



# Towards a digital database of Sardinian II WW military heritage: a first repertoire in the territory of Cagliari

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## ABSTRACT

The paper illustrates the decisions behind the creation of a digital database of military architectures built in Sardinia during the Second World War. This stylistic repertoire is characterized by an interesting historical-cultural and landscape value and composed by more than 1.500 artifacts positioned along the coast of the island to protect the major urban centers and the areas of strategic interest. A correct recovery and enhancement of these historical heritage necessarily needs a previous activity of knowledge and cataloging entrusted to integrated survey methods where digital and traditional tools works together to define an updatable and interoperable graphical model. The database become the place where studying these "stubborn ruins" also comparing geometry, materials and construction technique adopted in other countries. The need for mimesis has required an adaptation of the typological solutions designed by the Italian Military Genius and indicated in the archive documents offering interesting case studies. The first results of this path of knowledge is a complete catalog of small bunkers placed in the east sector of the territory of Cagliari, within the Natural Regional Park of *Molentargius-Saline*.

**Section:** RESEARCH PAPER

**Keywords:** IIWW heritage; integrated digital survey; Sardinia; Italy

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## 1. INTRODUCTION

The bunkers of the Second World War, scattered along the European Atlantic coasts, were the subject of an aesthetic attention for the first time in 1975 by Paul Virilio who considered them as the remains of a shipwreck [1]. A decade later, the scholar Rolf Rudi recorded and classified the entire defence system of the Atlantic Wall by means of 970 drawings, 360 photographs and 110 maps [2]; this work would be followed by other complementary ones [3], [4].

Other researchers have recently begun similar studies analysing military architectures built during the Great War and WWII along the Mediterranean coast of Italy and Spain, considering bunkers and other defences as objects of an industrial design process and as the elements of a network fused with the landscape. They have called this system 'Mediterranean Wall' putting it in parallel with the modern architecture of the twentieth century [5].

One of these researchers has studied the design solutions adopted during the Spanish Civil War along the stretch of coast between Cádiz and Girona, specifically in the province of Alicante [6], [7], defining a repertoire divided into categories (Figure 1); an investigation that began with the inventory of the bunkers, their survey (as the original plans were not available) and their typological classification. This has been the methodological starting point to start the digital map of all the existing defences on the coast of Sardinia.

A first result of this last study has revealed an interesting affinity between the Spanish and Sardinian coasts, both "Mediterranean", that share historical and architectural events since the Middle Ages and, with special intensity, in the Modern Age; one of them is represented by the close relationship between bunkers and watchtowers built from the second half of the 16th century to protect the population from the Turkish danger and used until the beginning of the 19th century [8].

This investigation continues with some insights in the disciplinary field of the history of architecture and the landscape

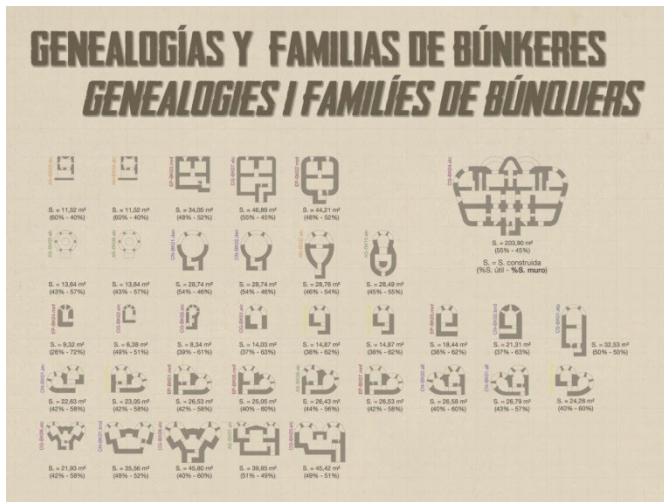


Figure 1. Catalogue of types of bunkers built along the coast of Alicante during the Spanish Civil War (Martínez-Medina 2016).

representation [9] integrating the state of the art on Sardinian architecture, until then consisting of historical studies [10], poorly supported by architectural surveys or analysis of the landscape context that host these buildings.

The design of a digital database needs a geo-referenced cartography; for this purpose, it has been identified the Regional Technical Map of Sardinia (C.T.R.), a 1:10.000 scale map dated 1998, integrated by a series of aerial surveys realized from 1954 to 2013 and by the 1:25.000 scale map prepared in the years 1941-42 by the Italian Military Engineers and kept by the Historical Archive in Rome (AUSMEE).

The compatibility between these documents allows an easy identification of the bunkers, leading the survey operations and the choice of some case studies.

To this purpose some sample areas have been identified in the territory of Sardinia: Santa Teresa Gallura and La Maddalena (OT) in the north coast, Bosa and Arborea (OR) in the west coast and the metropolitan area of Cagliari-Quartu Sant'Elena (CA) in the south coast.

The first territorial survey has showed an interesting repertoire of design solutions that take up shapes and dimensions indicated in a catalog, adapted to the morphological characteristics of the site and sometime integrated with the existing buildings (as coastal towers, *nuraghe*, civil or industrial dwellings) in order to achieve a complete mimesis with the landscape (Figure 2). This catalog is a part of the archival documentation, kept in the Military Archive of Cagliari (*Archivio Documentale del XIV Reparto Infrastrutture Esercito*), that describes, through quoted plans and sections, the design solutions to be adopted in relation to the task and the artillery equipment assigned (cannons, rifles, machine guns).

Once an analysis of these graphic representations has been carried out, an integrated digital survey has been designed.

This phase provides information on the architectural, geometric and material characteristics of single bunkers, contributing with a rigorous method to the construction of the scientific database [11].

Comparison between surveyed bunkers and archival models, examination of the qualities of the landscape contexts also leads to the creation of cultural itineraries as applied to other types of architectures at other latitudes [12] (sometime supported by Sardinian Regional Administration, as in the case of the locality called *Is Mortorius* in the territory of Quartu Sant'Elena) as the

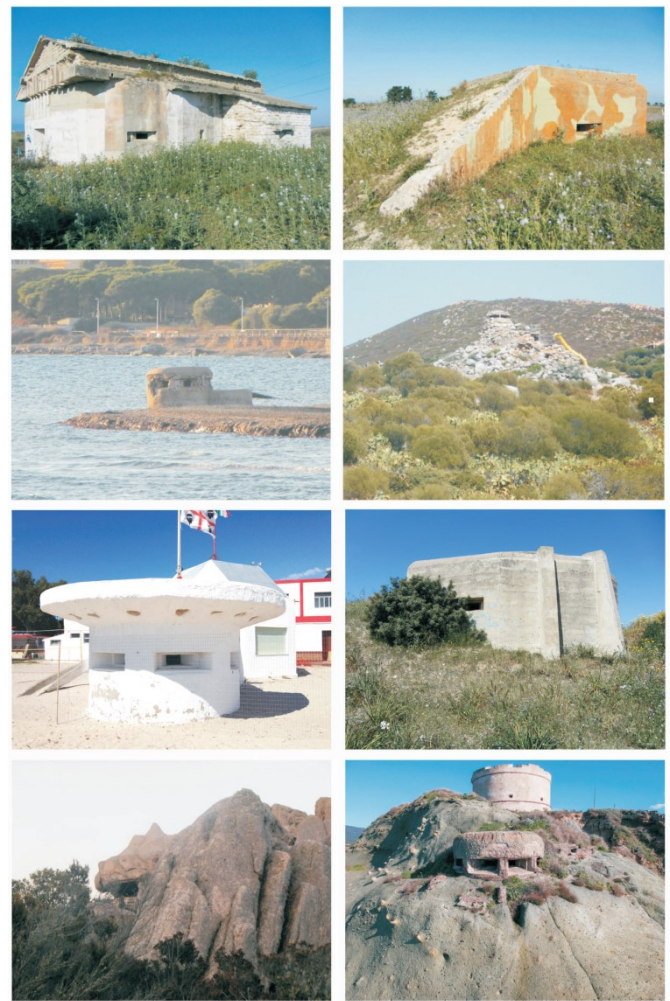


Figure 2. Some example of Sardinian military heritage of IWW: bunkers (1,2,6) in locality *Pitz'e'Serra*, pill-box (3) along the seaside of *Margine rosso* and bunker (4) designed using a part of an ancient architecture (*nuraghe*, an ancient Sardinian architecture) in the locality called *Is Mortorius* in the territory of Quartu Sant'Elena, bunker (5) placed along the Poetto beach in the seaside of Cagliari, (7) along the coast of Santa Teresa Gallura and (8) close to the sixteenth century tower of Bosa (photos by A. Pirinu).

object of this paper —a part of the defensive line designed to protect the city of Cagliari— inserted within the Natural Regional Park of *Molentargius-Saline*, an area of great environmental and landscape value.

## 2. THE NATURAL PARK MOLENTARGIUS-SALINE (CAGLIARI)

The planned interventions in Sardinia during the war (1940-1945) were carried out especially in the coastal area to prevent a possible landing by the allies; for this reason, the territory of Cagliari was interested by an important project well described on IGM maps elaborated by the Military Engineers (Figure 3). An analysis of this map allows a perfect understanding of the defensive strategy and an easy recognition of works carried out. This result has been achieved by means a graphical overlay between the military IGM map and a recent aero photogrammetric (dated 1998) survey integrated by an aerial view (dated 2008) and represented in Figure 4.

A part of this plan has interested the *Molentargius-Saline* compendium in which 10 bunkers have been identified and catalogued to become part of the digital database (Figure 5); they are placed in 4 strategic points (named sectors 1, 2, 3 and 4) and



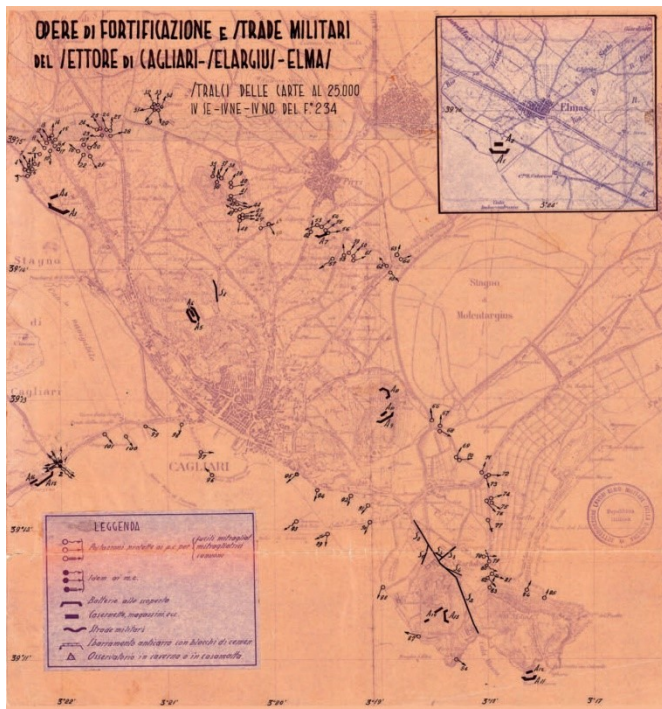


Figure 3. Military works planned in the sector of Cagliari, Selargius and Elmas (Military Archive of Cagliari).

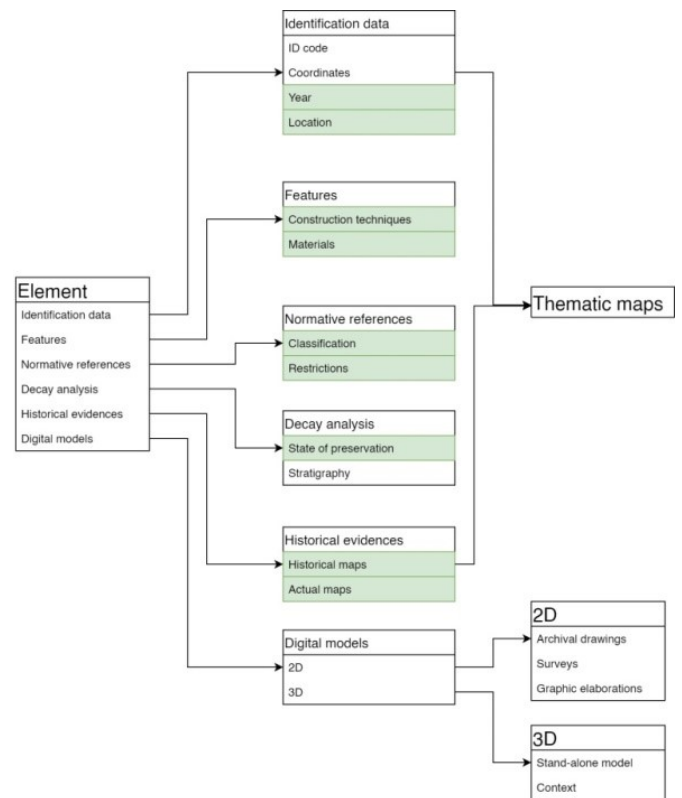


Figure 5. Digital database of IWW Sardinian military heritage (A. Pirinu & R. Argiolas).

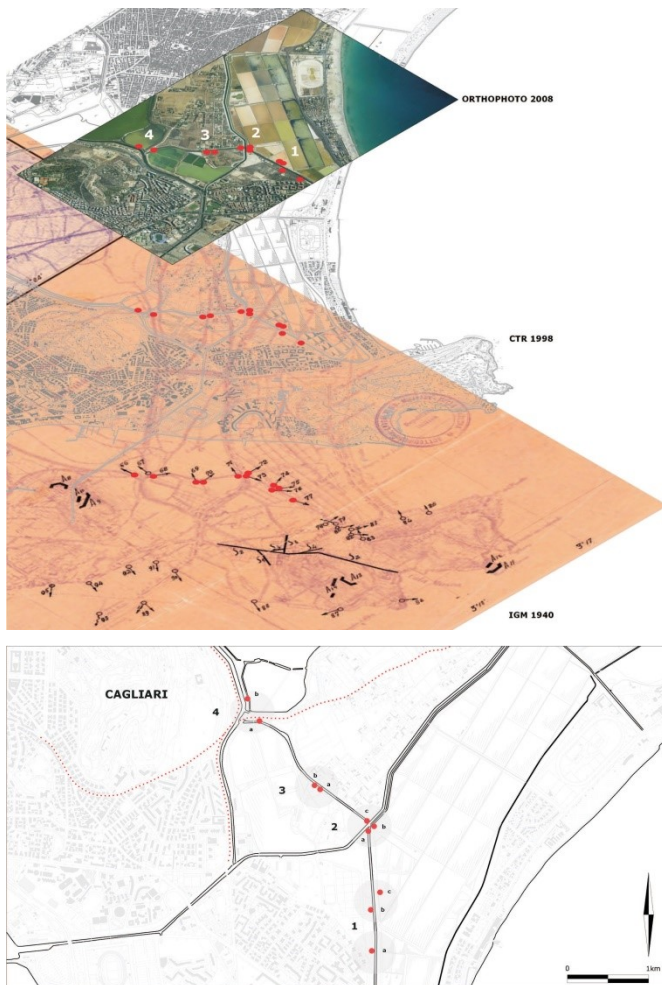


Figure 4. Sectors within the study area of Molentargius-Saline.

visually connected to each other to control waterways and road network that connect the city of Cagliari to the surrounding territory. Some of them, starting from the elementary geometry of the circle and the square (like historical watchtowers), have been modified to blend into the landscape, taking the shape of cisterns or becoming part of some buildings built during the nineteenth century to support salt works activities.

### 2.1. Survey and representation

In the area of the Natural Regional Park *Molentargius-Saline* the survey operations were entrusted to the photogrammetric method integrated and supported by a landscape drawing and a direct measurement of the internal and external dimensions, the latter useful to scale the model and to verify the software elaboration. This procedure made it possible to record the architectural and dimensional characteristics and to produce a digital representation of the studied bunkers.

During the design of the survey, the use of drone was evaluated. However, from an analysis of the ENAV cartography (the company that manages civil air traffic in Italy), it has been verified that the airspace related to the site falls within the Natural Regional Park *Molentargius-Saline* area, where flight is not allowed.

Consequently, it was not possible to make a wide view of the landscape context and the operation were mainly conducted on the architectural scale where the small size of the bunkers leads the choice for the use of a small Action Cam (20 MegaPixel camera resolution) installed on a telescopic support (maximum capacity of 8 meters).

Despite the good technical characteristics, the files processed by the camera highlight a limit in terms of dynamic range and image sharpness; for this reason, it was decided to make up for





Figure 6. Sector 1: Bunkers 1a, 1b, 1c: simple and integrated models. Detail of their position within the Natural Regional Park *Molentargius-Saline*.



Figure 7. Sector 1. (Top) Bunker 1a: circle + square at different level and (Bottom) Bunker 1b: circle + square at the same level (photos by A. Pirinu).

the poor quality of the image with a high number of shots of internal and external part of each bunker.

Once the necessary photographic documentation has been acquired the elaboration with the software is begun.

The data processing was performed with Agisoft Metashape Professional v.1.5.3 in which the internal and external images were processed separately. In fact, once the point clouds were acquired, the "chunks" were joined with the "point based" method to obtain a complete and perfectly aligned "Dense Cloud".

Finally, the dense cloud was managed within the software Cloud Compare v.2.10.2 and used to process 2D and 3D digital representation as plan, section, elevation and axonometric view.

## 2.2. Survey process: four sectors, ten bunkers

The application of traditional and digital integrated methodologies has allowed the complete survey of 10 bunkers distributed in 4 different sectors (a, b, c, d). They are part of a single defence system positioned along one of the inner channels of the salt pans that crosses the park in a south-north direction.

Each sector consisting of bunker groups is now well described through 3D and plans, sections and views (internal and external) directly extractable from the digital model.

The 2D drawings in particular contribute to the creation a part of the catalogue in which the case study are compared with the graphic schemes indicated in the archival documentation.

The 3D photogrammetric models offer instead the possibility to observe the position of the artefact with respect to the surrounding landscape, to observe the internal space of the bunker and the volumetric relationships between structure and internal environment (through the splits), understand the construction phases (Figure 18) and record the state of degradation of the material adopted that -in the observed cases- highlights the combination of reinforced concrete with local stone (integrated with the existing buildings) or with the concrete blocks used to hide these "sentries" from the eyes of enemy aviation.



Figure 8. Sector 1. Bunker 1c: two bunkers inserted in a vernacular building (photo by N. Paba).



### 3. THE BEGINNING OF THE DIGITAL CATALOG OF BUNKERS

The survey activity highlighted the correspondence between the design drawings and the works carried out. The models mainly use the basic shapes of the circle and the square; these are sometimes modified to allow integration with existing artefacts.

An application of this type can be traced in two of the bunkers found (Figure 6 – Figure 10) where the circular shapes are leaned/integrated with the historical volumes made with local stone. The circular shapes have a diameter of 2.45 m and thickness of the walls in reinforced concrete equal to 1.40 m that perfectly corresponds to the design models, as well as shape and geometry of the slits, wall thickness, empty and full percentage, internal height of the rooms also consistent with the archival drawings.

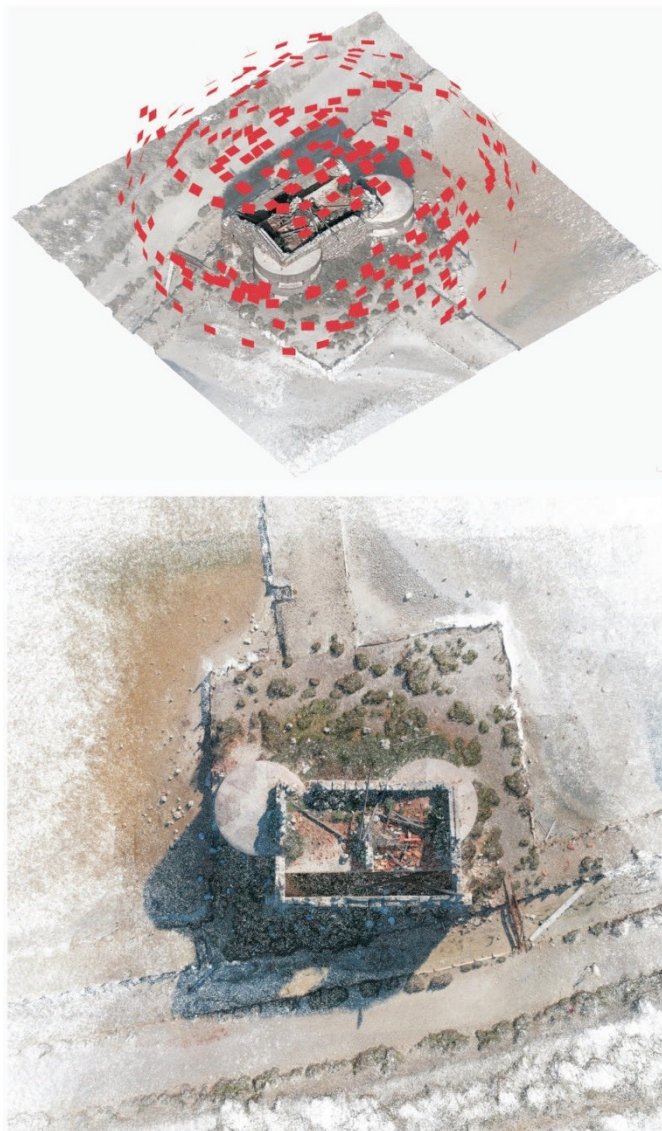


Figure 9. Sector 1: Bunker 1c. Photogrammetric survey of a complex building: aerial view and snapshot position (C.G.I. by N. Paba).

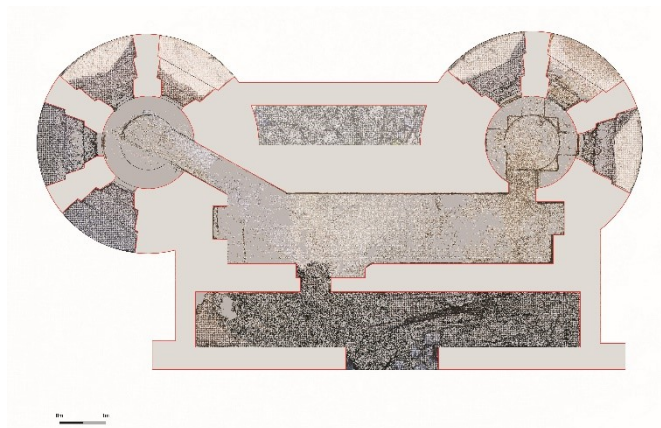


Figure 10. Sector 1. Bunker 1c: plan view obtained by means of photogrammetric survey (C.G.I. by N. Paba).

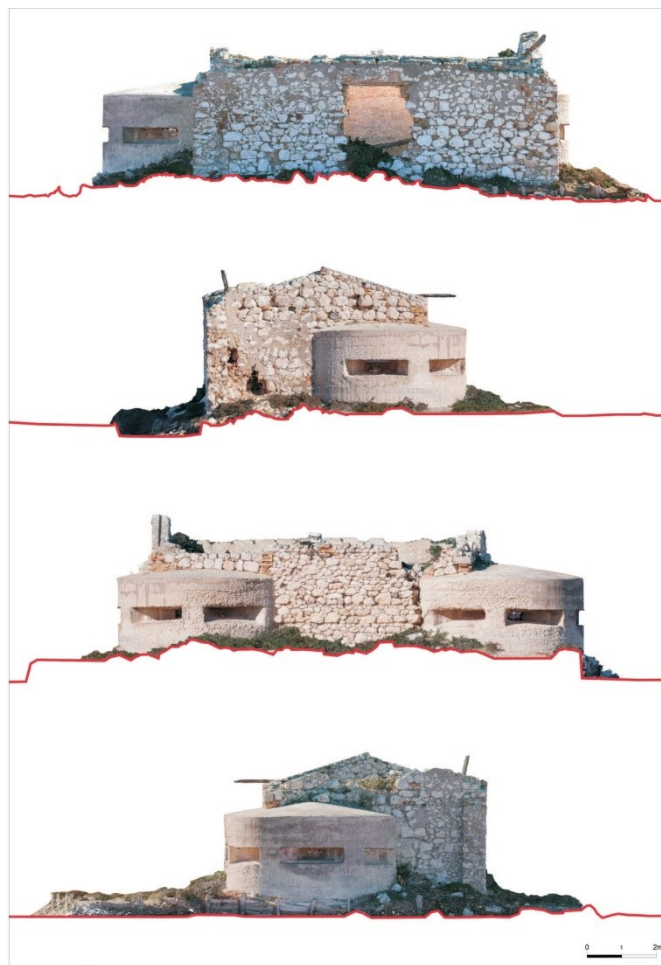


Figure 11. Sector 1. Bunker 1c: plan and building elevations by means of photogrammetric survey (C.G.I. by N. Paba).



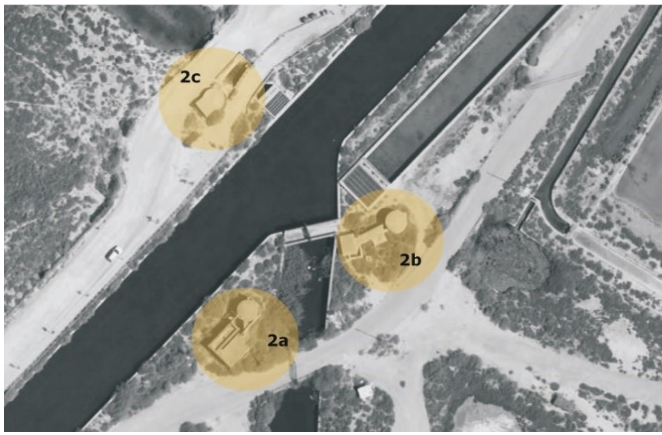


Figure 12. Sector 2: Bunkers 2a, 2b, 2c: simple and complex models.



Figure 13. Sector 2. (Top) Bunker modified as a water tank (2a to reach a complete *mimemisis* with the landscape), (Medium) circle + square connected through a vaulted passage (2b) and (Bottom) bunker designed combining circle + square (photos by A. Pirinu).



Figure 14. Sector 2: photographic survey (N. Paba).

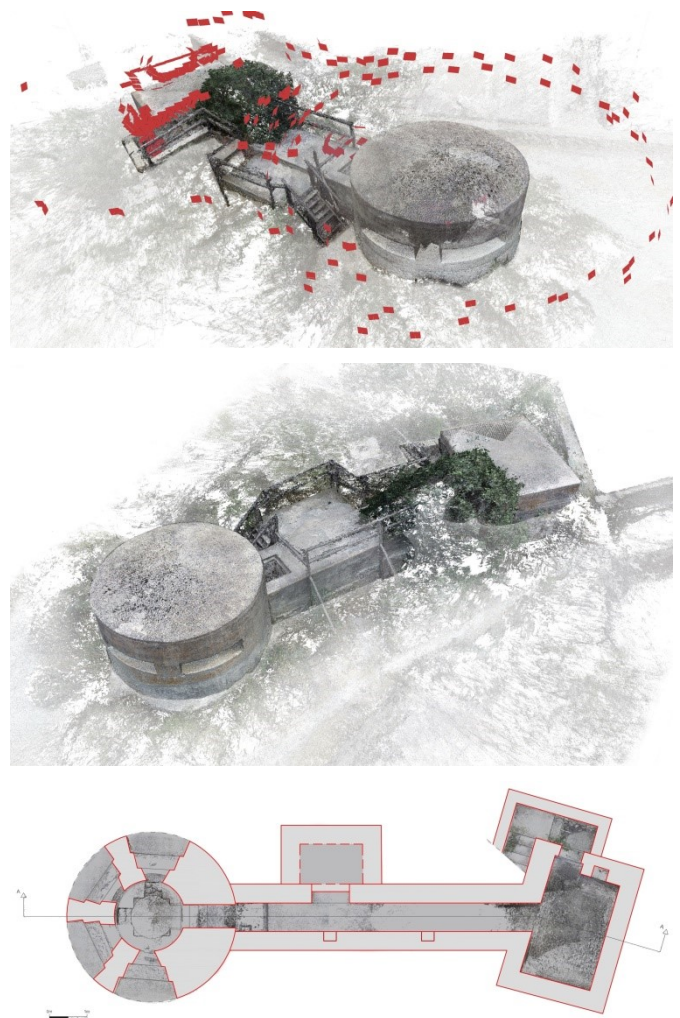


Figure 15. Sector 2. Bunker 2b: digital model (C.G.I. by N. Paba).



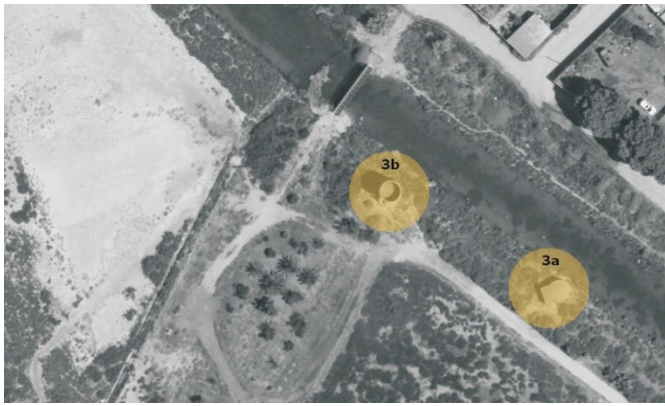


Figure 16. Sector 3. Bunkers 3a, 3b, simple and complex models



Figure 19. Sector 4. Bunker 4a e 4b.

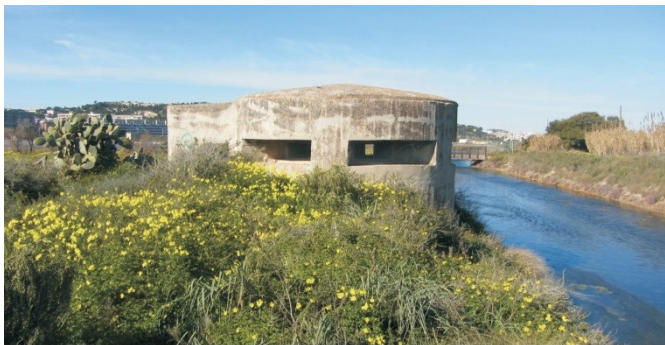


Figure 17. Sector 3. Bunker 3a, circle + square model (photo by A. Pirinu).



Figure 20. Sector 4. Bunker 4a. View from the left side of the canal and orthophoto obtained from the digital model (C.G.I. by N. Paba).

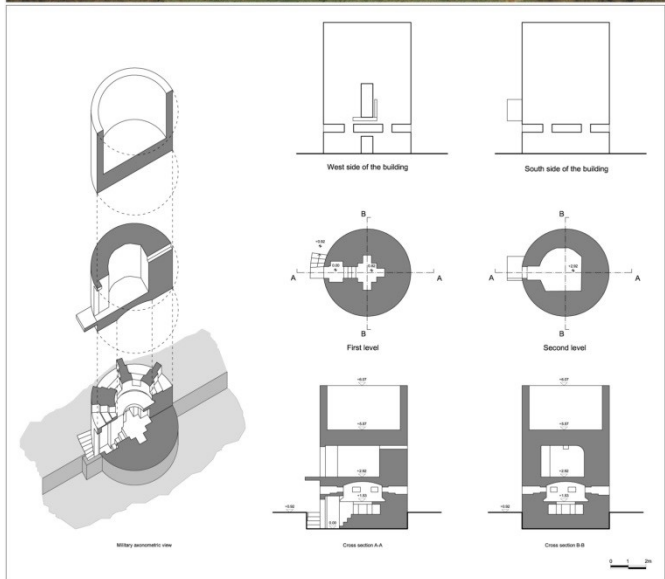


Figure 18. Sector 3. Bunker 3b (drawing by M. Chessa and E. S. Olla).



Figure 21. Sector 4. Bunker 4b: square + circle model (photo by A. Pirinu).



The construction technique employs high-quality reinforced concrete (as shown by the state of preservation of the artefacts, which are also subject to marine aerosol and placed close to the ponds) sometimes combined with concrete blocks or local stone. An example is bunker 2a and 3b (Figure 12b, Figure 16), whose forms recall functions of water reserve (cistern) and bunkers 1c and 4a (Figure 6 - Figure 19) integrated with the walls of nineteenth-century buildings.

A first catalogue of an important sector of the Cagliari defences is therefore complete and summarized, as regards geometric analysis, in Figure 22.

In this synthesis are well described, by means of 2D drawings, the plan schemes of 10 bunkers flanked by a first analysis of the main forms to highlight the use of the circle or the square sometimes combined or adapted for functional and mimetic purposes.

#### 4. CONCLUSIONS

The surveys of these existing bunkers located within the park of *Molentargius-Saline* in Cagliari, show that they were designed as "industrial objects" [5] since they are all serial pieces based on the projects of the 'Genius Militare'. Its execution in exposed reinforced concrete, brings to mind the defence system built by the German organization TODT for the Atlantic Wall, although the forts of Sardinia were designed for small skirmishes and for the control of infrastructures.

Unlike the German bunkers that emerge from the rock or sand like sentinels, on this island of ancient landscapes [13], the blockhouses are small in size and respond to extremely simple geometric patterns. Dimensions and contours make it easy for some of them to camouflage themselves with the environment

(imitating cisterns, huts or hermitages) to disappear before the eyes of the enemy aviation, becoming part of the surrounding landscape. This coupling of the artefact with the site, facilitated by the use of roofing materials from the area, makes perceive the historical landscape as a place as slowly transformed by the actions of men [14]. Pieces of engineering integrated with the environment or emerging slightly above it, building a new, more humanized rural landscape: architecture and nature coexist and complement each other [15]. A new function for many of these bunkers, due to their strategic location, is to serve as observation points for nature and its elements, such as fauna, flora and geology.

The survival of these stubborn ruins begins with their cleaning and recovery to allow access and continues with their documentation aimed at disclosure also through QR codes. These codes will be linked to the Digital Archive of the Bunkers of Sardinia (working in progress) and will indicate the cultural paths designed to enjoy this landscape. To set this process is necessary to overcome the idea that bunkers are abominable objects and begin to appreciate them as documents of material culture and technique. The concepts of "negative monuments" and "terrible inheritance" [16], coined to refer to the remains and vestiges of recent armed conflicts, as well as the supposed "value of discord" [17], question the consensus around heritage as shared identity sign. And this is a lesser heritage due to the size of the pieces, but greater because it is repeated in all the Mediterranean countries.

As David Rieff points out [18], facts and pain are erased from "memory" after four generations, while what has been erected to remember them remains for "history". Something similar happens with these stubborn bunkers that continue to merge and populate the physical landscape that humans perceive. Moreover, as added value, these bunkers are usually distributed on the territory along the coast, in proximity to land or maritime infrastructure, as in the case study proposed. These "unintentional monuments" could be thought -to use the classical theory of Alois Riegl [19]- as bearers of cultural values that neither commemorate battles nor heroes. These architectures represent past episodes and human knowledge that have used the technique to generate protection devices.

It is clear that any strategy of protection and recovery requires an in-depth analysis. This work is necessary to have complete information of the context and make a comparison with other similar case study. In our catalogue we have listed a total of ten bunkers, distributed in four sectors, located near water channels and rural roads, which respond to the type of circle and its cylindrical volume, which is repeated everywhere in Sardinia, adapted to any landscape and material context; their uniqueness lies in the way they have been combined with other existing buildings. Their conservation should not be the exclusive responsibility of the Public Administrations but should be supported by society itself and by civic associations [20] which promote the protection of the cultural and architectural heritage linked to local history and therefore to people [21].

In this sense, the digital recording of these bunkers located in the natural oasis of the *Molentargius-Saline* -as already done in Spain [22] and in other areas of Sardinia [9], [23], [24], [25], contributes to the creation of a map useful to preserve the landscape. The preservation of these ruins -which can be brought back to life with a new use of sentinel of new horizon- can probably be considered in a similar way of that proposed by M. Bassanelli and G. Postiglione for the Atlantic Wall: an archaeological landscape of conflicts [26], where the landscape is

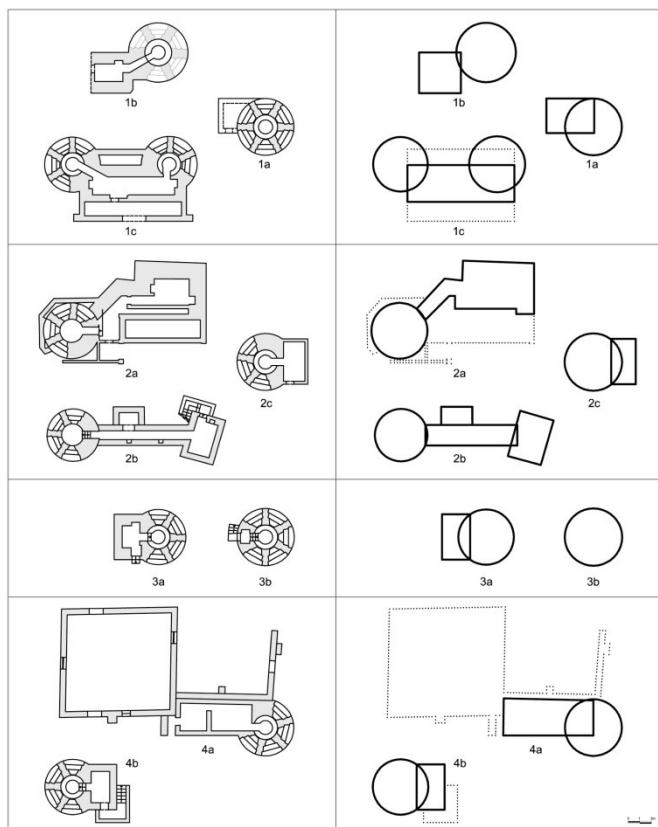


Figure 22. First catalog of the 10 surveyed bunkers: geometric analysis of design models located in four different sectors (drawing by A. Pirinu).



a museum itself. It is certainly appropriate to cite Walter Benjamin and his reflection: "Every document of culture is at the same time a document of barbarism" [27]. And it is in this way that the landscape of nature and the landscape of war merge, which in turn binds -for its very condition of 'invasion'- to tourism: "the journey is etymologically linked to aggression. Tourism and war seem to be the opposite extremes of cultural activity" [28].

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