# LASER SCANNER SURVEY OF AN ARCHAEOLOGICAL SITE - SCALA DI FURNO (LECCE, ITALY)

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**ABSTRACT:**

Under the LEADER + Puglia 2000/2006 project, the Community Initiative Programme aimed to promote the integrated, endogenous and sustainable development of rural areas and enhancement of specific experiences with the external territories, it has been conducted a terrestrial LiDAR survey of a protohistoric settlement dating from the period between the Bronze Age to the Iron age (XVIII-VIII century BC.). The possibility to exploit, and make available at the same time, this very perishable settlement (sandy site) took a survey of high detail aimed to the realization of a copy of the excavation to be placed in situ. Given the complexity, for some areas, such as the furnace, it was necessary an integration of LiDAR data with those from photogrammetric technique. The integrated survey allowed to return a 3D numerical model aimed at the next step of prototyping in 1:1 scale.

## 1. INTRODUCTION

The integration of the terrestrial LiDAR survey with metrics information acquired by photogrammetric technique is necessary when operating on very complex archaeological sites. The laser scanner and the photogrammetric techniques allow an overall representation and yet detailed of the whole site. Since, overall objective of any proposed excavation, is to gather, store and exploit data found, there is the need to provide appropriate dynamic tools dedicated to the protection and enhancement of this heritage. Respecting the existing environment, avoiding the installation of protective structures that would preserve the site and allow a vision by the visitor and still not preserved from external agents (being composed of sandy material and therefore brittle), has chosen the solution to reproduce the site by prototyping methodology. The model of the articulated industrial area in real size, therefore, is proof of the possibility of fruition of archaeological sites that have complex structures with particularly insecure in their consistency, to the benefit of the conservation of original structures in the presentation "live "risk the loss of their integrity.
The use of laser instruments and multimedia and 3D science allowed to reproduce the structures in their volume and to return the reproduction of the model in copy.

## 2. SOME ASPECTS OF INNOVATION IN ARCHAEOLOGY

\The enhancement of archaeological heritage was much discussed and still evolving. At the beginning of the debate, the main approach to the protection of heritage was the conservation. According to the archaeologist J. H. Stubbs the continued development of disciplines for the archaeological and architectural conservation, has improved the ability to preserve and present the archaeological remains in situ. Passing thus the protection phase to a more interesting historical and scientific reconstruction to make the public aware of the ruins. In recent years, through the research work done by various international and national Entities, it was shown a new interdisciplinary approach that, not only, takes into account the possibility of a museum on site according to those who are its archaeological emergencies, but, look, also, the applicability of other practices, far from classic ones. The synergy between the scientific research, industrial and archaeological sectors has made possible the development of techniques, methods and new approaches for musealization in situ. This allows, first, to improve the perception of the heritage without compromising the principles of protection and conservation, and secondly, to achieve better communication with a less experienced and casual audience.

## 3. CASE STUDY

The archaeological area, subject of the innovative action, is situated on the coast of Salento between the areas of Torre Lapillo and Porto Cesareo (Lecce - IT) in place “Scalo di Furno” (hence the name of the site) and was involved by intense campaigns of excavations carried out from 1968 until 1977, and resumed in 2000. “Little Peninsula” of “Scalo di Furno”, lagoon marina area south of the Gulf of Taranto, is among XI and XVII century. BC, which place of establishment of populations that show, in their habits, attention to the firing home ceramics for everyday use, as a sort of industrial manufacture of these products.
The area, dating from the period between the Bronze Age to the Iron age (XVIII - VIII century BC.), was a place of transit

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traffic in the Mycenaean to "Scoglio del Tonno" (south of the city of Taranto) a stable port for the relations between the Aegean on the Apulian arc ion between XI and XV century. BC, and was a sacred territory frequented by the Greeks, and Iapigi Messapians, between VIII to VI BC (is sparse, however, attendance in Roman times), characterized by a shrine Messapian archaic.


Figure 1. Framework of the archaeological area

The southern part of the protohistoric settlement is characterized by the presence of a neighborhood of pottery dating from the Middle recently Bronze phase. The installation of the "furnace" is organized with a demarcation zone defined by a curb in clay which includes a number of ovens, for which the analysis with specific X-ray diffraction carried out by Professor Claudio Giardino of the University Suor Orsola Benincasa - Naples, identified a range of heat temperatures between 600 °C - 900 °C. The groove on the curb perimeter shows the setting of a wall of tree branches that had to contain the heat. The excavations have revealed further remains of the chapel, hearths and an archaic megalithic wall delimiting the sacred area.

## 4. LEADER + PUGLIA 2000/2006 PROJECT

As part of strategies for the protection and preservation of environmental and cultural resources of Apulian rural areas, functional to collective use and developed with the project: Leader + Puglia 200 0/2006 Axis I "Territorial rural development strategies of integrated character, pilot and sustainable" this case is of particular importance. The project promoted by the Municipality of Porto Cesareo, in addition to the accommodation of the area adjacent to the excavation, provided the conservation of fragile structures that constitute the zone of the furnace and, if exposed to atmospheric agents, could suffer permanent damage to the total disintegration.

Figure 2. Detail of the furnaces

The realization of a true copy with high resistance to the environment and with great fidelity to detail was the winning solution for the administration, staff planners, and for the protection entities. Indeed, given the composition of the archaeological site, the traditional technique of the cast would bring damage to the structure. The solution adopted, therefore, allowed, thanks to scientific knowledge and advanced technology, to target non-invasive tools and methods while maintaining the full conditions of the site.

## 5. LASER SCANNER SURVEY

The survey involved an area of 100 square meters (figure 3).


Figure 3. Details of the surveyed archaeological area

For acquisition it was used a Leica HDS4500 laser. Given the complexity of some items of particular importance (furnaces) and to minimize shadows, there were performed 10 scans with a pitch of 2 mm, using 8 flat target for geo-referencing scans. The elaboration was performed first with the Cyclone software used for the pre-processing (filtering and noise reduction) and for the registration of point clouds.

Figure 4. Total Point Cloud recorded in Cyclone

The overall numerical model (Figure 4) was then exported in ASCII format for further development with the Geomagic software.
It was therefore generated a model surface (Figure 5) and on it

were made of typical procedures of Cleaning, Reducing Noise, Filling holes, Repairing normals and intersections.

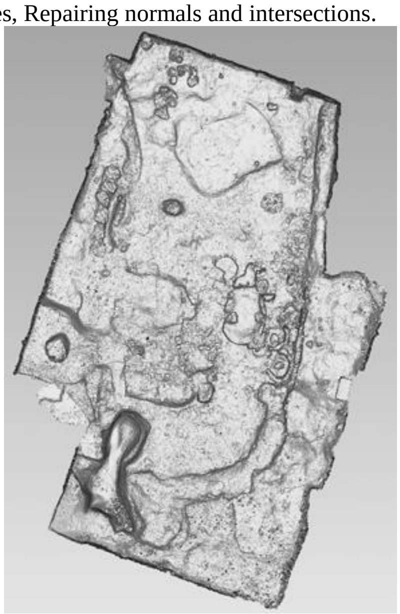

Figure 5. Mesh generated in Geomagic

## 6. PHOTOGRAMMETRIC SURVEY

It was performed, simultaneously, the photogrammetric survey of the area made necessary to better repay the more complex elements of the site and regions that, for reasons of considerable morphological variability showed significant gaps in the laser scanner. Having brought together the two survey methodologies led to perform a photogrammetric total coverage of the area of excavation. In the elaboration step were chosen the most suitable integrations.

The survey was conducted with a calibrated Nikon D1 digital camera.

the metric photos were imported and processed in the PhotoModeler Scanner software that enabled to generate a dense point cloud for areas of detail (Figure 6).

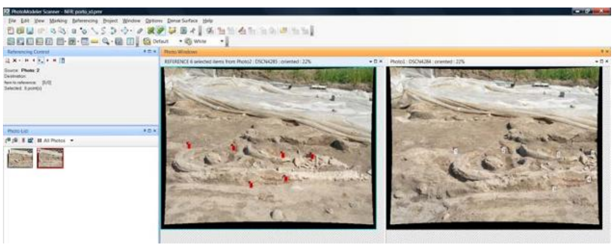

Figure 6. Particular of Processing in PhotoModeler Scanner

Figure 7. Detail of the final 3D model

The point cloud has been integrated, finally, to those from laser scanner to generate a final and more detailed 3D model (Figure 7). The model was intended to prototyping process that allows the production of complex geometries directly from the mathematical model of the object created with a three-dimensional system.

## 7. MAKING OF PROTOTYPE

The three-dimensional metric data collected, provided a site database at the time of the survey, which will be accessible by archaeologists in the future and, integrated with the photographic survey of the phases of excavation, will be a full information pack for the present and future studies. The activities to be carried to production and placement of the prototype site has faced numerous problems whose solution has been reached by observation and knowledge.

The first difficulty was the choice of the best system for preserving the archaic structures of ceramic firing, agreeing that it was what led them through the centuries until their discovery. The site, therefore, after being protected with sheets of nonwoven fabric, was again filling up according to specific guidelines to avoid even the slightest damage. The problems of realization of the copy to be placed over the original findings were numerous: the selection of techniques and materials that had to be strong and light enough to ease the burden on the site below, determining the methodology to reproduce parts providing a precision of the data collected, coordinating all the installation procedures in an area not easily accessible and solving technical problems such as stormwater runoff and changes the microclimate of the ground beneath the structure.

Figure 8. First inspection - Condition of the premises earlier operam

To resolve these problems, the company has dealt with prototype (the TryeCo), carried out a targeted action to coordinate their knowledge of information available and the contribution of the project partners. Through various digital simulations it was decided the number of blocks to divide the space trying to optimize the conditions of production, transportation and installation. The 18 basic blocks, have a footprint of 4x1 meters, while the remaining six board have the same width but variable length. For the basic structure was chosen density polystyrene 60 kg/mc, lightweight material which ensures durability not being biodegradable, non polluting and is totally recyclable (Figure 9).

Figure 9. Processing stages of milling

The milling is done from solid: through the use of more and more thin heads, the machine achieves a true copy of surface developments, after this stage, on the foam “block” is spread a layer of fiberglass as that used for the construction of the water hulls. This material adheres perfectly to the morphology of polystyrene template and then firms below. The fiberglass structure is the structure of the true model, the union with the foam causes the copy to be walked on for maintenance, protecting it from wear due to environmental conditions and does not change the weight of the blocks allowing the transport. (Figure 10).

Figure 10. Detail of functional block

Through a series of simulations on the digital model has been identified the location and the number of discharges to the stormwater. The drainage system is perfectly efficient only if reproduction is placed on a "perfect plan" in order to obtain the support base is perfectly flat, has been designed, built and controlled in situ a tubular aluminum structure with a phenolic plywood floor (Figure 11). The choice was determined by the fact that the first is a very durable and lightweight material, while the second is a type of treated plywood that can withstand outside for years without deteriorating.

Figure 11. Tubular aluminum frame

To maintain a low humidity in the prototype, it was then carried out an air interspace that not only allows the installation of floor level and ensures the passage of exhaust pipes, but also a sufficient flow of air to eliminate, in the hot season, the humidity rising from the ground. In a first time, the frame should be based on the walls of bricks at the nodes of the frame and properly placed far from the archaeological finds. The realization by the aluminum mesh allowed to change the regular pattern to meet this need.

Figure 12. Interspace

The “surrender to the truth” has dealt with the General Display Company, who worked most of the work in the laboratory and the phases of remodeling and sealing of the blocks on site.

Figure 13. Phases of the real yield in laboratory

Figure 14. Phases of the real yield in situ

For best results, the prototype was assembled in the factory where the operators, using the photographic documentation collected during the site inspection, together with the photogrammetric documentation consists of photo-plans, has made the finish on the plastic (Figure 15).

Figure 15. Assembly of the prototype plant

The surface treatment was performed with water-based acrylic paint, sands of various size and colour, as from samples taken on site. The entire surface was then treated with a protective polyurethane clear finish. Showed the need to use local materials for the construction of support walls of the casing. The prototype was harnessed with a belt of plywood used to store and distribute the thrust of the ground led to the sides of plastic (Figure 16). Above this belt has been stretched, and secured with metal rivets, a nylon cloth with high strength, dropping to contact the original floor level, to prevent debris and animals from entering the cavity. From the hinterland and from the side of the sea, were included tubes that allow the development of mild air flow, which ensures proper ventilation and prevents damage to both the archaeological site and to the base of the model, due to moisture.

Figure 16. Detail of accomodation

At the top, the grouting between the blocs was performed with silicone in depth, while closing, with a layer of concrete on which was sprayed on the adhesive and then set the toned made with sand and stain (Figure 17).

Figure 17. Grouting between blocks

Figure 18. Installation on site of the prototype

Figure 19. Details of the prototype

## 8. CONCLUSIONS

The application of laser scanners to archaeological excavation was necessary for the production of prototype aimed at its insertion in site allowing the usability of the area and an historical and realistic vision of the park. The integration of 3D techniques (laser scanners and photogrammetry) allowed to be metrically represented more complex details of this site hardly detectable by other techniques. The prototype required a significant commitment and continuous cooperation between actors at various stages of completion. This innovative system of representation and development of an archaeological site open a way that will allow the preservation of many other similar sites in Italy with low fees at the level of repair. Surely the staining pattern over the years will undergo changes, but the materials and the technologies used allow a few targeted interventions to resolve the problem. In case of reopening of the excavation, in addition, the prototype is designed to be removed without unpacking it, using a special harness and a crane, and to sacrifice long blocks of local stone that will inevitably be destroyed to remove them from frame. We are convinced that this innovative system can be a starting point for a new "musealization" of many areas of interest. This model, made with a good result for a find, provided the visibility of structures of industrial production of the ancient world, allowing the preservation of the original context to future centuries to the deepening of further knowledge on the history of mankind; it is also a way to steal the archaeological context to the actions of vandalism, actions that have already occurred during the reopening of the excavation.

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