

# 3D reconstruction and digitalization of an archeological site, Itanos, Crete

Rudy Ercek<sup>1</sup>, Didier Viviers<sup>2</sup> and Nadine Warzée<sup>1</sup>

<sup>1</sup> LISA Laboratory of Image Synthesis and Analysis, Université Libre de Bruxelles, Belgium

<sup>2</sup> CReA Centre de Recherches Archéologiques, Université Libre de Bruxelles, Belgium

## Resumen

La ciudad de Itanos está situada en el noreste de Creta. Entre 1994 y 2005, la Escuela francesa de Arqueología en Atenas (Efa) y el Centro de Estudios mediterráneos en Rethymnon realizaron campañas de excavaciones durante las cuales una necrópolis y un edificio arcaico se estudiaron por un equipo del CReA. Una colaboración estrecha entre los arqueólogos, los ingenieros y los diseñadores gráficos en 3D permitió la reconstrucción de estos restos. El arqueólogo pudo comprobar directamente su hipótesis durante el proceso de reconstrucción. En el verano de 2007 y 2008, una digitalización en 3D de Itanos se realizó con el objetivo de incorporar las reconstrucciones en 3D en el paisaje real.

**Palabras clave:** RECONSTRUCCIÓN EN 3D, DIGITALIZACIÓN EN 3D, ARQUEOLOGÍA, INFOGRAFÍA, REALIDAD VIRTUAL

## Abstract

The city of Itanos is situated in the North-East of Crete. Between 1994 and 2005, the French School of Archaeology at Athens (Efa) and the Center for Mediterranean Studies in Rethymnon carried out excavation campaigns during which a necropolis and an Archaic building have been explored by a team of the CReA. A very close collaboration between archeologists, engineers and computer graphic designers allowed the 3D reconstruction of these remains. The archeologist was able to directly verify his hypotheses during the reconstruction process. In summer 2007 and 2008, a 3D digitalization of Itanos was made in order to insert the 3D reconstructions into the actual landscape.

**Key words:** 3D RECONSTRUCTION, 3D DIGITALIZATION, ARCHEOLOGY, COMPUTER GRAPHICS, VIRTUAL REALITY

## 1. Historical background

The ancient city of Itanos is located in the North-East of Crete (Greek island) (Fig. 1), in a region which has been occupied since the Final Neolithic (GRECO, 2000). At least from the 8th century BC onwards, it played an important role in the contacts between the Levantine Coast and the rest of the Cretan island. In the Hellenistic period (3rd-1st centuries BC), it was directly involved in the commercial traffics between Eastern Mediterranean and Aegean Sea and became a military protectorate of the Ptolemaic monarchy. In the 7th century AD, the city has been abandoned and remained uninhabited until the end of 19th century.

## 2. 3D Reconstructions

Excavation and study campaigns were carried out by archaeologists of the CReA between 1994 and 2005. During these campaigns, a part of a necropolis (Fig. 2), located in the North of the site, has been explored (mentioned as [3] on Fig. 1).

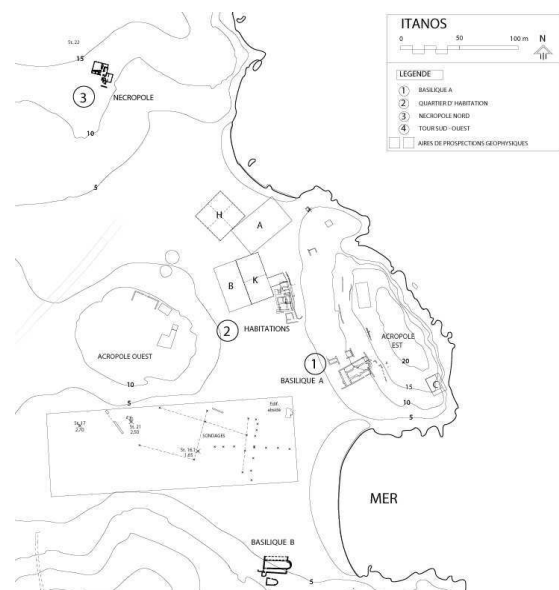


Figure 1. City of Itanos : main areas of excavation



Figure 2. Current state of the necropolis

The first occupation could be dated in the Late Geometric Period. From the late-7<sup>th</sup> century BC until the late 5<sup>th</sup> century BC, we observe a lack of inhumations before the area was used again as a cemetery, during the late Classical and Hellenistic periods. Consequently the archaeological stratigraphy of this necropolis is very rich and complicated by a high density of occupation. The last tomb is dated in the middle of the 1st century BC and the cemetery was spoiled in the proto-byzantine times (6th century AD?). At the West of this cemetery, an Archaic Building (Fig. 3) was discovered and dated in the end of the 7th century or the beginning of the 5th. It was located along a path bordering the necropolis on its western edge on the top of this low hill. The function of this large “house” is probably “public”, but remains unclear. The discovery of an athletic disc (probably for a child) and weights used for the sport suggest that it could be a sort of gymnasium, situated close to the necropolis (VIVIERS, 2006). The 3D reconstruction of the necropolis and the Archaic Building was made by students in computer graphic design (WARZEE, 2006).



Figure 3. Remains of the archaic building close to the North Cemetery

### 3. The necropolis

The stratigraphy of the necropolis is really complex because of its many phases of occupations (VIVIERS, 2006). Several hypotheses about the spatial organization of the cemetery have been proposed and need to be confirmed by a plausible restitution of the spatial evolution of the necropolis. Therefore, a

3D reconstruction of this necropolis has been prepared in order to help the archaeologists to test the different hypotheses (MILOJEVIC, 2005b). Moreover, a 3D model allows both realistic and synthetic visualization of the site (POLLEFEYS, 2000). Finally, this model offers a 3D record of the archaeological site which is partly unprotected and could be deteriorated (e.g. by visitors).

In order to create this model, different data have been used by computer graphic designers (COSMAS, 2001). During the “destructive” excavation campaigns, the archaeological information was recorded by specific commentaries and hand drawings.

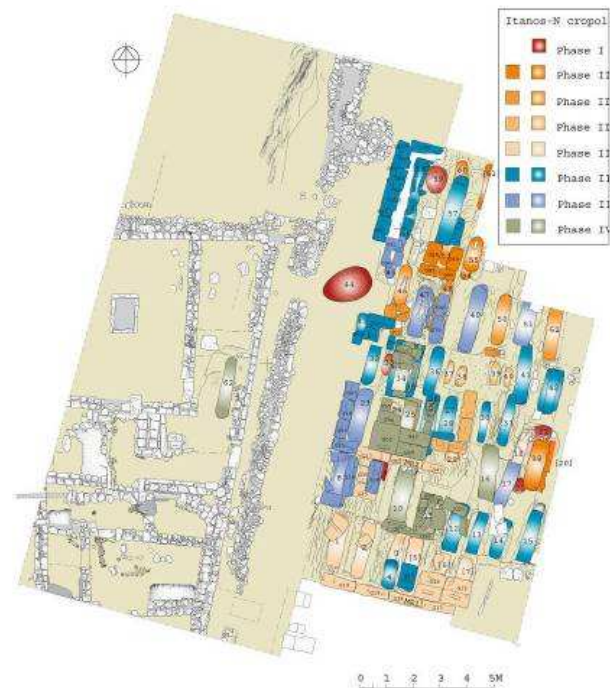


Figure 4. Plan of the necropolis and the Archaic Building

This information is recorded as (2D) digital vector drawings (Fig. 4), which are used to describe and reconstruct several occupation periods. But, visually, it lacks depth information and time dimension. Digital pictures were produced during and after the excavation campaigns. Measurements of all the archaeological remains were done, using classical triangulation techniques.

The funerary monuments, which were mainly build with large stones, were first modeled in 3D by using several layers of different colors to easily show/hide the different occupation phases with depth information (Fig. 5) (MILOJEVIC, 2005a). The stones were textured by using digital pictures. We started a first restitution of two important tombs dated in the late classical period, by moving some stones according to the archaeologist’s indications (Fig. 6). Some stones were moved in the Ancient times in order to be reused in other buildings. We tried to place them as they were originally. We also completed monuments by duplicating some stones which remained in situ and were often a part of the monument.

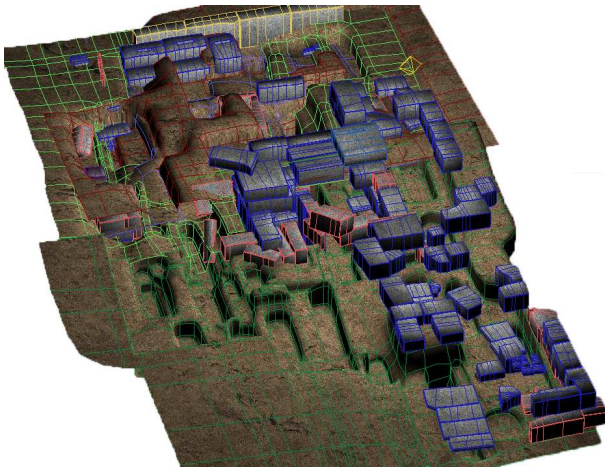


Figure 5. 3D reconstruction of the necropolis with layer selection visible by the wireframe color

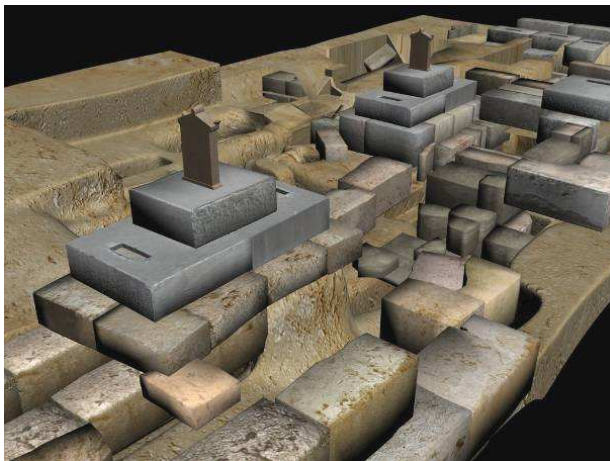


Figure 6. Provisionary restitution of two funerary monuments of the North Cemetery

#### 4. The Archaic Building

The Archaic Building (gymnasium?) was also modeled in 3D. Since there are only scarce remains of the building (Fig. 3), the restitution process of an entire building (Fig. 7) involved much more imaginative work.

A close collaboration between the archaeologist, director of the project, and the computer graphic designers was needed in order to obtain a correct restitution of this building. During the 3D model conception, the archaeologist had to question himself about some hypotheses or simple facts (ENGELS, 2007). Several door sills were discovered during the excavation of the building. By using the width of the door sills, the door type (single- or double-door) and the direction of the door opening were deduced.

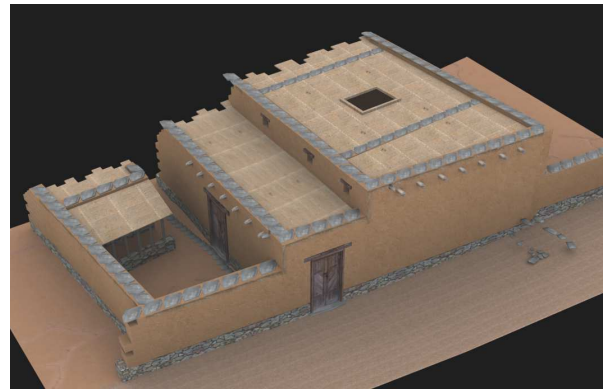


Figure 7. Restitution of the Archaic Building :  
general view

In the main room, provided with a hearth (Fig. 8), several configurations and dimensions of beds were tested before obtaining the best fit with the available place. Other propositions were tested and some important questions were put (about light, original elevation, water supply, etc.) (GURRI COSTA, 2000). The need of light inside determined some parts of the restitution and particularly the restitution of small windows in the southern wall of the main hall (Fig. 8). Moreover, the roof beams had to be placed according to the position of the hearth opening in the roof. Various water drains were set depending on the water flow on the roof and in the courtyard. Let us notice that figures 7 and 8 present a discontinuity on the walls and on the roofs in order to show the actual excavation limits.

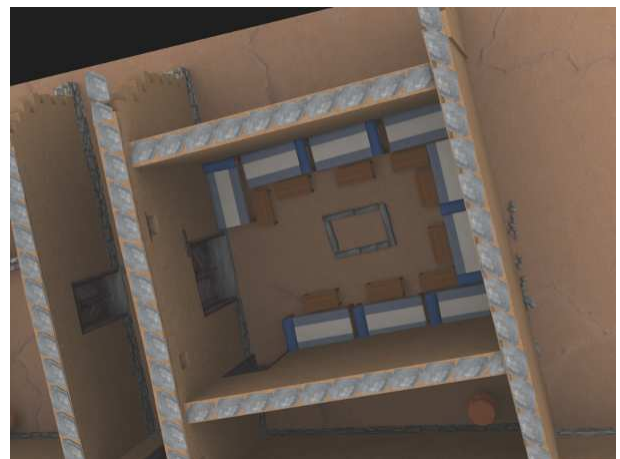


Figure 8. Restitution of the Archaic Building :  
top view of the main room

#### 5. 3D digitalization of Itanos

In summer 2007 and 2008, two 3D scanning campaigns were carried out with a long range 3D Scanner, a Riegl LMS-Z360i (Fig. 9). These scans intended to obtain a realistic global 3D model of the archaeological site in order to insert the 3D restitutions (the necropolis, the Archaic Building and the forthcoming restitutions of the Christian basilicas) for e.g. virtual

visits (MARTENS, 2000). The second target was to extract more precise elevation contours of the site.

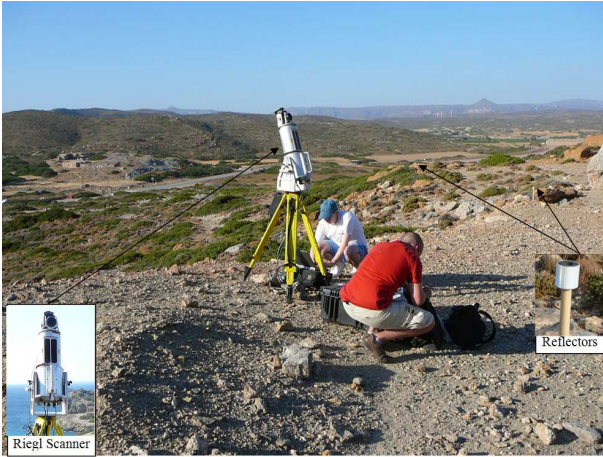


Figure 9. Digitalization of Itanos

Since the maximal range of the scanner is 200 meters, about 70 scans had to be done in order to have the complete model. Each scan is composed of approximately two million points. Ten digital pictures are taken by a calibrated camera per scan. The digital pictures allowed us to color the point cloud and to texture the mesh model. The different scan data were merged by using fixed reflectors as references. Those reflectors are also used to calibrate the camera mounting. As illustrated in fig. 10, some holes remain in the point cloud due to the presence of bushes and masking rocks. The positions and the number of scans were chosen in order to limit this problem and to fulfill our objectives.

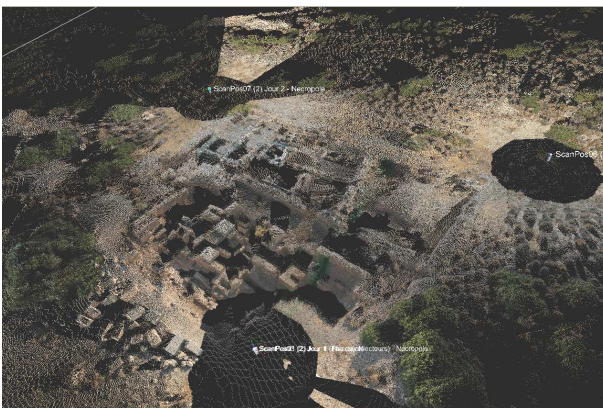


Figure 10. Colored point cloud of the necropolis (current state)

The post-processing of the scans is currently still in progress since there are much manual work and many problems. An issue was to merge scans of year 2008 with those of 2007 because no common reflectors were left on the archaeological site from one season to another, for practical reasons. This was solved by using manual corresponding points between both point clouds. But after having colored the point cloud of each scan with digital pictures, the global visualization of all scans cannot be done at once due to the huge amount of points. We tested a down-sampled point cloud but the loss of details was incompatible with our requirements. The solution could be found through a separate work on several subsets of the point cloud (Fig. 10). The point cloud is noisy and presents artifacts (sets of bad points) which have to be deleted, often manually, before applying noise reduction filters. The points corresponding to the ground could be extracted from the point clouds by a colored based filtering. So, a more accurate elevation contour map could be obtained. Moreover, a cleaned point cloud is really important in order to have a good 3D mesh model. The meshing process of the scans has to be done by dividing the model into several parts. For the moment, only the necropolis (Fig. 11) has been approximately meshed in order to have a “first” general view of it. As shown in figures 10 and 11, many “holes” were made in the necropolis for the inhumation of the deaths. Indeed, it was not fully scanned because this part of the model will be replaced by the restitution.

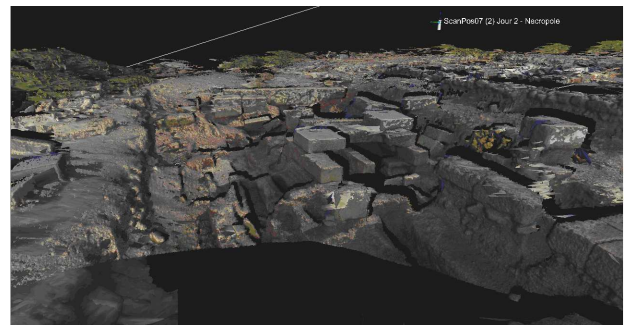


Figure 11. Partial mesh of the necropolis

## 6. Conclusions

The 3D reconstruction of the North Cemetery and the Archaic Building of Itanos implied a very close collaboration between archaeologists and computer graphic designers. The archaeologist was able to verify some hypotheses and other assumptions directly emerging from the 3D visualization of the reconstruction.

The 3D digitalization of Itanos has been carried out in order to create a 3D model where the monumental restitutions could be placed. It also allows to extract contour lines. A 3D colored point cloud has been generated but much work has still to be done in order to obtain a complete, but simplified, mesh model with textures.

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