The Lebanese Republic

There is evidence of human habitation in Lebanon for several thousand years from the mid-3rd millennium B.C. that had been under the control variously of Sumerians, Akkadians, Amorites, Egyptians, Assyrians, and Babylonians. Once part of the Persian Empire, Alexander the Great conquered the region in the 4th century B.C., and it later flourished under the Roman Empire. Lebanon was overrun by Muslim Arabs in A.D. 635-636, and remained under the Turks during the Crusades until the British and French invaded during WWI because Turkey was an ally of Germany.

Lebanon is almost three-fourths the size of Connecticut, and is comprised of a narrow coastal plain; the Bekaa Valley separates Lebanon and the Anti-Lebanon Mountains. Bordered by Israel (79 km) to the south and by Syria (375 km) to the east and north; the western side of the republic is the Mediterranean Sea (225 km). Lebanon has a territorial sea claim of 12 nautical miles, and the highest point in the country is Qurnat as Sawda' at 3,088 m. The League of Nations declared the republic independent of the French Mandate on 22 November 1943.

In 1799, Napoleon Bonaparte commenced his military campaign for the conquest of Egypt and "Upper Egypt" (the Palestine and Greater Syria). *La Carte d'Egypte et de Syrie* was published by the *Dépôt de la Guerre* beginning in 1808. The ersatz Datum was based on astronomical observations in Cairo and Jerusalem, and was referenced to the Plessis ellipsoid where the semi-major axis a = 6,375,738.7 m and the reciprocal of flattening $1/f$ = 334.29. Much of the coast was actually based on published British Admiralty charts of the time (see The State of Israel, *PE&RS*, August 2000). The projection was the ellipsoidal Bonne, the "standard" for France and most of Europe at the time. *"Le centre de la projection correspond à l'axe de la grande pyramide du Nord, à Memphis."* (The center of the projection corresponds to the axis of the great pyramid of the North at Memphis.)

The French *Expédition du Liban* (*1860-1861)* was made after the massacre of Christians in Syria (and Lebanon) occurred during the months of May and June of 1860. After enforcing the peace, one topographic brigade remained to perform some exploratory mapping. Some minor triangulation was performed from Tyre to Tripoli along the coast. This resulted in one reconnaissance sheet at 1:100,000 scale, and one 1:200,000-scale sheet being published in 1862.

The early maps of Turkey, including the Levant area, were on the Bonne projection also, but the projection origin was the finial of the dome of the Aya Sofia Mosque. The Ottoman Turkish ellipsoidal Bonne of Syria, used from 1909 to 1923 (and the territory of what is now Lebanon), had a projection Latitude of Origin (φ_o) = 28° 58' 50.8188" N and the Central Meridian (λ_o) = 39° 36' East of Greenwich. The geodetic network was calculated on the Clarke 1880 (IGN) ellipsoid where a = 6,378,249.2 m and $1/f$ = 293.4660208, and according to the *Service Géographique de l'Armée* (SGA), the Datum Origin was at the South End of the Base of Makri Keuî, near Constantinople (Istanbul). The 1:200,000-scale general map of Asia Minor was published in 1911 under the direction of General Mehmed Sevki Pacha, director of the Turkish Map Service. (In my column on Israel, I mistakenly referred to General Sevki as a Syrian officer.)

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The French established the *Bureau Topographique du Levant* in 1918, and after 1920, the chain of triangulation was extended eastward along the northern border of Syria with Turkey to Iraq. The French geodetic triangulation parties were quite impressed with the Bekaa Valley and the vast bounty of orange and banana harvests. Planimetric compilation was aided by aerial photography flown by a French military aviation squadron of the 39th Regiment. The Topographic Brigade was commanded by Lieutenant Colonel G. Perrier, and he organized the observations for the establishment of an astronomical origin for a datum in the Bekaa Valley of Lebanon that would serve Syria as well. The baseline was measured, and the South End of the Base at Bekaa was the fundamental origin for the astronomical observations. The Latitude of the pillar was observed by Captain Volontat in 1920 with a prismatic astrolabe where Φ_o = 33° 45' 34.1548" N. An azimuth was obtained at the same pillar with a microscopic theodolite by Captain Volontat, by observing Polaris at elongation. The direction was defined to a pillar constructed at the Ksara Observatory where α_o = 28° 58' 50.8188". Longitude was also observed by Volontat at the same observatory where Λ_o = 35° 53' 25.26" East of Greenwich. (The longitude was then geodetically transferred to the South End of the Bekaa Base).

In November of 1997, Colonel George Massaad, then the director of Geographic Affairs of the Lebanese Army, sent a photograph to me of the fundamental point at Bekaa South Base. The point is monumented by a stone pyramid that is over 2 m high, is approximately 2 m square, has an (apparently) bronze tablet describing the significance of the monument, is straddled by a great iron skeleton target obviously over 4 meters high, and the entire structure is enclosed by a formal iron fence! The monument recalls the aviation accident that took the lives of Captains Govin and Renaud of the Geodetic Section of the SGA on 15 July 1924 at Muslimié, near Aleppo. Shortly after WWII, the U.S. Army Map Service computed the coordinates of the origin of the Bekaa geodetic system on the New Egyptian Geodetic Datum as φ = 35° 45' 34.2205" N and λ = 35° 54' 36.4962" E. The geodetic coordinates of station Ksara are φ = 33° 49' 25.58" N and λ= 35° 53' 25.26" E. The Bekaa Valley Datum of 1920 is referenced

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to the Clarke 1880 (IGN) ellipsoid as previously defined. A check baseline was measured at Bab in Syria, and another astronomical position was observed (Laplace Station) where Φ_o = 36° 13' 48.77" N, Λ_o = 37° 30' 30.195" East of Greenwich, and the reference azimuth from Bab to Cheikh Akil signal is α_o = 179° 58' 33.152". The triangulation was computed on the Clarke 1880 ellipsoid, Levant Zone Grid, Lambert Conical Orthomorphic projection.

The Levant Lambert Zone (1920) is based on the French Army Truncated Cubic formulae where the developed meridional arc is expressed in series form and is truncated at terms higher than the cubic. Furthermore, another idiosyncrasy of the French Army formulae is that the Lambert (fully) Conformal Conic utilizes one of the principal radii of the ellipsoid called the Radius of Curvature in the Plane of the Meridian (ρ). The French Army instead substitutes the Length of the Ellipsoid Normal Terminated by the Semi-Minor Axis (υ). Although not strictly conformal, this is the system which was commonly used by the French in all their colonies (before WWII) that utilized the Lambert Conic projection. The Levant Lambert Zone, also known as the Syrian North Lambert Zone, has a Latitude of Origin (φ_o) = 34° 39' N and the Central Meridian (λ_o) = 37° 21' East of Greenwich. The Scale Factor at Origin (m_o) = 0.9996256 (secant conic) and the False Easting and False Northing = 300 km. The scale of the triangulation was governed by the two bases (Bekaa and Bab) which had an internal precision of one part in two million. In the case of the initial azimuth of the Bekaa Base, a large number of observations were made in order to determine the mean azimuth. The maximum range of the observations was 48" which does not represent good geodetic accuracy. Then a check azimuth, Latitude, and Longitude were measured at the Bab Base at Aleppo in Syria, and the differences from the geodetic values mathematically carried through the chain from Bekaa are as follows (Astronomic " Geodetic): $\Delta\varphi = -6.318''$, $\Delta\lambda = +10.789''$, and $\Delta\alpha = +21.125''$. Thus the SGA decided not to apply a Laplace correction to the azimuths, assuming the 21" was due to an error at the origin and not over the network. That 21" error was later verified by the U.S. Army Map Service (AMS), in the 1950s. AMS computed an azimuth between two stations in the area utilizing the geodetic coordinates of the station in terms of the European Datum Mediterranean Loop and the Bekaa Valley Datum values.

The Tripoli Lambert Grid of 1920 origin is based on the North End of the Tripoli Base where the Latitude of Origin (φ_o) = 34° 27' 04.7" N and the Central Meridian (λ_o) = 35° 49' 01.6" East of Greenwich. The Scale Factor at Origin (m_o) = 1.0 (tangent conic), and the False Easting and False Northing = zero. This quite obscure grid was probably used only for a hydrographic survey in the vicinity of Tripoli, and the South End of the Tripoli Base cartesian coordinates were published by the French as X = +1,257.02 m and Y = –1,197.29 m. Considering the tiny geographic extent of the survey, the Hatt Azimuthal Equidistant or the Roussilhe Oblique Stereographic equations would yield the same transformation results to cartesian coordinates.

In 1922, the *Travaux du Cadastre et*

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d'Amelioration Agricole des Etats, de Syrie,des Alaouites et du Liban sous Mandat Francais established the *Schema de la Projection Stéréographique* which was based on the Roussilhe Oblique Stereographic projection. The Latitude of Origin (φ_o) = 34° 12' N, the Central Meridian (λ_o) = 39° 09' East of Greenwich, the Scale Factor at Origin (m_o) = 0.9995341 (secant plane), and the False Easting and False Northing = zero. This grid has caused some consternation in the literature because attempts to substitute the fully conformal formulae of Paul D. Thomas' "Conformal Projections" fail to yield correct transformation results. In fact, the Roussilhe (Russell) formulae were developed by the Hydrographer of the French Navy in the late 19th century, and this is a common grid used on many hydrographic surveys by the French well into the 20th century.

The latest available transformation parameters from the Bekaa Valley Datum of 1920 to the WGS84 Datum are $\Delta X = -182.966$ m, $\Delta Y = -14.745$ m, and $\Delta Z = -272.936$ m. The mean planimetric error for these parameters is 5 meters. Example test point: Bekaa Datum Origin: φ = 33° 45' 34.1548" N, λ = 35° 54' 37.1188" E, and H = 870.513 m. WGS84 Datum coordinates of the same point are φ = 33° 45' 33.8602" N, λ = 35° 54' 40.6802" E, and h = 868.64 m. According to NIMA TR 8350.2, transformation parameters from the European Datum 1950 to WGS84 Datum are $\Delta X = -103$ m, $\Delta Y = -106$ m, and $\Delta Z = -141$ m for Lebanon.

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ASPRS has been requested by NIMA to publish the following notice for readers of the Grids & Datums Column.

NOTICE TO USERS

Regarding Local Datum Transformations and Geotrans Software

Local Datum Transformations

IMPORTANT NOTE: APPLICATIONS REQUIRING PRECISE POINT POSITIONS SHOULD NOT USE COORDINATES DERIVED FROM A DATUM TRANSFORMATION. USERS WITH HIGH ACCURACY REQUIREMENTS SHOULD CONTACT NIMA FOR ADDITIONAL GUIDANCE.

The National Imagery and Mapping Agency (NIMA) provides an official set of transformation parameters between local datums and WGS 84 in NIMA TR8350.2, Third Edition, 4 July 1997, entitled "Department of Defense World Geodetic System 1984, Its Definition and Relationships with Local Geodetic Systems." The parameters should only be used to transform local datum geodetic coordinates (j,l) to WGS 84 geodetic coordinates or vice-versa. Datum transformation parameters are available at the NIMA web site http://164.214.2.59/GandG/.

Wherever possible, error estimates with one-sigma (1s) uncertainties are included for each Dx, Dy, and Dz datum transformation component. These estimates do not include the errors of common control station coordinates that were used to compute the shift components. The estimates were assigned after careful consideration of datum transformation solutions and related geodetic information.

Transforming local datum coordinates to WGS 84 coordinates does not improve the accuracy of the transformed coordinates. In fact, transformed geodetic coordinates will be less accurate because the errors in the datum transformation are added to the errors in the original local datum coordinates.

Datum transformation parameters should only be used for the region for which they are specifically defined in NIMA TR8350.2, Appendices B and C. If there is a need for datum transformations outside their defined regions, contact the NIMA Customer Service numbers below.

GEOTRANS Software

GEOTRANS is the official software for datum transformation and coordinate conversion applications. The datum transformation error estimates output by GEOTRANS are only for guidance in assessing the limitations of the transformed information for a particular application.

Customer Service:

NIMA Geospatial Sciences Division (314) 263-4071, DSN 693-4071, gandg@nima.mil

NIMA Help Desk 1-800-455-0899, (314) 260-5032, DSN 490-5032, chdesk@nima.mil

For Crisis Actions Only:

NIMA Command Center (301) 227-7335, DSN 287-7335