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# 3D SURVEY AND HBIM FOR THE KNOWLEDGE AND VALORIZATION OF ARCHEOLOGICAL HERITAGE. THE CASE STUDIES OF THE CAPUA AND TELESIA AMPHITHEATRES

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**Abstract:**

Survey in Archaeology is aimed to represent, map and model the existent. The reality based modern techniques allow to acquire a large amount of geometric, colorimetric and volumetric informations on which deepen analysis of past artifacts. This paper describes the first phase of a work aimed to a better understanding of two Roman amphitheatres in Campania, the Capua and Telesia ones. The survey campaign, conducted by the integration of different techniques, from laser scanner to GPS, from total station to digital photogrammetry, allowed a full investigation about the construction of the two examples, in order to explain the differences and uniqueness. At the same time, the research purpose is to display and disseminate the results, structured according to the Historic Building Information Modeling. The structuring into three-dimensional families of parametric objects, connoted by various information that identifies them on time, allows the transmission of an in-depth systematized knowledge. This is able to communicate with the various professionals involved in the conservation and protection of cultural heritage. Parametric modeling is applied in the study for the remains of the two archaeological sites and also in the reconstruction of their original form.

**Key words:** virtual archaeology, cultural heritage, documentation, 3D modelling, 3D survey

## 1. Introduction

The modern techniques and 3D digital survey methodologies, with the development of more efficient sensors, allow the documentation, preservation and digital representation of sites and architectures with extraordinary geometrical and visual results (Remondino 2011). They are transforming the traditional approach to the study of the artifacts, based on two-dimensional drawings. The Three-dimensional models obtained are widely used in those areas where the display of the third dimension is particularly effective, as in archaeological studies that are governed by the fragmentary and paucity of remains. From these premises, the present study starts to aim at deepening the knowledge of some examples of the typical Roman entertainment architecture: the amphitheatres. Their development occurred throughout the Empire with variations in size and shape. Our case studies are the amphitheaters of Telesia and Capua Antica, located in Campania, a region of southern Italy. The purpose is to show, from the developed methodology to capture digital 3D information with integrated methodologies, the critical inferences that the acquired data have allowed to develop and the procedure to systematize and share the results, expanding the degree of knowledge and detail.

## 2. Case studies

The amphitheater of Telesia (Fig.1), the city currently known as San Salvatore Telesino, is located in the west, just outside the city gate. It's built in a natural valley arranged and adapted for that purpose. The building is entirely made of concrete and the construction scheme is made of approximately 64 radial wedges. The major axis of the arena is 67.80 meters in size and minor one is of 42.10 meters in size. The construction technique of the amphitheater, known as "quasi reticolato", allows to date the complex as built in the first half of the first century B.C. (Adam 2011), like the Pompei one. But when we see the architectural technique, we can notice that it would be the first example of "cavea sostruita" on a common system made of vaults cast on radial wedges. The Pompeian one has its substructure on the embankment instead.

The second amphitheater is the Capua one (Fig. 2), it is located in Santa Maria Capua Vetere, one of the most important cities of the Campania, which Tito Livio called "urbs maxima opulentissimaque Italiae" (the largest and richest city of Italy), and Cicero called "altera Roma" (second Rome). The size of the complex are: major axis, with N-S orientation, 167 meters; lower axis, with E-W orientation, 137 meters. The height of the façade was approximately 46 meters. It was divided into four levels:

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the first three have 80 rhythmic arches while the last one has a sequence of openings placed on axis of the underlying arches (Golvin 1988).

**Figure 1:** General view of the Telesia amphitheatre.

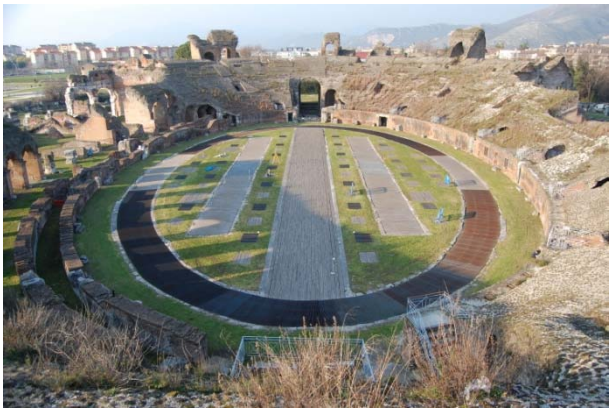

**Figure 2:** General view of the Capua amphitheatre.

## 3. Multi-technique surveying

The geometrical-dimensional data of the subject of study were captured by integrating different surveying methodologies.

The detection of the amphitheater of the ancient Capua was carried out using the GNSS mode and classifying it into the WGS84 system (reported to the Regional Network of GNSS Campania). A digital terrestrial photogrammetric survey phase was conducted by collecting image and location data. The equipment used is a NIKON D40 camera and a Laser Total Station TOPCON GPT-3000. Another survey phase was carried out by using a laser scanner CAM2 Focus3D Faro with a spatial resolution of 6 mm to 6 m, medium quality. This system produced 56 scans. The alignment and the registration of the scans were made by its proprietary software using plain and spherical targets. The result was a pointcloud made by approximately 250 mln of vertices (Fig. 3).

To capture the amphitheater of Telesia we used the range imaging technique of digital photogrammetry. The photographic acquisitions were made by a NIKON D40 camera equipped with a 18mm lens with constant focal length.The arena was captured by 62 frames which produced a pointcloud of 49765 vertices. The gate was captured by 58 shoots instead and the obtained pointcloud was made by approximately 218882 vertices (Fig. 4).

## 4. Surveying to discover

Combining different surveying methodologies we were able to document the conservation status for both complexes and to provide a scientifically rigorous base in order to develop deeper analysis. The survey in Telesia has allowed to increase the studies on the geometry of the arena. Obtaining the axis size (42.10 x 67.80 meters) and applying the mathematical rules related to the ellipse we proceeded to determine algebraically the coordinates of the foci. Then we applied the definition of ellipse: if you take any point on the ellipse, the sum of the distances to the focus points is constant (PF1 + PF2 = 2a constant). So we took any point from the arena perimeter and we noticed that we were not able to satisfy the above definition. Therefore, it was possible to affirm with certainty that the figure that defines the geometry of the arena is an oval. The redesign and overlapping an ellipse and an oval on the amphitheater plan confirmed our thesis (Fig. 5).

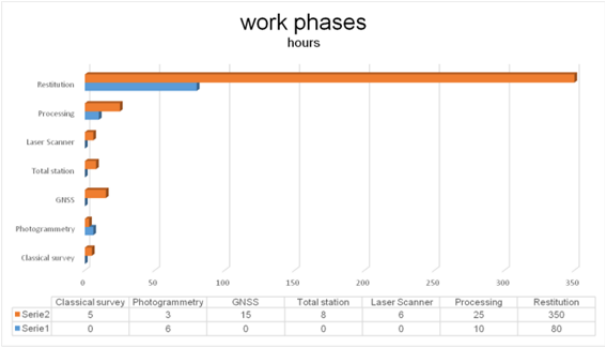


**Figure 3:** Comparative study of work phases: In blue Amph. Telesia, in red Amph. Capua Antica.

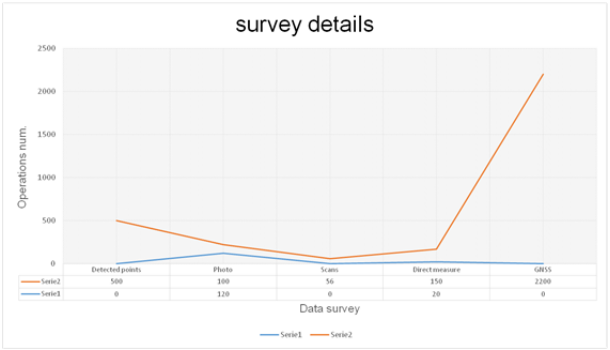


**Figure 4:** Comparative study of survey data.

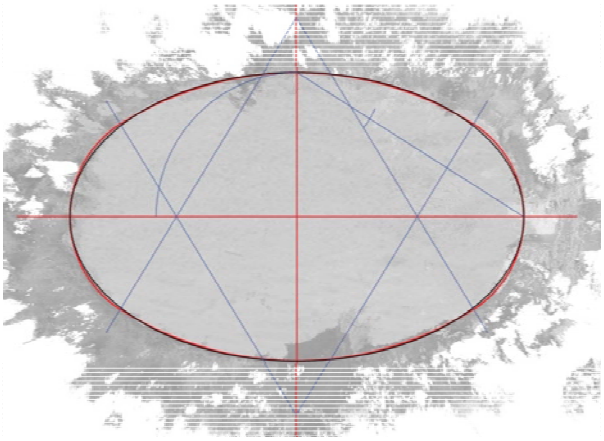

**Figure 5:** Geometric study about the Telesia's arena. In red the ellipse, in black the oval, in blue the construction lines of the oval.

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The survey of Capua antica was carred out for the whole archeology area including the first amphitheatre too, which is samller and older than the one we're studying. We noticed the existence of differences between the alignments of amphitheaters plans. Especially, the large amphitheater follows the major axis aligned in north-south direction while the small one, according to the same alignment, has a rotation towards the west of approximately 5°. Becaude of the high degree of precision of current instrumentation it is possibile to estimate this rotation but it is believed to be almost imperceptible or equal to zero in relation to the reduced degree of precision of the instrumentation of that period. However it is present and characterizing the archaeological complex. (Fig. 6).

The new discoveries, made possible by the survey, are an interesting progress in the state of knowledge relating to amphitheaters presented in this paper. In addition, the results have allowed us to start a further stage of work, currently on-going, consisting in modeling the whole anfiteatrale complex. The purpose of modeling is not limited to the simple reconfiguration of the morphology of the two amphitheatres. It wants to be a container of much more detailed and differentiated informations.The work is conducted in the context of Historic Building Information Modeling HBIM (Murphy *et al.* 2012). The point clouds were imported in a BIM software and segmented to locate, to map and to classify all observed architectural elements (arches, columns divided into base, shaft, capital, busts, etc). All these elements will be modeled from the cloud, involving not only sizing parameters but also informations regarding the construction geometry, color, material, state of preservation. The result will be a complete 3D model, which can be interrogated and investigated in all its aspects. In this first step, it has already been possible to find as, in relation with the parameters set for the acquisition of data, the cloud obtained by laser scanner enables a better reading of the points compared to that returned by digital photogrammetry (Fig.7). Finally, the union of these data will allow not only the spread of general knowledge of the sites to the general public therefore visualization but simultaneously the realization of an enriched documentation for experts who want to participate with cataloging, preservation or restoration.

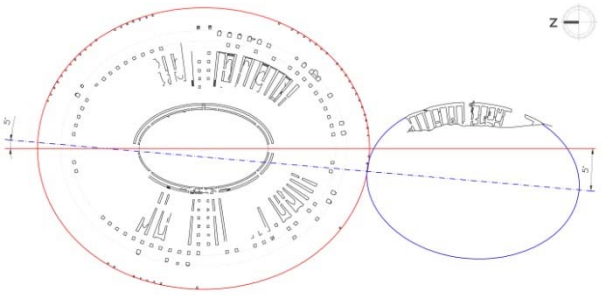

**Figure 6:** The 5° rotation between the two amphitheatres of Capua Antica.

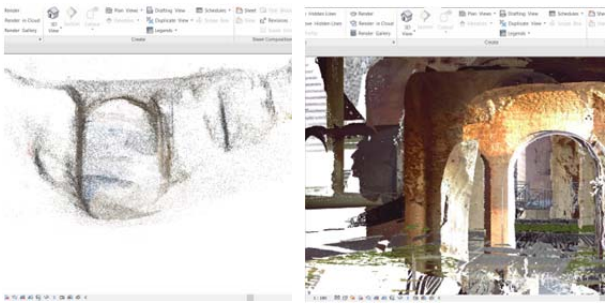

**Figure 7:** Differences between the two poincloud (TLS and photogrammetry) into software BIM.

## 6. Conclusions

The paper shows the on-going work of documentation and valorization of two evidences of the complex of Roman amphitheatres in Campania, Italy. The potential of surveying technologies - capable of acquiring in rapid time a large amount of metric and colorimetric data, highly accurate - in union with the most recent and smart modeling practices, Building Information Modelling - now applied to the historical heritage - made it possible to deepen the knowledge of representative architecture of the Roman Empire. The image based and range based tecniques allow to investigate the artifacts of the past, discovering underlying geometry, construction

techniques, guiding principles not otherwise detectable. At the same time, the 3D models made by these methodologies become the basis for new forms of heritage documentation: parametric queried models, profoundly innovative than the traditional way of representing, studying and displaying the remains of the past. Thanks to parametric modeling you can overcome the limits of conservation experts, who are very often not able to manipulate the data of point clouds used as a simple display devices. It allows to reach a rationally systematized documentation, that allows to communicate with the various professionals involved in the preservation and protection of cultural heritage.

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