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A System of Built-up, Building Height and Built-up Volume Layers for Spain -with regional, provincial and municipal statistics-

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WP-Ivie 2023-1

A System of Built-up, Building Height and Built-up Volume layers for Spain
—with regional, provincial and municipal statistics—

Francisco J. Goerlich[1]

Abstract

This work represents an effort to make accessible and manageable in a standard format, a common Coordinated Reference System and various resolutions, the information of the normalised Digital Surface Model of building heights for the whole of Spain -MDSnE2,5- distributed by the National Geographic Institute (IGN) and generated from the first nationwide LiDAR coverage.

From the original information we generate a series of layers in ETRS89-LAEA and different resolutions ranging from the original one, pixels of 2.5m x 2.5m up to 1km x 1km, which constitutes the standard European reference grid. All of them can be used for different analyses, depending on the objective of the work. In a way, this product represents the national version of the building height information from the Global Human Settlement Layer with global coverage, distributed by the Joint Research Center of the European Commission.

As a by-product, we obtain two other types of information consistent with the previous one. A built-up layer, which in its original resolution is binary, 1/0, depending on whether the pixel is considered occupied by a building or not, and which represents the percentage of the cell covered by buildings in lower resolutions layers. And a built-up volume layer, which combines the information from the built-up surface and the building height.

Keywords: LiDAR, raster data, built-up, building height, built-up volume.

JEL classification: R50

Resumen

Este trabajo representa un esfuerzo por hacer accesible y manejable en un formato estándar, un Sistema de Referencia Coordinado común y varias resoluciones, la información del Modelo Digital de Superficie normalizado de alturas de edificios para toda España -MDSnE2,5-distribuido por el Instituto Geográfico Nacional (IGN) y generado a partir de la primera cobertura LiDAR de ámbito nacional.

A partir de la información original generamos una serie de capas en ETRS89-LAEA y diferentes resoluciones que van desde la original, píxeles de 2,5m x 2,5m hasta 1km x 1km, que constituye la malla de referencia estándar europea. Todas ellas pueden utilizarse para distintos análisis, en función del objetivo del trabajo. En cierto modo, este producto representa la versión nacional de la información sobre la altura de los edificios de la Capa Global de Asentamientos Humanos con cobertura mundial, distribuida por el Centro Común de Investigación de la Comisión Europea.

Como subproducto, obtenemos otros dos tipos de información coherentes con la anterior. Una capa de edificación, que en su resolución original es binaria, 1/0, dependiendo de si el píxel se considera ocupado por un edificio o no, y que representa el porcentaje de la celda cubierto por edificios en capas de menor resolución. Y una capa de volumen edificado, que combina la información de la superficie edificada y la altura del edificio.

Palabras clave: LiDAR, datos raster, superficie edificada, altura media, volumen edificado.

Clasificación JEL: R50

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1.

Introduction

This work represents an effort to make accessible and manageable in a standard format, a common Coordinated Reference System (*CRS*) and various resolutions, the information of the normalised **Digital Surface Model** of **building heights** for the whole of Spain —MDSnE2,5— distributed by the National Geographic Institute (**IGN**), and generated from the first nationwide LiDAR —*Light Detection and Ranging*— coverage.

From the original information distributed by the **IGN**, and accessible in the **Download Centre**, we generate a series of layers in a single *CRS* —*ETRS89-LAEA*— and resolutions ranging from the original one, pixels of 2.5m x 2.5m up to 1km x 1km, which constitutes the standard European reference grid (**INSPIRE 2014**). All of them can be used for different analyses, depending on the objective of the work. In a way, this product represents the national version of the building height information from the ***Global Human Settlement Layer*** **(GHSL-H)**, with global coverage, distributed by the ***Joint Research Center (JRC)*** of the ***European Commission*** **(EC)**.

As a by-product, we obtain two other types of information consistent with the previous one.

On the one hand, a **built-up layer**, which in its original resolution is binary —1/0—, depending on whether the pixel is considered occupied by a building or not, and which represents the percentage of the cell covered by buildings in lower resolutions layers obtained by aggregation from the original binary layer. In a way, this product represents the national version of the ***European Settlement Map (ESM)***, with European coverage, or the built-up surface of *the* ***Global Human Settlement Layer*** **(GHSL-S)**, with global coverage.

On the other hand, a **built-up volume layer**, which combines the information from the built-up surface and the building height. We obtain a layer in the original resolution, 2.5m x 2.5m, and in all the lower resolutions as the previous layers. In a way, this product represents the national version of the built-up volume of the ***Global Human Settlement Layer*** **(GHSL-V)**, with global coverage[2].

The national product has higher initial resolution and, at the same time, we hope it has fewer errors, since the global products of the ***Global Human Settlement Layer*** are based on satellite images while the digital models of the **IGN** come from aerial orthophotographs and LiDAR sensors.

It should be noted that, although the first LiDAR coverage corresponds to the period 2009-2015, the second coverage —2015-2021— has already been completed, being pending, at the time of undertaking this work —October 2023—, the publication of this new information. Given that the process has been fully automated, as described be-

[2] The last version of the **Global Human Settlement Layer**, R2023, distinguishes between residential and non-residential buildings, this distinction is not possible without incorporating additional external information to the **IGN** digital surface models, and is therefore not incorporated in the present work. On the other hand, there is information in the **IGN** that may be more useful for this, such as the Spanish High Resolution Soil Occupation Information System 2017 (**SIOSEAR2017**).

low, the updating of the layers is (almost) direct, once the original information is available from the **IGN**.

The structure of the paper is as follows. Next, the original information is described, setting out some technical details and coverage. The third section details the processing of this information, which involves reprojecting the original raster files and the generation of a complete mosaic, initially maintaining the original resolution. This is followed by a description of the final layers produced, which are distributed in national files by variable and resolution[3]. Finally, regional and provincial statistics are offered as an example of use. A few brief comments conclude the work.

[3] All the generated information is freely available for download at https://zenodo.org/records/10171412.

2.

Original information: Digital building height models (2.5m x 2.5m)

The **National Aerial Orthophotography Plan (PNOA)** is a cooperative project involving the General State Administration and the Autonomous Communities. It began in 2004 with the aim of obtaining digital aerial orthophotographs of the entire Spanish territory, with a fixed updating period. In 2009, the LiDAR —*Light Detection and Ranging*— technology was incorporated into the **PNOA** project.

LiDAR is currently the technology that allows the most accurate capture of elevation information. Its development and consolidation throughout the 20th century has made it possible to obtain high quality information about the orography of the terrain. The fundamental objective of the use of LiDAR technology is the capture of three-dimensional information of the entire Spanish territory using airborne sensors, thus generating a series of products from this capture —cloud of points with coordinates—.

The derivative product used in this work, provided directly by **IGN**, is the **Digital normalized Surface Model** of the **building class** (MDSnE2,5) from the LiDAR information. It is a product in raster format that informs about the height above the ground of buildings, being a product of easier access, consultation and distribution than the original cloud of points.

Basically, from the LiDAR cloud of points we can derive two basic products. On the one hand, a **Digital Terrain Model**, which is simply a digital model referred to the terrain, without obstacles like trees or buildings. On the other hand, a **Digital Surface Model**, which is a digital model that represents the highest surface on the ground, that is, including obstacles, either of natural origin —vegetation— or artificial origin —buildings—.

Given that the **Digital Surface Model** can be classified according to different **classes**, for example, buildings or vegetation, it is possible to determine the height of these obstacles simply by taking the difference between the **Digital Surface Model** of a given class, buildings in our case, and the **Digital Terrain Model**. This difference is the **Digital normalized Surface Model** of the **building class** (MDSnE2,5), which represents the height of buildings above the ground.

The **Digital normalized Surface Model** of the **building class** used in this work correspond to the first LiDAR coverage, that took place between 2009-2015, with a minimum cloud density of 0.5 points/m^2 and a *Root Mean Square Error* in the Z coordinate ≤ 40 cm[4].

The information is distributed in the sheets of the National Topographic Map (MTN) 1/50,000 —MTN50—. An obsolete distribution system that involves handling more than 1,000 raster files in tif format[5]. The *CRS* is *ETRS89 —European Terrestrial Reference System 1989*— for the peninsula and the Balearic Islands, and *REGCAN95* for the Canary Islands, and *UTM —Universal Transverse*

[4] **Technical specifications**.

[5] Initially these were distributed as ASCII files, asc, known as **ESRI ASCII Grid** format, which does not include the *CRS* information, that has to be added after reading the file from the conventions in its name.

Mercator— projection in the corresponding zone, covering 29, 30 and 31 for the peninsula and the Balearic Islands and 28 for the Canary Islands[6].

In total we have 1,180 files, which correspond to as many sheets of the National Topographic Map (MTN). Some of them are redundant, since the sheets that are located between two zones are duplicated in the projections in both zones. Specifically, we have 46 duplicate files —corresponding to the same MTN sheet— as they are projected in the 29 and 30 zones, and 23 duplicate files —corresponding to the same MTN sheet— as they are projected in the 30 and 31 zones. There are therefore 69 redundant files that were not considered in the processing of the information. From a practical point of view, the files projected in zone 30 were taken in both cases. In addition, a file[7] has no information, as it contains no buildings, all values being missing. Consequently, **the unique files to be processed are a total of 1,110**, 30 files in *REGCAN95- UTM28*, 200 files in *ETRS89-UTM29*, 749 files in *ETRS89-UTM30* and 131 files in *ETRS89- UTM31*[8].

The **1,110 files to be processed cover the entire national territory** with the exception of the autonomous cities of Ceuta and Melilla, the island of Alboran —administratively belonging to the municipality of Almeria— and the African possessions —Perejil Islet, the Rock of Velez de la Gomera, the Rock of Alhucemas, the Islands of Alhucemas and the Chafarinas Islands—. In total we have just over 600 million pixels with building height values at a resolution of 2.5m x 2.5m[9]. Some of these values are negative[10], which makes no sense, and others are incredibly high, well over 250m, when the **tallest building in Spain** does not exceed that height. These values, which come from the automatic treatment of the LiDAR point cloud, and which curiously have not been filtered by the **IGN**, were treated in the processing of the information, as indicated in the following section.

The **original information** is **not masked by administrative boundaries**. Visual inspection of the border sheets shows pixels built in France. The **processed information** is also **not masked by administrative boundaries**, as it simply reprojects, merge and aggregates the original information. A precaution to be taken into account in the use of layers when results for specific administrative boundaries are desired, as shown in section 5.

[6] EPSG —European Petroleum Survey Group— codes are 25829, 25830 and 25831 for ETRS89 and UTM projection in zones 29, 30 and 31, and 4083 for REGCAN95 and UTM projection in zone 28.

[7] NDSM-Edificacion-ETRS89-H31-0669B-COB1.tif

[8] Two files were, however, in a different projection from the one in their nomenclature. These were file NDSM-Edificacion-ETRS89-H29-0001-COB1.tif, which should be projected in zone 29, but its reading indicated that it was in zone 30, and file NDSM-Edificacion-ETRS89-H31-0118B-COB1.tif, which should be in zone 31, but its reading indicated that it was in zone 30. A careful inspection of these files indicated that their resolution was not exactly 2. 5m x 2.5m, but somewhat higher, 2.504835m x 2.504835m in the first case and 2.501588m x 2.501588m in the second, so they are probably files reprojected from the zone given in their nomenclature to the zone obtained from their reading. In both cases, the correct projection was considered to be the one obtained from reading the file, and no modifications were made to them.

[9] Specifically, the 1,110 files processed contain 628,005,854 pixels with height values, representing 3,925km² of built-up area. However, since the distribution files have a certain degree of overlapping, the number of different pixels with height information is somewhat smaller.

[10] About half million points, which represents about 0.07%.

3.

Processed information

The process of generating a single national building height layer with 2.5m x 2.5m resolution and in *ETRS89-LAEA* from the original information requires the reprojection of the 1,110 downloaded raster files, originally in four different *CRS*, into a single *CRS* and their union into a single national layer.

It is widely known that there is no single way to reproject —or resample— a raster file. The process followed in this case was broadly known as warping by points (**Maffenini *et al.* 2023**) and consisted of the following steps[11]:

1. The original raster files were converted to point vector files —at cell center— and reprojected to *ETRS89-LAEA*[12].

2. The vector files were individually rasterized in the original resolution, 2.5m x 2.5m. Most pixels with height value only have a point from the vector layer, but in 2% of cases —about 12 million points— pixels accommodate two points of the vector information. In these cases the pixel value was averaged. In this step the negative height values were set to missing values, and values greater than 250m were truncated to that value[13].

3. Finally we make a mosaic by merging all the raster files from the previous step, averaging pixels when they overlap, and adjusting the extend of the final layer to the reference grid generated from the administrative contours (**Goerlich 2023a**)[14].

This is **our base layer**, which represents the **height of the buildings in a pixel of 2.5m x 2.5m**, a single *CRS* —ETRS89-LAEA— and full coverage of Spain, with strictly positive values in the interval (0, 250]. The height is expressed in meters. We name this layer Height_epsg3035_2.5m.tif. It has **588,149,113 pixels** with strictly positive height values and bounded above by 250m, representing **3,676km² of built-up area**, and an **average height of 6.9m**, approximately two floors. All other pixels in this layer are set to missing values.

All other information is derived from this base layer, that is simply the **Digital normalized Surface Model** of the **building class** —

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[11] Although the information was processed using the steps described below, all downloaded files —1,180— were reprojected —resampled— individually to ETRS89-LAEA using the nearest neighbor method. This includes duplicated sheets, between two zones, which are now available in the same projection. This information was not used in the generation of layers at the national level but is available from the **Ivie** upon request, in tif format files.

[12] They were saved in gpkg format —1,110 files—. This information is available from the **Ivie** upon request.

[13] After fixing negative values to missing values, the lower strictly positive values are ridiculously small to be considered building heights or constructions. In some cases less than 1cm, not even the 🐕 house! The message is that, probably, there is room for improvement in the sense of adapting the data to reality —for example by filtering all values below 1m or eliminating isolated pixels, since they represent a surface of only 6.25m², which can hardly represent a building— but it was decided to manipulate the original data as little as possible. Scripts allow, however, to make such modifications easily if necessary.

In this step we have 615,100,263 pixels with strictly positive height values and bounded above by 250m, representing 3,847km² of built-up area. These files were saved in tif format —1,110 files—. This information is available from the **Ivie** upon request.

[14] However, we don´t maks the data, neither by administrative contours, nor by the reference grid, only the extension of the layers is adjusted. **Goerlich (2023a)** derives a grid for Spain using European standards (**INSPIRE 2014**) and covering the contour of the whole country. The extension of the generated layers coincides, in all resolutions, with that of this grid.

the **MDSnE2,5** data set— distributed by the IGN in other *CRS* and in a single file.

The whole process was performed using free software based on the statistical calculation system R (R Core Team 2023), using ***tidyverse* libraries** (Wickham, et al. 2019) for data wrangling, ***sf*** library (Pebesma 2018) for handling vector information and ***terra*** (Hijmans 2023) and ***stars*** (Pebesma and Bivand 2023) libraries for handling raster information.

4.

Final layers

From the main layer produced in the previous section, Height_epsg3035_2.5m.tif, we generate the following information.

- **Height layers:** We lower the original resolution by aggregating Height_epsg3035_2.5m.tif at resolutions 5m, 10m, 20m, 50m, 100m, 200m, 250m, 500m and 1km. Aggregation uses simple averages.

  At 1km x 1km resolution we have **365,201** cells with strictly positive height values[15]. On the other hand the cells with population don´t reach 100,000 in the population grid from the 2021 census (Goerlich 2023b), which shows that many buildings are not populated.

- **Built up layer at original resolution:** By setting the values of the base layer of building heights to 1 and the missing values to 0 we get a binary layer of built-up surface at pixel level, where the pixel takes the value 1 if it is considered built and 0 if it is not. We name this layer Built-up_epsg3035_2.5m.tif. This layer has only 0/1 values and no missing values.

- **Built up layers:** As with the heights layers, we lower the original resolution of the built-up layer by aggregating Height_epsg3035_2.5m.tif at resolutions 5m, 10m, 20m, 50m, 100m, 200m, 250m, 500m, 1km. Aggregation uses simple averages, so all the values are in the interval [0, 1] and represent the share of built-up surface in the pixel.

- **Volume layer at original resolution:** Given the height of the 2.5m x 2.5m pixel —Height_epsg3035_2.5m.tif— and its surface, $6.25m^2$, it is direct to obtain a layer of built-up volumes per pixel, expressed in cubic meters. We simply multiply Height_epsg3035_2.5m.tif by 6.25, a simple local operation in raster algebra. The built-up volume is expressed in cubic meters. We name this layer Volume_epsg3035_2.5m.tif.

  According to our estimates the constructed volume amounts to about 25.244 hm^3.

- **Volume layers:** As with the height and built-up layers, we lower the original resolution by aggregating Volume_epsg3035_2.5m.tif at resolutions 5m, 10m, 20m, 50m, 100m, 200m, 250m, 500m, 1km. Aggregation uses simple sums. The built-up volume is expressed in cubic meters (m^3).

All the layers are saved in *tif* files with the following **nomenclature**: <var>_epsg3035_<res>.tif, where <var> is the variable involved: Height , Built-up or Volume , for built-up volume, and <res> is the resolution: 2.5m, 5m, 10m, 20m, 50m, 100m, 200m, 250m, 500m or 1km. So, we have 30 files in total, 10 by each variable.[16]

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[15] Even if only 362,118 cells with strictly positive height values fall within our reference grid determined by the Spanish contour (**Goerlich 2023a**).

[16] These files can be downloaded from **zenodo**. The distribution files are made in simple precision calculations. The height and volume files are also available in double precision, which are considerably more cumbersome to handle. The building volume calculations in the following section use the results calculated in double precision.

As an example, map 1 shows the percentage of built-up in 20m x 20m pixels of the urban area of Valencia, corresponding to the layer Built-up_epsg3035_20m.tif.

The data for the 1km x 1km resolution for the 3 variables was transferred to the grid statistics of Goerlich (2023a) in vector and tabulated form, so it can be readily integrated with other statistics in this format.

Map 1. Built-up share at 20m x 20m pixels

Source: Own elaboration based on the built-up layer at 20m x 20m resolution (Built-up_epsg3035_20m.tif)

5.

Example of use: Regional, provincial and municipal statistics

From the generated layers, we derive —using the original pixel resolution of 2.5 m x 2.5 m— the built-up surface and its proportion with respect to total regional surface, the average height of the buildings and the total built-up volume within the regional —Autonomous Communities—, provincial and municipal administrative boundaries. As a by-product, we also include the total number of pixels involved in the calculations and the built-up pixels.[17]

Regional data —Autonomous Communities— are shown in table 1. The numbers given in this table are slightly lower than those mentioned in the previous sections because they are cut by administrative boundaries, whereas the previous ones are the original ones from the information distributed by the IGN and we have already mentioned that they include buildings beyond our borders.

The calculations involve just over 80 billion pixels, although the built-up pixels are only **585,722,033**, representing a built-up area of **3,661 km²**.

At the national level, the percentage of built-up area as a percentage of the total is 0.72%, but some communities register notably higher percentages. Madrid, with 2.59%, and the Canary Islands, with 2.46%, stand out, although highly touristic regions, such as the Balearic Islands and the Valencian Community, also register notable values, 1.87% and 1.77% respectively.

The average height of buildings at national level is almost 7 metres, slightly above 2 floors, although the Basque Country slightly exceeds 10 metres, and Madrid is close to it. At the other extreme, the regions with the lowest average building heights are Extremadura and the region of Murcia, with 5.8 and 5.4 metres respectively. According to our estimates, the national building volume amounts to 25,153hm³.

It would be interesting to compare our estimates, derived from LiDAR, with those obtained, for the same variables, from Cadastral information (Goerlich 2023c; Uhl *et al.* 2023).

Provincial data are shown in the appendix. Regional, provincial and municipal data are available from zenodo in an Excel file format.

[17] Of course, the surfaces are no more than the number of corresponding pixels scaled by 6.25m², which is the surface of a pixel.

Table 1. Built-up statistics by Region —Autonomous Communities—

Region		Pixels		Surface (km²)			Height (m)	Volume (hm³)
Code	Name	Total	Built-up	Total	Built-up	Share (%)		
01	Andalucía	14,015,675,866	106,412,386	87,597.97	665.08	0.759	6.29	4,184.75
02	Aragón	7,635,399,895	27,336,895	47,721.25	170.86	0.358	6.47	1,104.60
03	Asturias	1,696,623,246	10,271,029	10,603.90	64.19	0.605	8.34	535.69
04	Illes Balears	798,526,935	14,967,915	4,990.79	93.55	1.874	6.20	580.07
05	Canarias	1,191,218,325	29,294,704	7,445.11	183.09	2.459	5.99	1,097.60
6	Cantabria	852,811,513	6,196,150	5,330.07	38.73	0.727	7.63	295.36
07	Castilla y León	15,075,788,352	53,288,382	94,223.68	333.05	0.353	6.10	2,030.56
08	Castilla-La Mancha	12,713,325,984	46,267,241	79,458.29	289.17	0.364	6.02	1,741.00
09	Cataluña	5,138,402,549	68,280,324	32,115.02	426.75	1.329	8.25	3,518.78
10	C. Valenciana	3,722,424,368	66,008,199	23,265.15	412.55	1.773	6.86	2,831.19
11	Extremadura	6,661,570,038	19,692,099	41,634.81	123.08	0.296	5.75	707.87
12	Galicia	4,734,244,185	47,424,389	29,589.03	296.40	1.002	6.31	1,870.34
13	Madrid	1,284,950,672	33,217,928	8,030.94	207.61	2.585	9.69	2,011.59
14	R. de Murcia	1,810,606,472	27,333,961	11,316.29	170.84	1.510	5.43	928.21
15	Navarra	1,662,561,998	8,803,164	10,391.01	55.02	0.529	8.16	448.80
16	País Vasco	1,157,566,860	16,238,349	7,234.79	101.49	1.403	10.12	1,027.27
17	La Rioja	807,180,736	4,688,918	5,044.88	29.31	0.581	8.17	239.55
18	Ceuta y Melilla	5,482,440		34.27				
España		**80,964,360,434**	**585,722,033**	**506,027.25**	**3,660.76**	**0.723**	**6.87**	**25,153.22**

Source: MDSnE2.5-National Geographic Institute (IGN) and own elaboration.

6.

Concluding comments

This work presents a re-elaboration of the **Digital normalized Surface Model** of the **building class** —the **MDSnE2,5** data set—provided by **IGN** in order to facilitate their use. In particular, all building height information is provided in a single national file, in the *CRS* which is normally used in spatial analysis at European level —*ETRS89-LAEA*—, in a reasonable size and with minimal treatment in the data to make it more in line with the variable it represents[18].

From this file, which represents a notable improvement in terms of ease of manipulation on the original data provided by **IGN**, we proceed to the aggregation at lower resolutions until the European standard grid of 1km x 1km of cell size.

From the original information, we also obtain two derived products that are not directly offered by the **IGN**. A layer of **built-up surface** and another of **built-up volume**, in both cases in all the resolutions derived for the layer of **buildings height**.

Additionally, this information is transformed into administrative level statistics: regions —Autonomous Communities—, provinces and municipalities. And, given its resolution, it can be transformed to other areas of interest at various resolutions.

The information processed in this work comes from the first LiDAR coverage corresponding to the period 2009-2015. However, the process is automated in its (almost) totality, so the developed scripts can be used, (almost) without modifications, for the generation of the same information from the second LiDAR coverage —corresponding to the period 2015-2021—, which will be available in the near future. Or for the generation of the same information from the **Normalised Digital Surface Model** of the **vegetation class** —the **MDSnV2,5** dataset[19].

[18] Other treatment is easily possible, if desired, from the intermediate working files.

[19] Scripts that perform the calculation are also available from the **Ivie** upon request.

Annex: Provincial statistics

Table A1. Built-up statistics by Province

Province		Pixel		Surface (km^2)		Share (%)	Height (m)	Volume (hm^3)
Code	Name	Total	Built-up	Total	Built-up			
01	Alava	485,923,238	4,165,590	3,037.02	26.03	0.857	8.99	234.06
02	Albacete	2,388,279,619	7,643,706	14,926.75	47.77	0.320	6.47	309.08
03	Alacant/Alicante	930,905,471	27,048,875	5,818.16	169.06	2.906	6.19	1,046.36
04	Almeria	1,403,769,135	16,685,218	8,773.56	104.28	1.189	5.23	545.89
05	Avila	1,287,946,058	4,499,185	8,049.66	28.12	0.349	5.54	155.69
06	Badajoz	3,482,694,952	11,953,143	21,766.84	74.71	0.343	5.60	418.45
07	Illes Balears	798,526,935	14,967,915	4,990.79	93.55	1.874	6.20	580.07
08	Barcelona	1,236,983,936	36,079,653	7,731.15	225.50	2.917	9.30	2,096.79
09	Burgos	2,286,584,424	6,913,450	14,291.15	43.21	0.302	7.14	308.33
10	Cáceres	3,178,875,086	7,738,956	19,867.97	48.37	0.243	5.98	289.42
11	Cádiz	1,190,137,607	12,747,944	7,438.36	79.67	1.071	6.63	528.53
12	Castellón/Castelló	1,061,488,008	12,016,906	6,634.30	75.11	1.132	6.25	469.61
13	Ciudad Real	3,169,880,313	10,764,964	19,811.75	67.28	0.340	5.77	388.38
14	Córdoba	2,203,310,330	13,542,295	13,770.69	84.64	0.615	5.26	445.58
15	A Coruña	1,274,161,598	17,067,629	7,963.51	106.67	1.340	6.65	709.51
16	Cuenca	2,742,176,655	6,414,066	17,138.60	40.09	0.234	5.95	238.48
17	Girona	945,333,022	11,294,880	5,908.33	70.59	1.195	7.03	496.15
18	Granada	2,023,508,823	11,021,813	12,646.93	68.89	0.545	6.80	468.76
19	Guadalajara	1,954,145,714	5,678,822	12,213.41	35.49	0.291	6.36	225.77
20	Guipúzcoa	317,160,959	4,994,191	1,982.26	31.21	1.575	10.33	322.34
21	Huelva	1,620,350,285	8,201,607	10,127.19	51.26	0.506	5.92	303.37
22	Huesca	2,501,953,894	7,552,433	15,637.21	47.20	0.302	6.00	283.38
23	Jaen	2,159,470,722	8,810,787	13,496.69	55.07	0.408	6.47	356.36
24	León	2,492,446,143	8,999,011	15,577.79	56.24	0.361	6.75	379.56
25	Lleida	1,946,929,906	9,156,872	12,168.31	57.23	0.470	6.72	384.81
26	La Rioja	807,180,736	4,688,918	5,044.88	29.31	0.581	8.17	239.55
27	Lugo	1,577,237,906	9,003,047	9,857.74	56.27	0.571	5.71	321.23
28	Madrid	1,284,950,672	33,217,928	8,030.94	207.61	2.585	9.69	2,011.59
29	Málaga	1,169,344,307	14,583,206	7,308.40	91.15	1.247	7.68	699.76
30	Murcia	1,810,606,472	27,333,961	11,316.29	170.84	1.510	5.43	928.21
31	Navarra	1,662,561,998	8,803,164	10,391.01	55.02	0.529	8.16	448.80
32	Ourense	1,163,906,291	7,736,738	7,274.41	48.35	0.665	5.91	285.70
33	Asturias	1,696,623,246	10,271,029	10,603.90	64.19	0.605	8.34	535.69
34	Palencia	1,288,371,654	3,754,401	8,052.32	23.47	0.291	6.37	149.57
35	Palmas de Gran Canaria	651,153,919	14,296,564	4,069.71	89.35	2.196	6.06	541.66
36	Pontevedra	718,938,390	13,616,975	4,493.36	85.11	1.894	6.51	553.90
37	Salamanca	1,975,985,281	7,838,093	12,349.91	48.99	0.397	5.48	268.33
38	Santa Cruz de Tenerife	540,064,406	14,998,140	3,375.40	93.74	2.777	5.93	555.94
39	Cantabria	852,811,513	6,196,150	5,330.07	38.73	0.727	7.63	295.36
40	Segovia	1,107,673,668	4,354,447	6,922.96	27.22	0.393	5.63	153.18
41	Sevilla	2,245,784,657	20,819,516	14,036.15	130.12	0.927	6.43	836.51
42	Soria	1,649,140,311	3,117,199	10,307.13	19.48	0.189	5.42	105.69
43	Tarragona	1,009,155,685	11,748,919	6,307.22	73.43	1.164	7.37	541.03
44	Teruel	2,369,448,638	6,554,733	14,809.05	40.97	0.277	5.53	226.55
45	Toledo	2,458,843,683	15,765,683	15,367.77	98.54	0.641	5.88	579.29
46	Valencia/València	1,730,030,889	26,942,418	10,812.69	168.39	1.557	7.81	1,315.22
47	Valladolid	1,297,686,463	7,351,842	8,110.54	45.95	0.567	6.72	308.86
48	Vizcaya	354,482,663	7,078,568	2,215.52	44.24	1.997	10.64	470.87
49	Zamora	1,689,954,350	6,460,754	10,562.21	40.38	0.382	4.99	201.35
50	Zaragoza	2,763,997,363	13,229,729	17,274.98	82.69	0.479	7.19	594.68
51	Ceuta	3,203,763		20.02				
52	Melilla	2,278,677		14.24				
España		**80,964,360,434**	**585,722,033**	**506,027.25**	**3,660.76**	**0.723**	**6.87**	**25,153.22**

Source: MDSnE2.5-National Geographic Institute (IGN) and own elaboration.

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Event
Event Budget for Event : EXPENSES
Actual Cost Breakdown
Estimated vs. Actual

Ivie