Grids & Datums

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The Hellenic Republic

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 Hellenic Republic was originally printed in 2002 but contains updates to their coordinate system since then.

The region of present-day Greece was occupied in the Paleolithic period, and Indo-European invasions began about 2000 *B.C.* Ancient Greece was never unified, but the city-states of Athens and Sparta dominated while other cities shifted alliances over the centuries. Alexander the Great conquered most of the Mediterranean region and spread Greek culture throughout the known world. However, Greece was conquered by Rome in 146 *B.C.,* and by 1456 *A.D.* Greece was completely under the Ottoman Turk Empire. Greece won its independence from Turkey in the war of 1821-1829, and celebrates its Independence Day on 25 March (1821). The former Kingdom of Greece is now a parliamentary republic; the monarchy was rejected by referendum on 08 December 1974. Greece is slightly larger than the state of Alabama, and it is bordered by Albania (282 km), Bulgaria (494 km), Turkey (206 km), and Macedonia (246 km). The lowest point in Greece is the Medi-terranean Sea, and the highest point is Mount Olympus (2,917 m).

In 1889, the Greek Army Geo-graphical Service was formed, and classical triangulation commenced immediately. The agency name was later changed to the Hellenic Military Geo-graphical Ser-vice (HMGS). The initial starting point for the triangulation was the Old Athens Observatory where $\Phi_o = 37° 58' 20.1''$ North, $\Lambda_o = 23° 42' 58.5''$ East of Greenwich, and was referenced to the Bessel 1841 ellipsoid where the semi-major axis a = 6,377,397 155 meters and the reciprocal of flattening $^1/_f$ = 299.1528128. The Yeografikí Ipiresía Stratoú map series at 1:20,000 scale was produced from 1926 through 1947, and had the Greek Military Grid shown on some sheets. The series covered the northern border and scattered strategic areas through-out Greece. The Greek Military Grid was based on the Hatt Azimuthal Equidistant projection, a system origi-nally presented on the sphere by Guillaumme Postel.

Hatt was the hydrographer of the French Navy, and later taught at a university in Paris. Apparently he made quite an impression on a Greek student because the Hatt projection, used by the French Navy for local grids of hydrographic sur-veys, became the national grid system of Greece in the 20th century. The Hatt projection is quite similar to the Azimuthal Equidistant projections used in Yemen, Guam, and Microne-sia; the differences are based on the mathematics used to com-pute the ellipsoidal geodesic for the direct and inverse cases. Gougenheim, another French hydrographic engineer, later published a number of treatises on the geodesic that were later picked up by Paul D. Thomas who published a treatise for the U.S. Navy on the same subject in the 1970s. Thomas presented extensive computational proofs of Gougenheim's work that established the standard for "hand and mechanical calculator" solutions of the geodesic for global ap-plications of the U.S. Navy. In the 1980s, Thomas' work inspired my re-search partner at the University of New Orleans, Dr. Michael E. Pittman, to publish his original solution of the "Principal Problem of Geodesy" in the *Surveying and Mapping* journal of the ACSM. The other projection variants mentioned above for

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Yemen and Guam used the ellipsoidal geodesic solutions developed by Puissant and by Andoyer-Lambert. The Azimuthal Equidistant for Micronesia was developed by the late John P. Snyder using the "Clarke Long Line Formula" originally developed by Colonel A. R. Clarke of the British Royal Engineers (*PE&RS*, February 1999). Hatt's projection was an enormous influence on Euro-pean cartography world-wide for many decades, and I am often amused to see con-temporary software packages list unknown projections and grid systems as "Systémé Rectangulaire Usuel" with no further information. That "Usual Rectangular System" found worldwide is the Hatt projection! Nevertheless, the only country that adopted the Hatt Azimuthal Equidistant projection as the national grid was Greece. In 1980, Brigadier General Dimitri Zervas, commander of the Hellenic Military Geographical Institute, sent a treatise to me entitled *Η ΑΖΙΜΟΥΘΙΑΚΗ ΙΣΑΠΕΧΟΥΣΑ ΠΡΟΒΟΛΗ ΤΟΥ HATT, 1963* (HATT AZIMUTHAL EQUIDISTANT PROJEC-TION). The 21-page tome was written entirely in Greek by John Bandecas, but General Zervas mercifully penciled-in English translations of paragraph headings so that I could understand the mathematics presented. That was my one and only experience with Greek geodesy in which the only thing I could comprehend was the Greek symbols for standard geodetic terms in the math!

Coordinates later published for the Datum Origin were Φ_o = 37° 58′ 18.680″ North and Λ_o = 23° 42′ 58.815″ East of Greenwich, but curiously the National Topo-graphic Series published by the Greek Military used the *Athens Observatory as their national prime meridian*. The map series at various scales were based on integer minute differences from the Athens meridian. The basic series were based on 30- by 30-minute blocks with latitudes of 36° 30′ N to 42° 00′ N and longitudes of 4° 30′ W of Athens to 3° 30′ E of Athens (23° 42′ 58.815″ East of Greenwich).

The "Revised Military Grid" used in some national applications after WWII was based on the Lambert Conformal Conic projection. Using the same central meridian as the Athens Observatory, the three ***tangent*** zones had latitudes of origin of 35°, 38°, and 41°with False Eastings of 1,500 km, 2,500 km, and 3, 500 km, respectively, and all three zones had False Northings of 500 km. The "Old Military Grid" used from 1931 to 1941 had the same parameters except that there were no false origins.

From 1925 to 1946, there were two "British Grids" used by the Allied Forces. The Mediterranean Zone was a *secant* Lambert Conical Orthomorphic where the central meridian was 29° East of Greenwich, and the latitude of origin was 39° 30′ N, the scale factor at origin was 0.99906, the False Easting was 900 km, and the False Northing was 600 km. The Crete Zone was a *tangent* Lambert Conical Orthomorphic where the central meridian was Athens (24° 59′ 40″ East of Greenwich), the latitude of origin was 35° N, the scale factor at origin was 1.0 (by definition of a *tangent* zone), the False Easting was 200 km, and the False Northing was 100 km.

There is a new reference system used in Greece nowadays. It is called the Greek Geodetic Reference System of 1987 (GGRS87) where Φ_o = 38° 04′ 33.8107″ North, Λ_o = 23° 55′ 51.0095″ East of Greenwich, N_o = 7.0 m, and the new Greek Grid is based on the Transverse Mercator projection (presumably Gauss-Krüger) where ϕ_o = 0°, λ_o = 24° E, the False Easting = 500 km, and the scale factor at origin (m_o) = 0.9996. Generally, I have serious doubts concerning any "new" grid system that uses some non-standard variant of the UTM Grid, but I understand that this particular one was devised by Professor Veis of the Technical University of Athens. If Professor Veis ap-proved of this new grid, then there certainly must be a valid technical reason for the curious parameters chosen. Thanks for the above parameters go to Yannis Yanniris, a photogrammetrist in Athens.

The National Imagery and Mapping Agency (NIMA) has published datum shift parameters from the European Datum of 1950 in Greece to the WGS84 Datum where ΔX = –84 m, ΔY = –95 m, and ΔZ = –130 m; however, this solution is based on only two points and the accuracy of the components is stated to be ±25 m. Users interested in geodetic applications of GPS in Greece should read the NIMA notice published next to my column in *PE&RS* October, 2002. The European Petroleum Studies Group has published shift parameters from GGRS87 to WGS84 as being ΔX = –199.87 m, ΔY = +74.79 m, and ΔZ = +246.62 m. The EPSG published no accuracy estimates for their parameters, so ***caveat emptor***.

The Hellenic Republic Update

The Hellenic Positioning System (HEPOS) is based on 98 GPS Continuously Operating Reference System (CORS) sites operated by the commercial organization KTIMATOLOGIO, S.A. The Hellenic Terrestrial Reference System 2007 (HTRS07), based on the ETRS89/ETRF05 reference frame underlies HEPOS, and an evaluation of 2,430 geodetic benchmarks revealed that the accuracy level is better than 10 cm in terms of the rms value for the total transformation error.

Katsampalos, K., Kotsakis, C., Gianniou, M., Hellenic terrestrial reference system 2007 (HYTS07): a regional realization of ETRS89 over Greece in support of HEPOS, Bollettino di Geodesia e Scienze Affini, Instituto Geografico Militare, Vol. LXIX, N.2-3, May/December 2010.

A recent publication addressed two-dimensional cartometric transformations of old Greek topographic maps to the HTRS87 Datum as discussed in the original Grids and Datums column.

Moschopouos, G., Demirtzoglou, N., Mouratidis, A., Perperidou, G., Ampatzidis, D., Transforming the old map series to the modern geodetic reference system, Coordinates, Vol. XVI, No.7, July 2020.

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