblate ellipsoid.

Thanks to the *History of the Finnish Geodetic Institute*, "In 1748, a special surveying committee was established in Finland, and as its first observator (*sic – Ed.*) was named Jakob Gadolin. He measured in 1748-1750 and 1752-1753 the Turku-Åland triangle chain, and from there on across the Åland Sea to the Swedish side at Grisslehamm. In 1754, Johan Justander continued the work of Gadolin, who had gone to Turku University to be come Professor of Physics, by extending the triangulation Eastward from Turku, along the coast of the Gulf of Finland, arriving in Helsinki in 1774.

"The next important triangulation in our country was performed 1801-1803, when the Swedish Jöns Svanberg repeated Maupertuis' measurements along the original triangle chain, at the same time extending them to both North and South. The interest of Svanberg was not however mapping but a check on the flattening ratio of the Earth.

"Also the *Russian-Scandinavian* grade measurement, planned by one of the great names in astronomical history, Wilhelm Struve, was done to check the dimensions of the Earth. This measurement started at the Danube delta, ran through Bielo-Russia and Estonia to Finland and from here onward into the Norwegian fiords and the Arctic Sea. It entered Finland from Gogland island (Suursaari) and, passing west of Loviisa to the area of Jyväskylä and from there on through Kajaani, Oulu, Torno and Muonio to Hammerfest. The measurements were started in 1816, and the angle observations in the part located in Finland were done in 1830-1845.

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"Of the triangulations which took place during the last century (*19th – Ed*), also the *Baltic triangulation* must be mentioned. It was done by the Hydrographic Department of the Russian Naval Ministry in 1828-1838. This measurement ran along the coast of the Gulf of Finland from the Eastern border to Åland and from there to Sweden, where it connected to the points *Söderarm, Arholm and Grisslehamn* determined by Swedish geodesists. All in all, 398 triangulation points were measured on the Finnish territory.

"Neither of these measurements mentioned above, the Russian-Scandinavian and the Baltic triangulation, was very useful to Finnish mapping. In both measurements the triangulation point set was poorly marked in the terrain, as a result of which points were later difficult to find, and a large part of them soon vanished completely. Also the measurement precision was questionable." From my readings of the common practices of the Czarist Topographic Corps throughout Russia in the 19th and early 20th centuries, they commonly erected triangulation targets of up to 30 meters high made of scantlings (split

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"Besides the geodetic measurements summed up above, also original geodetic research was done in Finland during the last century (*19th – Ed.*), especially by the Turku astronomer H.J. Walbeck. In 1819, at the age of 25 only, Walbeck published the work *De forma et magnitudine telluris ex dimensis arcubus meridiani definiendis* (Determining the figure and size of the Earth by means of meridian grade measurements). In it he, as one of the first to do so, applied the least squares procedure known from mathematical statistics to the determination of the figure and dimensions of the Earth. He derived the dimensions of the Earth from five different grade measurements, obtaining a=6,376,896m and $1/f$ = 1:302.8, values used in Russian geodetic measurements for almost a century. Through his publication, Walbeck got acquainted with the famous director of the Tartto Observatory, Wilhelm Struve, and planned on Struve's request the course through Southern Finland of the triangulation chain belonging to the Russian-Scandinavian grade measurement." (*Note that in this context, a "grade" is 1/400th of 360° - Ed.*)

Thanks to Marko Ollikainen in *The Finnish Coordinate Reference Systems*, "When the Finish Geodetic Institute (FGI) started carrying out triangulation in 1919 in Finland, the Hayford ellipsoid … was chosen as the reference ellipsoid. The dimensions of the ellipsoid , also known as the International ellipsoid 1924 , are as follows: a=6,378,388.0 m, $1/f$=297.0." Many early map sheets produced by the Government Printing Office (*Maanmittaushallituksen*), referenced the prime meridian at Helsinki which is +24°57'16.5" East of Greenwich, (*AMS Geodetic Memo* 915.0263, 1947).

In 1922 the Gauss-Krüger Transverse Mercator projection was selected for mapping purposes. The majority of the *mapping* was referenced to Helsinki Observatory and was known as the Helsinki System, or VVJ (*Vanha Valtion Järjestelmä*), where the origin was at: Φ_o=60°11'02.33"N and Λ_o=24° 57' 08.94"E. The VVJ Grid System is based on 3 Belts, the scale factor at origin is equal to unity (1.0), and the Central Meridian of the various zones with False Eastings are as follows: zone 0 = 18°E, FE=500km, zone 1=21°E, FE=1,500km, zone 2=24°E, FE=2,500km, zone 3=27°E, FE=3,500km, zone 4=30°E, FE=4,500km, zone 5=33°E, FE=5,500km.

When the Finnish Geodetic Institute published the results of its first triangulation chain from Åland to Helsinki in 1924, the origin chosen was at Hjortö, in Korppoo. The Hjortö System soon proved unsuitable and was abandoned in 1927. In 1931, a new system was published partly based on gravimetric measurements and was referred to as the "second adjusted system." The fourth system used by the Finnish Geodetic Institute was the all-European ED-50, or European Datum 1950; the starting coordinates of which were defined such that they produced a least squares solution for the deflection of the vertical for approximately 100 points. The results of the adjustment of the primary triangulation of Finland published in 1967 were given on the ED-50 System.

The ED-50 was recognized as a good improvement to the Helsinki System of 1931. It was used as a model for a subsequent adjustment known as the KKJ 1970 System (*Kartastokoordinaattijärjestelmä*). However, it differs from the ED-50 in that it is a 3-parameter transformation from ED-50 to match the VVJ system as closely as possible through two translations and one rotation. The ellipsoid of reference remains unchanged from the VVJ and the ED-50. The difference between VVJ and KKJ coordinates is 2m on average, and the maximum difference is approximately 10m (*Eino Uikkanen's Homepage*). The KKJ Grid system is the same as the VVJ Grid system, except that there is also a single KKJ Grid for the entire country that corresponds to the parameters listed for Zone 3. The University of Jyäaskylä has prepared a system of transformation parameters consisting of translations and polynomial coefficients for transforming back and forth between the 48 VVJ municipal coordinate systems and the KKJ national coordinate system. Access to these parameters is through the website of the National Land Survey of Finland.

The seven-parameter transformation from KKJ to the European Terrestrial Reference System of 1989 (ETRS89) is: ΔX =–96.062 m, ΔY =–82.428 m, ΔZ=–121.754 m, Rx =–4.801", Ry =–0.345", Rz =+1.376", and Δs =+1.496 × 10^{-6}. The average error of transformation is estimated at ±0.8m and the maximum error at ±2m, based on a least squares solution of 90 collocated points. The hierarchy of rotations ***appears*** to match the standard U.S. convention rather than the left-handed preference of many European publications. The reader is cautioned to find a test point for verification of this guess! Thanks go also to Dr. Roy Ladner of the U.S. Naval Research Laboratory who submitted a research paper on mapping and geodesy of Finland for a graduate credit course at the University of New Orleans back in 1999.

The contents of this column reflect the views of the author, who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the American Society for Photogrammetry and Remote Sensing.