# Designing a map using Open Data coming from different sources. Methodology, problems and solutions concerning the 1:100.000 map of Prefecture of Magnisia, Greece

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**Abstract.** The synthesis of a map is always a demanding procedure, in which all the characteristics of an area are combined and depicted on a map with a proper way, so as the map to be easily used by all the people to whom it is addressed. The most important steps of this procedure are the collection of the data and their homogenization, in order to fit together and to ensure accuracy on a map. Moreover, the digital geodata produced by different public services are recently provided free online to users through the National Geospatial Infrastructure. In this paper, open data coming from this Infrastructure are used for the compilation of the map for the prefecture of Magnisia, following a specific procedure in order all these data to be homogenized and included to a common geodatabase. In this procedure, different problems are confronted with various solutions each of them, so as to have a better result.

**Keywords:** open geodata, data homogenization, map design, map production, National Geospatial Infrastructure of Greece

## 1. Introduction

Designing an accurate printed paper map, useful and easily readable by all its future users is not something easily accomplished. There are many parameters, necessary to be taken into account in every step of the procedure, from the data collection to the final printing of the map.

The main concern in the map compilation is to ensure the reliability of its geometric content in combination with its geometric infrastructure i.e. map scale, geodetic and projected reference system, by the evaluation and the homogenization of the available geometric and thematic features, which are going to be used. On the other hand, map design, typology and symbology (colors, symbols, typefaces) used for every feature in the map, as well as the layout for printing are also significant parameters in order to have a map, which can be easily readable by the users.

Map production using digital cartographic methods and techniques, having as goal not only the digital composition and presentation of the maps, but also their high quality printing has started in the Department of Cadastre, Photogrammetry and Cartography of the School of Rural and Surveying Engineering of Aristotle University of Thessaloniki (Greece) since the mid 1990s and continues until today, giving specific emphasis on the production of standard sheets of the country's prefectures in scale 1:100.000.

The geometric background used for the composition of these maps was principally the paper 1:50000 map sheets compiled by Hellenic Military Geographical Service. Following a particular procedure described more analytically below, these maps were scanned, georeferenced in their projection system, digitized and then, corrected and updated from other more recent sources, usually from satellite images covering the area. Recently, digital geodata produced by different public services are provided free, online, to users through the National Geospatial Infrastructure, a system established by the National Cadastre and Mapping Organization, in the frame of INSPIRE Infrastructure for Spatial Information in Europe.

In this paper, the methodology developed for the production of maps is applied to the synthesis of the prefecture of Magnisia map in scale 1:100000, combining the existing topographic map sheets by Hellenic Military Geographical Service and satellite images with the recently available geodata provided digitally through the National Geospatial Infrastructure, recording a variety of difficulties and providing solutions for them, in order to get finally a map, geometrically accurate (as its scale requires) and graphically readable, depicting the physical characteristics of the prefecture highlighting areas of special environmental interest.

Magnisia is one of one of the most beautiful and touristic regions in Greece, including the Centaurs' Mount Pilion and the complex of Sporades Islands white the National Marine Park of Alonissos.

## 2. Methodology for the synthesis of a map

For the compilation of a map, the procedure followed consists of three basic stages (*Figure 1*), important to be done correctly in order to ensure the reliability and the accuracy of the result. These stages are:

a) *compilation of the final vector file of the map*, which is the result of the synthesis of all the map characteristics that were digitized, corrected or updated,

b) *map design*, which concerns the typology and the symbols of the thematic features used for the map, as well as the addition of the map elements responsible for the map's external recognition and reading (Livieratos 1988), such as the legend, title, north arrow, graphic scale bar and other information about its synthesis, and

c) *final editing* of the different elements of the map in order to take its final form and to be printed.

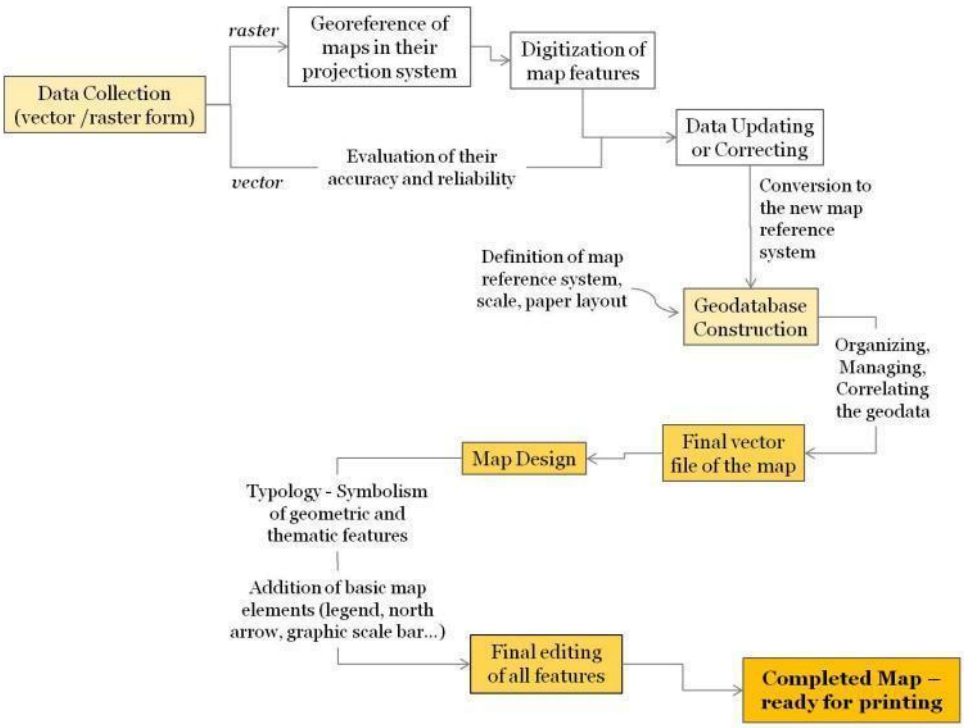


**Figure 1.** Diagram of the procedure followed for the synthesis of a map. Different colors show the important stages of the whole procedure.

In order to construct the final vector file, there are some basic steps which should be followed. First of all, it is important to collect raster and vector data depicting the main characteristics of the area (road and hydrological network, settlements) but also its specific characteristics (sites of touristic interest, areas of specific environmental interest). For the raster data, an important thing is the georeferencing of maps in their projection system mainly using an external grid so as the maps to be correctly rectified on the grid.

The next step is the digitization of the different map features in layers, in order to be evaluated together with the vector geodata for their accuracy and reliability. This can be done by using other maps or satellite images, the precision of which was already evaluated and accepted for the construction of the map, according to the scale requirements. Based on these maps, the data then are corrected and updated.

Of great importance in the procedure is the definition of the projection, in which the new map will be drawn, as well as of the paper layout based on the extent of the area and the final scale of the under construction map. All the digitized characteristics will be converted in this projection system, in order to be aligned to each other. For this reason, it is necessary to build a geodatabase which will work as a central data repository for spatial data storage and management. Through this, data both in vector and raster form will be better organized and map characteristics can be correctly combined to each other, in order to constitute the final vector file which then, with the definition of the proper typology and symbology of its geometric and thematic features, will get its final form.

## 3. Map of the Prefecture of Magnisia, Greece in scale 1:100000

The prefecture of Magnisia map in scale 1:100000 is a map constructed following the procedure described above. This map belongs to the standard map series of the country's prefectures in scale 1:100.000[1], produced in the

[1] Apart from the map of the prefecture of Magnisia, there are also other map sheets constructed in the some scale 1:100000. These are the maps of the prefectures of Xanthi, Kavala, Kilkis, Kozani, Kastoria, whereas the map sheets of Rhodopi and Chalkidiki are under construction. The same typology and symbology are followed also for the maps for Paphos and Limassol districts of Cyprus, in scale 1:75000 (DCPC - RSE, AUTh 2004-2011).

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These map sheets are compiled following the specific standards set for all the maps in this category, which means that they use the same typology and symbology for all the geometric and thematic features depicted on them. The reference system of these maps is the transverse Mercator projection applied in one zone, with the central Meridian on 24 degrees and the WGS84 datum.

## 3.1. Collecting data from different sources

### *a. Existing maps*

Collecting data in order to combine it for the compilation of a map demands to search for maps in analog or digital form and vector files through internet or public services in order to combine them appropriately and to use for the construction of the new map. Due to the fact that these data are coming from different sources, it is necessary to be evaluated before their use, mainly for the accuracy of their geometric content but also for the existence of the thematic characteristics they depict. This means that their origin should be known and checked for its consistency, precision and reliability.

Some years ago, the data used for the composition of new maps were exclusively derived from older maps in analog form, which were scanned, georeferenced and digitized in order to be combined together and to be used as a background for the composition of a new map. These maps were principally the 1:50000 map sheets compiled by Hellenic Military Geographical Service (H.M.G.S.)[2], the period between 1974-1980. Their map content was since then updated and corrected from other more recent sources, usually from satellite images covering the area giving to the map its final form.

For the map of Magnisia prefecture, the corresponding map sheets were georeferenced in their projection system (*Figure 2*), and features like the hydrological network (rivers, stream, lakes), the administrative boundaries of the prefecture (municipalities borders according to Kapodistrias and Kallikratis administrative plan) were digitized, as well as some other physical

[2] The Hellenic Military Geographical Service (HMGS) produces all the cartographic products needed for supporting the Hellenic Armed Forces, as well as a variety of products for the development of the country and the needs of the general public. Among them and probably the most useful are the 1:50000 map sheets cover the whole Greece (HMGS website, http://web.gys.gr/).

characteristics of the area and the onomatology of the settlements, islands, promontories, bays, channels and narrows. The reference system of this map sheets is the Universe Transverse Mercator projection, applied in 34 zone with central Meridian on 21 degrees, using the European datum 1950 and the reference ellipsoid of Hayford.

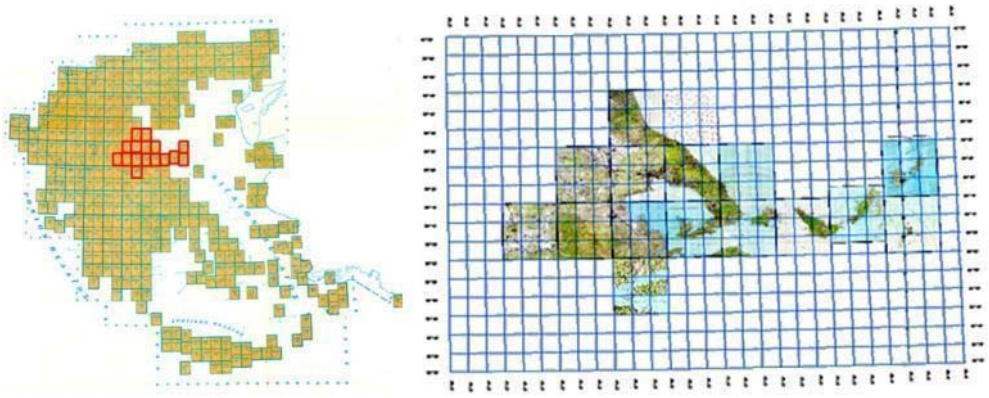

**Figure 2.** Left: Tiles of the map series 1:50000 constructed by H.M.G.S. (Source: Hellenic Military Geographic Service). Right: Map sheets covering the area of Magnisia prefecture, georeferenced on UTM projection grid.

Touristic or other special maps showing the special thematic features of the area in different scales are also used for the construction of the map. These maps were also georeferenced to their projection system and the necessary characteristics were digitized in layers.

### *b. Online digital geodata*

Recently, things have been changed, in Greece, since digital geodata produced by different public services is provided free, online to users through the National Geospatial Data Infrastructure, a system established by the National Mapping and Cadastre Organization[3], in the frame of INSPIRE Infrastructure for Spatial Information in Europe. According to the National Law 3882, adopted by the Greek State on September 22nd 2010 to comply

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[3] National Mapping and Cadastre Organization (HEMCO) is the coordinating agency in Greece on issues about the INSPIRE and the National Geospatial Data Infrastructure (NGDI). It belongs to the Ministry of Environment, Energy and Climate Change (http://www.okxe.gr, http://www.ypeka.gr/Default.aspx?tabid=649&language=en-US).

with the INSPIRE Directive, geospatial datasets and services would be provided free online to everyone without institutional or technical barriers.

Access to these data is possible through the geodata.gov.gr portal, which was designed and developed *"…with the aim to provide a focal point for the aggregation, search, provision and portrayal of open public geospatial information"*, according to its policy. Practically, somebody can view, search and download data for free and he can use it in his application. These datasets are coming from different public organizations, each of which is responsible for its own data. For this reason, it is important to evaluate and to check the accuracy and the reliability of the geodata, downloaded from this Infrastructure, before their use for the construction of a map in a particular scale.

The geodata, according to their form (shapefiles, wms services, GML or KML files), are using different reference systems. The vector and the GML files are using the Greek Geodetic Reference System 1987 (GGRS87) or Greek Grid[4], since it is the official reference system of Greece, whereas the KML files are using the WGS84, so that they can be easily visible by all users, also in Google Maps and Google Earth applications (*Figure 3*).

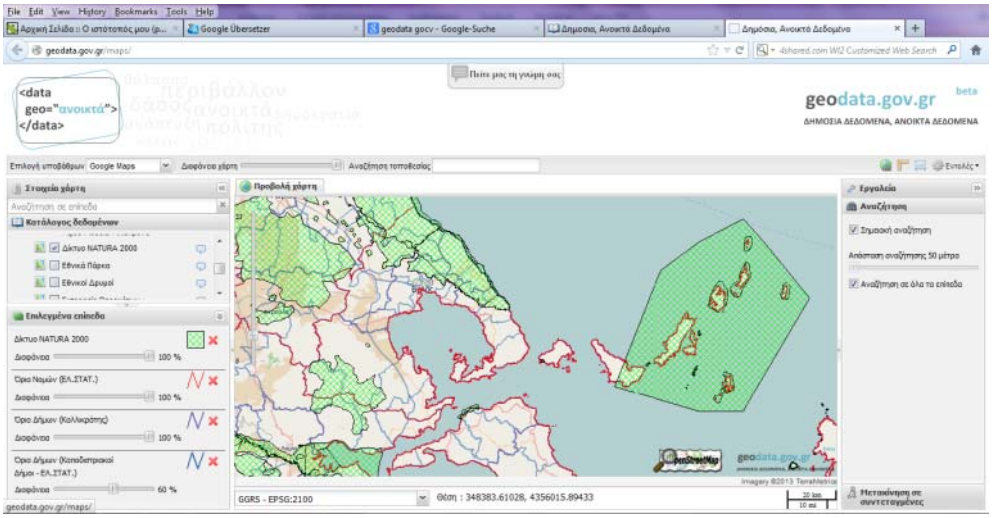


**Figure 3.** The geodata.gov.gr portal depicting some of the provided geodata of the Prefecture of Magnisia (Source: http://geodata.gov.gr).

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[4] The Greek Geodetic Reference System 1987 (GGRS87) uses the transverse Mercator projection and the GRS80 ellipsoid. Its fundamental point is located at the Observatory of Dionysos in Athens (Livieratos & Fotiou 2000).

The geodata downloaded from the National Geospatial Data Infrastructure in order to be used for the construction of Magnisia map are recorded in *Table 1,* together with the public authorities providing the data.

| Geodata | Authority | Format | Reference System |
|---|---|---|---|
| Prefecture borders | Hellenic Statistic Authority (HSA) & HEMCO | .shp | GGRS87 |
| Kallikratis borders | HEMCO | .shp | GGRS87 |
| Kapodistrias borders | HSA & HEMCO | .shp | GGRS87 |
| Municipalities of Kapodistrias to Kallikratis | Ministry of the Interior, Decentralization and Electronic Governance | .xls | |
| Lakes, Rivers, Hydrological Network | Ministry of Environment, Energy and Climate Change | .shp | GGRS87 |
| Natura 2000, National Parks, Protected Areas of Greece | Ministry of Environment, Energy and Climate Change | .shp | GGRS87 |
| Railway Network | Ministry of Public Order and Citizen Protection | .shp | GGRS87 |
| Settlements | HSA & HEMCO | .xls & .shp | |
| Coastline | HEMCO | .shp | GGRS87 |
| Ancient Monuments | Diazoma Association | .shp | GGRS87 |
| Orthophotos from Greece | Ktimatologio S.A. (Greek Cadastre) | .wms | WGS84 |

**Table 1.** Geodata from National Geospatial Data Infrastructure, used for the construction of the map for Magnisia prefecture.

## 3.2. Constructing a geodatabase

In order to store all the data, vector and raster correctly, in a uniform projection system, aligned properly to each other, it is necessary to build a geodatabase. The projection system of this geodatabase will be the reference system of the under construction map, which in our case is the Transverse Mercator projection, applied in one zone with the prime meridian on 24 degrees and applying the WGS84 datum.

The existence of geodatabase offers many advantages in the organization and the management of the spatial data, since it can store raster and vector data with different kinds of formats in a centralized location, it can apply sophisticated rules and relationships to the data or to define advanced geospatial relational models (e.g., topologies, networks). Having all the data in a database gives the opportunity to maintain integrity of spatial data with a

consistent, accurate database work within a multiuser access and editing environment (ESRI, Apsey 2008).

### 3.3. Updating the geodata

In order to ensure the accuracy of the map, it is necessary to check its characteristics, to update them or to correct them in some cases based on reliable data. For this reason, the orthrophoto images provided by Ktimatologio S.A., a company responsible for the study, development and operation of the Hellenic Cadastre were used, since they consist the most updated mapping database for the country.

The images are the result of aerial photography procedure between 2007 and 2009, and their spatial resolution is 20cm for urban areas and 50cm for non-urban areas. This large scale orthophoto imagery is provided online to citizens free of charge through the Orthophotos Viewing Service - which is the official name for the web service developed by Ktimatologio S.A. The service can be accessed in two ways, either through the company's website where the reference system used is the GGRS87 or connected to the WMS server and working online on the appropriate GIS program. The reference system used by the WMS server is the geographic WGS84.

**Figure 4.** The places for which land surveying measurements are available to be used for the evaluation (Source: Ktimatologio S.A.).

The use of this product requires its evaluation at first. For this reason, we used measurements from land surveying on different places, covering the northern and central part of Greece (*Figure 4)*. The measured points were also drawn in the Greek Geodetic Reference System 1987. The next step was to bring all the files in the same reference system and to compare the coordinates of the specific piece of land. These transformations were performed on-the-fly through the GIS software used also for the construction of the Magnisia map.

The result of this comparison shows that the coordinates were exactly the same in the case of land measurements and those coming from Ktimatologio website, whereas there were displacements comparing to the wms service. These displacements are not the same for all the places in Greece and it depends on the geographic area, each place belongs.

Measuring the displacements in every place (*Figure 5*), using the average coordinates of each piece of land, recording them in a catalogue (*Table 2)* and depicting them on a map (*Figure 6*) makes easier to understand their magnitude, range and the average deviation in geographic longitude and latitude (*Figure 7*) and in association with the final printing scale of the under construction map, to decide if the orthrophotos can be used for updating and correcting the existed data used for the compilation of the map.

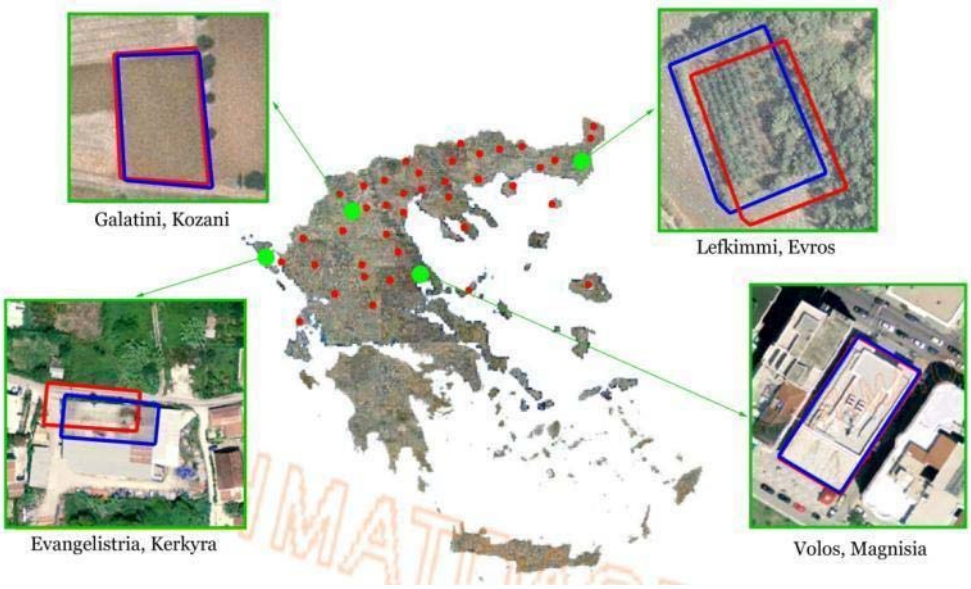


**Figure 5.** Differences in the location of 4 places of northern Greece as they are depicted on orthophotos (blue) and also drawn from land measurements (red).

| Place | Mean Latitude φ (deg) | Mean Longitude λ (deg) | Displacements (m) | | |
|---|---|---|---|---|---|
| | | | ΔX (m) | ΔY (m) | S (m) |
| Volos, Magnisia | 39° 21' 38.1096" | 22° 56' 39.9624" | 0.22 | 0.36 | **0.47** |
| Flabouro, Larissa | 39° 58' 34.8888" | 22° 15' 5.4252" | 0.57 | -0.32 | **0.70** |
| Drepano, Kozani | 40° 21' 44.2764" | 21° 50' 21.9948" | 0.51 | -0.78 | **1.01** |
| Galatini, Kozani | 40° 19' 36.8292" | 21° 34' 11.622" | 1.44 | -1.29 | **1.99** |
| Pontoirakleia, Kilkis | 41° 5' 10.8636" | 22° 37' 17.0832" | -2.62 | 0.77 | **2.75** |
| Thessaloniki | 40° 39' 21.2436" | 22° 56' 33.3024" | -2.63 | 1.51 | **3.04** |
| Pedino, Kilkis | 40° 54' 30.546" | 22° 52' 38.0028" | -2.86 | 1.44 | **3.21** |
| Megala Kalyvia, Trikala | 39° 30' 39.8988" | 21° 47' 7.2168" | 3.06 | -1.31 | **3.35** |
| Lefkada, Fthiotida | 38° 54' 44.9928" | 22° 0' 10.602" | 3.28 | -1.62 | **3.71** |
| Marathousa, Chalkidiki | 40° 33' 19.4868" | 23° 28' 21.4572" | -3.70 | 2.22 | **4.33** |
| Serres | 41° 5' 4.6356" | 23° 32' 30.9768" | -4.95 | 2.71 | **5.65** |
| Theriakisio, Ioannina | 39° 29' 42.252" | 20° 51' 24.3468" | 5.11 | -3.31 | **6.10** |
| Vathitopos, Drama | 41° 21' 16.0884" | 23° 42' 37.1988" | -5.91 | 3.34 | **6.79** |
| Xirotopos, Drama | 41° 11' 30.84" | 24° 6' 0.2592" | -6.79 | 4.01 | **7.89** |
| Igoumenitsa | 39° 31' 4.6128" | 20° 12' 9.6156" | 7.15 | -4.34 | **8.37** |
| Vasiliki, Lefkada | 38° 37' 46.8336" | 20° 36' 22.4424" | 7.92 | -4.31 | **9.03** |
| Evangelistria, Kerkyra | 39° 35' 47.994" | 19° 53' 47.3064" | 7.92 | -5.11 | **9.43** |
| Kalloni, Lesvos | 39° 12' 46.0008" | 26° 12' 55.8432" | -8.09 | 5.38 | **9.73** |
| Echinos, Xanthi | 41° 18' 36.6624" | 24° 57' 13.3416" | -9.22 | 5.54 | **10.77** |
| Arisvi, Evros | 41° 5' 21.0732" | 25° 35' 30.3792" | -10.58 | 5.91 | **12.13** |
| Lefkimmi, Evros | 41° 2' 42.792" | 26° 8' 25.98" | -11.47 | 6.81 | **13.36** |
| Vrysika, Evros | 41° 24' 52.6212" | 26° 20' 36.1428" | -13.10 | 7.44 | **15.07** |
| Sterna, Evros | 41° 35' 3.8112" | 26° 23' 42.8388" | -13.71 | 7.65 | **15.71** |

**Table 2.** Displacements of some places used for the evaluation of the project. The places marked in red, are those depicted in the previous figure.

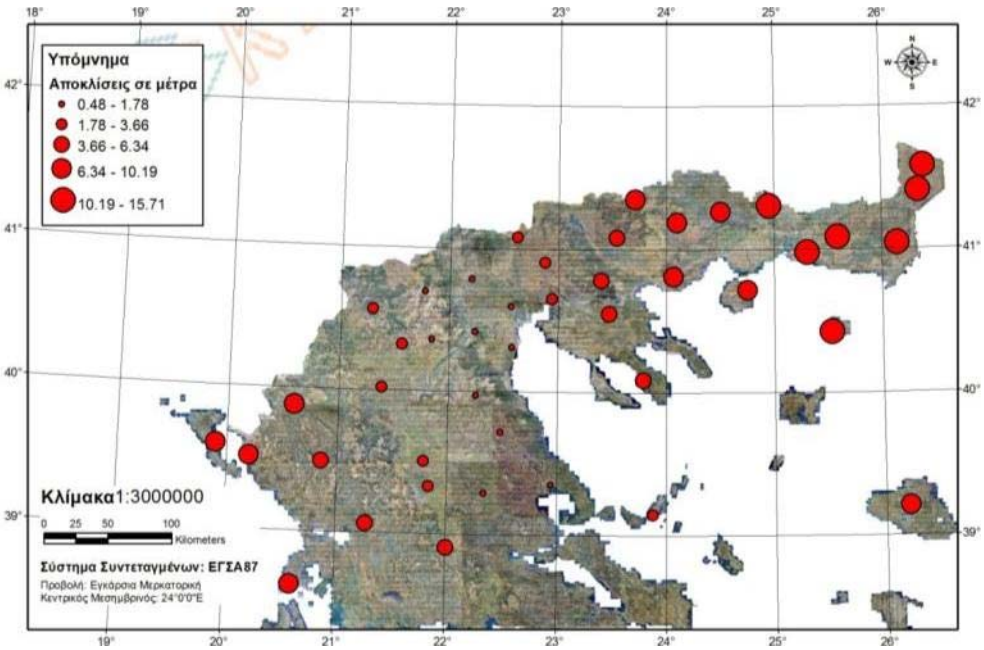


**Figure 6.** Displacements in meters on particular areas of northern Greece.

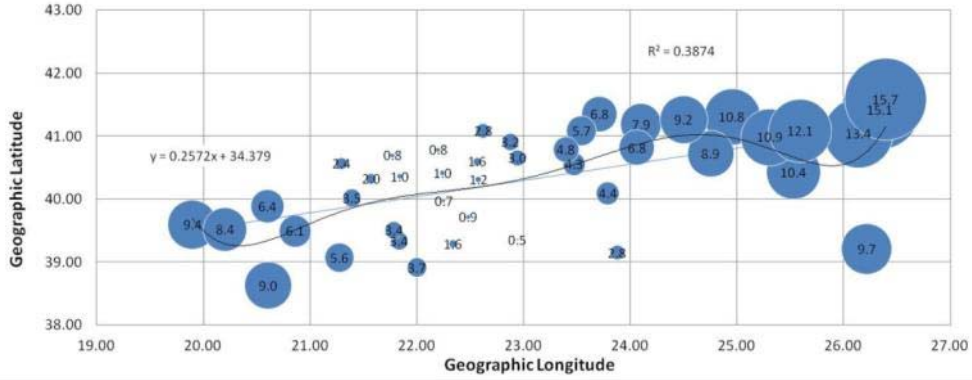


**Figure 7.** Average deviation in geographic longitude and latitude throughout Northern-Central Greece

Looking at this map, it is obvious that there is an almost diagonal zone in the central part of northern Greece where the differences between the coordinates of points depicted on orthophotos are almost the same to the originals, while the differences become bigger towards west and even bigger in the north-eastern borders of the Greek territory. The minimum value of displacement is recorded approximately between longitudes 21.8 and 22.9 and between latitudes 39.4 and 40.8.

From this evaluation, we came to the conclusion that the orthophoto images can be used for updating earlier existed data for the construction of maps depending on the scale of the final map but they cannot be used in case of a topographic diagram of scale 1:1000 or 1:5000. For the synthesis of Magnisia map in scale 1:100000, the orthophotos can be used, since the prefecture of Magnisia is extended between the geographic longitudes 22.5 and 24.3 and the latitudes 38.9 and 39.5 and belongs to the central zone where the displacements are not very serious in the particular scale (*Figure 8*).

Additional maps are used as well for the correction of similar data provided by different public services. An example of this is the case of the administrative municipality boundaries according to Kapodistrias plan which are provided by the Hellenic Statistical Authority and by the Hellenic Mapping and Cadastre Organization and traced differently in municipalities of Volos and Nea Ionia. In order to solve this problem, we used the map compiled by the Department of Urban Planning of Municipality of Volos, we georeferenced it and corrected the borders based on it (*Figure 9*).

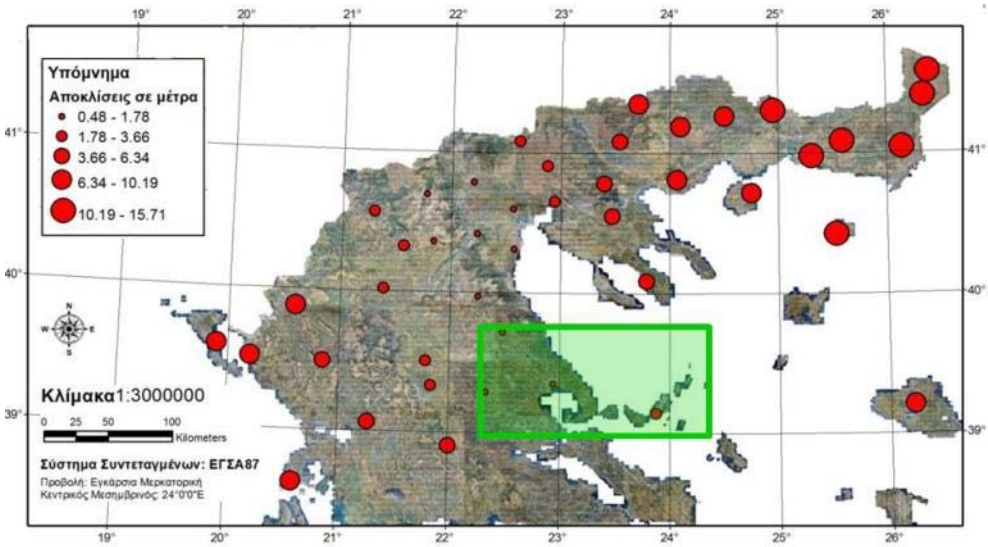


**Figure 8.** The area covered in Magnisia Map (green) drawn on the displacement map of northern Greece.

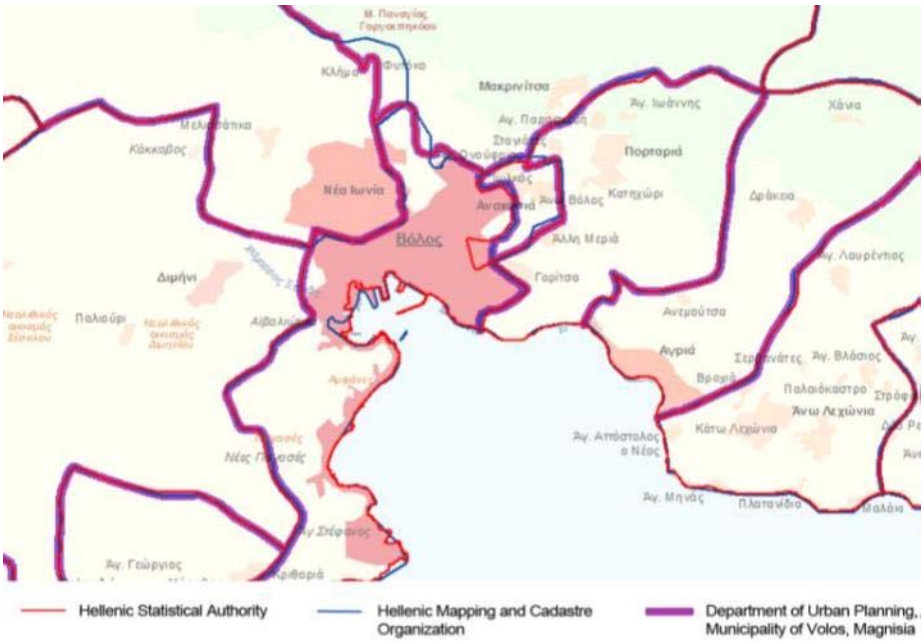


**Figure 9.** Municipality borders provided by Hellenic Statistical Service (red) and Hellenic Mapping and Cadastre Organization (blue) and the corrected borders based on the map constructed by the Department of Urban Planning of Volos Municipality (purple).

### 3.4. Map Design - Final editing of the map

The last step of the whole procedure is the definition of the proper typology and symbology of the map's geometric and thematic features, in order the vector file to get its final form and to be ready for printing. Important in this procedure is the editing of the map, which should be done in such way that all the characteristics of the map to be easily readable.

The specific typology determined for all the maps in scale 1:100000 constructed by our Department in Aristotle University of Thessaloniki is applied, adding also -if necessary- new typology, such as new thematic symbols, for special characteristics nonexistent on the other map sheets.

The main features of the map are the road and railway network, the hydrological network, the settlements, the administrative boundaries and other elements depicting the area of Magnisia prefecture. Each one of these is divided in smaller categories, for which different symbology is required. A detail of the map in scale 1:100000 is presented in *Figure 10*. The explanation of the symbology used for the different characteristics and elements of the map can be found in *Figure 11*.

The road network is divided in five categories, namely national, peripheral, main asphalt, asphalt and dirt road and the railway network in two, the main railway and the railway track in Mount Pilion (*Figure 12*). The settlements are divided in six categories according to their population, which are the settlements with no inhabitants, from 1 to 2000, from 2001 to 5000, 5001 to 10000, 10001 to 50000 and over 50000 inhabitants (*Figure 13*).

On the map, it is also depicted the hydrological network of the area (rivers, streams, lakes) and the four categories of administrative boundaries, namely the municipalities' borders according to Kapodistrias and Kallikratis plan, the prefecture borders and the region borders (*Figure 14*).

Important part of the map is its thematic content. For this reason, all the special characteristics of the area are presented on it with different discrete symbols in a way to be easily understandable by every user. The map is completed with the addition of the map elements useful for the external recognition of the map: the legend, the title, the north arrow, the graphic scale bar and other information about its synthesis.


**Figure 10.** Detail of the map of Magnisia prefecture in scale 1:100000.


**Figure 11.** The legend of the map of Magnisia prefecture.

**Figure 12.** The seven different categories of road and railway network.

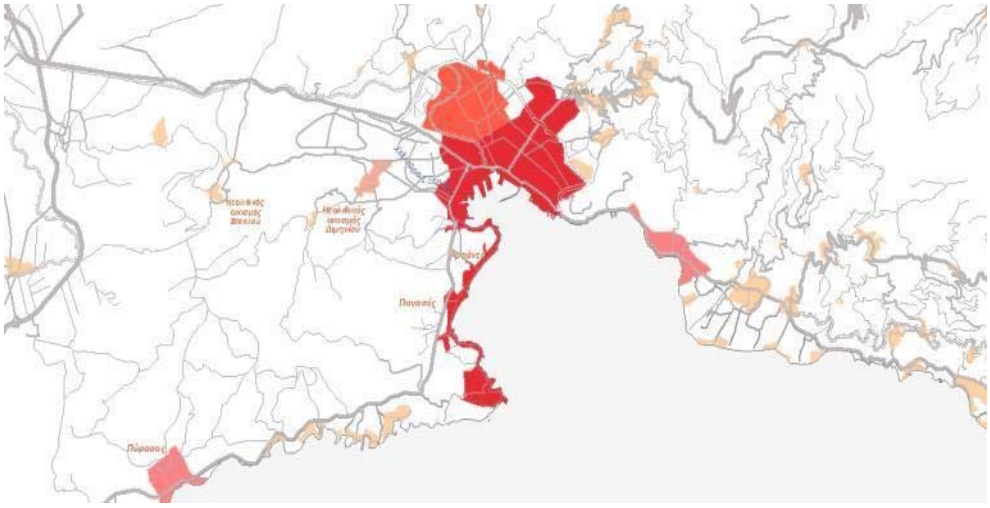

**Figure 13.** The five categories of the settlements according to their population.

The specialty of Magnisia map is that it covers an area of 160 km and for this reason it is printed in two sheets (*Figure 16 & 17*) of dimensions 100 x 75 cm. The two map sheets have overlapping area of 40 cm in the centre of the map (*Figure 15*).

**Figure 14.** The administrative borders (4 categories).

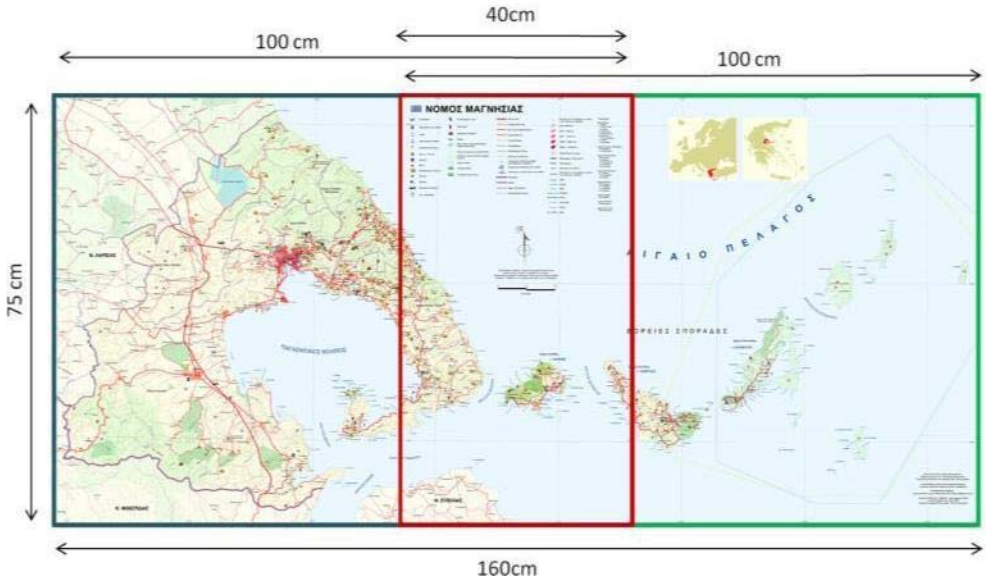


**Figure 15.** The division of Magnisia map into two overlapping sheets.


**Figure 16.** The first map sheet of Magnisia prefecture.

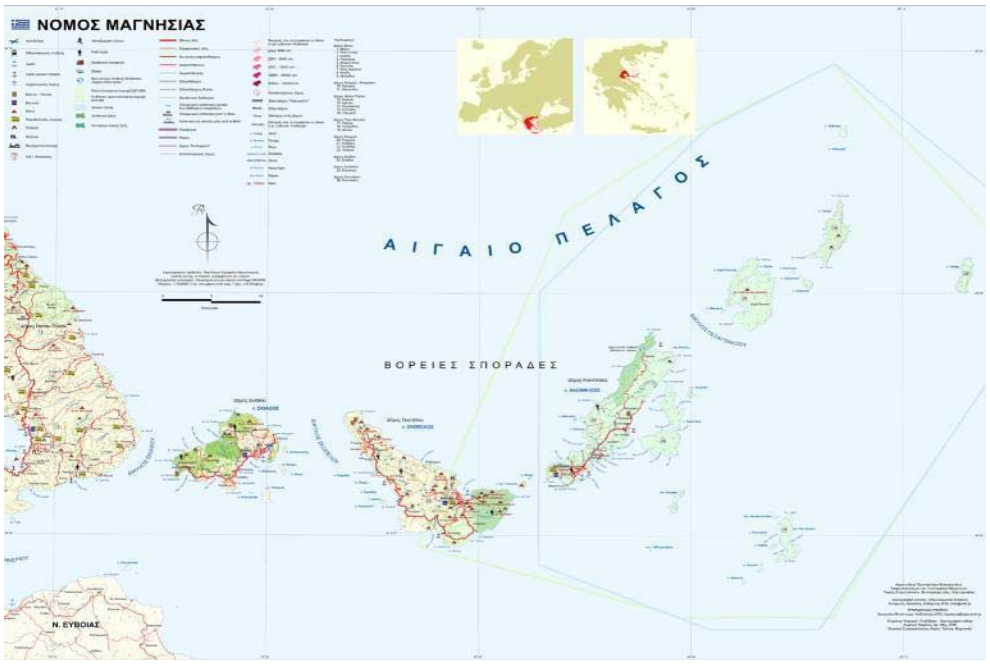


**Figure 17.** The second map sheet of Magnisia prefecture.

## 4. Conclusion

Having access to open geodata free available to all users is crucial in map production, since it provides georeferenced data, ready to be used on the map. However, the fact that this geodata are coming from different public services makes also important and necessary the evaluation of the accuracy and the reliability of geodata and also their homogenization in order to be aligned to each on the map.

These procedures can be easily applied nowadays using different digital tools in order to overcome possible problems appeared in every step and finally construct a map geometrically accurate and graphically "readable", depicting the geometric and thematic features of the area, according to map scale requirements.

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