

## SIMPLE METHODS OF PHOTOGRAMMETRY: EASY AND FAST

**Antonio Almagro**

Escuela de Estudios Arabes, CSIC  
Cuesta del Chapiz 22, E-18010 Granada, Spain  
Phone: +34 958 222290, E-mail: [aalmagro@cica.es](mailto:aalmagro@cica.es)

**KEY WORDS:** simple photogrammetry, architectural recording, training

### **ABSTRACT:**

The need for surveying and recording the cultural property is increasing every day and is demanding proper answers from experts and scientists. The answer to such a problem must be based in the use of photogrammetry and other new technologies whose use must be widely extended. Experts in such technics are not enough in number for solving the problem. This means that they can't take on their shoulders the responsibility of the complete task

The real problem today for the developing of the use of photogrammetry lies in training the people able to operate those systems: Architects, archeologists, art historians, curators, draftsmen and technicians in general. Photogrammetry should be promoted and taught to these professionals, not as a sophisticated and complex systems requiring costly instruments and specialized technicians, but as a methodology that is accessible today to most of professionals and which is not as costly as it was before. Photogrammetry can contribute not only with precision, but specially with speed and efficiency regarding to documentation; It is an ideal system for producing 3D models, for creating data bases, and offering efficient solutions in emergency cases, etc.

There are here some examples of the use of digital photogrammetry based on systems and methods which make possible to operate reducing the working time in the site, and operating very light and inexpensive equipment. This system is specially adapted to emergency works and archaeology, when it is needed to work on field without the full support of a complete office equipment. The use of the system is actually taught to architecture students in short courses proving how easy is its handling.

### **1. INTRODUCTION**

It was 30 years ago that I finished my studies and I started working as an architect in the field of architectural conservation. With it I also started in a more or less systematic way my works in documentation of monuments and buildings. A few years later, in 1973, I had my first contacts with photogrammetry helped by Maurice Carbone and Hans Foramitti, founders of CIPA. Those were times of the big analogical devices which implied great costs and limited and complex use and of the Foramitti's first attempts to adequate the equipments to the needs of architecture and to simplify its use.

For fifteen years I still had to do 90% of the survey by direct methods (metric tape, water level and plumb-line) and the use of some simple systems with rectified photographs. It is only in some cases that I could use photogrammetry, always in extensive projects with considerable budget to cover expenses and turning to specialists and equipments from institutions not related to the Cultural Heritage. Fifteen years ago I had the chance to organise the first department in Spain working on architectural photogrammetry. I had to learn how to use the analog plotters, and to teach later to my staff. In this years the use of analytical plotters start but their cost was still very great and few people knew and had any access to their use.

I think that nowadays the outlook in photogrammetry has changed in a radical way. It is my opinion that, had I had the means and knowledge that I have now when I started working, my labour during these years would have been much easier and, what is more important, more fruitful. But to get to where we are today, two main things had to happen. Firstly, the availability of effective systems that were simple to use and not too expensive at the same time. Secondly, a sufficient diffusion of these systems and, above all, the knowledge needed for its use and application.

For me, these two events have already happened and today I can arrange and use fully effective systems, at a low cost and whose use is simple. I can even utilize them at home. These devices, in my case are synthesised in three basic software applied specifically to the production of surveys, to which we could add other standard drawing programmes or image-treatment programmes of common use. Firstly, I use a self-made software used for calculation of topographic measures that allows the computation of canevass, intersections and radiations, transformation of coordinates and drawing the computed points in AutoCAD. The second software I use is an image rectifier to make photo-plans of flat surfaces (such as facades and pavements). The third software is a programme for stereoscopic and tri-dimensional plotting based on the view through an stereoscope of images visualized on the computer screen. All this software operates on simple PCs and even on laptops, fact that makes the work easier anywhere and under any circumstance. In order to obtain the images, I use a digital camera although sometimes I also use scanned conventional photographs, obtained with semi-metric cameras.

This equipment is based in two basic ideas: firstly that is of very simple use and easy to learn, which make it easier to work fast and with little field equipment and, by doing so, make it possible to sensibly reduce the amount of work that is necessary on field, outside the office. Secondly, its cost not superior to 6.000 US\$. I am supposing that it should not be necessary to buy the topographic instruments, as they can be rented in most countries at reasonable prices. Moreover, some of the procedures are designed to avoid topographic measurements in order to simplify both the process and the necessary equipment. All of them are situated in the column designated as simple systems in the diagram shown at the Olinda Symposium (Fig. 1) which, due to unknown reason, is not visible in the proceedings published in CD-ROM.

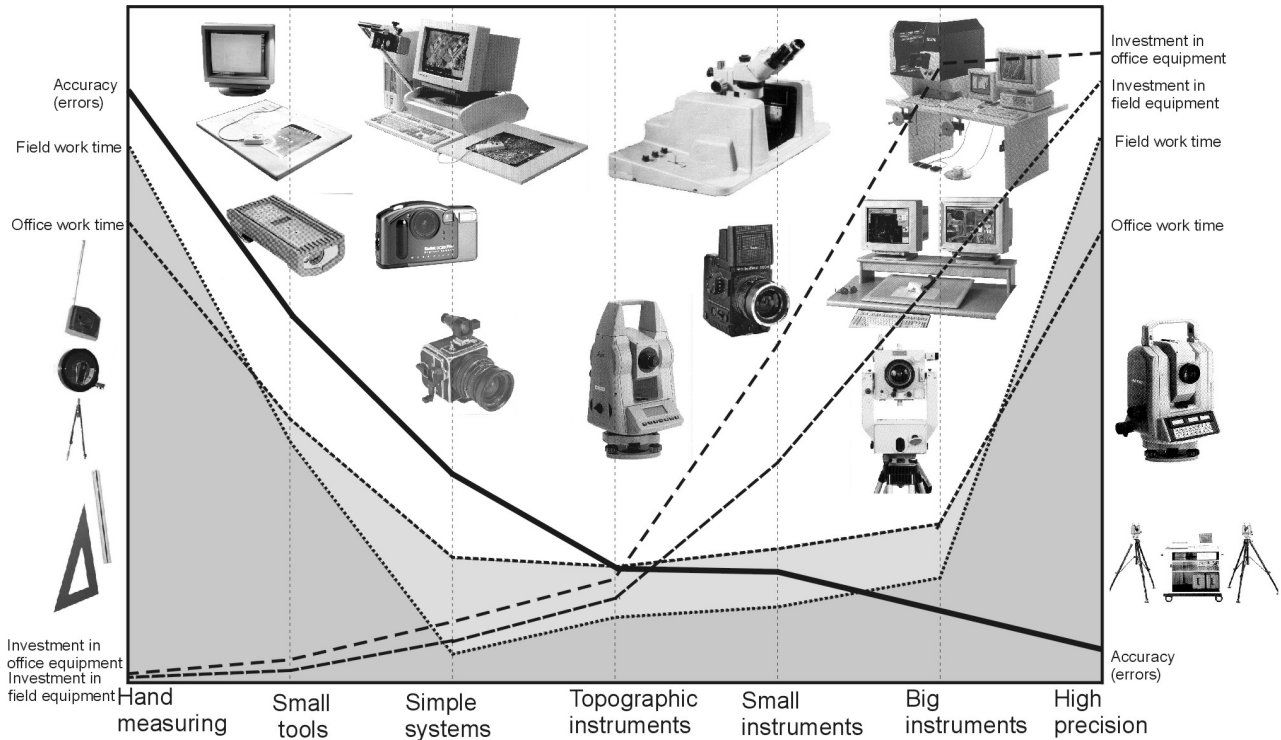


Fig 1: Optimization of architectural survey

These personal experiences I think can be useful for many cases. The needs that the Heritage protection and safeguard raise in the field of documentation are great and continue to increase. The concept of Heritage is constantly enlarged and new of its elements are endangered every day. It is urgent, therefore and firstly, to document them adequately. To document means to know, and that knowledge is essential in order to preserve. And this problem is even more compelling in developing countries where much of their Heritage is badly known and is in serious danger. It is unavoidable to provide efficient answers. Showing the achievements and possibilities of photogrammetry is useless if those successes are based only on sophisticated and expensive system, only available to experts and specialized centres and institutions, and with economic costs completely inaccessible to great part of the institutions responsible for the Heritage in many parts of the world. In that way, we will only be able to solve a minor part of the problem. It may be the most conspicuous one, but that solution is far from being the most realistic and effective one.

## 2. THE TOOLS

The rectifier software **ASRix** (Fig2) has been developed by Steve Nickerson, a CIPA member with a great experience in surveying, with the collaboration of André Streilein for the mathematical model. It is a software easy to use that barely requires any previous learning and provides great possibilities in every field of Heritage documentation. Flat elements are very common in architecture and rectified images are a simple and fast way to document them. This method can complement other ones that rectify vector drawings. VSD software has a system to reconstitute from individual photographs that allows the rectification of the drawings performed over the oblique images. Because of its simplicity and minimum cost must be mentioned the software **Homograph**, (Fig 3) which was developed by Prof. Ramón Maestre at Alicante University. A small book that includes the software presents this simple application that works in AutoCAD and enables the rectification of the drawings made on oblique images in a simple way.

The stereo plotting system, **VSD** (Fig 4), produced by the Department of Photogrammetry and Remote Sensing Informatics of AGH represents a clever answer to the need of low-cost but high quality systems of recording cultural Heritage. Undoubtedly the greatest opportunity offered today in the field of architectural documentation is the availability of reasonably-priced systems and the prospect of even lower costs in the future, given that there will be sufficient demand. The potentiality of this demand is large, due to the fact that the field of architectural Heritage is in need of adequate documentation capable of solving problems in areas where more

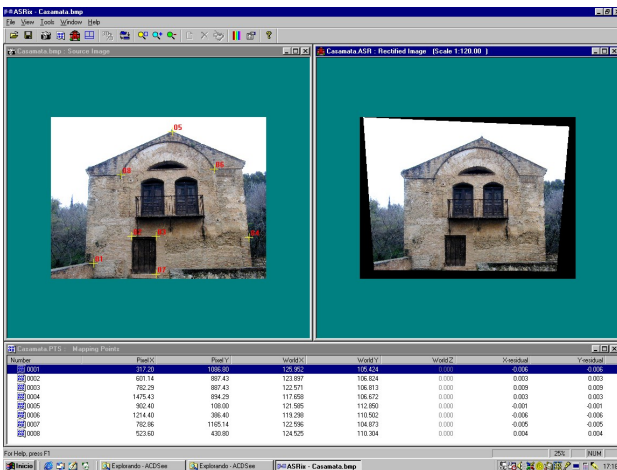


Fig 2: ASRix image rectifier

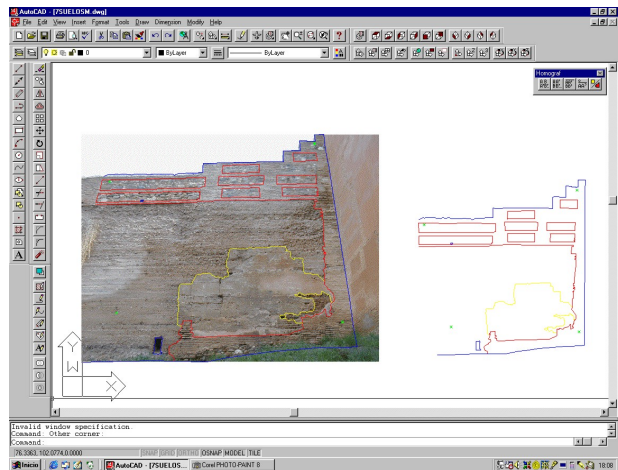


Fig 3: Homograf vector rectifier

traditional means are unable to produce the same results. VSD is giving a real answer to these possibilities and offers real solutions to the problems of recording our architectural and archaeological Heritage.

Our experience has made us trust this system and since we had knowledge about its existence, we have been working in order to improve its applications and broadcast its use. CIPA has been until now a meeting point between Prof. Jachimski and me, where from the beginning we have been participating experiences and have talked about needs and how to attend them. Great part of our suggestions has been understood and accepted by Prof. Jachimski being carried out by improvements in the software. The concession of a license to test VSD allowed us to verify in a practical way the great advantages of this system and its application possibilities in our working fields. That allowed us to promote its use between colleagues who came to ask for our opinion or our help in order to start working with photogrammetry. This kind of demand made us go further in our cooperation with the Department of Photogrammetry and Remote Sensing Informatics of the AGH, in order to adapt the software to the existing necessities. One of the first works undertaken was the complete translation of all the program messages to Spanish. This simple act made the acceptance of this system much easier for Spanish colleagues, specially in the teaching field, as having both the manual and the software itself in Spanish made it easier to be learnt. It is also of relevance the creation of a proceeding for absolute orientation of models by not using control points, but only references on the object in order to define the reference planes and the measuring of, at least, one length in order to give scale to the model. This process allows us to make simple surveys with very simplified resources and, consequently, lower costs and less field working time.



Fig 4: Desktop version of VSD



Fig 5: Portable version of VSD

The software has been specially welcomed in the teaching field. More than half of the actual licenses now used in Spain, about 25, are being employed to teach on photogrammetry to students of architecture, topography and photogrammetry. Its characteristics make this software specially suitable for teaching, because it is not only simple to be used and to understand photogrammetry principles, but it also allows the teacher to control the students' work and the correct prosecution of the tridimensional model.

There are already three archaeological teams working with VSD in Spain, on different sites and different circumstances. In other cases, the system is being used by professionals or institutions dedicated to studying or restoring Architectural Heritage. In all these occasions neither is the software being employed or the restitutions made by photogrammetry specialists, and all of the users have started using these technics with the VSD system. This makes evident its easy learning, which is also proved by the results on the courses on building surveying dedicated to architects at the School of Architecture of Granada University, in which, in spite of the short time available according to the studies programme, students are able to fulfil quite complicated restitutions.

The increasing demand for VSD licenses brought the obligation for us to provide stereoscopes for tridimensional viewing of the model on the screen. First, we used stereoscopes available on the market, making suitable supports for its use in front of the screen. Afterwards, we decided to search for a more simple and cheap solution, designing stereoscopes specially adapted to our particular needs and, specially, the use of VSD in laptop computers. The design is based both on simplicity and strength in the different parts and on the easiness to find and manipulate the materials. The structure of the stereoscope is a simple rectangular aluminium tube cut and modified with the tools of an aluminium carpenter workshop. Different supports for each kind of screen are built with ironmonger shop pieces and metallic shelves which are unexpensive and easy to buy.

Another problem that had to be solved is how to obtain digital images with enough quality and reasonable price. We started working with photographs taken with a semimetric camera and digitalized by different kinds of scanners. Normal desktop scanners did not work satisfactorily, as the non-homogeneous movement of the CCD causes uncontrolled y-parallax. A special scanner for large format slides has just been bought and has allowed us to get acceptable results, although it also needed a high inversion for its buying (5000US\$).

We have achieved better results using digital cameras of standard production. Although the resolution of their images is still low, their metrical qualities are far higher than the ones obtained using desktop scanners. First tests were made with a Kodak DC200 camera of 1152x1864 pixels (1Mpixel), which has the advantage of having a completely fixed lens. In spite of the reduced resolution, we could verify its excellent results in the relative orientation of these images. We worked, afterwards, with a Nikon Coolpix 700 camera which, although is an auto-focus camera, allows blocking the focus on fixed positions. This camera has a resolution of 1600x1200 pixels (2 Mpixel). The final results are similar, but with a sensible improvement in image details. The cameras were calibrated with the ORIENT bundle adjustment software from the Institute of Photogrammetry and Remote Sensing at the Technical University of Vienna.

Finally, we have worked in order to combine all these elements in the development of a portable photogrammetric system (Fig 5), able to be carried and used anywhere, and with a wide range of possibilities specially in the field of archaeology. With this aim, we used a laptop computer with one of the already described stereoscopes correctly fixed to the screen and combined with a digital camera. This system enables us to acquire images in the site, to transfer them to the computer and to convert them for their use with the VSD and to plot without depending on any photographic laboratory or any other resource not mentioned before. This system has been tested widely enough and is, in our opinion, a revolution in photogrammetry applications, with assumable costs in an archaeological project and offering a very important reduction of costs specially in field survey time.

These experiences have encouraged us to continue to work in this direction. Currently we have been able to set up a programme to continue cooperating with the Escuela de Estudios Árabes (CSIC) and the Department of Photogrammetry and Remote Sensing Informatics of AGH in order to improve the capacities of VSD programme specially in architectural uses. We have also stimulated Steve Nickerson in perfecting his ASRix programme and providing it to the users at a reasonable price, which we are sure will allow a fast diffusion as an everyday working instrument among many Heritage documentation specialists. With this action we are trying to approach one of the aims set out in our paper presented at the Olinda Symposium and that constitutes one of the difficulties for the development in the use of architectural photogrammetry. It is not enough to be able to do certain things or that one special person can solve one particular problem. It is necessary that many people can solve these same problems using the software developed for this special task. And, in order to do that, these developments must be easy to used and put in the market with adequate prices. Only then we will be able to approach efficiently the enormous documentary needs Heritage has.

### 3. SOME RESULTS

As an example, here we will present some projects carried out with these proceedings. Firstly, some rectifications made with the ASRix programme by the students at the course on building survey (Figs 2, 3).

The gate Bab Agnau at Marrakech (Morocco) (Fig 6) has been recorded starting from two stereo-pairs taken with a 2 Mpixels digital camera. Two distances were taken as control measures, checking visually that the walls were vertical. Time expended taking data was barely ten minutes. The survey has been made with a VSD software. A similar project is that of the small *qubba* at the Chella necropolis, in Rabat (Morocco) (Fig 7).

It is also worth mentioning the projects carried out by the students at the University of Granada, as, for instance, the survey of the external bastion erected at the end of the 15<sup>th</sup> Century to defend the Arrabal gate of the Alhambra (Fig 9). Topographic measuring, as

well as stereoscopic plots and photographic rectifications have been combined in this documentation work carried out by people without experience in photogrammetry and after a fast learning. The survey of a military construction in the aforesaid bastion was made using stereoscopic plotting with VSD.

A greater project, in which a theodolite was used with a distance-metre, is that of Piñar Castle (Granada, Spain). In that case, data taking implied about six hours' work (Fig 8). Aerial photogrammetry plots were combined with others of terrestrial photogrammetry and photographic rectifications of some of the faces of the walls.

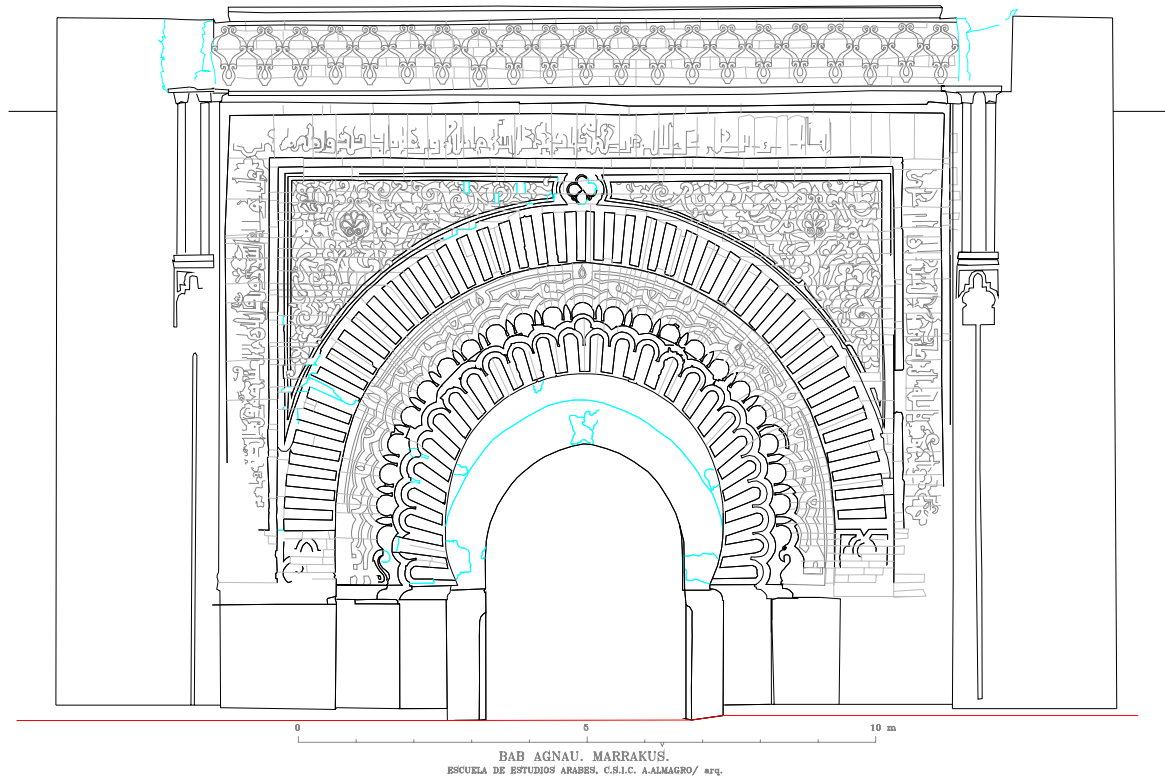


Fig 6: Bab Agnau. Marrakech

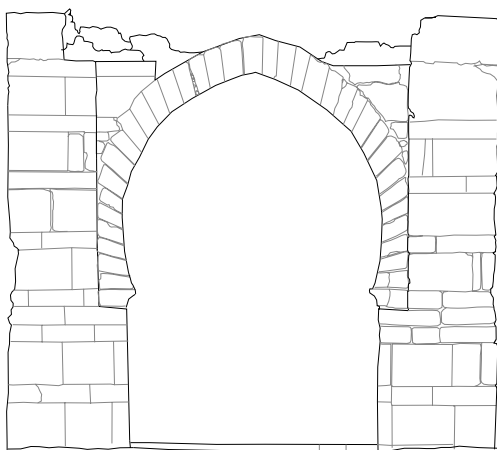
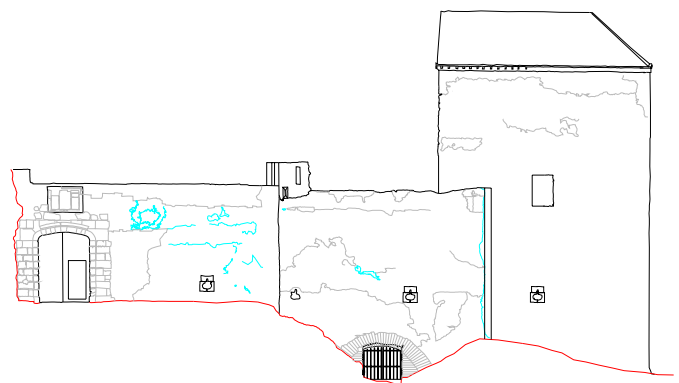


Fig 7: Ruins of a marabout in Chella. Rabat





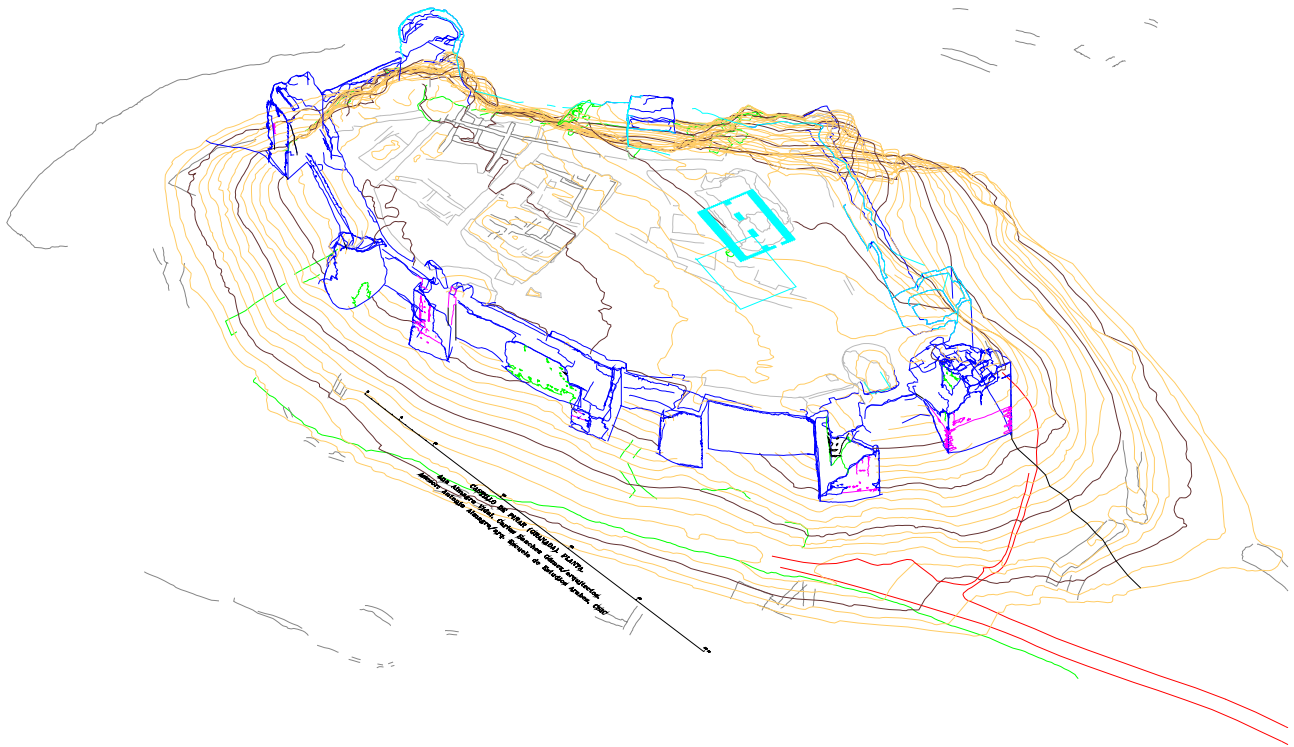


Fig 9: The castle of Piñar (Granada. Spain)

#### 4. THE TRAINING

Another of the action lines forwarded in Olinda was that of the learning and teaching of survey techniques. In this field, we have continued with some actions already held in the past, starting and planning new ones for the future. We believe that the achieved experiences are important and encouraging. For four years now we have been giving courses on building survey at the School of Architecture in Granada. In this course, 60 academic hours long, students accomplish surveys using VSD and ASRix systems. The obtained results are greatly satisfactory in spite of the limited time available and show that people without any previous knowledge on photogrammetry can use this technique and make surveys after a short period of learning. We have also imparted more reduced courses in different Masters and specialised courses on architectural conservation for architects and historians.

In May this year, and for the first time, we tried the experience of holding an intensive specialization course on documentation techniques celebrated in the Historic town of Albarracín. A group of nine people, formed by two archaeologists, two architects, a surveyor, two Art-historians and two Arts-graduated learnt in a course 36 hours long the basic knowledge for the use of these systems. The course showed that people with very different background can learn how to use photogrammetry without any special problem.

In this line, we have also started preparing simple manuals to use the software described above and with which expect to create finally a survey handbook that allows architects, archaeologists and historians to accede easily to these instruments and system. As a continuation of these labours, we have now the necessary funds to develop a program to prepare architectural survey technicians in Morocco. The Spanish Agency for International Cooperation is to finance the bought of the equipment as well as the expenses to impart learning courses on architectural and archaeological photogrammetry for technicians of the Cultural Affairs Ministry in Morocco. The first course will start next Autumn in Marrakech.

We strongly believe that only if we can get a sufficient number of technicians and professional using photogrammetry in a regular way, an adequate level of our Heritage documentation will be accomplished. And to achieve this it is absolutely necessary to provide them with the right instruments, simple and at reasonable cost, and with the appropriate formation. I think that this aim ought to be one of our prior objectives in CIPA.

## References

- Almagro, A. 1999b, "Photogrammetry for everybody", XVII CIPA Symposium, October 3-6 1999, Recife/Olinda- PE-Brazil. Publication in CD-ROM.
- Almagro, A. Jiménez, P. Navarro, J. 2000, El Palacio omeya de Amman III. Investigación arqueológica y restauración 1989-1997, Granada.
- Almagro, A. 2000a, "Fotogrametría para arquitectos. El estado de la cuestión". Actas del VIII Congreso de Expresión Gráfica Arquitectónica. EGA 2000. Barcelona.
- Almagro, A. 2000b, "VSD in Spain. Cooperation between Poland and Spain in Terrestrial Photogrammetry. Fotogrametria, Teledetekcja i GIS u Progu Trzeciego Tysiąclecia, Archiwum Fotogrametrii, Kartografii i Teledetekcji, Vol. 10, Crakow, p. 6.1-6.9
- CIPA 1983, Hans Foramitti et le développement de la photogrammetrie architecturale.
- Jachimski, J. 1995, Video Stereo Digitizer. A small digital stereophotogrammetric working station for the needs of sit and other applications, Geodesy, Photogrammetry and Monitoring of Environment (Chosen Problems), Geodezja, 38, p.71-93.
- Maestre, R. 2000, Levantamiento de planos de fachadas a partir de una fotografia. Perspectivas. Homograf.1 Aplicación infográfica para AutoCAD 14, Alicante.