

TOPOGRAPHIC AND PHOTOGRAMMETRIC RECORDING OF THE ACROPOLIS OF ATHENS

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ABSTRACT

In the Acropolis Restoration Works photogrammetric recording was used from their very beginning. This paper will focus on the discussion of the topographic and photogrammetric recording of the Acropolis from the beginning of the current restoration works (1975) until today. It will be articulated in two parts. The first part will be an attempt 1. to present the most significant photogrammetric studies already conducted, 2. to evaluate their technical efficiency and to investigate whether they have achieved their primary aim. The second part will deal with the studies which are now in progress and will outline the problems and difficulties posed, during their elaboration.

1. INTRODUCTION

The Acropolis is the most striking and complete ancient monumental complex still existing in our times; an architectural treasure that belongs not only to the Greek patrimony but also to the worldwide cultural heritage (Figure 1). It is situated on a medium height hill (height 156m) that rises in the basin of Athens. Its planimetric extents are approximately 170X350m. The hill is rocky and sheer on all sides except for the west, and has an extensive -nearly- flat top. Fortified with strong circuit walls (760 m in length) comprises a large number of monuments including the Parthenon, the Erechtheion, the Propylaia and the temple of Athena Nike. These buildings have survived for almost twenty-five centuries through wars, explosions, bombardments, fires, thefts and interventions as well as alterations connected with different usage. Moreover, the extensive restorations carried out, throughout the 19th and at the beginning of 20th century, gave the Acropolis monuments the appearance they have today. All of the above have caused extensive damages to the monuments. Those damages had to be confronted and thus a new restoration project begun in 1975 and is continued until today.



Figure 1. The Acropolis of Athens. View from west. By S. Mavrommatis

The main characteristic of this restoration project is the interdisciplinary approach to the interventions and the special studies carried out prior to this on the basis of the principles and methodology formed by the Committee for the Conservation of the Acropolis Monuments (Acropolis Committee-ESMA), which has the scholarly supervision of the works. Studies and interventions, all across their phases, are both closely connected to scholarly research in various fields of knowledge.

In the year 2000 the administrative reorganization, with the foundation of the Acropolis Restoration Service (autonomous Special Regional Service of the Greek Ministry of Culture), made possible the tremendous development of the restoration works. This permitted the increase of academic and technical personnel and the direct administration of the funds by the newly established Service. The incorporation of the works in the Third European Community Support Framework insured uninterrupted funding. These adjustments provided the impetus that has brought the Acropolis works to a peak of development, the greatest since the establishment of the Greek state. It should be noted that the urgent pace of the works has in no way compromised their universally acknowledged high quality.

2. GEOMETRIC DOCUMENTATION

In a restoration project precise documentation before intervention, during the course of work and after its completion is an indubitable requirement, according to the Venice Charter, the international framework for the conservation and restoration of monuments and sites. One of the most important parts of documentation is the detailed recording of the object in question. Contour lines, digital terrain models of the surface or profiles are vital for the researchers involved, such as architects, archaeologists, and civil engineers.

In recent years new survey technologies have been applied. Orthomosaics based on reliable elevation information and 3D phototextured models are now, perhaps, the standard photogrammetric products for archaeological and architectural documentation (Mavromati et al. 2002, Georgopoulos et al. 2005). An orthophoto constitutes a powerful textured

representation combining geometric accuracy with high visual quality and a wealth of detail, providing invaluable information about morphology and deformation. Hence, it is a non-generalized background and the vectorized interpretation to be overlaid is left to architects. A fully 3D photo-textured surface model provides photorealistic visualization, high geometric accuracy and facilitates geometric or morphological documentation and analysis.

3. A BRIEF FLASH BACK

3.1. The studies between 1971-2000.

In 1971 and 1974 the first photogrammetric recording of the Acropolis and the immediate vicinity was carried out by the Insitut Géographique National in Paris-UNESCO at a scale of 1:1000 (Figure 2).

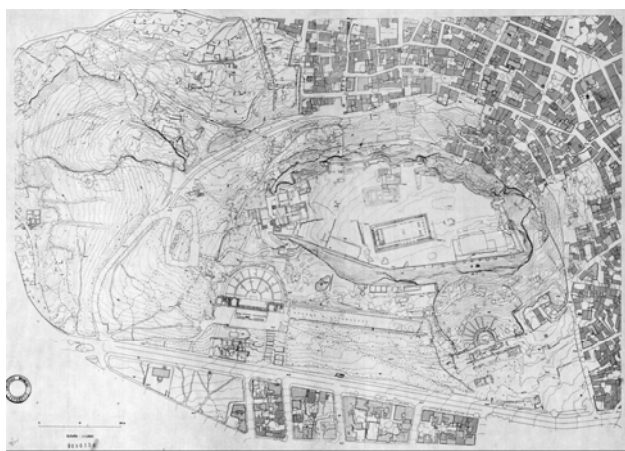


Figure 2. The first photogrammetric recording of the Acropolis. By the Insitut Géographique National in Paris-UNESCO

In 1976 a topographical survey was carried out by the National Technical University of Athens (NTUA), a network of fixed points was established and the ground plan was drawn up at a scale of 1:100 and of 1:200. Also a photomosaic of the Acropolis area at a scale of 1:200 was created (Figure 3). The photographs used, were acquired from a balloon by the staff of the Photogrammetry Laboratory of the NTUA.



Figure 3. Acropolis. Photomosaic of the plan view. By the Photogrammetry Laboratory of the NTUA

In 1977 the work of recording the Erechtheion began. A three-dimensional grid with units of one meter was used as the fixed system of coordinates, based on fixed trigonometric points on the Acropolis rock, thus it was made possible to check spots or areas where deformations were developing (geometric changes,

mechanical changes, deterioration of the surface). Photogrammetric line drawings were produced for the interior surfaces of the Erechtheion south and west walls where the type and extent of damage could not be gauged by means of classical methods (Casanaki et al, 1985). These line drawings also depicted contour lines of one centimeter. The images had been acquired from a distance of 6m and covered an area of 12X20m. Additionally, rectified photomosaics had been produced for both sides, inner and outer, of the south and the west wall. (Erechtheion Study, 1977) (Figure 4).



Figure 4. Rectified photomosaic of the Erechtheion interior west wall. By the Photogrammetry Laboratory of the NTUA

In 1979, the same method was used for the work on Propylaea. At the same time, the project of recording the Parthenon began as well. The Parthenon floor provided the fixed system of coordinates used in measuring i.e. the lines of the outer edges and the joints of the colonnade stylobate and of the cella stylobates and toichobates. This system was preferred for it was realized that no precision instruments could produce a system of lines finer and straighter than those of the Parthenon itself (Casanaki et al, 1985). On the basis of this system the original geometry of the superstructure was calculated by means of direct accurate measurements. In recording complex Parthenon forms such as sculpture or fragmentary column drums, three different systems were used: 1. a 3D orthogonal coordinate system, 2. orthographic projection and 3. stereopantograph. The interior structure of the temple was also investigated and became possible to measure blocks and parts of the building in inaccessible places by means of mirrors and steel wire (Casanaki et al, 1985).

At the beginning of the project, the application of photogrammetry was considered as the appropriate method of recording the monuments' areas, especially under high pressure of time. But the results, despite the initial enthusiasm, were inadequate. The drawings yielded only the general morphology of the surface together with the damage from fractures. Furthermore, they were not accompanied by qualitative analysis. Thus the final users were not able to understand the features represented. In many cases the interpretation of the elements recorded gave false representation and the final product had to be corrected and supplemented by observations made on the spot in order to supply specific information such as determining contours, the position of joints, preserved original surfaces and restorations, signs of later operations (Figures 5, 6).

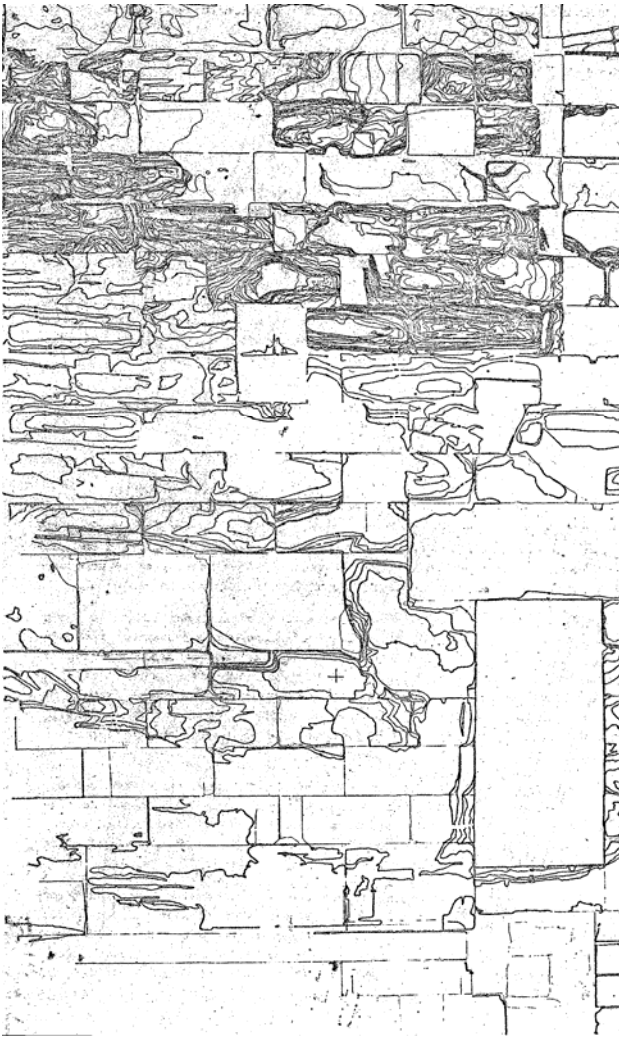


Figure 5. Erechtheion. South Wall. Photogrammetric line drawing of the westermont section of the interior. By the Photogrammetry Laboratory of the NTUA

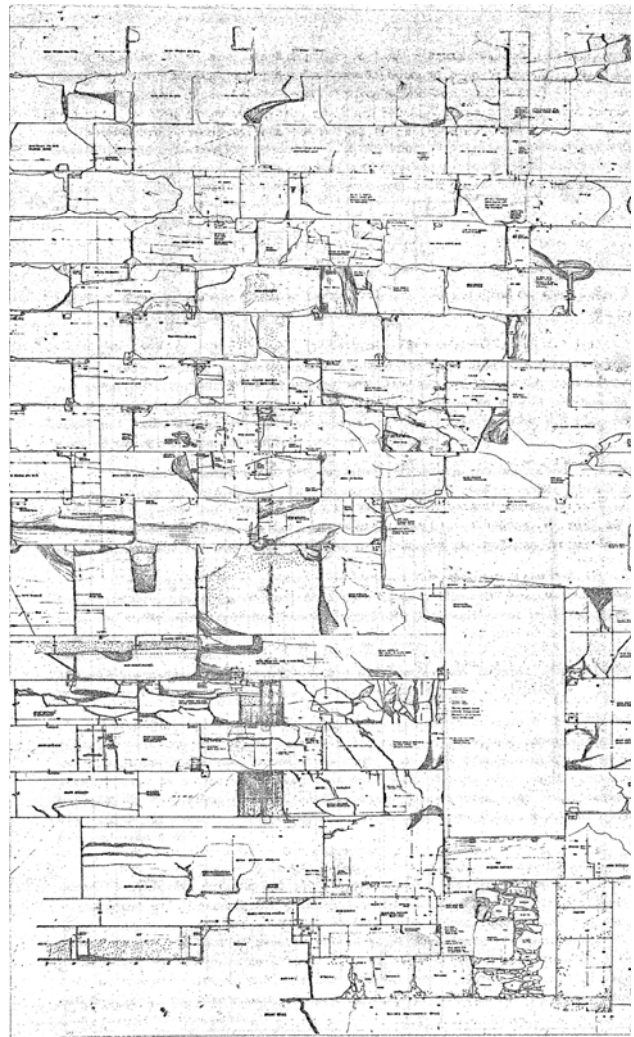


Figure 6. Erechtheion. South Wall. Line drawing of the of the westermont section of the interior on the basis of the photogrammetric survey supplemented by observations made on the spot. By E. Moutopoulos.

Besides the interpretation issues, the scale of the original images had to be larger in order to correspond to the accuracy and the visual quality of the expected final products. Also their overlap could not ensure the avoidance of any occlusions. Thereby the Acropolis Committee and the stuff of the Technical office were reluctant to use photogrammetric drawings thereafter.

3.2. The studies between 2000-2006.

The Acropolis Restoration Service, in its effort for constant documentation and recording of the monuments, realized that the advent of new technologies and the development of photogrammetric techniques can offer a wide range of benefits, such as the production of large scale orthomosaics with high geometric accuracy, reliable 3D meshes and photo-textured 3D surface models with the use of 3D laser scanners. 2002 was the inaugural year of the production of rectified photomosaics of the south circuit wall at a scale of 1:50. Contour lines with an interval of 20 cm were overlaid (by E. Kapokakis). The images needed, were acquired by the Directory of Topography, Photogrammetry and Land Register of the Ministry of Culture (D.T.Ph.L.R.), using a small balloon.



Figure. 7. South Circuit Wall. Detail of the rectified photomosaic. By E. Kapokakis

This was also an attempt crowned not with the expected success, since the south circuit wall was originally considered to be nearly flat and the method applied was planar rectification instead of orthorectification. This led to geometric errors and consequently to significant problems along the seam lines such as displacements and double visions (Figure 7).

In 2006 the full geometric documentation of the poros remains of Arrephorion was carried out, the latter being a square building with a side of 12 m of length, dating from the 5th century BC. The detailed documentation was necessary because the monument had to be reburied for protection, since there was no other way of saving its remains. The first step, completed by now, was the production of a full 3D surface model in order to have all the necessary details and profiles. The site has been recorded using a CYRAX 2500 scanner at a resolution of about 5mm to 1cm (by L. Grammatikopoulos, E. Kalisperakis, and V. Pagounis). Due to the object's morphology it was impossible to avoid surface occlusions (Figures 8, 9). In some cases it was impossible even to place the scanner conveniently. For the future, the filling of the voids of the scanning process and the production of orthomosaics for the plan view and each façade of the monument are scheduled.



Figure 8. Arrephorion. Inside view from the west.

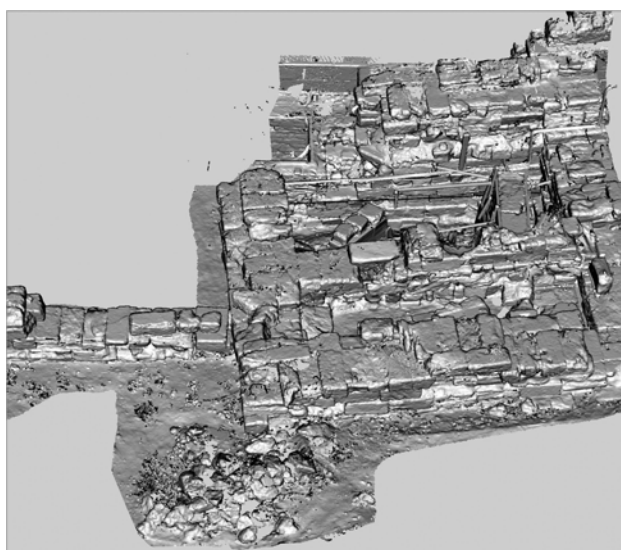


Figure 9. Arrephorion. Shaded surface model. By L. L. Grammatikopoulos, E. Kalisperakis, and V. Pagounis

The same year the D.T.Ph.L.R. created the orthomosaic of the plan view of the west part of the superstructure of Parthenon's north side at a scale of 1:10 (by D. Mavromati). The original images were 20 at a scale of 1:80. The latter product, having achieved the expected accuracy (2-3 mm) and the needed visual quality, will be used for further restoration planning of the area (Figures 10, 11).



Figure 10. Parthenon. Part of the north side superstructure. Original photo of the plan view. By the D.T.Ph.L.R. (S. Gesafidis)

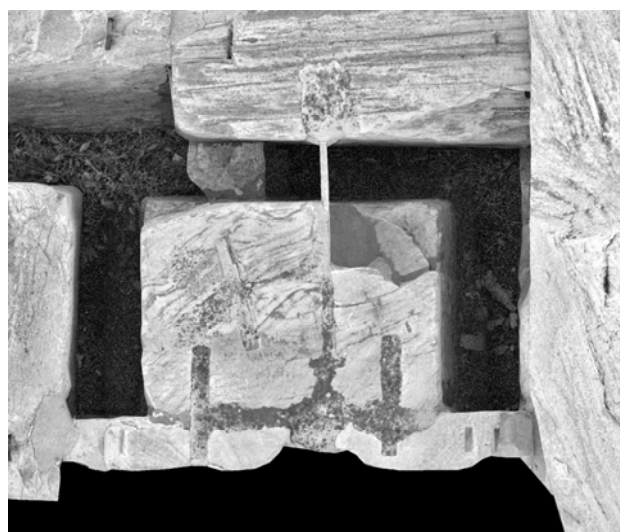


Figure 11. Parthenon. Part of the north side superstructure. Orthophotomosaic of the plan view. By the D.T.Ph.L.R. (D. Mavromati)

4. THE CURRENT PROJECT

One of the primary aims of the Acropolis Committee, since its inception, was the recording and documenting the Acropolis circuit walls. The walls are very valuable because of the great quantity of material from various Acropolis structures built into them; a fact that makes the lack both of adequate measurements and of plans all the more noticeable (Figure 12).



Figure 12. Acropolis north circuit wall. Detail.

Unfortunately financial reasons as well as the urgent monuments' needs turned the Committee's attention towards the rescue interventions on the monuments.

Having secured in 2005 funding from the European Union and the Greek State, (ap. €1.000.000), the Service initiated a project and prepared a detailed plan of implementation, developed by: 1. analyzing the existing data, 2. recording the problems, 3. defining the needs, 4. establishing project goals, 5. determining steps needed to achieve those goals, 6. determining a realistic time-frame for the project, 7. determining costs and 8. evaluating whether the project is worth doing given projected time and cost (Moullou et al, 2006).

Now after two years of systematic research the project is well in process and its completion is estimated by 2008.

The project has a dual goal consisting of: Firstly the production of the scientific infrastructure needed for current or future restoration planning, with the emphasis laid on the Acropolis circuit walls. The project will cater for the investigation of the various interventions the walls have sustained across time, for the location and study of the poros limestone and marble blocks reused in them and for the examination of their static sufficiency. And secondly the exposure of all information gathered over the years about the interventions and the new historical, archaeological, architectural evidence that has been forthcoming from recording the monuments, inventorying and identifying scattered architectural members and dismantling the buildings.

4.1. Expected final products

The steps to achieve the above mentioned goals are the following:

- Establishment of four new trigonometric points (combined with the three old ones) covering in visibility the whole monument
- Establishment of a new polygonometric network.
- Production of orthomosaic at a scale of 1:50 (pixel size 5mm) of the north, west, east circuit wall façades.
- Production of orthomosaic at a scale of 1:25 (pixel size 2mm) of the wall areas where built-in significant architectural members exist (areas of special interest).
- Production of orthomosaic at a scale of 1:100 (pixel size 10mm) of the plan view of the hill.
- Production of full 3D surface models (and photo-textured surface models) of the rock, the walls and Erechtheion derived from 3D Laser Scanning at a resolution of 1cm for the areas of special interest, 5 cm for the rest of the walls, including its interior

façades and 0.5 cm (or even better where it is needed) for the Erechtheion.

- Development of a G.I.S. based on the above mentioned orthomosaic and the existing architectural plans, aiming at constituting a valuable documentation and restoration management tool.
- Connection of the G.I.S with the upgraded documentation database and publish them on the internet.

4.2. Major problems and difficulties

Today the archaeological site of Acropolis is both an enormous worksite and the main tourist attraction of Athens: scaffolding covering extensive parts of the monuments, various scale constructions and hundreds of scattered architectural members covering the surface, two cranes in the Parthenon, two large bridge-cranes in the Propylaea, and another in the Temple of Athena Nike, men working both up in the scaffolding and on the ground, hundreds of visitors wandering around.

Considering the above, it is obvious that the major problems will occur during the data acquisition process, which could be summarized as followed:

1. the outstanding importance of the site, which determines the high level of accuracy required and the platforms of image acquisition to be used. It is worth mentioning that all flights over Acropolis monument should be performed at least above 5000 FT for propeller aircraft or helicopter and also that no UAV, or any other remote controlled platform is allowed. Thus, the only accepted platforms could be balloons and/or cranes.
2. the fact that most of the days are extremely windy on the hill might cause serious problems in handling the balloon platform,
3. the constant presence of hundreds of visitors,
4. the object size and morphology,
5. the abrupt changes in relief, compared to the small recording distance
6. the obstructions caused by vegetation, scaffoldings, cranes, and scattered architectural members, pose severe problems to orthoimaging and laser-scanning (Figures 13, 14, 15, 16. See also Figure 12)

Therefore, it is evident that the supervision, the organizing, the management and the provision of efficient, functional and realistic solutions is a challenge for the researchers involved.



Figure 13. Parthenon. Inside view from the west. By S. Mavrommatis



Figure 14. North circuit wall. By P. Konstantopoulos



Figure 15. Propylaia and its worksite constructions. View from the north. By M. Ioannidou



Figure 16. Parthenon. North colonnade. By L. Lamprinou

5. CONCLUSION

Documentation of classical monuments should be considered as an interdisciplinary task. It requires researchers of almost all fields (archaeologists, historians, architects, civil engineers, surveyors, specialists in photogrammetry, chemical engineers, conservationists etc).

When it comes to geometric documentation of such monuments high accuracy and large scale end products are presupposed. But that alone cannot ensure that everyone involved can actually use it. Therefore the end product must comprise all information needed in order to avoid misunderstandings.

The authors' experience has shown that the end product must be clearly specified a priori, according to strictly defined needs. It is only then that the pursued results will be accomplished, being, in fact, a sufficient amount of accurate information meeting the scholar needs of all the scientists involved, producing an atmosphere of fruitful and orchestrated work.

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