Grand Duchy of Luxembourg

Included in the Roman Empire from 50 *B.C.*, Luxembourg was later a part of the Frankish kingdoms of Austrasia and of Charlemagne. According to the CIA's *World Factbook*, "Founded in 963, Luxembourg became a grand duchy in 1815 and an independent state under the Netherlands. It lost more than half of its territory to Belgium in 1839, but gained a larger measure of autonomy. Full independence was attained in 1867. Overrun by Germany in both World Wars, it ended its neutrality in 1948 when it entered into the Benelux Customs Union and when it joined NATO the following year. In 1957, Luxembourg became one of the six founding countries of the European Economic Community (later the European Union), and in 1999 it joined the euro currency area."

Bordered on the south by France *(PE&RS*, January 2001) (73km), on the north and west by Belgium (*PE&RS*, October 1998) (148km), and on the east by Germany (138km), the Grand Duchy is comprised mostly of rolling uplands with shallow valleys and forms part of the plateau of Ardennes. There are uplands rising to low mountains in the north with a steep slope down to the Moselle basin flood plain in the southeast and is watered by the Sûre and Alzette rivers. The lowest point is the Moselle River (133 m) and the highest point is Buurgplaatz (559 m). Luxembourg is slightly smaller than Rhode Island and is completely landlocked.

J. Hansen produced maps at a scale of 1:50,000 between 1883 and 1906. During WWI, the British produced a series of topographic maps with the Nord de Guerre Zone shown by full lines. The French Nord de Guerre Zone (1914-1948) was based on the French Army Truncated Cubic Conic where the Latitude of Origin was $\varphi_o = 49°\ 30'\ 00"$, the Central Meridian was $\lambda_o = 7°\ 44'\ 13.95"$ East of Greenwich, the Scale Factor at Origin $(m_o) = 0.999509082$, the False Easting was 500 km and the False Northing was 300 km. The ellipsoid of reference was the Plessis Reconstituted where $a = 6,376,523.994$ m, and $1/f = 308.624807$. The datum used at the time was the New Triangulation of France (NTF 1887). The 1:50,000 scale series produced by J. Hansen and by the French Institut Géographique National (IGN) 1:50,000 and 1:100,000 series were expressed in degrees with longitudes referred to Paris ($\lambda_o = 2°\ 20'\ 13.95"$ East of Greenwich). The old IGN 1:20,000, 1:25,000, and 1:50,000 series *also* have coordinates in grads referred to Paris.

The national datum of Luxembourg (LUREF) was established in 1930 with its fundamental point (LaPlace astronomical point) at Habay-la-Neuve in Belgium, and the ellipsoid of reference is the Hayford International 1924 where: $a = 6,378,388$ m and $1/f = 297$. The Luxembourg Transverse Mercator grid was adopted in 1940 and uses the Gauss-Krüger equations where: the Latitude of Origin, $\varphi_o = 49°\ 50'$ N, the Central Meridian, $\lambda_o = 6°\ 10'$ East of Greenwich, the Scale Factor at Origin is unity, the False Easting = 80 km, and the False Northing = 100 km. The Administration du Cadastre et de la Topographie (ACT) offers a worked example: $\varphi = 49°\ 34'\ 17.60287"$ N, $\lambda = 5°\ 55'\ 50.69323"$ E; X (Northing) = 70,910.00 m, Y (Easting) = 62,935.00 m.

The National Luxembourg Height Datum, *Nivellement General du Luxembourg (NG-L)* has its initial reference point at Wemperhardt (near the northern border with Belgium) where the elevation is 528.030 m. This is based on the reference Tide Gauge at Pegel, Amsterdam. "The NG-L is based on geometric levelling *(sic)* only, it counts 3800 points which corresponds to a density of 1.8 points/km^2."

I wrote a letter of inquiry to the ACT in October, 1997 regarding the Luxembourg TM as well as the transformation parameters from LUREF to WGS84/EUREF89. Mr. Patrice Schonckert, Director of ACT, replied the same month and he verified that the projection parameters were unchanged, but that the datum transformation parameters were released "only to recognized users." The transformation parameters from LUREF to WGS84/EUREF89 are now public.

The Bursa-Wolfe Transformation Model: $\Delta X = -192.986$ m, $\Delta Y = +13.673$ m, $\Delta Z = -39.309$ m, $R_x = 0.4099"$, $R_y = 2.9332"$, $R_z = -2.6881"$, and Scale Factor = 0.43 ppm. Although the International Association of Geodesy (IAG), the *Bundesamt für Kartographie und Geodäsie* (German Federal Office for Cartography and Geodesy), and Eurographics publish the parameters also, they use the European sign convention for rotations which is *opposite* from the United States (and Australian) standard. To my surprise, the Luxembourg government (ACT) publishes their parameters above with the United States standard!

Curiously, ACT also uses the American standard rotation convention for the Molodensky-Badekas model: $\Delta X = -265.983$ m, $\Delta Y = +76.918$ m, $\Delta Z = +20.182$ m, $R_x = 0.4099"$, $R_y = 2.9332"$, $R_z = -2.6881"$, and Scale Factor = 0.43 ppm, and the Rotation Origin is: $X_o = 4,098.647.674$ m, $Y_o = 442,843.139$ m, and $Z_o = 4,851,251.093$ m. Since the Molodensky-Badekas model is usually employed (by me) when the datum origin or fundamental point is in another country or at a great distance away from the region of interest, I transformed the rotation origin geocentric coordinates to geodetic coordinates with the expectation that I would obtain the coordinates of Habay-la-Neuve in Belgium. No such luck; the rotation origin offered by ACT is merely the projection origin of the Luxembourg TM grid.

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