THE KINGDOM OF SPAIN

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The Greeks and the Phoenicians settled Spain on the southern and eastern coasts. The Mediterranean coastal region was ruled by Carthage, which ceded it to Rome in 201 *B. C.* Invaded by Vandals in 409 *A. D.*, the Muslims of North Africa conquered Toledo from 711-719. The last of the Moors were expelled from Granada in 1492. Spain occupies the greater part of the Iberian Peninsula, and the Kingdom claims the Balearic and Canary Islands. Most of the peninsula is plateau – averaging 1,250 meters (4,100 feet).

Spain's cadastre began in 1854, but the Law of Cadastre established the way to perform the work in 1906. This was essentially a rural method for taxation until 1964 when urban areas of the Kingdom were brought into the cadastre.

The Spanish first-order triangulation of 1858-1885 consists of ten principal arcs: the meridional arcs of Salamanca, Madrid, Pamplona and Lerida; the parallel arcs of Palencia, Madrid and Badajoz; and the diagonal arcs of the North, East and South coasts. The origin of the Madrid Observatory Datum of 1853 is Φ_o = 40° 24' 29.70" North (after 20 years of observations), Λ_o = 03° 41' 14.546" West of Greenwich. The defining azimuth was determined from the observatory to station Hierro as: α_o = 154° 31' 06.90" *from south*, and is referenced to the Struve 1860 ellipsoid where a = 6,378, 298.3 meters, and 1/f = 294.73. However, the Spaniards did not use Greenwich as a Prime Meridian at the time; they used Madrid. Every country in Europe used their own Royal Observatory as their national prime meridian back then. The original triangulation comprised 235 triangles, which was observed with Repsold, Pistor, Brunner and Kern theodolites. A polyhedric system of projection has been reported for the early topographic maps. In 1875, the Spanish Military adopted the Lambert Conformal Secant Conic Grid that has a Latitude of Origin (ϕ_o) = 40° 00' North, a Scale Factor at Origin (m_o) = 0.9988085293 and a Central Meridian (λ_o) = 03° 41' 14.546" West of Greenwich. The False Northing and False Easting were both equal to 600 km. That Grid is still in use. However, in 1880, the Military adopted a Bonne projection for the Itinerario Militar (military route map) with a Latitude of Origin (ϕ_o) = 40° 45' North, a Scale Factor at Origin (m_o) = 1.0 and a Central Meridian (λ_o) = 04° 26' 14.55" West of Greenwich. That Bonne base remained in use until 1951 when the UTM was adopted for all military applications in Spain.

During World War II, the Iberian Peninsula Lambert tangent Zone was used by the Allied Forces. This Grid had a Latitude of Origin (ϕ_o) = 40° 00' North, and a Central Meridian (λ_o) = 03° 41' 14.546" West of Greenwich. The False Northing = 600 km, and the False Easting = 530 km. A later triangulation densification in 1930-33 was observed with Wild T3 theodolites. During the war, the Germans developed a series of computations for the Spanish Triangulation Network referenced to the Clarke 1880 ellipsoid. After the war, those German tables were useful in the re-computation of the classical triangulation of the Kingdom onto the European Datum of 1950 (ED50) which was referenced to the International Ellipsoid. The subsequent transformation of the Spanish Net to ED50 was based on a two-step two-dimensional Helmert transformation. The initial step computed by the Axis (Germans) was still on a Lambert Conformal Conic projection, but referenced to the Clarke 1880, which was the standard for France. That series of collocated points that started computations in the Pyrenees Mountains was continued into a substantial portion of the Iberian Peninsula. After the war, the U. S. Army Map Service decided that the best way to merge the Madrid Observatory Datum of 1858 into the new ED50 was to use the existing German data as an intermediate step. In computing the new French datum values of the Spanish triangulation, use was made of the German adjustment of 1938. Values of the New Triangulation of France (NTF) were available for the following 11 Spanish triangulation stations: Forceral, Canigou, Licuses, Rouge, Cabére, Maupas, Anie, Orhi, Baigura, La Rune, and Biarritz. Computations to the Madrid Datum of 1858 were performed by V.U.K.A. 631 (April 1943) and by Kriegskarten und Bermessungsamt, Paris (August 1943).

Other Datums of Spain include San Fernando Observatory where: Φ_o = 36° 27' 54.6" North, Λ_o = 06° 12' 17.8" West of Greenwich. Another version of the same point is where: Φ_o = 36° 27' 41.52 North, and Λ_o = 06° 12' 19.5" West of Greenwich. This same point on the "Salamanca Datum" is: Φ_o = 36° 27' 54.65" North, and Λ_o = 06° 12' 18.00" West of Greenwich.

Pico de las Nieves Datum of 1934 in the Canary Islands is where the origin is: Φ_o = 27° 57' 41.273" North ±0.130", and Λ_o = – 15° 34' 10.524" West of Greenwich ±0.380". The defining azimuth was observed to station Iselta as: α_o = 212° 34' 48.30" *from south*, and the elevation is 1949.14 m. It is referenced to the International ellipsoid of 1909 (Madrid 1924) where a = 6,378,388 meters and the reciprocal of flattening (1/f) = 297. Also found on the Canary Ise Abona Datum that is referenced to

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the International 1909 ellipsoid. The origin of that Datum is: Φ_o = 28° 08' 22.93" North ±0.102", and Λ_o = – 16° 25' 01.92" West of Greenwich ±0.105". The defining azimuth was observed to station Roja as: α_o = 221° 48' 27.48"", and the elevation is 16.82 m. The Royal Spanish "Servicio Geografico del Ejercito" (Army Map Service) Grid of 1945 for the Canaries is on the International 1909 ellipsoid. The Latitude of Origin (ϕ_o) = 28° 30' North, and a Central Meridian (λ_o) = –12° 00' West of Madrid (therefore, λ_o = –15° 41' 14.546" West of Greenwich). The Scale Factor at Origin (m_o) = 0.9999244799, and the False Northing (FN) and the False Easting (FE) = 400 km.

Interestingly, the British Grid system for the Canary Islands used during WWII by the Allies was also based on a secant Lambert Conformal Conic projection. The Latitude of Origin (ϕ_o) = 27° 00' North, and a Central Meridian (λ_o) = –17° 00' West of Greenwich. The Scale Factor at Origin (m_o) = 0.9993817, the False Northing (FN) = 100 km, and the False Easting (FE) = 200 km. This Grid was referenced to the Clarke 1880 ellipsoid presumably because the Canary Islands are so close to Africa. That ellipsoid is/was the (British) standard for that continent. (Some of the WWII-era British Grids were based on ersatz Datums "cooked up" for reasons of expediency during the war.)

The Balearic Islands in the Mediterranean Sea are said to be on the Madrid Datum of 1858, but I do not think that is true. Ten years later, station Mola was observed for the Balearic Islands Datum of 1868 where: Φ_o = 38° 39' 53.17" North, and Λ_o = +5° 13' 19.94" East of Madrid (therefore, +1° 32' 05.394" East of Greenwich). The longitude is also defined as –0° 48' 11.26" West of Paris, which leaves a discrepancy of 2.71" in Longitude between Greenwich and Paris. This is not a large error for an "Astro" shot done on an island in 1868, but it is quite large for the relation between two national observatories. The defining azimuth was observed to station Furnas as: α_o = 177° 39' 11.03" *from south,* and to station Camp Vey as: α_o = 160° 15' 40.48" *from south*. The elevation of Mola is 192.25 m, and, of course, the ellipsoid of reference is the Struve 1860.

NIMA lists the three-parameter datum shift from the European Datum 1950 (in Spain) to WGS84 as: ΔX = –84m ± 5m, ΔY = –107m ± 6m, ΔZ = –120m ± 3m, and is based on an 18-station solution.