

# Photogrammetry and Archaeology: An integrated case study in the Archaeological Site of Philippoi in N. Greece.

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## *Abstract*

At the Archaeological site of Phillipoi in Northern Greece excavations are taken place for the past 90 years. During the excavations, a small part of the famous Egnatia route of the Roman period have been uncovered; the city of Phillipoi being an important crossroad of commercial value. This paper presents the contribution of Photogrammetry in revealing the still undiscovered traces of Egnatia route and a part of a fortification wall as well. For this purpose, all available information is processed and cross-evaluated. Current aerial photographs have been used for orthophotomap production at 1:5,000 scale. Additionally, old cadastral maps (1928, 1938, 1940, 1957, 1960) have been used. On these maps the old geomorphology (old streams, old ownership boundaries, etc), which does not exist, is shown. Using the above information, the current images were digitally processed and interpreted. The results are quite revealing, since a buried construction, unknown till now for the archaeologists, 4 still buried parts of Via Egnatia and a part of a fortification wall are clearly shown. On the other hand the photogrammetric process of terrestrial photographs conducted in the production of the 3D model of the theatre of Philippoi.

## *1. Introduction*

The present study belongs in the field of Geoinformation's applications that are related with the documentation, management, protection and promotion of archaeological sites. The value of these applications in national and worldwide level is obvious, because, the essential tools for the continuous follow-up and management of Cultural Heritage are offered. Digital photogrammetry, one of the basic tools in this field of applications, is the method which in comparison with other techniques like topographical survey or 3D scanning, offers the most advantages for the identification, understanding, interpretation and presentation of an archaeological site or a manmade construction. Namely a few of such advantages are:

- *simultaneous* acquisition and production of quantitative and thematic data,
- *extremely* accurate 3D data and ability to produce an accurate model of an archaeological site or object,
- *least amount* of money and time,
- etc

The use of the aerial photogrammetry for the monitoring of the remains of past human activities, especially when they are of complex form, is well known (Doneus 2001, Patias, Karapostolou and Simeonidis 2002, Tozzi, Harari and Veneta 1984). The application of digital

methods of photogrammetric processing, often of a large number of aerial photographs, gives all the necessary outputs for this purpose, as maps, DTMs, orthophotomaps, 3D models, etc. Especially the orthophotomap, which combines the quantitative information of a map and the thematic information of a photograph, plays a significant role in archaeological research.

On the other hand, the terrestrial photos are more appropriate for the documentation of manmade constructions. The fusion of different (aerial and terrestrial) data is a very interesting process because it offers an integrated product (Patias, Karapostolou and Simeonidis 2002).

This project has as object the digital photogrammetric process of aerial and terrestrial photos as well and the production of suitable products aiming at:

- the documentation of an archaeological site,
- the location of buried archaeological remains and
- the application of virtual reality techniques aiming at the study and the analysis of archaeological landscape and of man-made constructions as well.

The project concerns the first results of a research that our group, in the Aristotle University of Thessaloniki, is working on. Our group is interdisciplinary and is consisted by Photogrammetrists and an Architect-Archaeologist.

## 2. The area of study

The area of study is the archaeological site of Philippoi and his major area, in Northern Greece. Philippoi belongs in the Prefecture of Eastern Macedonia and Thrace and it is in a distance of about 150 km from Thessaloniki (Fig. 1).



figure 1

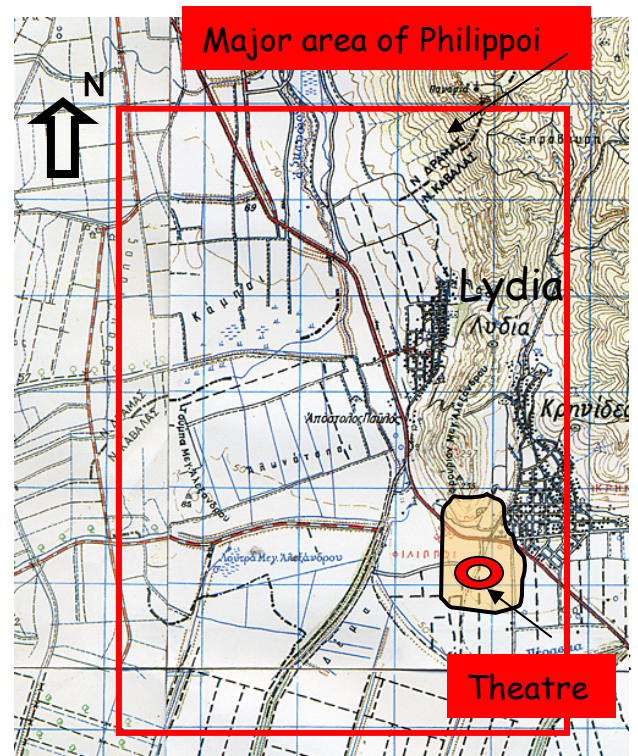


figure 2

The most important dates of history of Philippoi are:

- 360/359 BC: foundation of city of Krinides by colonists from the island of Thassos. The name is preserved till now for a small town, next to the ancient city.
- 356 BC: occupation by the king of Macedonia Philippos II, the father of Alexander the Great, who renamed it "Philippoi".
- 2th century BC: construction of the Roman road Via Egnatia, which ran for around 500 miles across northern Greece, passing next to the city of Philippoi.
- 42 BC: the battle of Philippoi between Marc Antony - Octavian and Brutus - Cassius, which was decisive for the future of the Roman Empire.
- 49 or 50 A.C: Apostle Paul visited the city and he established the first Christian Church of Europe.

At the archaeological site of Philippoi, excavations are taken place for the past 90 years. During the excavations, characteristic monuments of the Hellenistic, Roman and Early Christian period were discovered. Among them the theatre of Philippoi, a small part of Via Egnatia and the city wall.

The project can be divided in two parts:

The first one concerns the archaeological site of Philippoi and his major area, where is the place of the battle of Philippoi at 42 BC. and the second one is about the theatre (fig. 2).

### 3. *The archaeological site and the major area of Philippoi*

In the major area of the archaeological site of Philippoi the aim of research was:

- the compilation of a vector map and the production of an orthophotomap at an appropriate scale, that is the production of the appropriate cartographic data for a future archaeological GIS for the site,
- the research for the eventual location of buried archaeological remains

#### 3.1 *The data*

The data that has been used was of different form and they came from different sources.

*Photogrammetric data:* 4 aerial photos in BW, scanned at 1200dpi (1 pixel corresponds to 20 µm in the photo and 30cm in the ground), scale 1:15,000, date September 1996. The coverage was in the direction E-W ~ 3.5Km and N-S ~ 4.5 Km (fig. 2)

*Cartographic data:* 11 cadastre maps 1:5,000, dated from 1926 to 1960, from where information about the changes of the landscape and the fields has been drew off,

*Historical sources:* very important information has been drew off from the historian Appianos (Appianos IV), who describes in detail the landscape of the major area of city of Philippoi and gives interesting information about the battle of Philippoi and the fortification of the place.

Finally information from the *archaeological excavations* has been used.

### 3.2 The photogrammetric process

A Digital Photogrammetric Workstation (Helava – Socet Set) has been used. The process included: a bundle adjustment with 7 control points measured by GPS, production of a Digital Terrain Model, production of an orthophotomap at 1:5.000 scale and compilation of a vector map at the same scale (Kaimaris 2002). In fig. 3 is presented the orthophotomap (zoom out) and in fig. 4 an extract at the original scale 1:5,000.



figure 3 - The produced orthophotomap ( zoom-out)



figure 4 - An extract of the orthophotomap  
at 1,500 scale

### 3.3 Photointerpretation

During the photogrammetric process, the current images were examined carefully and a lot of traces has been located (fig. 3). In the figures 5, 6, 7, 8, 9 few examples are shown. By considering the basic characteristics of the photographic images as the shape, the size and the tone all these traces have been interpreted.

In this point it must be mentioned the location of a very interesting trace (fig. 5). On the top of a small hill (tomba in Greek), called today the hill of Alexander the Great, are shown the evident traces of a buried construction 53 x 47 m, unknown till now even for the archaeologists.

In the next step all traces have been relocated on the orthophotomap (fig. 1). In this way it was easy to have a total view of the whole area with the traces and consequently to correlate various traces and to extract additional conclusions empowering the initial estimations. Thus

the spatial arrangement of 4 separated traces (for example fig. 7, 8) in connection with the fact that these traces had common characteristics as shape, size and tone led us to suppose that they are parts of a long straight element, a “construction” of 6 m width, maybe a road.



*figure 5* - Traces of an unknown buried construction



*figure 6* - Long trace in dark colour. Covered old stream?



*figure 7* - Straight trace of 6m width in light colour. An old road?



*figure 8* - Another straight trace of 6m width in light colour.



*figure 9* - Straight trace of 7.8 m width.



After that, the attention was focused on the research for the estimation of the chronological period that these traces appeared above the ground.

### 3.2 Digital cartographic process

The older aerial photographs that exist for the area of Philippoi are dated in 1945 and they are of bad quality. For this reason older cadastre maps of different dates (1928, 1938, 1940, 1957 and 1960), have been used. On these maps the old geomorphology (old streams, old ownership boundaries, etc), which does not exist, is shown. The cartographic process involved:

- scanning,
- transformations - georeferencing to the same cartographic projective system as the orthophotomap
- merging of all cadastre maps in one file and finally
- superimposition of the merged file on the orthophotomap

An extract of this product is presented in fig. 10. The accuracy of the superimposition was very high. The examination of the map of fig.10 indicates that in the plain of Philippoi today there is a total change of the shape of the fields and the coverage of a branch of Gagitis river.

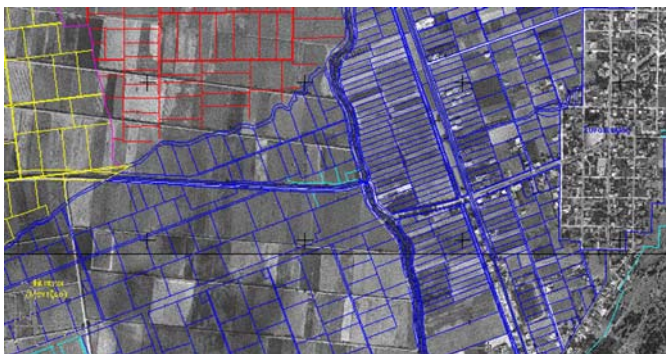


figure 10 - Orthophotomap and cadastre maps

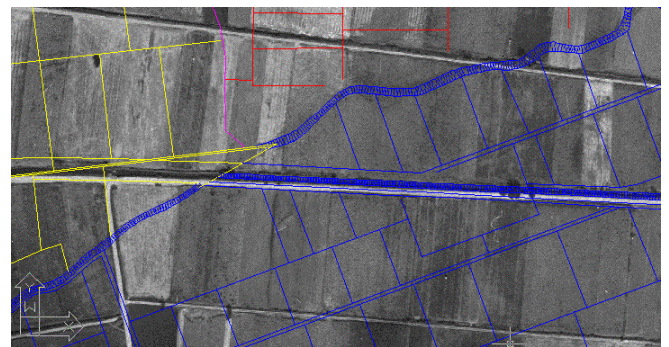
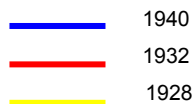


figure 11 - Gagitis river is shown on the cadastre maps of 1928, 1932 and 1940

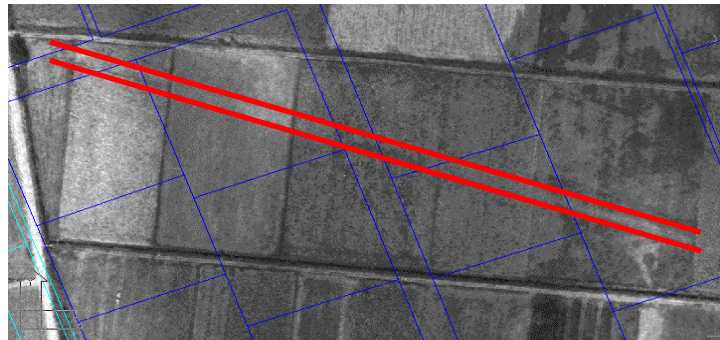
### 3.3 Cross-evaluation of the available data

#### 3.4.1. Photointerpretation – cadastre maps

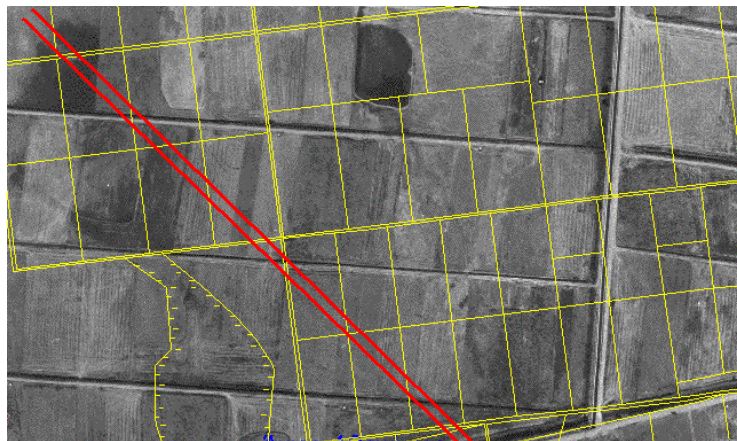
As it has been mentioned above, after the photointerpretation of the images the attention was focused on the research for the estimation of the chronological period that the traces appeared above the ground, using the orthophotomap and the processed cadastre maps.

In some cases our initial estimation became true, like in case of the branch of Gagitis river. Thus on the cadastre maps of 1928, 1932 and 1940, the river is shown (fig. 10, 11). Today is covered, leaving only its traces in the photos (fig. 6).

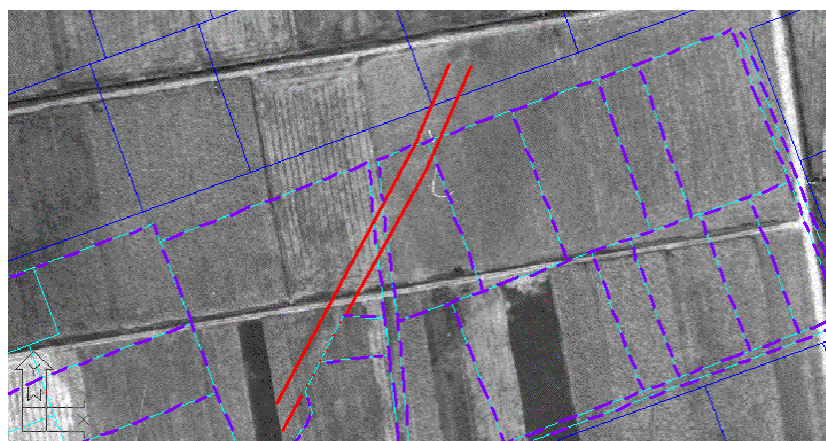
With the same procedure-analysis the initial estimations about different traces has been confirmed like in the case of rural roads, watering canals etc. But in other cases, the cadastre maps did not help us at all because nothing was shown on them (fig. 12, 13, 14), leading us to the conclusion that the traces belong to "something" before the time of maps. In these cases significant role was given to historical sources and archaeological finds.



*figure 12 - Cadastre map of 1940. With red colour the trace of fig. 7*



*figure 13 - Cadastre map of 1928. With red colour the trace of fig. 8*



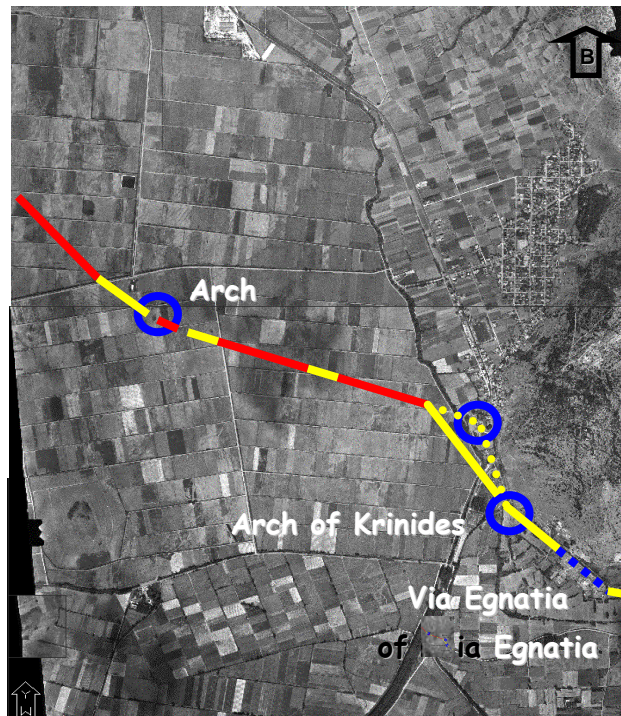
*figure 14 - Cadastre maps of 1940 and 1960. With red colour the trace of fig.10*

### 3.4.2. Photointerpretation – cadastre maps – historical sources – archaeological excavations

#### VIA EGNATIA

As it has been mentioned above on the orthophotomap, 4 traces have been correlated because they had common characteristics as shape, size and tone (for example fig. 7, 8). The spatial arrangement of these traces led us to conclude that are parts of a long straight element of 6m width, that are buried before 1940 (fig. 12) and 1928 (fig. 13).

By considering the pattern and the location of these elements in relation to archaeological finds like the Roman arch, the arch of Krinides and the excavated part of Via Egnatia inside the city wall, it was possible to conclude that this is a buried part of Via Egnatia (fig. 15 )



of Via Egnatia

- figure 15. Via Egnatia
- traces
  - estimated path
  - ⋯ excavated part of Via Egnatia

#### DEFENSIVE WALL

The straight trace in light colour that is presented in fig. 9 is of 7.8 m width and 194 m long. The cadastre map of 1960 (fig. 14 ) shows a non uniformity of the fields in this site. Maybe in this area was an obstacle above the ground, which functioned like a physical boundary of the fields. In this place according to Appianos before the battle of Philippoi, the democrats constructed various fortifications. Therefore is it a part of a buried fortification wall? Extending the red line to the south-west it strikes ahead to the hill of Alexander the Great, where we located the buried construction (fig.16). Appianos describes in detail the landscape



of the major area of city of Philippi. He mentions Gagitis river and gives interesting information about the battle of Philippi and the layout of the fortification.

Thus we can conclude that this trace eventually is a part of the defensive wall, that Appianos describes. With dotted line a possible layout of the fortification a long the river Gagitis as Apianos mentions

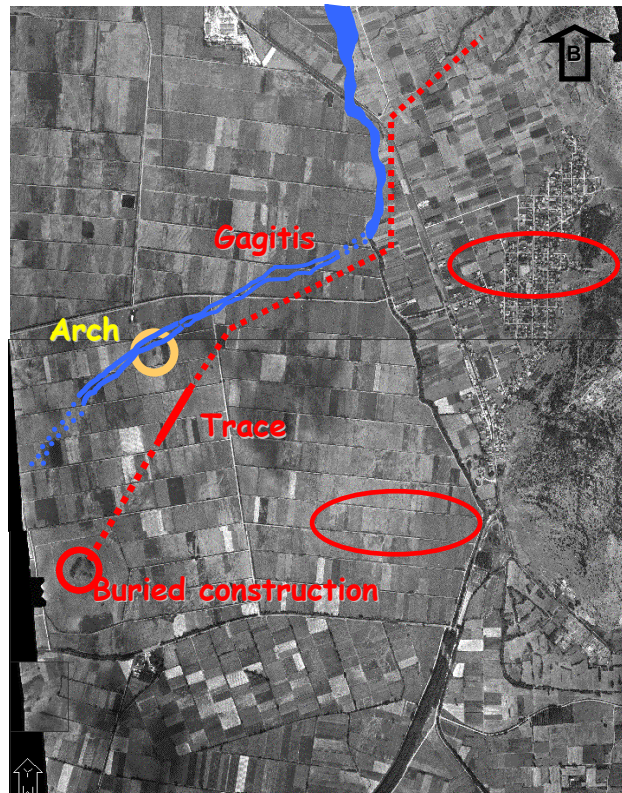


Figure 16 - The defensive wall

- trace
- ⋯ possible layout of the fortification along the river

### HISTORICAL MAP

After that a reproduction of a historical map of the possible landscape of that time and of the battle of Philippi has been done. The anaglyph (contour lines produced photogrammetrically), Gagitis river, Via Egnatia, the defensive wall and the city of Philippi, are shown in fig. 17

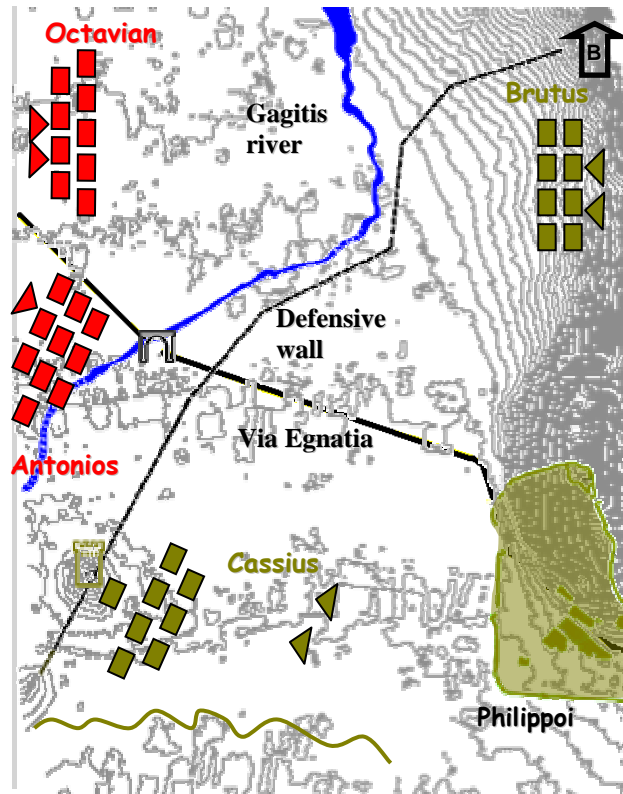


figure 17 - A historical map of the major area of Philippi

### FLY-THROUGH VIDEO

The combination of the photogrammetric products (the DTM and the orthophotomap) has been used for the creation of the image-draped model of the area. In that way a realistic view of the archaeological site and the major area of it has been created (fig. 18). Using Microstation SE and rendering techniques, a series of images were created and composed. A fly-through video sequence around the model has been created as an AVI file format that anyone can use to fly virtually around. Additionally, Microstation SE provides the ability to export the textured model of a CAD model in a VRML format file. This way interactive navigation around the archaeological site became feasible through Internet (Bakourou et al. 2002).

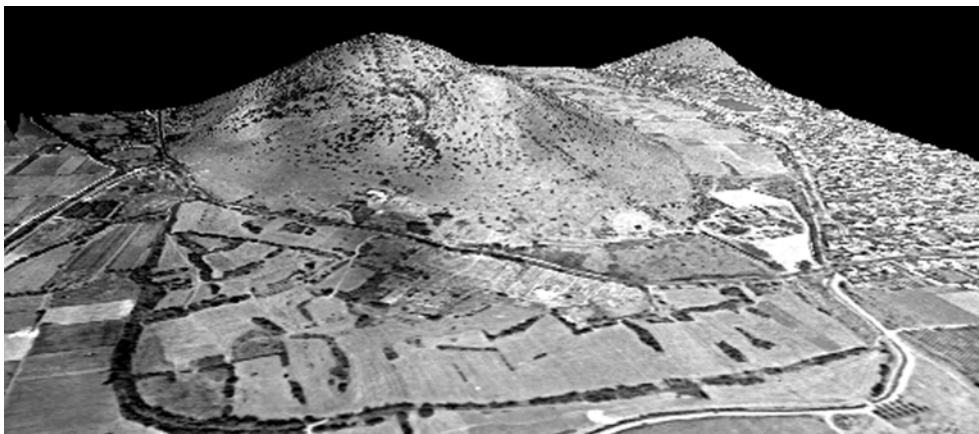


figure 18 - The image-draped model of the area

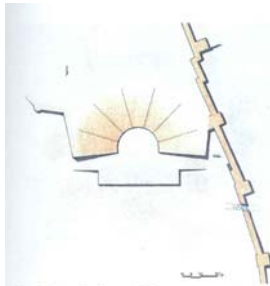
#### 4. The theatre

The necessity for precise documentation-records of cultural heritage is well known (Patias, Karapostolou and Simeonidis 2002). Especially, in the case of works of preservation, restoration and excavation, the recording is essential because offers a unique way to give meaning, understanding, definition and recognition of the monument. In the theatre of Philippoi the last years extended anastylosis-restoration works are in progress. These works are based on the result of a study of the theatre according to the archaeological excavations that are continuing, under the direction of the architect-archaeologist Prof. Karadedos. The historical and constructional phases of the theatre and the eastern city wall are presented in the fig. 19a, b,c, d, e, f and 20

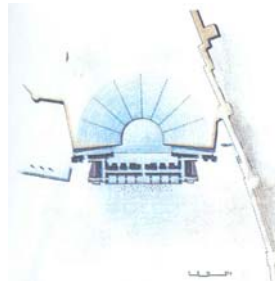
The aim of the project is:

- to surveying photogrammetrically the current status of the theatre
- to produce accurate 3D models of the different historical and constructional phases of it.
- to proceed with visualization and virtual reality techniques that provide a better inspection of the theatre in study.

Till now, the photogrammetric process of the terrestrial photos of the theatre has been finished (fig. 21) and the constuction of the 3D models is in progress (fig. 22).



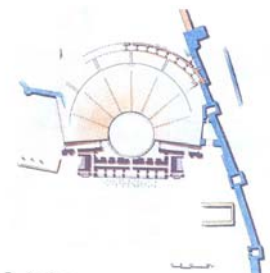
*Fig. 19* Initial phase



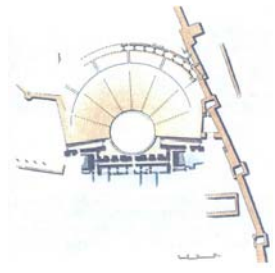
*Fig. 19b.* Second phase



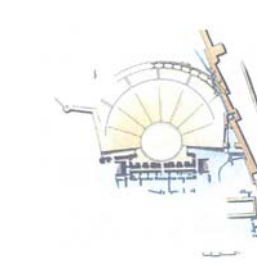
*Fig. 19c* Third phase



*Fig. 19d* - Forth phase



*Fig. 19e* - Fifth phase



*Fig. 19f* - Sixth phase

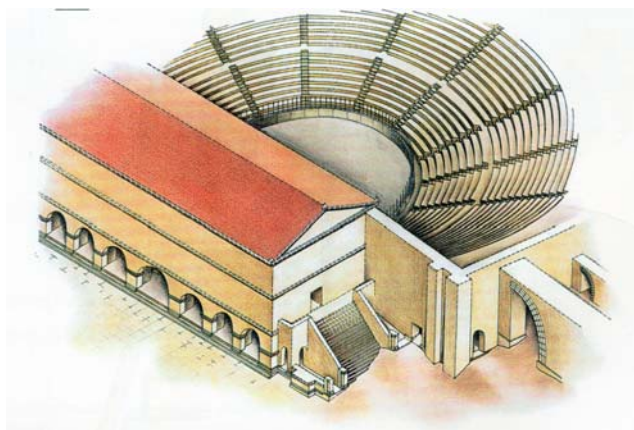


figure 20 - Detail of a constructional phase of the theatre

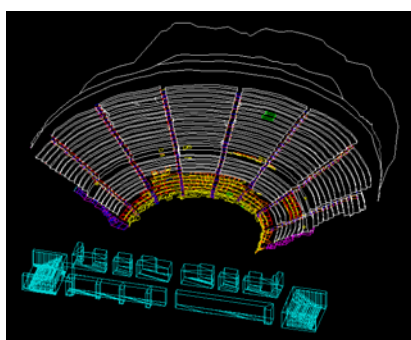


figure 21 - Initial photogrammetric product

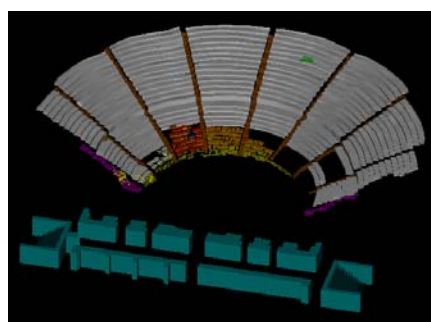


figure 22 - 3D model of the theatre

## 5. Conclusions

Photogrammetry gives more than simple maps. It gives suitable products aiming at the documentation of an archaeological site, the location of buried remains of past human activities, the application of virtual reality techniques aiming at the study and the analysis of archaeological landscape and of man made constructions as well etc.

These first encouraging results enforce us to continue the research in this area. In the near future we will process satellite images B/W (geometrical resolution ~ 70cm) and multiband image (resolution ~ 2m) for an extended area of Philippoi.

## 6. References

APPIANOS IV:105-115.

BAKOUROU, E., TSIUKAS, V., KATZOURAKI, I., STYLIANIDIS, E., PAPADIMITRIOU, K. and PATIAS, P., 2002. The promotion of Cultural Heritage through Internet using advanced audio-visual information: the Venetian castles of Peloponissos. *Proceedings of the ISPRS Commission V Symposium, Close-Range Imaging, Long-Range Vision*, Corfu, Greece, 2-6 September 2002, Vol. XXXIV, P5, Com. V:298-301.



DONEUS, M., 2001. The impact of vertical photographs on analysis of archaeological landscapes, Archaeological Prospection in Austria. *Proceedings of the 4<sup>th</sup> International Conference on Archaeological Prospection*, Vienna, 19-23 September 2001:94-96.

KAIMARIS, D., 2002. Photogrammetry-Photointerpretation: tools for the Archaeological research. Postgraduate diploma thesis, The Aristotle Univeristy of Thessaloniki (in Greek).

PATIAS, P., KARAPOSTOLOU, G. and SIMEONIDIS, P., 2002. Documentation and Visualization of Historical City centers: A multi-sensor approach for a new technological paradigm. *Proceedings of the ISPRS Commission V Symposium, Close-Range Imaging, Long-Range Vision*, Corfu, Greece, 2-6 September 2002, Vol.. XXXIV, P5, Com. V:393-399.

TOZZI, P., HARARI, M., Eraclea VENETA, 1984. *Imagine di una citta sepolta*. Compagnia Generale Aerea, Italy.