Grids & Datums

Republic of Cyprus

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The island of Cyprus has evidence of human inhabitation dating back to 6,000 *B.C.* Influenced by Minoan and Mycenaean cultures, the island was colonized by the ancient Greeks and Phoenicians. Richard the Lionhearted captured Cyprus during the Third Crusade in 1191. The government was administered by Great Britain from 1878-1914 and became a British Crown Colony in 1925. Cyprus became an independent republic in 1960. Unrest and armed strife between Turkish and Greek inhabitants prompted establishment of a UN Peacekeeping force in 1964. Turkish troops invaded in 1974 and established a separate Turkish Federated State of Cyprus, which was proclaimed in 1975 (*Webster's Geographical Dictionary*). Cyprus has an area of 9,250 km^2 and is about 0.6 times the size of Connecticut. The island comprises two almost parallel mountain ranges going from east to west and an almost flat plain extending between the ranges from Morphou to Famagusta through Nicosia, the capital. The coastline is 648 km, the lowest point is the Mediterranean Sea (0 m), and the highest point is Olympus (1,952 m).

Cyprus has appeared on maps since about 1200 *A.D.*; the first Italian map of Cyprus was produced in 1478 (Bartolomeo Zamberti dalli Sonetti), and reproduced in 1490. Subsequent versions appeared in 1528 (Genedetto Bordone), 1538 (Matheo Pagano), and 1585-1595 (G. F. Camocio). The first hydrographic survey work in Cyprus was performed in 1849 by Lord Lieutenant John T. Browne of the Royal Navy and by Captain Thomas Graves of H.M.S. Volage. During that same period, several benchmarks were established on public buildings in Limassol and Cape Gata, all referenced to chart datum. Records also show that real property conveyances were recorded in a cadastre.

Lieutenant H.H. Kitchener, later known as Lord Kitchener of Khartoum, based the first known accurate map of Cyprus on a classical triangulation survey from 1878-1883. Kitchener, assisted by a number of Royal Engineers started the survey in September 1878. In February 1883, he reported to the Chief Secretary of Cyprus that the triangulation and survey had been completed and that all the original observations and coordinates had been sent to Stanford's Geographical Establishment in London for publication. The planimetric map (scale: 1 inch = 1 mile) was published in 15 sheets, copies of which are still maintained in the offices of the Department of Lands and Surveys in Nicosia.

In July 1880, a law was passed providing for a fiscal survey. This commenced in 1883, following the completion of the planimetric survey. Kitchener's successor was Grant who was Director of Surveys in 1884, and was responsible for a resurvey of Cyprus at a scale of four inches to one mile. The survey was only performed with a magnetic compass and the basic triangulation was used as control. Therefore, the survey was insufficiently reliable to form a basis for a land registration system and was even unsuitable for its intended fiscal purpose.

A new survey was started in 1904 for the purpose of a cadastre in the Famagusta district. The survey commenced in the southeastern portion of Famagusta and was based on Kitchener's triangulation. The planetable survey was purely graphical, and no field notes were recorded. Subsequently called the "unsound survey," it continued for seven years over the Famagusta plains. Nevertheless, it has formed the basis for a general registration of land titles and has been in use until the present!

In 1909, a law was enacted that required compulsory registration of titles to all real property in Cyprus as well as forming the basis for a uniform assessment for taxation. The existing planetable compilation of the Famagusta plains was adequate, but it was not suitable for extension into the hilly areas. The system became unusable when the survey reached the hills of the northern range, which extends into the Karpas peninsula. A subsequent minor triangulation of the Karpas peninsula was undertaken in September 1911.

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Captain Lyons, D.Sc., F.R.S., Director-General of the Survey of Egypt was invited to Cyprus in November 1911 for a couple of weeks to consult on the need for further geodetic control of the island. Lyons' report of 1912 is still the basis of the design of the cadastral survey used to the present day. He recommended that the basic scale of 1:2,500 was the best for rural areas, and the urban areas should be mapped at a scale of 1:250 or larger. He recommended that a new and more accurate triangulation be undertaken to replace the Kitchener triangulation (1878-1882) as well, because many of the original monuments had become lost or destroyed.

The uniform re-triangulation of the island commenced in 1913 and lasted 18 months, including computations. Upon completion of

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the primary triangulation, it was broken down into third-order and fourth-order surveys for detail mapping. After Famagusta and Karpas, the survey of Kyrenia was undertaken with the same specifications. However, it soon became evident that the legislated deadline for a comprehensive island-wide mapping could not be accomplished in ten years with the methods currently being employed. Therefore, a tacheometric planetable survey at a scale of 1:5,000 was initiated for the remainder of the rural areas of Cyprus. By 1929, 20 years after the law had been enacted, all real property on the island was surveyed by one method or another, and that comprised the "cadastral survey."

For the cadastral survey, the island was divided into 59 rectangular sheets, each comprised of 8×12 square mile areas. Each of these sheets was further divided into 64 parts called cadastral maps, with each map covering an area of 1×1½ square miles. The survey of Cyprus was cast on the Cassini-Soldner projection where the latitude of origin (ϕ_o) = 35° 00' 00"N and the central meridian (λ_o) = 33° 20' 00"E, referenced to the Clarke 1858 ellipsoid where a = 6378235.6 meters, and $1/f$ = 294.2606768. In 1928, Brigadier Winterbotham recommended that all cadastral maps be reduced graphically and mechanically in scale to produce the 2 inches to 1 mile scale series of maps, as well as the ¼ -inch scale Cyprus Administration map and the ½ -inch scale Cyprus Motor map.

In 1931, the British Naval ship *HMS Ormonde* made astronomical observations at several triangulation stations in Cyprus. The origin point for Famagusta Bastion Datum at Cavalier Flagstaff is where: Φ_o = 35° 07' 02.044" N, Λ_o = 33° 57' 17.053" E, α_o = 228° 22' 22" to station Acheritan, and is referenced to the favorite of the British Admiralty at the time, the Clarke 1858 ellipsoid. In similar fashion, the origin point for Kantara Datum on the Karpas Peninsula was observed where: Φ_o = 35° 20' 43.05" N, Λ_o = 33° 59' 59.228" E, and of course the Clarke 1858 was the reference ellipsoid. When the reduced astro positions were compared to the published triangulation positions of the collocated points, it was noted that Cyprus had been located about 1 minute of arc too far to the east and about 30 seconds of arc too far south, or about 6,000 feet too far east and 3,000 feet too far south. The Director of Surveys and the British Admiralty's Hydrographic Department agreed to adopt the *HMS Ormonde's* values for longitude and to leave the latitude unchanged. In order to avoid any shifting of the sheet lines of the cadastral survey, it was decided to subtract 1 minute of arc from the longitude of each triangulation point as well as from the point of origin of the Grid system. The new 1935 basic point of origin for the island's Cassini-Soldner Grid system was modified to be such that: the latitude of origin (ϕ_o) = 35° 00' 00"N and the central meridian (λ_o) = 33° 19' 00"E, and it was still referenced to the Famagusta Bastion Datum of 1935, commonly referred to as the Cyprus 1935 Datum. *HMS Ormonde's* calculations were proven correct when the British Army connected Cyprus trigonometrically to Syria in 1944 and to Turkey in 1954, the latter with the European Datum of 1950.

During WWII the Director of Military Surveys of the British Army undertook the preparation of a 1:50,000 scale topographic map of Cyprus in color based on the 2 inches to 1 mile series, revised in the field by planetable methods and verified by aerial photography. The altitudes were obtained from aneroid altimeter traverses, which were in turn connected to the trigonometric control already heighted. This provided vertical control for photogrammetric plotting by Multiplex and produced contours at a 100 foot interval with dubious accuracies. The map series of the island was divided into 16 sheets, and was cast on the Cassini projection, but was referenced to the Clarke 1880 ellipsoid where a = 6,378,249.145 m and $1/f$ = 293.465. The map series established by the British Army General Staff, Geographical Section (GSGS) and published by the U.S. Army Map Service, U.S. Lake Survey in 1944, is where the "Cyprus Grid" is referenced to the Clarke 1880 ellipsoid, the latitude of origin (ϕ_o) = 35° 00' 00"N and the central meridian (λ_o) = 33° 19' 00"E, the same as the Cyprus Datum of 1935, but with a False Easting = 200 km, and a False Northing = 150 km. The limits of the GSGS Cyprus Grid were for the north, the parallel of 34° 45' N eastwards to 33° 45' N and thence a loxodrome to 36° 10' N, 35° E; the East limit was the meridian of 35° E; the South limit was the parallel of 34° N; and the West limit was the meridian of 31° 50' E. The color of the Grid was purple. A "Cyprus Grid" test point provided by the Lake Survey is: ϕ_o = 34° 30' 17.366"N, λ_o = 33° 54' 39.271"E, X = 254,573.63 m, Y = 95,229.58 m.

Although Cyprus was triangulated by Kitchener in 1878, re-triangulated in 1913 on Lyons' recommendations, and trilaterated in 1962 with Telurometer instruments, the Island of Cyprus had never been covered by an adequate network of elevation benchmarks. The need for a First-Order leveling net was realized when topographic mapping was started in 1964 for development projects. The First-Order leveling started in 1964 and completed in 1966 provided for consistent contouring for the island as a whole.

The existing geodetic network has proven to suffer from both observational and computational errors. The Department of Lands and Surveys decided to establish a new Primary Geodetic Network for the basis for both the Resurvey program and the Land Information System. After a number of studies and tests, it was decided to adopt the GRS80 ellipsoid, and a local datum. A Local Transverse Mercator (LTM) projection system was also chosen. The Cyprus LTM has the same Central Meridian (33° E) as the zone 36 of the UTM System, but a better scale factor (0.9999) was used. With these elements, the maximum scale error in any place of the country is 1:7500.

Using GPS technology, a new primary and secondary network has already been established. The primary network consists of 40 points and the secondary network consists of 254 points. The Tertiary network will consist of points, 200 to 500 meters apart.

To add to the bewildering array of ellipsoids, grids, and datums comes the AMS/NATO convention of casting all 1:50,000 scale topographic map series on the European Datum of 1950 as mentioned above when the British Royal Engineers connected Cyprus to Turkey (and earlier to Syria). For the military (only) topographic maps of Cyprus, the published transformation parameters FROM ED50 TO WGS84 are: $\Delta X = -104$ m ± 15 m, $\Delta Y = -101$ m ± 15 m, $\Delta Z = -140$ m ± 15 m, and this solution was based on 4 station observations. Someday, perhaps the Cypriot government will publicly release the transformation parameters among their local coordinate systems and an ITRF epoch.

The majority of the historical details were garnered from a UN Report prepared by A. Christofi of the Department of Lands and Surveys, Cyprus in 1970. Thanks go to John W. Hager for the coordinates of the various datum origins and helpful insight regarding Admiralty Office customs.