& GRIDS & DATUMS

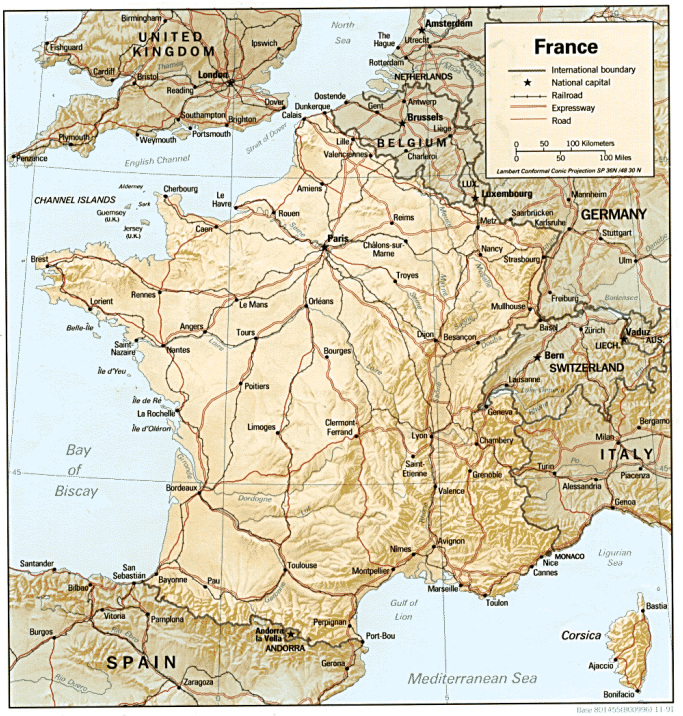
THE FRENCH REPUBLIC

BY Clifford J. Mugnier, CP, CMS, FASPRS

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 French Republic was originally printed in 2001 but contains updates to their coordinate system since then.

The French Republic, originally known in the south as *Gallia Narbonensis*, was a province of the Roman Empire from 121 BC. The north and central parts, known as Gaul, were conquered by Julius Caesar from 58-51 BC. In 1789, the French Revolution overthrew the Royal government, and tumultuous times continued for over 100 years, including the reign of Napoleon Bonaparte and his First Empire. The northern part of the Republic was ravaged by fighting in World War I (1914-18), then conquered and controlled in World War II (1940-44) by the Germans. The Fourth Republic was established in 1945, and the Fifth Republic in 1958. President Charles de Gaulle resigned in 1969 following defeat of a referendum on constitutional reforms.

The Dépôt de la Guerre, established in 1688, was responsible for all military surveys. When the English scientist Sir Isaac Newton suggested that the shape of the Earth was an oblate ellipsoid, France countered that Cassini's triangulation showed that the Earth was a prolate ellipsoid. France sent expeditions to Stockholm and Quito that only served to prove the Englishman's theory correct! (See Grids and Datums of Ecuador, *PE&RS*, May 1999). The first published ellipsoid was by Bouguer and Maupertuis in 1738, as a result of their historic expeditions. During the Napoleonic Wars, Cassini was the first topographer to utilize a grid overprint on a topographic map for the "coordinated" control of artillery fire. In apparent deference to the great German cartographer, Cassini chose the Bonne equal-area projection. That projection choice, also for France's first major topographic map series of 1818-1887, influenced the rest of the world for over a century with the Carte de l'État-major au 1:80,000. The Old Triangulation of France Datum of 1818 was referenced to the DeLambre ellipsoid where the semi-major axis (a) = 6,376,985 meters and the reciprocal of flattening ($^1/_f$) = 308.64. The Carte de l'État-major Latitude of Origin is φ_o = 45° 10′ 00″, and the Central Meridian is λ_o = 2° 20′ 13.95″ East of Greenwich in today's convention - but was actually zero at the time. The French considered Paris as the Prime Meridian for the world, and many other countries agreed. The French Navy began publishing the *Annals Hydrographiques* in 1844 that contained latitude and longitude coordinates of stations observed astronomically worldwide, as well as details on local datums that had been established. That first tome has an amusing passage regarding the "friendly natives" encountered in an expedition to Tahiti – not all was geodesy and hydrographic surveying!



During the second half of the 19th century, France was the epicenter of mathematical cartography in the world. Tissot and Germain published their monumental works on projec-

Photogrammetric Engineering & Remote Sensing
Vol. 85, No. 1, January 2019, pp. 13–15.
0099-1112/18/13–15

doi: 10.14358/PERS.85.1.13

tions, and the Service Géographique de l'Armée was founded in 1887. The New Triangulation of France commenced in 1887 (NTF 1887), and the small-scale Dépôt de la Guerre (Carte de l'État-major) map series was continued until 1915 on the Bonne projection. Germain developed his Projection of Minimum Deformation, and it was chosen for the new large-scale topographic map series based on the NTF 1887. The ellipsoid of reference was the modified DeLambre 1810, or Plessis Reconstituted, where the semi-major axis (a) = 6,376,523.994 meters and the reciprocal of flattening ($^1/_f$) = 308.624807.

During this time, the French were developing a philosophy of categorizing map projections. This penchant, when combined with another factor, created some curious developments. Since logarithms were the universal tool for hand computations, great algebraic effort was made to simplify equations whenever possible. With numerical techniques being practically restricted to expressions in the form of infinite series, equations were always truncated to only yield the necessary computational precision. Extra digits were too expensive in terms of labor to waste on niceties. The tables of equations for the different categories of map projections showed terms only to the third power, the cubic. When Germain's Projection of Minimum Deformation was truncated to the cubic, it became identical to the Lambert Conformal Conic when truncated to the cubic. Since the late Heinrich Lambert was senior to Germain, the former's name was given to the new projection adopted for the new large-scale map series. The French tables were computed with the Lambert Conformal Conic projection of the developed meridional distance formulae truncated to the cubic term. This did not result in a strictly conformal projection, but it was deemed close enough at the time. This convention for the French Army Truncated Cubic Conic was also applied for decades to practically all of the French colonies, including Syria, the Levant or Palestine (*PE&RS* August 2000), Morocco (*PE&RS* June 1999), Algeria, Tunisia, and French Indochina (Laos, Cambodia, and Vietnam).

When the officers of the French Army fled France after the Kaiser invaded their country, they carried many of their surveys and map manuscripts to London. The United States commissioned some mathematicians and geodesists with the Coast Survey into the Corps of Engineers and sent them to London to assist the Royal Engineers and the French. Upon arrival, they noticed the scarcity of the Tables of Projection for the northern war zone (Nord de Guerre), and sent one copy back to Washington for tabular extension and duplication. In Washington, it was noticed that the documented formula was truncated at the cubic term. They apparently decided to develop tables that not only had greater latitudinal extent, but they also decided to use more terms for the developed meridional distances. Shortly after a group of mathematicians was assigned to perform the task, others at the Coast Survey decided that it was a nifty idea to use a conformal projection for a basis of survey computations. Another group was assigned to perform the same task, but instead of using the Plessis ellipsoid for the Nord de Guerre Zone of France, they used the Clarke 1866 ellipsoid for the United States. Computations for both tables were completed at the same time, and both manuscripts were sent to the Superintendent of Documents at the same time. When the printing office sent the crates of tables back to the Coast Survey, the wrong crate was shipped to London. After some consternation, the proper crate arrived, only to cause further consternation. The fully conformal tables for the Lambert Conformal Conic would not cast a graticule to match the existing Nord de Guerre Zone sheets based on the French Army Truncated Cubic Conic. The new tables were discarded, the Royal Engineers and the French Army Engineers "made do" with what they already had. **Moral: use the same projection formulas as the originating country uses. It is not "correct" unless it matches native work.**

The French Kilometric Quadrillage (AEF) of 1918 was based on the Fully Conformal Lambert Conic where the Latitude of Origin was φ_o = 49° 30′ 00″, and the Central Meridian was λ_o = 7° 44′ 13.95″ East of Greenwich, the Scale Factor at Origin (m_o) = 0.999509082, and both the False Eastings and False Northings were 500 km. The ellipsoid of reference was the Clarke 1866, and this Grid was never used. On the other hand, the French Nord de Guerre Zone (1914-1948) was used, and it was based on the French Army Truncated Cubic Conic where the Latitude of Origin was φ_o = 49° 30′ 00″, the Central Meridian was λ_o = 7° 44′ 13.95″ East of Greenwich, the Scale Factor at Origin (m_o) = 0.999509082, and the False Easting was 500 km and the and False Northing was 300 km. The ellipsoid of reference was the Plessis Reconstituted.

After WWI, the French developed four Lambert zones for the country. From 1920 to 1948, Zone I (Nord) parameters were where the Latitude of Origin was φ_o = 49° 30′ 00″, the Central Meridian was λ_o = 2° 20′ 13.95″ East of Greenwich, the Scale Factor at Origin (m_o) = 0.999877340, and the False Easting was 600 km and the False Northing was 200 km. The ellipsoid of reference was the Clarke 1880, where the semi-major axis (a) = 6,378,249.2 meters and the reciprocal of flattening ($^1/_f$) = 293.4660208. In France, for Zone II (Centre), the Latitude of Origin was φ_o = 46° 48′ 00″, the Central Meridian was λ_o = 2° 20′ 13.95″ East of Greenwich, the Scale Factor at Origin (m_o) = 0.999877419, and the False Easting was 600 km and the False Northing was 200 km. In France, for Zone III (Sud), the Latitude of Origin was φ_o = 44° 06′ 00″, the Central Meridian was λ_o = 2° 20′ 13.95″ East of Greenwich, the Scale Factor at Origin (m_o) = 0.999877501, and the False Easting was 600 km and the False Northing was 200 km. In France, for Zone IV (Corse) Corsica, the Latitude of Origin was φ_o = 42° 09′ 54″, the Central Meridian was λ_o = 2° 20′ 13.95″ East of Greenwich, the Scale Factor at Origin (m_o) = 0.999940004, and the False Easting was 600 km and the False Northing was 200 km. All four of these zones were based on the French Army Truncated Cubic Conic projection.

In 1940, the mapping agency was renamed the Institute Géographique National (IGN). The French government de-

clared, "C'est pourquoi il fut decide en 1948 de subsituer des formulas rigoureuses aux développements limités, en conservant les mêmes limites de zones et les mêmes modules d'homothétie." In other words, France went to the rigorous fully conformal formulae in 1948 for the Lambert Conic. Since then, only Algeria has deemed to do the same in the early 1960s, according to Roger Lott, the chief surveyor of British Petroleum. The other old French colonies, although now independent, still use the French Army Truncated Cubic. Some old colonies still consider Paris as the origin of longitudes (*PE&RS* February 2000). One caution for the U.S. practitioner: the French do not use degrees-minutes-seconds for angular measurement; they use Grads where $400^G = 360°$.

After 1948, the new French Lambert zones (I-IV) retained the same parameters as listed above for the Republic. Only the formulae changed. During that same era, the U.S. Army Map Service directed the recomputation of all the triangulations of Europe and the Mediterranean to the European Datum of 1950. Everything was sequentially tied to France (*PE&RS* October 1998, October 1999, and July 2000), and the unifying tool was the UTM Grid. France is covered by UTM zones 30-32 referenced to the EU50 Datum and the International ellipsoid where a = 6,378,388 m and $(1/f) = 297$.

IGN currently publishes their general national 3-parameter transformation from NTF to WGS84 as: dX = +168 m, dY = +60 m, dZ = –320 m.

Update

The IGN.FR (Institut Géographique National) now maintains a website[1], which describes how the country has a complete dense coverage[2] of public GPS Continuously Operating Reference Station (CORS[3]) sites, and IGN offers a free computational web page that accepts the user's choice of up to four National CORS sites to process with their own observations[4] in a manner somewhat akin to the U.S. National Geodetic Survey's Online Positioning User Service or "OPUS"[5] The IGN website is well-designed and covers practically anything a potential user could ask for regarding France proper as well as for all of its Overseas Territories.

1 http://www.ign.fr/. Accessed 12 Decmeber 2018.
2 http://rgp.ign.fr/. Accessed 12 Decmeber 2018.
3 https://www.ngs.noaa.gov/CORS/. Accessed 12 Decmeber 2018.
4 http://rgp.ign.fr/SERVICES/calcul_online.php. Accessed 12 Decmeber 2018.
5 https://www.ngs.noaa.gov/OPUS/. Accessed 12 Decmeber 2018.

The contents of this column reflect the views of the author, who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the American Society for Photogrammetry and Remote Sensing and/or the Louisiana State University Center for GeoInformatics (C[4]G).

This column was previously published in *PE&RS*.