

## **Methodological notes on reference systems and cartographic projections used in the Atlas maps National of Spain**

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## 1 Reference systems

Thematic data represented on maps must be related to a coordinate reference system linked to three-dimensional reality. With the help of cartographic projections, the positions related to this system are transferred to a two-dimensional surface, such as paper or a flat screen. Thus, to obtain the map, both the coordinate reference system and a cartographic projection are required.

The choice of the coordinate reference system in Spain is officially recorded in Royal Decree 1071/2007, of 27 July, which regulates the official geodetic reference system. It adopts the ETRS89 system (European Terrestrial Reference System 1989) as the official geodetic reference system in the Iberian Peninsula and the Balearic Islands, and in the case of the Canary Islands, the REGCAN95 system (Geodetic Network of the Canary Islands 1995) is adopted.

However, in the National Atlas of Spain (ANE), the data sets that can be downloaded from the Download Center (see below) are delivered only in ETRS89 to facilitate their use in a single system. For cartographic purposes, it is possible to assimilate these Canary Islands data to REGCAN95. This means that the positions of the same real object in the Canary Islands area, referred to both ETRS89 and REGCAN95 systems,

There are differences, but they are not perceptible at the working scales used by the ANE (approximately between 1:3 000 000 and 1:150 000 000). Due to these differences and the modifications that the geometries undergo due to the cartographic generalisation inherent to these scales, this product is not compatible with high-precision applications.

For maps whose scope exceeds national boundaries, the coordinate reference system is compatible with WGS84 (World Geodetic System 1984), since much of the data is obtained from sources in that system. As in the previous case, they could also be assimilated to ETRS89 because ETRS89 and WGS84 are also compatible for cartographic purposes.

## 2 Cartographic projections and map scale

As regards the choice of cartographic projections, there are various possibilities in an Atlas, since the geographical scope is usually varied. In the case of the ANE, there is a clear orientation of the contents towards Spain, although some topics are also dedicated to the representation of the European, world or other more specific areas (although sometimes it is for purely educational purposes). Thus, the basic principles must be taken into account when making the selection: purpose of the map, scale of the final map and characteristics of the area to be represented: dimensions, shape and location on the globe.

The aforementioned Royal Decree states the following: "For basic and derived terrestrial cartography, at a scale equal to or less than 1:500,000, the ETRS-Lambert Conformal Conic coordinate reference system is adopted." And it makes sense, because the territory is slightly predominantly in the East-West direction and the geographic area is far from the Equator (with these characteristics, if it were close to the Equator, the Mercator projection could have simply been used). In addition, it allows all the data for the Peninsula and Balearic Islands to be represented in a single projection with simpler calculations, which offers greater performance for computer processing and is more direct and intuitive than if the UTM projection were used.

The use of the Lambert projection for national cartography in the ANE has been common since the first National Atlas in 1965, both for national and European cartography. Historically, various projections have been used, although in 2008 the projections currently used were formalized (Alonso JJ

*Cartographic projections in the maps of the National Atlas of Spain.* 2014.

Available in:

<http://www.ign.es/web/resources/docs/IGNCnig/ProyeccionesMapasANE.pdf>.

Specifically, a Lambert conformal projection is used for the Peninsula and the Balearic Islands and another for the Canary Islands in order to minimise deformations and thus avoid the need to use equivalent projections for maps of Spain. The preferred scale range for the use of this projection is 1:3 000 000 to 1:13 500 000.

However, for maps of Europe, working in a scale environment of approximately 1:14 000 000 to 1:45 000 000, the area to be represented is larger and the deformations in the extreme zones of the represented area are usually greater, so that sometimes a conformal Lambert projection is used and sometimes an equivalent one, depending on the data represented; specifically the Lambert EPSG:3034 and EPSG:3035 projections respectively (Annoni A. et al. *Map projections for Europe.* 2001. Available at:

<http://mapref.org/LinkedDocuments/MapProjectionsForEurope-EUR-20120.pdf>).

For example, a road map uses a conformal projection to get a better idea of the shape of the network, since it is important to maintain the directions relative to those that exist in reality. However, in a map of population density of countries, an equivalent projection is used because the data is tied to the area of those countries, and it is important that the map does not deform the surfaces (alter their values in the geometric drawing) according to their position on the globe, in order to better compare the density between different countries.

For world maps, the working scale range can be between approximately 1:60,000,000 and 1:150,000,000. In this case, the choice of projection is more complex, because there is no way to transfer the points of the ellipsoid to the plane in such a way that there are no deformations between reality and the plane. It is only possible to preserve the areas, or the directions, or the distances along some directions. Thus, when it comes to representing world data, it has been found more convenient to use projections that try to minimize the deformations in these three properties at the same time (aphylactic projections), in order to be able to establish better projections.

comparisons between different maps. The Winkel III projection is generally used in a similar way to that used by other international organisations.

The Van der Grinten I projection is gradually falling into disuse in the ANE, because it presents large deformations beyond the parallels 60° N and 60° S.

When it comes to continental geographical areas other than Europe, it is used the cartographic projection most appropriate to the specific purpose of the map and the characteristics of the area.

In many cases, regional data are also represented at scales greater than 1:3 000 000, such as 1:250 000 or 1:25 000. In these cases, the UTM projection is usually used (see RD 1071/2007).

### 3 Information for download at CNIG

Cartographic editing is usually carried out in the coordinate system established by the reference system used, ETRS89 or compatible with WGS84 (*geographic coordinates - without cartographic projection*). Only when dealing with grid data (raster), the coordinates in the system established by the cartographic projection are used directly (*projected coordinates*). These are the data made available to the user in the Download Center of the National Geographic Information Center (CNIG), in the products *Base Cartography of the National Atlas of Spain* and the product *Thematic Maps of the National Atlas of Spain*.

The ANE cartographic bases, as well as the reference systems used, are detailed in the product documentation available for download at CNIG:

#### ***Base cartography of the National Atlas of Spain (CartoBase ANE)***

Data:

<http://centrodedescargas.cnig.es/CentroDescargas/catalogo.do?Serie=CAANE#selecte>  
[dSeries](#)

Documentation:

<http://centrodedescargas.cnig.es/CentroDescargas/documentos/InformacionCartograf>  
[iaSIANE.zip](#)

The documentation provides a technical description of the cartography of the National Atlas Information System of Spain (SIANE).