Grids & Datums

Arab Republic of Egypt

by Clifford J. Mugnier, C.P., C.M.S.

The roots of Egyptian civilization go back more than 6,000 years to the beginning of settled life along the banks of the Nile River. "The regularity and richness of the annual Nile River flood, coupled with semi-isolation provided by deserts to the east and west, allowed for the development of one of the world's great civilizations. A unified kingdom arose circa 3200 B.C., and a series of dynasties ruled in Egypt for the next three millennia. The last native dynasty fell to the Persians in 341 B.C., who in turn were replaced by the Greeks, Romans, and Byzantines. It was the Arabs who introduced Islam and the Arabic language in the 7th century and who ruled for the next six centuries. A local military caste, the Mamluks took control about 1250 and continued to govern after the conquest of Egypt by the Ottoman Turks in 1517. *[The Mamluks were such fierce and respected fighters that the U.S. Marine Corps adopted their ivory-hilted sword design for their officers' ceremonial dress – Ed.]* Following the completion of the Suez Canal in 1869, Egypt became an important world transportation hub, but also fell heavily into debt. Ostensibly to protect its investments, Britain seized control of Egypt's government in 1882, but nominal allegiance to the Ottoman Empire continued until 1914. Partially independent from the U.K. in 1922, Egypt acquired full sovereignty with the overthrow of the British-backed monarchy in 1952. The completion of the Aswân High Dam in 1971 and the resultant Lake Nasser have altered the time-honored place of the Nile River in the agriculture and ecology of Egypt (*CIA World Factbook, 2008*)."

Egypt is bordered by the Gaza Strip (11 km), Israel (266 km) (*PE&RS*, August 2000), Libya (1,115 km) (*PE&RS*, June 2006), and Sudan (1,273 km); its coastline on the Mediterranean Sea and on the Red Sea totals 2,420 km. Slightly more than three times the area of New Mexico, the terrain is comprised mainly of a vast desert plateau interrupted by the Nile River Valley and its delta. The lowest point is the Qattara Depression (–133 m), and the highest point is Mount Catherine (2,629 m).

The first serious mapping of Egypt on modern lines was undertaken in 1798 by Napoleon for his survey of Egypt. A Topographic Section was formed which consisted of four officers, an astronomer, and four "intelligent soldiers." Bases were measured at Alexandria and Cairo by the *"Service Topographique de l'Armee d'Egypte,"* and topographic maps were compiled with a 10 km grid with an origin at the great pyramids of the North in Memphis, *"Le centre de la projection correspond à l'axe de la grande pyramide du Nord à Memphis."* Referenced to the Plessis ellipsoid where a = 6,375,738.7 m, and $^1/_f$ = 334.29, the projection was the ellipsoidal Bonne, the "standard" projection for Europe at the time. The maps of Egypt and the Palestine were later published in 1808 (*The Lebanese Republic* in *PE&RS*, October 2002).

In 1874 a number of expeditions were led by British scientists to various European colonies in Africa and the Indian Ocean in order to simultaneously observe the transit of Venus for the purpose of precisely determining differences in longitude. Locations included Mauritius, (*PE&RS*, February 1999), Rodrigues, Réunion, St. Paul and Egypt. Helwân Observatory situated on Az Zahra Hill in the Al Moqattam Hills, Qalyûbîya of Cairo was utilized for the observations, and the station was termed "F_1" where: Φ_o = 30° 01' 42.8591" N, Λ_o = 31° 16' 33.6" East of Greenwich, the initial LaPlace azimuth being measured from Station O_1 (Helwân) to Station B_1 (Saccara), α_o = 72° 42' 01.20" from South, and H_o = 204.3 m, based on mean sea-level at Alexandria. This is considered the origin of the "Old Egypt Datum of 1907." A point of much heated contention among geodetic surveyors has been the "rumor" that the Clarke 1866 ellipsoid was once used in Egypt.

It just so happens that M. Sheppard, director general of the Survey of Egypt, reported (*in French*) to the Secretary General of the Geodesy Section of the International Union of Geodesy and Geophysics that the initial geodetic work performed in Egypt was computed on the Clarke 1866 ellipsoid where *"a, demi-grande axe equatorial = 6.378.206m.(sic), α = 1/295,0. (sic)."* Sheppard went on to say that all cultivated lands in the Nile Valley that were based on 2nd and 3rd order triangulations (for cadastral applications) initially used this ellipsoid, but that a later controlling chain of triangulation spanning the length of the Nile Valley was computed with the later adopted Helmert (1906) ellipsoid where a, = 6.378.200 m, $^1/_f$ = 1/298,3. Everything was later re-calculated on the Helmert ellipsoid and also on the International 1924 ellipsoid where a = 6,378, 388 m, $^1/_f$ = 297 (*Bulletin géodésique, no. 8, 1925*).

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"Although a great deal of survey work of various kinds had been done in Egypt from time immemorial up to 1907, and this, as regards the Framework, culminated in a certain amount of modern triangulation of secondary order executed between the years 1898 and 1907, it was not until the latter year that a triangulation of the first order was undertaken. The secondary triangulation was necessary to control the modern Cadastral Survey, but the urgency with which the latter had to be completed made it impracticable to undertake work of full first-order accuracy at the beginning. Accordingly, although the existing Survey of Egypt, as founded by the late Sir Henry Lyons, dates from 1898, the geodetic survey proper may be said not to have started until 1907 (Geodesy in Egypt, *Empire Survey Review*, No. 60)."

The British established a number of grid systems in 1929 for the Old Egypt Datum of 1907, each Gauss-Krüger Transverse Mercator Belt being designated with a different color: **Purple Belt** – Central Meridian (λ_o) = 27°E, Latitude of Origin (φ_o) = 30°N, Scale Factor at Origin (m_o) = 1.0, False Easting = 700 km, False Northing = 200 km, and South of the False Origin add 1,000 km to the northings; **Red Belt** – Central Meridian (λ_o) = 31°E, Latitude of Origin (φ_o) = 30°N, Scale Factor at Origin (m_o) = 1.0, False Easting = 615 km, False Northing = 810 km and South of the False Origin add 1,000 km to the northings; **Green Belt** – Central Meridian (λ_o) = 35°E, Latitude

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of Origin (φ_o) = 30°N, Scale Factor at Origin (m_o) = 1.0, False Easting = 300 km, False Northing = 100 km and South of the False Origin add 1,000 km to the northings.

In 1930, after a re-adjustment of the classical network, the New Egypt Datum of 1930 was published, also referenced to the Helmert 1909 ellipsoid. The Purple, Red, and Green Belts were retained with no modifications. The common abbreviation for the new datum is "EG30." This remains the current classical system used in Egypt for civilian mapping purposes.

After WWII, the U.S. Army Map Service (AMS) undertook the re-computation of all classical datums that covered lands involved in the European Theater of War, including all of North Africa. That new unified system was the European Datum of 1950 (ED50), and was referenced to the International 1924 ellipsoid. The longitude of F_1, Venus Station at Helwân, was changed to Λ_o = 31° 16' 37.05" East of Greenwich as a result of observations for the deflection of the vertical, but this change was only with respect to its re-computation on the International 1924 ellipsoid. All coordinates on ED50 for Egypt were published on the UTM Grid and generally are considered useful only for military mapping purposes, not for civilian use. A number of datum shift algorithms on the complex plane were developed by AMS to convert directly from the Purple, Red and Green Belts to the UTM ED50 Grids. Although classified Secret at the time, they were declassified in 1956.

TR8350.2 lists a couple of datum shifts from classical to the WGS84 Datum. **From** Old Egyptian 1907 **to** WGS84: $\Delta X = -130$ m ±3 m, $\Delta Y = +110$ m ±6 m, and $\Delta Z = -13$ m ±8 m, and is based on 14 stations used in the derivation. This compares favorably with my own computations, but using fewer stations. **From** ED50 **to** WGS84, $\Delta X = -130$ m ±6 m, $\Delta Y = -117$ m ±8 m, and $\Delta Z = -151$ m ±8 m, and is *also* based on 14 stations used in the derivation.

Using the full Molodensky 7-parameter datum shift model (including the datum origin coordinates) with 23 points, I derived the following **From** Egyptian 1930 **to** WGS84: $\Delta X = -137.5$ m ±0.5 m, $\Delta Y = +105.0$ m ±0.4 m, and $\Delta Z = -18.1$ m ±0.4 m, $\delta s = +4.38 \times 10^{-6} \pm 1$, $R_x = -5.0$" ±0.70", $R_y = +1.59$" ±0.48", $R_z = +1.51$" ±0.26". A solution with 19 differentially weighted points and 5 check points for a much larger area of

Egypt yielded the following 7-parameter Bursa-Wolfe model **From** Egyptian 1930 **to** WGS84: $\Delta X = -88.832$ m ± 0.02 m, $\Delta Y = +186.714$ m ± 0.03 m, and $\Delta Z = +151.82$ m ± 0.01 m, $\delta s = -6.413 \times 10^{-6} \pm 1.84$, $R_x = -1.305$" ± 2.21", $R_y = +11.216$" ± 1.57", $R_z = -6.413$" ± 1.84" (*Shaker, Prof. A.A.,* et al., *Remove-Restore Technique for Improving The Datum Transformation Process, FIG Working Week 2007, Hong Kong, 13-17 May 2007*).