The Portuguese discovered the island of Madagascar in 1500, which was in the same era as their explorations of the entire eastern coast of Africa. The French established some colonial stations temporarily in the 17th century, and re-established their presence in the 18th century. The local native Hovas group signed a treaty with France in 1868, and France declared that Madagascar was a French protectorate in 1882. The French reorganized the administrative system of Madagascar in 1924 and independence was achieved in 1960.

Madagascar is the fourth largest island in the world; its length is almost 1,600 km (995 miles) and its maximum width is 576 km (360 miles). Tsaratanana Massif in the northern part of Madagascar is the highest point at 2880 m (9449 ft). The island is obliquely oriented to the cardinal directions on a northeast to southwest angle, and this fact has had a whopping affect on the development of mathematical cartography for the island. The centrally located capital of the Republic of Madagascar is Antananarivo, and other major cities include Tolitara in the south, Mahajanga in the northwest, Antsiranana in the north, and Toamasina in the east. The port of Hell-Ville is on the island of Nosy Bé off the northwest coast.

Original survey observations were performed by Owen of the British Royal Navy in 1824-25, and French Navy observations followed in 1830 and 1850. Geodetic triangulation for a hydrographic survey of the Bay of Diego Suarez was commenced by Colonial Engineer M. Grégoire in 1887. The baseline was measured for a length of 1,044.295 meters, and a repeat measurement differed by a millimeter. This is typical quality for the French in the late 19th century. The Antsiranana Datum of 1887 was established at the Antsiranana pillar where: \( \Phi_o = -12° 16’ 25.5” \) South, \( \Lambda_o = 46° 57’ 36.2” \) East of Paris. The defining azimuth was determined from Antsiranana to signal station Oronjia as: \( \alpha_o = 79° 12’ 19” \). Antsiranana 1887 Datum is referenced to the Clarke 1880 ellipsoid where \( a = 6,378,249.145 \) meters, and \( 1/f = 293.465 \).

French Navy observations followed in 1887 where: the Central Meridian, \( (\lambda_o) = 46° 55’ 34.669” \) East of Paris, the Latitude of Origin, \( \phi_o = -12° 16’ \) 26.148” South, a False Easting of 80 km, and a False Northing of 30 km. Considering the coordinate precision reported, the International 1924 ellipsoid was presumably used where: \( a = 6,378,388.3 \) m, and \( 1/f = 297 \).

The Nosy Vé Datum of 1907 was established for the hydrographic survey of the waters off the port of Tuléar (Toliara) in southwest Madagascar. The origin is at the meridian pillar where: \( \Phi_o = -23° 39’ 00.20” \) South, \( \Lambda_o = 12° 16’ 44.2” \) East of Paris. The Hellville 1888 Datum and the Hatt Azimuthal Equidistant Grid also used the quadrant system.

In 1926, the Hellville 1888 Datum was re-defined in terms of longitude where \( \Lambda_o = 48° 16’ 28.95” \) (“1.5”) East of Greenwich. Presumably, this change was identified as the Hellville Datum of 1926. Although the original meridian pillar was gone, the new origin was observed to have the coordinates of \( X = -28.1 \) m, \( y = -2.6 \) m (note: \( X, y \ s.i.c. \)).

In 1928 Laborde, a colonel in the French artillery, wrote that the Bonne projection chosen for the Service Géographique de Madagascar was as bad a choice as it had been for France. “Beginning in 1924, the defects of the Bonne Projection became totally inconvenient for use on the first part in geodetic work for the calculation of geodetic coordi-
nates on the ellipsoid, and on the other part the rectangular topographic surveys accumulated a substantial error. In 1925, regions quite removed from the Bonne Axis of projection, notably the delta region of Mangoky in the southwest part of Madagascar, attained errors of 22' for angles and ±1/580 for lengths. It was decided to find another solution urgently so that the quality would not be compromised for the survey campaign of 1925. Pressed for time, a local provisional projection was adopted in which the distortions were practically negligible within the region of application. Furthermore, difficulty was encountered in recruiting specialized personnel, and in 1926, the triangulation operations were constrained for lack of officers. Since training had to be furnished to the personnel because of the isolation of the survey parties do to the topography; the field calculations had to be simple to employ and therefore rectangular coordinates were used. Since the Bonne Projection was useless, provisional local coordinates systems were improvised. Between 1925-26 four local projections were put into service based on the Gauss Conformal Projection. (Ed. note: The actual math model used for all four was the Gauss-Schreiber Transverse Mercator.) The Laborde Projection, adopted in 1926, was put into full use for the reduction of the calculations of the 1926 geodetic survey campaign and for the topographic survey campaign of 1927."

The Laborde Projection is a triple conformal projection, designed to have two lines of zero scale error oblique to the meridian. The projection of the ellipsoid onto the plane is carried out in three steps; the first is the projection of the ellipsoid on the sphere. The second step is a Gauss-Schreiber Transverse Mercator projection of the sphere onto a cylinder that is symmetrically secant about the central meridian of the projection. The third step in forming the Laborde Projection is a conformal distortion of the plane through a rotation in the secant case. Beginning with the first step (the conformal projection of the ellipsoid on the sphere), Laborde followed Gauss. Gauss showed that the ellipsoid could be mapped conformally on the sphere in such a way that the distortions in the neighborhood of some chosen point are of the third order or higher. Also note that the indirect or double projection through the sphere is not exactly the same as the direct one in that they differ concerning the higher order terms of the expanded transformation formulae. The conformal projection of the ellipsoid on the
sphere was used by the Prussian Land Survey in 1876–1923 as the foundation for a double projection, and it is currently used in computations for cadastral retracement. This triple projection of Laborde’s, using the Gaussian Sphere to achieve an Oblique Mercator, is fundamentally different from the method used some 20+ years later by Brigadier Martin Hotine of the UK. Most commercial software houses that I have noticed are abysmally ignorant on this point. (I’ll grousse on this later.)

In reference to the four provisional coordinate systems mentioned earlier by Laborde, he later commented on the relation of these local systems to the Laborde Projection. His discussion referred to the local systems to the Laborde Project of Madagascar. After John diddled a while with trying to see how close the Hotine Rectified Skew Orthomorphic (RSO) Oblique Mercator would fit, he concluded that he could match my transformations to only “about 0.08 meters for my part of Madagascar … worse of course away from the island.” This approximation is of interest for U.S. Geological Survey medium scale cartographic applications, but it is useless for geodetic work and for large scale engineering mapping. I have seen examples of much (apparent) hand wringing done by software organizations (U.S. and elsewhere), that have attempted to foist this sort of “work-around” on government agencies in Madagascar. The Grid is commonly used at great distances from the mainland because of the existence and official publication of a False Easting at False Origin!

The RSO is not a valid substitute for the Laborde of Madagascar.

The U.S. National Imagery and Mapping Agency (NIMA) publishes a parameter set for transforming from the Madagascar Datum of 1925 (“Tananarive 1925”) to WGS 84 Datum. However, they offer no information on accuracy of, or the origin of, the parameters. I tried a nine point solution and I obtained slightly different results as:

$$ΔX = -191.745 \text{ m}, ΔY = -226.365 \text{ m}, \text{ and } ΔZ = -115.609 \text{ m}.$$  

The resultant rms for Latitude is 0.215 m, for Longitude is 0.323 m, and for ellipsoid height (h) = 9.958 m. The WGS 84 Datum observed coordinates for Morondava are: $ϕ = -20° 17’ 34.2443” \text{ South, } λ = 44° 16’ 52.6884 \text{ East of Greenwich,}$

Northing $= 174896.590 \text{ m}$, and Westing $= 644433.000 \text{ m}$. (H = 31.421 m).

Back in September of 1992, the late John P. Snyder asked for a copy of my 1982 stuff on the Laborde Projection of Madagascar. After John diddled a while with trying to see how close the Hotine Rectified Skew Orthomorphic (RSO) Oblique Mercator would fit, he concluded that he could match my transformations to only “about 0.08 meters for my part of Madagascar … worse of course away from the island.” This approximation is of interest for U.S. Geological Survey medium scale cartographic applications, but it is useless for geodetic work and for large scale engineering mapping. I have seen examples of much (apparent) hand wringing done by software organizations (U.S. and elsewhere), that have attempted to foist this sort of “work-around” on government agencies in Madagascar. The Grid is commonly used at great distances from the mainland because of the existence and official publication of a False Easting at False Origin!

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