

Integrated digital survey for the knowledge and enhancement of the IIWW heritage. The Natural Park *Molentargius-Saline* (Cagliari, Italy)

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Abstract –The essay illustrates the choices aimed at building a digital database of military architectures made in Sardinia during the Second World War.

It is an historical cultural heritage characterized by an interesting landscape value, composed by more than 1.500 artifacts positioned along the coast of the island and designed to protect the urban centers and areas of strategic interest.

The small bunkers built adapting the models designed by the Italian and German Military Genius gave rise to an interesting repertoire.

The need for mimesis of these 'sentries' has in fact required an adaptation to the places of the typological solutions indicated in the archive documents.

A possible recovery and enhancement of this heritage necessarily passes through an activity of knowledge and cataloging entrusted to integrated digital survey methods.

I. TOWARDS A DIGITAL DATABASE OF II WW SARDINIAN MILITARY ARCHITECTURES

The Sardinian coastal landscape is characterized by the presence of towers, built between the sixteenth and eighteenth centuries by the Spanish and Piedmontese Kingdom, in activity until the first half of the nineteenth century.

Designed to control the coasts, these architectures 'mark' the rhythm of a landscape shaped by high cliffs, coves, lagoon and sandy coasts. During the Second World War the same positions will be re-occupied by small reinforced concrete bunkers built in a very short time by the Italian and German Military Engineers to thwart an announced allied landing on the island.

This heritage, composed of "industrial pieces", today is mostly abandoned and lack of specific a protection and safeguard rules. In fact, no official cataloging activity [1] or specific regulation guarantees their protection or directs a possible reuse within historical and cultural itineraries. The only regulatory reference remains the PPR (Sardinian Landscape Plan) of Sardinia which identifies "refuges, bunkers and caves" [2] among the

'identity assets' subject to protection pursuant to art. 143 of Legislative Decree no. 42/2004.

However, the historical and cultural value of bunkers, representative architectures of a (recent) past not to be forgotten [3], is evident as well as the landscape value linked to their original position; in the past, sentries to control the sky, seas and cities and today, 'windows' to look and appreciate the landscape. Placed in different areas they make it difficult -but not impossible- to coordinate the intervention strategies. Abandoned along the sandy or rocky coasts, immersed in the rural or urban landscape of the major centers of the island, they coexist with the recent stratifications that have welcomed them.

The organization of a digital database projected to manage two-dimensional and three-dimensional models is the first step to reorganize the knowledge and plan a reuse of this built heritage.

To this aim digital survey methodologies support the recording of scientific data and information computer technologies allow the design of interoperable digital models.



Fig. 1. Tresnuraghes (OR), Natural Park "Molentargius-Saline" (Cagliari), Quartu Sant'Elena (CA), Santa Teresa Gallura (OT)

II. BUILT A DIGITAL DATABASE OF II WW HERITAGE

The development of information technologies and tools for architectural and environmental survey and representation has facilitated the development of interesting initiatives aimed at cataloging the existing built heritage and at the creation of digital archives for their protection, recovery and enhancement.

Laser scanning technology and photogrammetric methods (and an increasingly use of drones, particularly useful in limited accessibility contexts) makes it possible to have a thorough knowledge of the architectural and material characteristics of historical centers, as well as monumental complexes, achieve three-dimensional representations of the landscape and create virtual tours and cultural heritage routes [4].

However, the bunkers of the Second World War only recently have been the subject of interest and studies aimed at an in-depth knowledge although a first cataloging (survey and classification) of the Atlantic Wall is dated 1985 and is due to the scholar Rolf Rudi [5].

A first investigation have highlighted an interesting affinity between the Spanish and Sardinian coasts, "Mediterranean" areas that share historical and architectural events since the Middle Ages and with particular intensity in the modern era. This research [6,7] has interested the design solutions adopted along the Spanish coast between Cadiz and Girona -specifically in the province of Alicante- and has defined a repertoire divided into categories (fig. 2).

The study was subsequently the subject of some insights, related to the disciplinary field of history of architecture and landscape representation [8], with particular attention to the relationship between the identified models and the watchtowers built from the second half of the sixteenth century along the coasts of Spain and Sardinia [9]. The design of a digital database of Sardinian architectures needs a geo-referenced cartographic base; for this purpose it is been identified the Regional Technical Map (C.T.R.) dated 1998 on a numerical scale of 1:10.000, modified to become GIS oriented, integrated by aerial surveys dated from 1954 to 2013 and by the maps prepared by the Italian Military Engineer on a numerical scale of 1:25.000 in the years 1941-42.

The compatibility between the selected documents allows an easy identification of the bunkers and the subsequent inspection aimed at verifying the site conditions and planning the survey operations.

The distribution of the architectures in different landscape contexts of the island requires a territorial planning of the surveys and a choice of some case studies on which to deepen the knowledge of the design characteristics and evaluate the landscape value.

To this end, field operations are conducted on different scales of investigation - architecture and landscape.

Through the use of integrated survey methodologies is possible to acquiring information on the architectural, geometric, material characteristics of single bunkers and landscape qualities of the contexts that host them; all of these data make up the scientific database (fig.3) and are aimed at cataloging and studying the military heritage.

Comparison with the archival models, examination of the state of degradation, analysis of the landscape value, also aimed at the construction of cultural itineraries, are just some of the possible uses of this catalog.

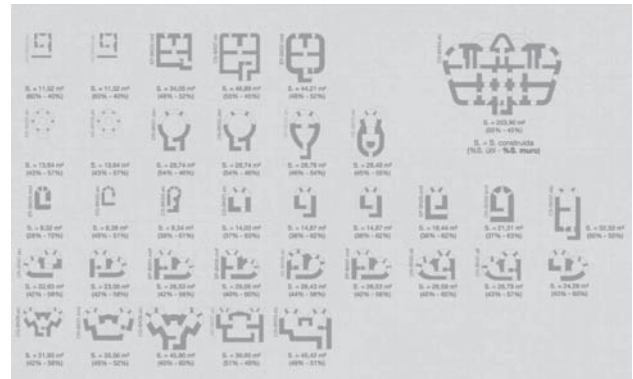


Fig. 2. Catalog of bunker built during the Spanish Civil War (1936-39) in the territory of Alicante (Martinez-Medina 2016)

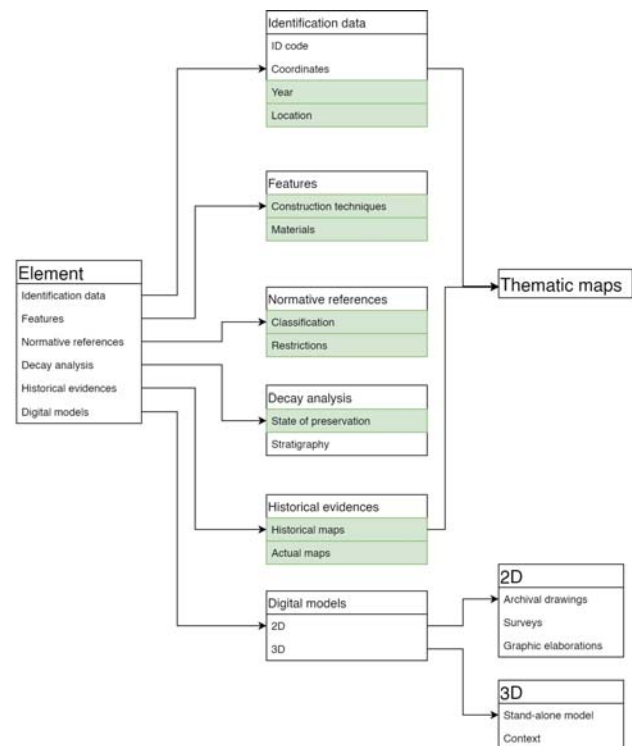


Fig. 3. Main structure of Sardinian IIW heritage database (design by A.Pirinu & R.Argiolas)

III. SURVEY, REPRESENTATION AND CATALOGING IN THE “NATURAL PARK MOLENTARGIUS-SALINE” (CAGLIARI)

The interventions planned in Sardinia during the 1940s was carried out especially in the coastal area.

The projects are well described in the archival documentation kept in the Military Archive of Cagliari (*Archivio Documentale del XIV Reparto Infrastrutture Esercito*) and at the Historical Archive in Rome (*Archivio dell'Ufficio Storico Stato Maggiore Esercito*).

The bunkers location is identified on a IGM maps elaborated by the Military Engineers (fig. 4); it allows an easy recognition of works carried out.

Starting from an analysis of these documents a territorial survey has been realized; this first step as highlighted an interesting repertoire of design solutions that show the presence of models, that take up shapes (circle and square as in figg. 6-7-8) and dimensions indicated in the military catalog, sometime integrated with existing buildings (coastal towers, civil/industrial dwellings) in order to achieve a complete mimesis with the landscape.

One of the case studies investigated is the *Molentargius-Saline* compendium in Cagliari in which 11 bunkers are identified and cataloged; placed in 4 strategic points (sector 1,2,3,4) and visually connected to each other, they was built to control crossroads and canals. Some of them have been modified to disguise themselves by acquiring the shape of cisterns (figg. 9-10) or becoming part of some buildings built in the nineteenth century to support salt works activities (figg. 12-13).

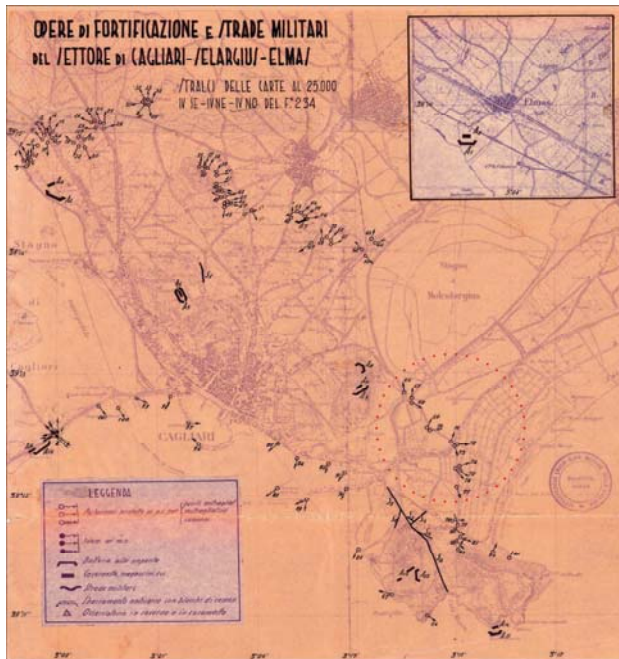


Fig. 4. Military works planned in the sector of Cagliari. The red dotted line identified the survey area

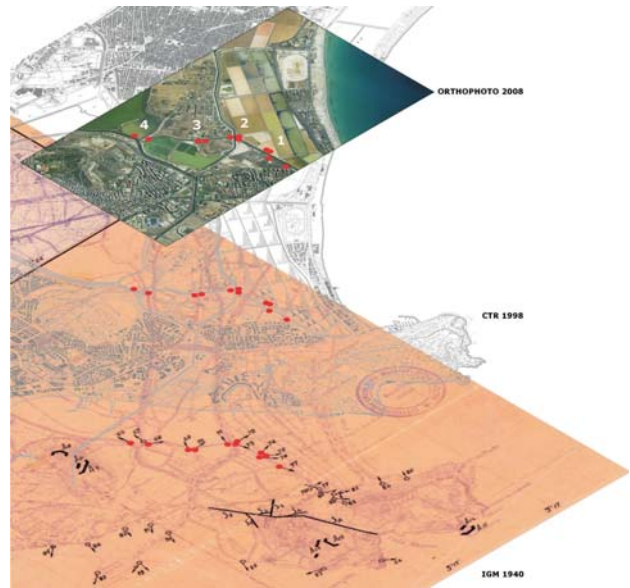


Fig. 5. Military works realized in the Natural Park of Molentargius-Saline (drawing and C.G.I. by A.Pirinu).



Fig. 6. Design model: circle + square in the sector 1



Fig. 7. Design model: circle + square - sector 2



Fig. 8. Design model: circle + square - sector 3



Fig.11. Bunker positioned along the canal - sector 4



Fig.9. Bunker as a cylindrical water tank - sector 3



Fig.12. Bunker incorporated in a building - sector 1



Fig.10. Circle + rectangle (as a water tank) - sector 2



Fig.13. Bunker incorporated in a nineteenth century building to control waterways and road that connected in the 1940s Quartu Sant'Elena to Cagliari - sector 4

In the area of the *Molentargius* (fig.14) the survey operations were entrusted to the photogrammetric method preceded and supported by a direct measurement of the internal and external dimension, useful to scale the model.

This procedure made it possible to record the architectural and dimensional characteristics of all the bunkers identified and to produce a digital representation, of which the sequence of images in figure 17 is an example.

Regarding the operational aspect, during the “design” of the survey, the use of drone was evaluated.

However, from an analysis of the ENAV (the company that manages civil air traffic in Italy) cartography, it is been verified that the airspace related to the site falls within the Natural Park *Molentargius-Saline* area, where flight is prohibited.

Consequently, it was not possible to make a wide view of the landscape context and survey operation were mainly conducted on the architectural scale.

The small size of the bunkers leads the choice for the use of an inexpensive Action Cam (20MegaPixel 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 the poor quality of the image with a high number of shots.

This expedient has made it possible to achieve the intended purposes, that is the documentation of the bunkers (made with the use of simple construction models and regular surfaces in reinforced concrete of excellent quality) on the architectural scale.

The data processing was performed with Agisoft Metashape Professional v.1.5.3 in which the internal and external images were processed separately.

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.

All of this scientific information gives a further contribution to the construction of IIW Sardinian military architecture database and -together with the case studies already examined in the area of Bosa (OR) and Quartu Sant'Elena (CA) and to those still in progress in the north of the island in the territories of Santa Teresa Gallura (OT) and La Maddalena (OT)- to the recovery and enhancement of this important historical cultural heritage.



Fig. 14. Strategic points to control roads and waterways



Fig. 15. Bunker located in the sector 2



Fig. 16. Photographic survey– sector2

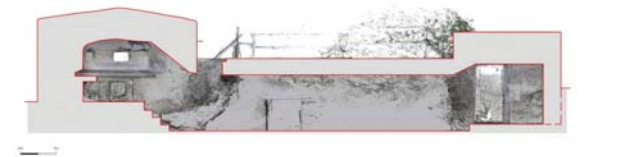
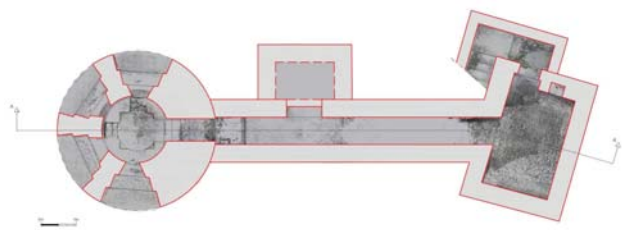
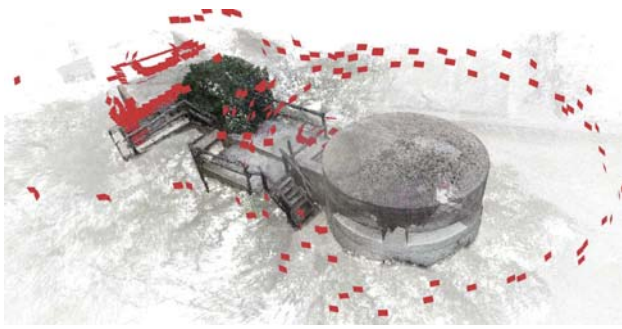


Fig.17. Digital models of surveyed bunker (drawing and C.G.I. by N.Paba, scientific coordinator A.Pirinu)

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