Geographic Information System Applied in Archaeological Site

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SUMMARY

The use of GIS in archaeological sites is pointed out and an application at the site of ancient Messene is presented. To create the cartographic base for the GIS, maps of the region supplied by the HGMS (Hellenic Geographical Military Service) were digitized. Separate layers were used for every separate object entity such as roads, findings, buildings, waters and contour lines found on the maps. This base was updated using orthophoto maps. Then the monuments and the ruins found after the excavations were placed on the digital map. Therefore terrestrial surveys took place at the archaeological site. Finally the digital map topology was created. After that a database was created containing archaeological and spatial data along with photos of the findings. The database was then linked with the digital map to complete the GIS. The computer applications used were Autocad Map 2000i and MS Access 2000.

This GIS implementation integrated a large amount of data to a user-friendly environment. It enables a common user to access and visualize data and related information about the archaeological site of Messene. It was also easier to manipulate and analyze formerly scattered data. In addition, it provides the potential to keep and maintain up-to-date the database with the latest findings as the excavation continues and may be used as a digital museum combined with a 3D representation of the city.

Messene is an ancient Greek city which is stated in south-eastern utmost of Peloponnesos on Ithome Mountain. It was founded at 369 BC and was depopulated after its destruction by the Goths at 397 AD. The extensive excavations that took place revealed many artefacts and buildings ruins and are continued up to this day. Important for the city’s life are the ancient Agora, the Stadium, the Theatre, the Asklepieion complex and the Gymnasium. In addition, temples, fountains, fortifications, towers, walls and tombs, many of them in good condition, were found.

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1. INTRODUCTION

A geographic information system (GIS) is a composition of many different tools for the collection, storage, updating, manipulation, analysis and output of spatial data, which are land related. The main purpose of a GIS is the aim of decision-making on specific segments. The base of a GIS is a unified reference system (geographic), which also facilitates the connection of data between them as well as with other systems that contain similar land information. Consequently, the application of a GIS to an archaeological site is a very useful tool, which provides many possibilities to the users. First of all it provides a connection between all the existing types of spatial information in a common reference system. That reference system is the digital map. Thus, it can be easily connected, in the data base of a GIS, information about surface research, excavations, expropriations, planning of action's, recording and denoting of findings. Therefore, we can connect a map (spatial data) with documents or photographs (thematic data) or even with land-survey data (measuring data). With a proper elaboration it could become accessible to any user even if he doesn't have thorough knowledge of such programs.

During the last decades in many countries was realized that the need for reliable and up-to-date information about the earth, the society and the environment could not be fulfilled with the conventional ways of collecting, recording, updating and processing data. Thus, the Geographical Information Systems - GIS or Land Information Systems – LIS, came into an exceptionally big development, specifically from the beginning of '80^{s}.

Certain years ago the term LIS was reported mainly for systems with information on cadastral level, information relative to the utility networks or other that concern the local government. On the other hand GIS were considered for the systems with information relative to the forests, the agriculture, the geological background, the transportation, the environment, the health etc. Nowadays, the wide growth of both systems of information makes it difficult to distinguish the bisector line between them.

We should refer here to the four basic characteristics of information that are used in GIS:

- The *phenomenon* itself and its characteristics. That is the parameters which determine it, as e.g. its name, its price etc.
- Its *place* in the space. That is its coordinates.
- The time. That is the time moment or the duration in which the phenomenon takes place.
- Its *topology*. That is its relations with other phenomena.

2. GEOGRAPHIC INFORMATION SYSTEMS

Various definitions have been given occasionally for these systems. Perhaps the more precise definition has been given by the FIG (Fédération Internationale des Géomètres) in 1984, according to which: "Land Information Systems is a tool for legal, administrative and economic decision-making, and an aid for planning and development, which consists on the one hand of a data base containing spatially referenced land-related data for a defined area, and on the other hand, of procedures and techniques for the systematic collection, updating, processing and distribution of the data. The base of LIS is a uniform spatial referencing system for the data in the system, which also facilitates the linking of data within the system with other land related data".

In general a Geographic Information System is an organized total of machinery, software, geographic data and personnel aiming at the collection, storage, updating, management, analysis and distribution of geographic information.

A GIS can answer the following questions:

- What is found in a certain place?
- Where is a characteristic that fills certain given criteria?
- What are the changes in a certain characteristic or in a certain place in various time moments?
- What territorial models exist and in which certain places these are followed?
- What will happen in a region if some parameters following some model will change?

The GIS is not only a computerized system which creates maps, even if it can be used for this reason, but also GIS is an analytic tool, because it allows the users to determine the relations between the characteristics of the map and because it stores the data from which we can create a map that serves a certain aim. It is supported from a data base in which all the attributes of characteristics of the map are registered. Also GIS can create new relations between the characteristics and new attributes in order to specify these relations, supported by the already existing data.

Finally the GIS connects with a common defining element the territorial information of the map, as these are attributed with the use of coordinates, with descriptive information which have the form of documents in a data file.

The *simplicity* is the most basic principle that should be fulfilled at the planning of each information system, because a complex system leads to more problems for the planning team, harder work for every update and many difficulties for the end-user.

A second principle of planning is the *continuity*, so the integration of new data should be a routine and the redesign of the GIS should be avoided from the beginning.

The *compatibility* is another principle. With the term compatibility is meant the possibility of collaboration, exchange of information and completion with other information systems as statistical information, geological data, circulatory measurements etc.

Consequence is another planning principle, which figures the satisfaction of various users. The achievement of this requirement is particularly difficult process because the system will be supposed to satisfy needs, with just a few common characteristics, as e.g. the benefit of elements for the long-term developmental measures and programs, the assistance in the decision-making of clearly local character etc.

The *facility* constitutes basic principle of GIS, so it would be possible for not specialized personnel to utilize the system.

Also *plenitude* is the precise determination of the type and the procedure of using conventional and automated processes.

A GIS differs from a CAD system regardless the fact that they both are based on Graphical User Interface (GUI). Both of them can manipulate graphical and non-graphical elements and they can also describe and use topological relations, of different structure though, between the objects. Their basic difference lies in that a GIS can integrate and manipulate a greater variety and larger amounts of data and it can use analysis methods which cannot be found on a CAD system. Also a CAD system cannot answer to queries, because it is not supported by a database. A CAD system should be considered as just one (main) part of a GIS.

Another difference that should be mentioned is the one between a GIS and a CAC (Computer Assisted Cartography) system. Both of these two systems refer to geographic data they can manipulate the same procedures. Their difference lies on the main purpose of their usage. The main purpose of a CAC system is to produce maps, on the other hand a GIS is used to aim a decision-making tool. Thus, a GIS produces special products in digital or printed form that does not produce a CAC system, which on the contrary gives us the abilities of changing projective systems, separating layers by color, using several types of characters and special cartographic symbols etc. which is essential for the production of maps.

The main advantages of a Geographic Information System concerning the traditional ways of collecting, recording, updating and processing data are the following:

- Serving the special needs of many different users.
- Considerable reduction of multiple storing data.
- Unified specifications for gathering and storing data (common codification).
- Continuous observing and updating the progress of phenomena.
- Providing safety for managing and storing the data.

3. DATABASES

A database is a collection of data that are related with a particular object or serve a specific aim. This collection is organized and modified in a way to provide an easy research of the records. We use the term relational database for the description of a specific model in database creation. The data of a relational database are saved in tables. Two or more tables constitute an entity and they are correlated with the use of their common fields.

The data manipulation takes place with the use of data manipulation language. Via that language the user can import, modify, erase or appear data from the tables of a database, as well as to execute these functions under conditions. There are also and some data integrity rules which deter the import of mistaken or misleading data.

A database is constituted by various elements. In the terminology of computer science, these elements called objects. The basic object clusters in a database are:

- *Tables*, in which are stored the data that the base manages. Columns and rows constitute each table. The section of a column and a row called field.
- *Queries*, with the use of which data from many tables can be combined simultaneously, de done data calculations and modifications or even created new tables.
- *Reports* that are essential in the creation of synopses or clusters of data. or even for the record of new data.
- *Forms*, which are used for the presentation of data in the screen or for the record of new data.
- *Macros*, which are certain sequences of commands, which leads automatically the database.
- *Modules*, that era parts of a code in the Visual Basic for Applications (VBA) language that can be used in the database. These functional units are more powerful and complicated than macros and they can be used for the execution of complex calculations.

4. ARCHAEOLOGICAL SITE OF ANCIENT MESSENE

Fig 1: Location of Messene

The ancient city of Messene was founded by Epaminondas from Thebes in 369 BC. The city is located in the southwest part of Peloponnesos and lies in the foothills of Ithomi mountain and the Steniclarou valley (Fig. 1).

Ithomi was the first name of the city. The name Messene which refers to the whole area was given to the city at about the 3rd century BC, when it has prevailed over the area and became the dominant city. From that age the city began to prosper and flourish and that continued until the Roman Times. At the 4th century AD massive distractions occurred to the city either by earthquake or by Barbarian raids and it was gradually abandoned.

The city holds the privilege never to have been covered by newer settlements. Thus, it presents an intact ancient city in a Mediterranean environment. The first excavation took place by the members of the French Archeological Mission of Moreas in 1828. Extensive scientific excavation continues up to this day.

All the buildings of Messene have the same orientation and they are located in the grid formed by horizontal lines directed from East to West, and vertical lines directed from North to South, having as a result the well-ventilated and sunny houses. This urban planning system is widely known as Hippodamian.

4.1 The Walls

The walls of the city follows the mountainous regions surrounding the valley including Ithomi forms one of the better preserved in Greece today (Fig. 2).

Fig. 2: View of the Walls in the West side

Fig. 3: The Arcadian Gate

The walls were built by large rectangular limestone quarried by the rocky volume of Ithomi. The best preserved part of the fortifications lies in the North North-West side where the Arcadian Gate is located (Fig 3). The total length of the fortifications is calculated to be 9.5 Km by the traces of the walls.

4.2 The Grave Monuments

The grave monuments lie in the right side of the ancient road leading from the Arcadian Gate to the Stadium. Many archeological findings came to light such as sarcophagus made by marble and a lot of pottery and other objects used in the burial ceremony.

4.3 Asklepieion

It is the most renowned complex of the ancient city, center of the public life and was built in 215 BC. (Fig. 4) It consists of the following buildings:

1) The doric temple
2) Eastern and Western Propyleaun
3) Eclessiasterion
4) Bouleuterion
5) The Archive of the Conventions Secretary
6) Sevasteion
7) The late Roman Stoa
8) Artemision

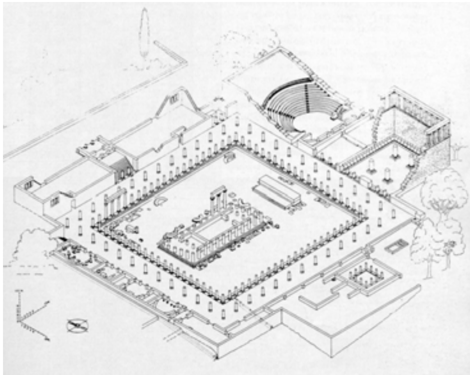

Fig. 4: Isometric view of the Asklepieion from SW

4.4 Theater

It lies in the North-West side of Asklepieion. Its larger part is distracted

4.5 Agora

It lies in the North-West side of the Asklepieion and in the East side of the Theater

4.6 Stadium and Gymnasium

It is one of the most impressive and well preserved building complexes in ancient Messene (Fig 5). It is a place with great importance for the local community not only for working out, but also a place where reading, writing, arithmetic and geometry were being taught.

4.7 Valaneion

It was the Hellenistic baths built in the period during 4^{th} to 2^{nd} century BC
There are a lot of other buildings and monuments such as roads, stoas, the Heroon, Fountain Arsinoe, Fountain Clepsidra and several temples and altars.

Fig. 5: NE View of Stadium and Gymnasium Complex

5. CREATION OF THE DIGITAL BASE MAP FOR MESSENE

The analog map we used for ancient Messene came from four joined map sheets provided by Hellenic Military Geographical Service (HMGS) in Hatt projection. The center point of the projection was of Meligalas and the map scale 1:5000.

The joined analog map was scanned as a black and white drawing in tif format (raster image). To create the vector image the application Scan2CAD v.6.1 was used. The dxf file produced was imported to AutoCAD Map 2000i program for further processing. Due to the monochrome image coloring all lines were automatically placed in one layer by Scan2Cad. Thus, the lines and objects scanned had to be separated in different layers and corrections had to be made because of the errors produced by the automatic vectorization. To apply all these modifications the raster image was placed in the background of the digital map. A special case need to be mentioned is the contour lines. Each contour line had to be a closed polyline without breakpoints so as to apply altitude properties. To achieve this, the 'pedit' command was used and all the separated segments of a single contour line were joined together. The next step was to define the altitude property by adding the correct value in the elevation cell of the properties dialog box for every contour line. Several layers were created representing monuments, artifacts and all the map details.

To complete the procedure further corrections had to be made to the digitized base map due to distortions occurred to the original map by photocopying and scanning. To correct these errors the application Istos 2000 for AutoCAD was used. Firstly, an affine transformation was performed to achieve the right scale and proportions on the map. After the successful affine transformation a correction to the coordinates had to be made so as to correspond with those on the original map. The digital map was then translated to the known coordinates of the triangulation point "Panagia" Several known points was then checked to verify the digital coordinates with the real ones. The final step was taken to perform a projection transformation from Hatt to EGSA '87. To perform this transformation the application Istos 2000 was used once more. The new coordinates were those expected after being verified with known ones on the new projection (EGSA '87).

The final stage for the completion of the digital map used in the GIS was to update, correct and enrich it with the latest data. This was made possible by using four othophotomaps of the area provided by the Ministry of Agriculture. These photomaps were in EGSA '87 projection and were taken in1996. The four orthophotomaps were joined together to create a single map using Corel Photopaint. This single map was scaled and transformed to the digital maps coordinates and placed in the background. The Stadium's and Gymnasium's plans, which were derived from terrestrial surveys, used to draw them and to find their exact location on the digital map. The final digital map is shown in Fig. 6. The buildings and the monuments with archaeological interest are being represented in blue color.

Two databases were created. One was holding the data of the monuments, artifacts and buildings and another one holding the drawings, plans and images. The application used was MS Access 2000.

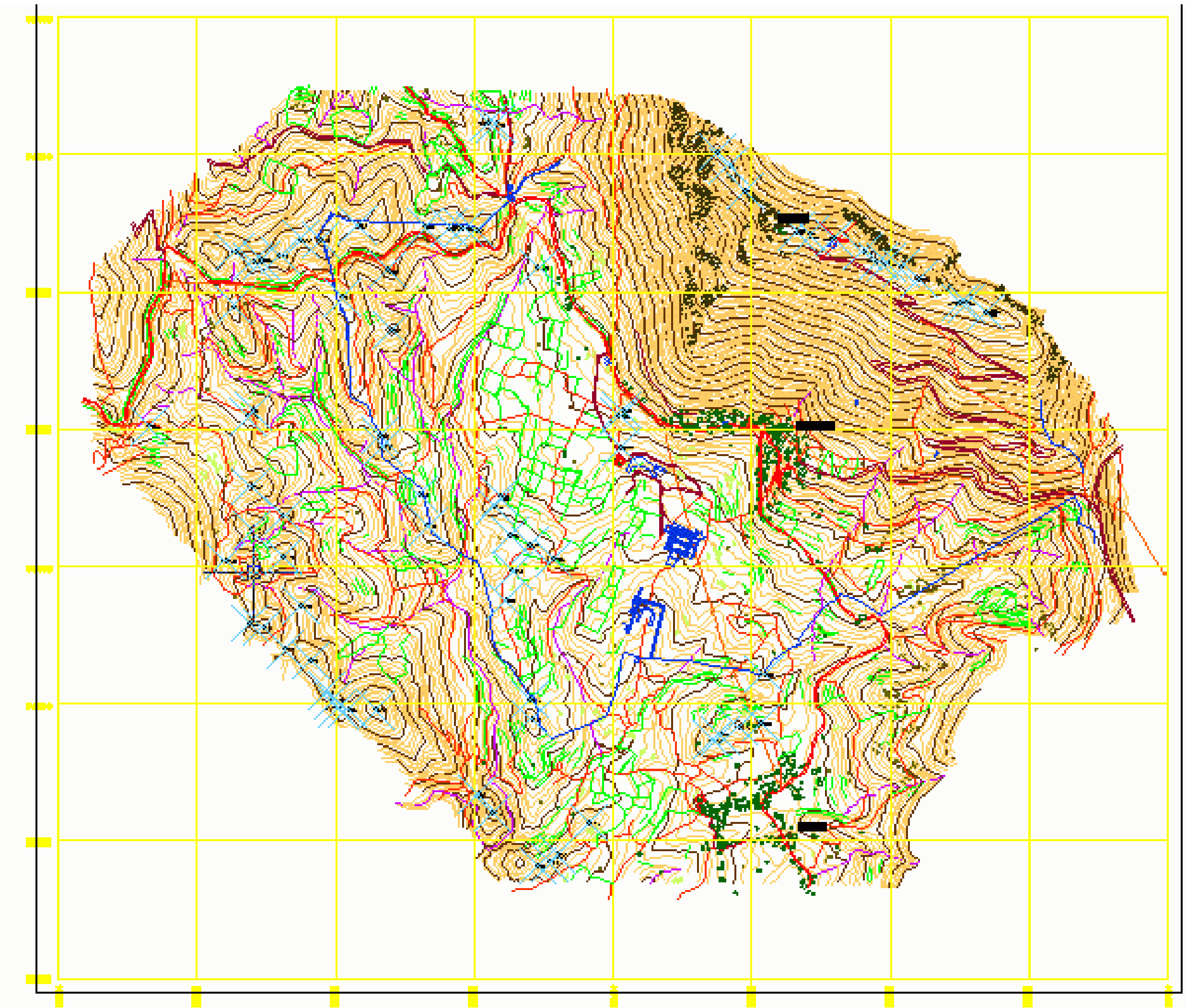

Fig. 6: The Digital Map

6. CREATION OF THE GIS FOR THE SITE

To create the GIS of Ancient Messene, a connection between the digital map and the database had to be established. In addition, every monument was linked with its own database record in each base.

We can view the images by using the menu command:

Map → Object data → View → Associated document
While the information can be viewed either by using the menu command
Map → Database → Link manager

Or by right clicking on the image and then selecting the command Link.

Fig. 7: The Arcadian Gate hyperlink

Fig. 8: The Asklepieion complex with the doric temple link

Finally, the use of hyperlinks resulted in cursor indication (name of the object) every time the mouse cursor is moving over it (Fig. 7, Fig. 8). In the background the reader can see the orthophoto map.

7. CONCLUSIONS

All the archaeologists, who have seen the results of the present program, have been impressed from the flexible and supervising way of presentation. The helping ability provided by the GIS tool to the historians and the archaeologists was proven, especially in Greece where there are so many antiquities. Using GIS as a tool they can study much more data and they can correlate archaeological places or findings. Consequently they can conclude easier, faster and safer about characterization of archaeological places or findings.

With a proper elaboration GIS could be placed on a touch screen monitor in the museum, so the visitors could have direct information about the archaeological site. There is also the possibility of its connection with the program of Ministry of Culture so that it could be accessible through the Internet. And of course there are many more sites to work with similar projects.

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