

# Grids & Datums

## REPUBLIC OF SENEGAL

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

Senegal was part of the Ghana Empire in the 8<sup>th</sup> century and the Djolof kingdom in the area between the Senegal River and modern-day Dakar. The Toucouleur people, among the early inhabitants of Senegal, converted to Islam in the 11<sup>th</sup> century, although their religious beliefs retained strong elements of animism. The Portuguese had some stations on the banks of the Senegal River in the 15<sup>th</sup> century, and the first French settlement was made at Saint-Louis in 1659. Gorée Island became a major center for the Atlantic slave trade through the 1700s, and millions of Africans were shipped from there to the New World. The British took parts of Senegal at various times, but the French gained possession in 1840 and made it part of French West Africa in 1895. Dakar was built as the administrative centre, and as early as 1848 Senegal had a (French) deputy in the French parliament. In 1946, together with other parts of French West Africa, Senegal became an overseas territory of France. On June 20, 1960, it formed an independent republic federated with Mali, but the federation collapsed within four months. Although Senegal is

(*Mission Hydrographique de L'Afrique Occidentale*) by *Capitaine de Frégate* M. Lebail. A survey of the Casamance River estuary near the southern border with Guinea-Bissau was controlled by a short triangulation base line of 323.003 meters measured from 23 February to 27 May of 1909. The origin of the Hatt Azimuthal Equidistant Grid was  $\Phi_o = 12^\circ 35' 05.10''$  N,  $\Lambda_o = 16^\circ 42' 47.45''$  West of Greenwich, no False Origin was used (*Jacob M. Wolkau, AMS memo 27 Oct. 1947*). In Dakar, an astronomic observation pillar was constructed near the Armory, and from astrolabe observations over four months, the latitude was determined to be:  $\Phi_o = 14^\circ 40' 40.6''$  N. An updated position for the 1903-1904 latitude of the old jetty was determined to be:  $\Phi_o = 14^\circ 40' 26.8''$  N. A baseline of 641.60 meters was measured, and a reference azimuth from the East Terminal of the Baseline to Signal Gorée was:  $\alpha_o = 137^\circ 14' 43.8''$ . Another Hatt Azimuthal Equidistant Grid was used for the hydrographic survey of Cape Vert, and the origin point was the West Terminal of the Baseline and no False Origin was used.

---

Thanks to John W. Hager, “the International Hydrographic Bureau published another list of coordinates in 1961, the France section included a number of points for Senegal. In 1977, the Canadian Hydrographic Service conducted a LORAN-C and SatNav-based survey off Senegal and The Gambia. The ‘Datum’ for the shore based LORAN-C stations was given as Clarke 1880!!”

neither a large nor a strategically located country, it has nonetheless played a prominent role in African politics since its independence. As a black nation that is more than 90% Muslim, Senegal has been a diplomatic and cultural bridge between the Islamic and black African worlds. Senegal has also maintained closer economic, political, and cultural ties to France than probably any other former French African colony (*InfoPlease, 2010*).

Slightly smaller than South Dakota, Senegal borders The Gambia (740 km), Guinea (330 km), Guinea-Bissau (338 km), Mali (419 km), and Mauritania (813 km) (*PE&RS, June 2009*). The lowest point is the Atlantic Ocean (0 m), and the highest point is an unnamed feature near Nepen Diakha (581 m) (*WorldFactbook, 2010*).

The earliest geodetic reference in Senegal is to the longitude of a light on the east jetty of Dakar in 1885 by telegraphic determination from San Fernando Observatory (Cadiz, Spain) by Bouquet de la Grye which also gave a position for a chimney at the Dakar dry dock. The earliest geodetic survey in Senegal seems to have been in the City of Dakar by Rounguer and Laurent, 1903-1904 where the origin (at the old jetty) was:  $\Phi_o = 14^\circ 40' 27''$  N,  $\Lambda_o = 17^\circ 25' 22''$  West of Greenwich. The next survey apparently was done by the French Navy in the 1909-1910 Hydrographic Mission to West Africa

The French 1922 report to the IUGG gave general details of their work up to then. An additional Astro position was determined at Saint-Louis:  $\Phi_o = 16^\circ 01' 31''$  N,  $\Lambda_o = 16^\circ 30' 23''$  West of Greenwich.

The 1930-1931 Hydrographic Mission of Saloum (*Mission Hydrographique du Saloum*) by *Lieutenant de Vaisseau Tromeur* was performed because of the steadily increasing shipping tonnage with the river port of Kaolack. A Hatt Azimuthal Equidistant Grid was used for the hydrographic survey of the Saloum River, and the origin point chosen was one earlier established by Lebail in 1910 where:  $\Phi_o = 13^\circ 51' 11.22''$  N,  $\Lambda_o = 16^\circ 45' 29.97''$  West of Greenwich was the South Terminal of the Saloum 1,102.8675 meter Baseline, and the reference azimuth was:  $\alpha_o = 001^\circ 25' 06.2''$ . A secondary coordinate system used an origin at the South Terminal of the 1,896.1760 meter Baseline at Diamniayo where:  $\Phi_o = 14^\circ 03' 19.36''$  N,  $\Lambda_o = 16^\circ 35' 13.00''$  West of Greenwich, and the azimuth from the South Terminal to the North Terminal was:  $\alpha_o = 047^\circ 25' 41''$ . All angles observed were with a WILD Heerbrugg Universal Theodolite, and to this date (1931), no mention of any ellipsoid of revolution was given for Senegal. However, in later memoranda of the French *Institut Geographique National (IGN)*, the use of the Clarke 1880 ellipsoid in all of French Africa was implicit.

continued on page 524

The definitive geodetic survey of Dakar was that of *Lieutenant de Vaisseau Bonin* as reported in *Annals Hydrographiques de 1937*. The origin was defined as the South Terminal of the Base of the Route d'Yof (*Terme Sud de la Base de la Route d'Yof*) where:  $\Phi_o = 14^\circ 43' 53.2''$  N,  $\Lambda_o = 17^\circ 29' 18.4''$  West of Greenwich, and the ellipsoid of reference was the Clarke 1880 using the specific French definition parameters where:  $a = 6,378,249.2$  m and  $1/f_f = 293.4660208$ . In *Wolkau, ibid*, "However, these geographics are not consistent with the geographics of *Gouvernement* as cited. The geographics of *Terme Sud de la base de la route d'Yof* that are consistent with these of *Gouvernement* are:  $\Phi_o = 14^\circ 43' 53.1''$  N,  $\Lambda_o = 17^\circ 29' 19.1''$  West of Greenwich. It appears that this inconsistency was noted by the French and corrected in their city plan of *Port Da Dakar*, but their published rectangular coordinates were not corrected. These positions are regarded as local UTM coordinates and made to refer to the 15<sup>th</sup> meridian which is central to UTM Belt 28." In 1938, Gougenheim densified the triangulation of Dakar, using the same Hatt Grid as Bonin, but with a False Easting = False Northing of 50 km.

In 1944, the U.S. Lake Survey, New York Office, Corps of Engineers published tables for the Senegal Belt on the Transverse Mercator projection. The ellipsoid of reference is the Clarke 1880 with the standard U.S. Army parameters being:  $a = 6,378,249.145$  m and  $1/f_f = 293.465$ . The latitude of origin is  $\phi_o = 13^\circ$  N, Central Meridian,  $\lambda_o = 16^\circ$  West of Greenwich, Scale Factor at origin,  $m_o = 0.99975$ , False Easting = 400 km, False Northing = 500 km, Limits of Belt North: Parallel of  $16^\circ$  N; East: Meridian of  $14^\circ$  West; South: Zero meter Northing line of Senegal Belt; West: Meridian of  $19^\circ$  West. A test point is provided where:  $\phi = 15^\circ 47' 39.616''$  N,  $\lambda = 14^\circ 02' 29.729''$  W,  $X = 609,817.26$  m,  $Y = 810,047.94$  m.

From October 1946 to August 1948, *Capitaine de Corvette M. Paul Bonnin* led the *Mission de Triangulation de L'A.O.F.* Utilizing WILD Heerbrugg T-2 and T-3 theodolites with Bilby towers, the triangulation party started about 30 km southeast of Dakar, and occupied a couple of existing triangulation stations named Tiao and Niangol. According to *Instruction N° 1312 S.G.C. de l'Institut Géographique National*, dated 12 December 1945, a new Grid was used to calculate the triangulation; *Fuseau Senegal*, the parameter of which were: latitude of origin,  $\phi_o =$  Equator, Central Meridian,  $\lambda_o = 13^\circ 30'$  West of Greenwich, Scale Factor at origin,  $m_o = 0.999$ , False Easting = False Northing = 1,000 km, and surprisingly the ellipsoid of reference was the International 1909 where:  $a = 6,378,388$  m and  $1/f_f = 297$ . Coordinates of these two points are: Tiao:  $\phi = 14^\circ 39' 32.270''$  N,  $\lambda = 16^\circ 59' 14.945''$  W,  $X = 624,488.42$  m,  $Y = 2,622,547.50$  m, and Niangol:  $\phi = 14^\circ 37' 28.384''$  N,  $\lambda = 17^\circ 09' 28.763''$  W,  $X = 606,046.48$ ,  $Y = 2,619,027.27$  m (*Annales Hydrographiques, 3<sup>e</sup> série, Tome vingt-et-unième, Année 1949, pp. 49-68*).

From 5 January 1949 to 12 May 1950, Mannevy densified Bonin's triangulation in the region south of Dakar, and used *Fuseau Senegal* as the Grid system for his computations and published coordinates.

On 20 September 1950, *SGC 1312* was rescinded by the *IGN* in Paris in favor of the UTM Grid for Senegal, using the Clarke 1880 (AMS version) as the ellipsoid of reference.

A detailed triangulation and hydrographic survey of the mouth of the Casamance River was performed from 17 February to 6 June 1951 and from 20 February to 20 March 1952, led by M. Alain Le Fur. Astro station Djogué (in the vicinity of the Djogué Lighthouse), was observed with an astrolabe, and the final coordinates were:  $\Phi_o = 12^\circ 34' 14.5''$  N,  $\Lambda_o = 16^\circ 44' 28.5''$  West. The triangulation was computed and

published on *Fuseau Senegal*. From 1 October 1953 to 1 November 1954, M. Albert Sauzay, Principal Hydrographic Engineer performed a survey of the Saloum River in a continuation of Bonin's work and Sauzay continued with computations and publication of his Trig List on the *Fuseau Senegal* Grid.

Re-observed in 1958, Astro station Djogué was updated to  $\Phi_o = 12^\circ 34' 14.3''$  N,  $\Lambda_o = 16^\circ 44' 25.5''$  West, and was re-published on the UTM Grid, Zone 28 by M. Jean Bourgoïn, Principal Hydrographic Engineer (*Mission Hydrographique de la Côte Ouest d'Afrique*). The local hydrographic survey of the mouth of the Saloum River was a continuation on the local Djogué Datum, Clarke 1880 ellipsoid. From January to March of 1960, M. André Comolet-Tirman extended a triangulation traverse from the Saloum River to the border with Gambia. Published in UTM coordinates, Zone 28, the Djogué Datum origin was updated again to:  $\Phi_o = 12^\circ 34' 14.7''$  N,  $\Lambda_o = 16^\circ 44' 25.5''$  West,  $X = 310,918.9$  m,  $Y = 1,390,166.1$  m.

In January 1962, M. Antoine Demerliac measured a baseline in the city of Thiès, east of Dakar. The average of 4 invar measurements was 3,710.5040 meters. This compared favorably with a Tellurometer measurement of 3,710.5093 meters (*Annales Hydrographiques, 4<sup>e</sup> série, Tome quatorzième, Années 1967-1968*).

Thanks to John W. Hager, "the International Hydrographic Bureau published another list of coordinates in 1961, the France section included a number of points for Senegal. In 1977, the Canadian Hydrographic Service conducted a LORAN-C and SatNav-based survey off Senegal and The Gambia. The 'Datum' for the shore based LORAN-C stations was given as Clarke 1880!!" In a note from Mr. Russell Fox of the Ordnance Survey, Southampton to Mr. Malcolm A. B. Jones of Perth, Australia of 7 December 1999, "I believe that Yoff 200 and Point 58 datums were IGN adjustments of the Senegal-Mali section of the 12<sup>th</sup> Parallel Survey. Yoff 200 was used in the Senegambia adjustment, linking the Senegal and Gambia trig networks. Adindan Datum itself was the US DMA adjustment of the entire 12<sup>th</sup> Parallel survey. I believe the main Senegal Datum is Dakar-Hann IGN 1952, using Clarke 1880 (SGA-IGN) spheroid." In a related note from Mr. Jean-Pierre Pirat of the French IGN to Mr. Malcolm A. B. Jones later that month, "The geodetic Systems that one finds in Senegal were established during the measurement of the geodetic advance of the 12<sup>th</sup> parallel in 1968 (Senegal-Sudan crosses). They are composed of the Adindan system as you say it in your message, but also Yoff datum and Point 58 datum. Yoff (or Yoff-200 datum): the datum is the astronomical point of Yoff (n°200 in the repertory of the 12<sup>th</sup> Parallel), spheroid Clarke 1880. Adindan datum: the datum is the astronomical point of Adindan located as the border Sudan-Egypt, spheroid Clarke 1880. It is the system retained for the international geodetic connections. The parameters of passage (datum shifts) of these local systems towards World System WGS84 are respectively: Yoff-200 towards WGS84:  $T_x = -31$ ,  $T_y = +173$ ,  $T_z = +90$ ; Adindan (Senegal) towards WGS84  $T_x = -128$ ,  $T_y = -18$ ,  $T_z = +224$ , Point 58 towards WGS84: no comment."



*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<sup>2</sup>G).*