

## The Portuguese Republic

Inhabited by late Stone Age people, many megalithic tombs date from 2500 BC. Portugal is one of the oldest nation states in Europe, and its foundation in 1139 predates Spain by nearly 350 years. The Romans arrived in 216 BC, and named the entire peninsula Hispania. However, the region between the Douro and Tagus Rivers was named Lusitania by the Celt-Iberian inhabitants. Later overrun by Germanic tribes and then by the Moors, eventually the kingdom of Portucale, comprising León and Castile, was declared independent by King Afonso Henriques. Portugal is slightly smaller than Indiana; it is mountainous north of the Tagus River, and has rolling plains in the south. With its only border being Spain to the east and north, the North Atlantic Ocean is on Portugal's west and south. Portugal holds sovereignty over the Azores and Madeira Islands; both archipelagos are strategic locations along the western sea with approaches to the Strait of Gibraltar. The highest point is Ponta do Pico on Ilha do Pico in the Azores at 2,351 m.

According to the Portuguese Instituto Geográfico do Exército (Army Map Service), in 1420, aware of the navigational importance of cartography, Prince Henry the Navigator commissioned the master cartographer Jácome of Majorca to teach apprentice cartographers in Portugal the art of preparing navigational charts. One of the oldest existing maps, thought to have been prepared by the cartographer Pedro Reinel, dates from 1500. Portuguese cartographers of the period were considered the most skilled in the world, their maps providing the most accurate representation of the Earth. Conscious of the importance of cartography in tackling the country's economic problems, Queen Mary of Portugal created the Royal Military Archive in 1802, in order to house the different national cartography departments. This body was the precursor of the Military Geographic Institute. At the end of the eighteenth century, having closely followed the progress of this science, it was the Portuguese military cartographers that established and developed the geodesic (*sic*) network in Portugal. Modern Portuguese cartography dates back to

1778 when work began on the first fundamental geodetic triangulation network, which lasted until 1848. The survey work for the 37 sheets which make up the Carta Geral do Reino (General Map of the Kingdom), also known as The Chorographic Map of Portugal, at a scale of 1:100,000, lasted from 1853 to 1892. Produced almost entirely by Army officers, the map series was awarded the "Lettre de Distinction" during the Paris International Congress of Geographic Sciences in 1875. Based on the Castello de São Jorge Datum in Lisbon, the ellipsoid of reference was the Bessel 1841 where  $a = 6,377,397.155$  meters and the reciprocal of flattening  $(1/f) = 299.1528128$ . The projection *de jour* in Europe at that time was the ellipsoidal Bonne, and for this series the Latitude of Origin ( $\phi_0$ ) =  $38^\circ 42' 43.631''$  N and the Central meridian ( $\lambda_0$ ) =  $9^\circ 07' 54.806''$  West of Greenwich. The scale factor at origin was equal to unity, and there was no False Easting or False Northing.

In 1881 the Army Staff Department published the Carta Itinerária da 1ª Divisão Militar (*Itinerary Map of the 1st Army Division*) at a scale of 1:250,000. In 1891 the Army Staff Department began work on the publication of the Carta dos Arredores de Lisboa (Map of the Outskirts of Lisbon) at a scale of 1:20,000. This was the first military topographic map, which later became known as the Map of Portugal. The ellipsoidal Bonne projection was used for this series also, and the Latitude of Origin ( $\phi_0$ ) =  $39^\circ 40' N$  and the Central meridian ( $\lambda_0$ ) =  $8^\circ 07' 54.806''$  West of Greenwich. The scale factor at origin was equal to unity, False Easting = 200 km and False Northing = 400 km. The two baselines were observed in 1886-1889, and were at Batel-Montijo and at Melriça.

In 1911 the Military Cartographic Section of the Army General Staff was created and continued the work on the Map of the Outskirts of Lisbon at 1:20,000 scale, and the Map of Portugal at 1:250,000 scale. Later, work was suspended on these two series during the restructuring process of the services which

started in 1926 and ended in 1932 with the creation of the Serviços Cartográficos do Exército (Army Cartographic Service).

The Regulatory Decree dated 24 November 1932 established the Serviços Cartográficos do Exército (SCE) (*Army Cartographic Service*) under the aegis of the Army Staff (EME), and the heirs of Portuguese cartographic traditions. The initial priority of the SCE was to publish the Military Map of Portugal, the Itinerary Map of Portugal, and other documentation necessary for the defense of Portugal. The first sheet, produced at a scale of 1:25,000, covered the Abrantes region. Thus, in 1937, the SCE adopted purely classical methods in their survey activities. From then on, photogrammetric processes were initiated, and by 1940 were exclusively used in medium-scale mapping.

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In 1995 the survey for the Military Map of Continental Portugal was completed at a scale of 1:25,000 with a total of 639 sheets. The Gauss-Krüger Transverse Mercator Grid was used for this series where the Latitude of Origin ( $\phi_0$ ) = the equator (by definition) and the Central meridian ( $\lambda_0$ ) =  $8^\circ 07' 54.862''$  West of Greenwich. The scale factor at origin was equal to unity, False Easting = 300 km, and False Northing = 200 km. This is based on the Castello de São Jorge Datum where  $\phi_0 = 38^\circ 42' 43.631''$  N and the Central meridian  $\lambda_0 = 9^\circ 07' 54.8446''$  West of Greenwich. The ellipsoid of reference is the Hayford 1909 or the International (Madrid) 1924 where  $a = 6,378,388$  m and  $1/f = 297$ . This series was then followed by the survey of the islands of Azores and Madeira with 51 sheets at the same scale. The Gauss-Krüger Transverse Mercator Grids for the islands of the Azores Archipelago are quite similar in that the parameters are  $\phi_0 = 0^\circ$ ,

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the scale factor at origin is equal to unity, False Easting = zero, and False Northing Latitude of Origin ( $\phi_{RN}$ ) = 38° 45' N. For Ilha de São Jorge, the Central Meridian ( $\lambda_o$ ) = 28° West of Greenwich; for Ilha do Faial,  $\lambda_o$  = 28° 42' W; for Ilha do Pico,  $\lambda_o$  = 28° 20'; and for Ilha Graciosa,  $\lambda_o$  = 28° W. For the Madeira Archipelago, the Ilha de Porto Santo Gauss-Krüger Transverse Mercator  $\phi_o$  = 0°, the scale factor at origin is equal to unity, False Easting = zero, False Northing Latitude of Origin ( $\phi_{RN}$ ) = 33° 03' 23.9412" N, and  $\lambda_o$  = 16° 20' 01.2304" West of Greenwich. For the Ilha de Madeira e Desertas,  $\phi_o$  = 0°, the scale factor at origin is equal to unity, False Easting = zero, False Northing Latitude of Origin ( $\phi_{RN}$ ) = 32° 45' N, and  $\lambda_o$  = 16° 55' West of Greenwich.

In the 1960s and at the outset of the 70s, various types of cartographic survey work were carried out. These included orthophoto and image maps of the former Portuguese territories in Africa (Angola, *PE&RS* March, 2002 and Moçambique, *PE&RS* September, 1999) and important photographic documentation taken dur-

ing combat in the last colonial war and today considered of extreme historical importance.

The complete survey of the Cape Verde archipelago at a 1:25,000 scale and with identical specifications to those of the Military Map of Portugal is also of particular importance. The said series is composed of 64 sheets, being concluded in 1980 under the terms of a cooperative agreement signed with the Republic of Cape Verde. The current existing cartography of the Republic of Guinea-Bissau at a scale of 1:50,000 and totaling 75 sheets was also produced by the Portuguese Army Cartographic Services. Aerial triangulation techniques became regularly used in the cartographic production chain from 1968 onwards. The year of 1974 saw the beginning of the systematic use of analysis and research with technical documentation related to computerized cartographic processes. In 1986, the SCE acquired an automated cartographic system.

The first GPS (Global Positioning System) receivers arrived at the SCE during the year 1992, and a marked improvement was witnessed in the speed, economy, and precision of survey work. In 1992 the research work on the building and design of the Geographic Information System (SIG) was started. The Serviço Cartográfico do Exército (SCE) became the Instituto Geográfico do Exército (IGeoE) (The Army Geographic Institute) on 01 July 1993 upon order of the Ministry of Defense, thus becoming the heir to the longstanding Portuguese military cartographic traditions. IGeoE became the organization responsible for the production of Military cartography under the aegis of the Logistic Command.

The Lisboa Datum to WGS84 Datum transformation parameters are  $\Delta X = -302.581\text{m} \pm 0.49\text{m}$ ,  $\Delta Y = -61.360\text{m} \pm 0.65\text{m}$ , and  $\Delta Z = +103.047\text{m} \pm 0.49\text{m}$ . The Datum 73 to WGS84 Datum transformation parameters are  $\Delta X = -223.116\text{m} \pm 0.11\text{m}$ ,  $\Delta Y = +109.825\text{m} \pm 0.15\text{m}$ , and  $\Delta Z = +36.871\text{m} \pm 0.11\text{m}$ . The European Datum of 1950 (EU50) to WGS84 Datum transformation parameters (my ten-point solution) are  $\Delta X = -85.858\text{m} \pm 0.19\text{m}$ ,  $\Delta Y = -108.681\text{m} \pm 0.26\text{m}$ , and  $\Delta Z = -120.361\text{m} \pm 0.19\text{m}$ . The National Imagery and Mapping Agency (NIMA) published a mean solution of 85 points in Europe that are  $\Delta X = -87\text{m} \pm 3\text{m}$ ,  $\Delta Y = -98\text{m}$

$\pm 3\text{m}$ , and  $\Delta Z = -121\text{m} \pm 5\text{m}$ . The Porto Santo Datum of 1936 for Ilha de Madeira to WGS 84 Datum parameters (my six-point solution) are  $\Delta X = -542.544\text{m} \pm 0.31\text{m}$ ,  $\Delta Y = -235.514\text{m} \pm 0.31\text{m}$ , and  $\Delta Z = +285.877\text{m} \pm 0.31\text{m}$ . NIMA published a two-point solution in 1991 where  $\Delta X = -499\text{m} \pm 25\text{m}$ ,  $\Delta Y = -249\text{m} \pm 25\text{m}$ , and  $\Delta Z = +314\text{m} \pm 25\text{m}$ . The São Brás Datum on Ilha São Miguel to WGS84 Datum parameters (my 4 point solution) are  $\Delta X = -203.584\text{m} \pm 0.26\text{m}$ ,  $\Delta Y = +96.902\text{m} \pm 0.26\text{m}$ , and  $\Delta Z = -62.965\text{m} \pm 0.26\text{m}$ . NIMA published a two-point solution in 1987 where  $\Delta X = -203\text{m} \pm 25\text{m}$ ,  $\Delta Y = +141\text{m} \pm 25\text{m}$ , and  $\Delta Z = -53\text{m} \pm 25\text{m}$ .

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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).