Knowledge, Representation and Communication of the Military Landscape of Sardinia During the Second World War

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Abstract

A mastery in the use of tools, methods, and graphic techniques essential for a thorough understanding and representation of cultural heritage has traditionally been recognized in the field of Drawing. Today, this capability is enhanced by the development of digital technologies which, when combined with the latest surveying systems, contribute to the creation of high-value scientific interoperable digital databases. However, beyond the necessity of detailed data acquisition, significant importance is also placed on the communication of architectural and landscape heritage, which distinguishes the various forms of historical settlements. Expressing and sharing the results and findings of these investigations play a fundamental role in raising awareness among those who inhabit these places and are part of them. This process fosters a 'new' sensitivity, an important goal for ensuring the protection of endangered heritage and an essential contribution to preserving its memory. In this respect, the landscape of the 20th-century wars in Sardinia serves as a significant example that is common to the coasts of the Western Mediterranean. It characterizes the urban contexts of Cagliari and La Maddalena and, to a lesser extent, the entire region.

Keywords: survey, representation, communication, historical military landscape, Sardinia.

Introduction

Sardinia preserves an architectural and landscape heritage linked to territorial defense of the highest value. Punic walls and Byzantine garrisons, medieval castles, coastal towers, and modern fortresses have reshaped the island's landscapes up until the first half of the 19th century using local materials and construction techniques shared across the Mediterranean area. Around the 1940s, a sentinel system designed by the Italian Military Engineering Corps was positioned along the entire coastal perimeter. Consisting of about 1,500 reinforced concrete bunkers, this new defense line created an almost uninterrupted network overseeing beaches, lagoons, isolated coves, and major urban centers. These works were conceived according to precise graphic models well-illustrated in the documentation kept at the Archive of the Infrastructure Department of the Army in Cagliari. The territorial scale drawing, developed on IGM maps and stored at the AUSSME (Historical Office Archive of the Army General Staff) in Rome, characterizes the design of the network; this condition directs the two different scales of investigation necessary for understanding this heritage: the architectural scale and the landscape scale. The former focuses on the dimensional, geometric, constructive, and material cataloguing of the models, while the latter on the analysis of the choices that determined the position and function of the defensive sectors and individual architectures. Recognizing and analyzing the existing models involves a series of interconnected operations

aimed at creating interoperable and multi-scalar graphic models. This result is achieved through the reworking of heterogeneous base material consisting of current and archival graphic and photographic documentation, historical cartographic productions compatible with those available on the RAS portal, and field operations carried out with traditional techniques, laser scanner surveys, and UAV photogrammetric surveys. These UAV systems can observe the selected sites from a privileged vantage point, often characterized by degradation or reduced accessibility. During these operations, it is necessary to reflect on the limits to which data recording accuracy should be pushed if one of the objectives of the survey is to develop graphic forms that are simple to understand and share, especially enriched by a perceptual component related to the human dimension. In this context, it is worth considering Vladimiro Valerio's 2014 statement in his essay conclusion, asserting that: "the primacy of accuracy over expressive clarity is a fairly recent communicative and cultural derailment worth reflecting upon" [Valerio 2014, p. 91].
Previously we have highlighted the possibility of documenting heritage through digital graphic models characterized by remarkable precision and reliability. Among these, recent applications using UAV systems [Pirinu et al. 2021; 2022; 2023] and some integrating laser scanner surveys with photogrammetric surveys [Empler et al. 2022] for the study of 20th-century military architectures are noteworthy. This latter combination is necessary when intending to acquire comprehensive documentation of both the architectures and the context

Fig. 1. Selection of models in the containment arc of Quartu Sant'Elena (photos by Andrea Pirinu, 2017-2024).

in which they are embedded. 'Embedded' is the most appropriate term since we are dealing with 'industrial' models characterized by a significant underground portion necessary for *camouflage*.
The result obtained through digital surveying is undoubtedly of great interest for the study and protection of these defensive systems and serves as a useful support for all territorial transformation activities. However, it is the result of computer procedures that risk neglecting a necessary component for the study of the landscape that derives from direct experience: the perception of the place. Moreover, the outcome of digital processing, performed with automatic or semi-automatic procedures, produces graphic models accessible only to specialists, excluding from the debate those who are an integral part of these places and live there daily. Therefore, today's opportunity and challenge may lie in designing a graphic model derived from high-level computer procedures but characterized by easy-to-understand and immediate communicative graphics. These graphic expressions can, due to a data base acquired through highly performing digital tools, based on the set objectives and following a simplification operation, present less accuracy and produce a product useful for critical reflection and broad sharing. This operation does not result in a loss of information since the data acquired through digital tools are stored in an interoperable database, open to incorporating new multidisciplinary contributions, and even unconventional graphic forms.
Here lies the peculiarity of a 'hybrid' model, which is not a novelty as a tool for representing architecture [Parrinello et. al. 2019] and territory but today acquires new strength and meanings due to the available IT resources. The possible dynamic reading through digital tools meets the specificity of a constantly changing landscape, a complex and mutable element that can be conceived as a layering of informational strata [Colaceci et al. 2022] that must necessarily include and comprehend the 'time' variable. Therefore, the 'hybrid' model offers a break from the "uniformity in digital representation" [Pirinu et al. 2023, p. 304] since the inclusion of analogue drawings within a digital product facilitates the inclusion of the designer who becomes part of the place, participates in the construction of the scene, and adds unique connotations related to direct experience.
The proposed case study, located in the territory of Quartu Sant'Elena (CA), falls within an activity that for

over a decade has involved a comparison, within an Erasmus protocol, with similar experiences conducted in Spain [Martínez-Medina 2016] and constitutes the theme of a doctoral research involving the University of Cagliari, the University of Alicante, and the University of Rome, La Sapienza. The path undertaken so far has allowed for the recording of structures present along the Mediterranean coasts of Spain and Sardinia through predominantly planimetric graphic schemes and the initiation of an interesting typological catalogue. Census, cataloguing, and initial comparisons were subsequently integrated with surveys conducted at the landscape scale using UAV systems integrated with field reconnaissance [Pirinu et al. 2021]. This extension of operations to the landscape context has favored the acquisition of data relating to territorial contexts and their potential in terms of recovery and reuse. The outcome of an experiment aimed at forms of documentation containing scientific rigor and communicative capacity is a mosaic of graphic models with different levels of detail, where the military landscape is proposed as a stratification. This succession of reading plans can be identified, observed, represented

Fig. 2. Map IGM used by the Military Engineering for project representation. The bunkers highlighted are no longer existing or they are embedded in the current building fabric and not visible.

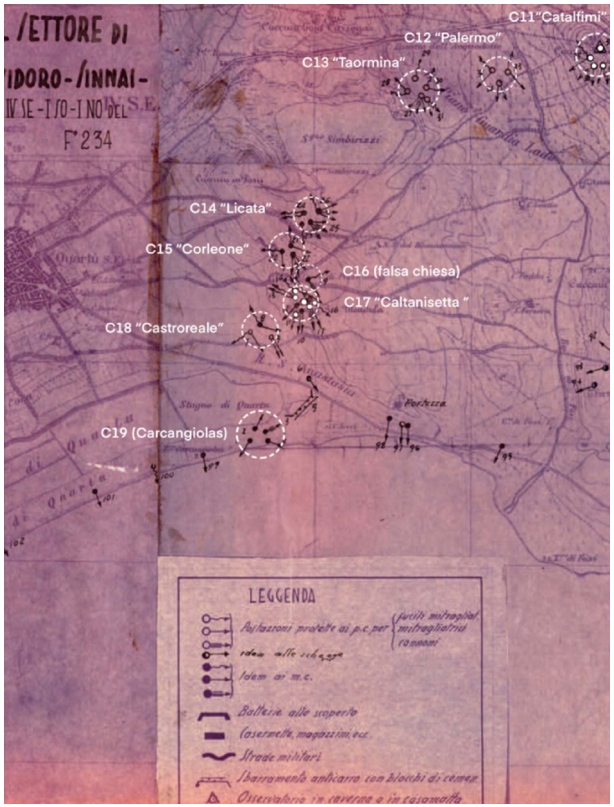


Fig. 3. Identification on a RAS map (1989) of the studied strongholds (graphic elaboration by Giancarlo Sanna).

and communicated through the integration of multiple information levels, where each layer represents a different aspect of the natural and built environment, which the 'hybrid' graphic model allows to observe individually and relate with the other layers and with the whole system.

The Containment Arc of Quartu Sant'Elena (1942-1943)

The containment arc of Quartu Sant'Elena was constructed between 1942 and 1943 based on a design by the Italian Military Engineering Corps. The defense line, composed of smaller structures compared to the models of the Atlantik Wall [Virilio 2012], was created with the aim of opposing an Allied landing and protecting the urban, agricultural, and industrial areas within the territorial context of Cagliari, the island's capital. This line consists of 107 reinforced concrete defensive structures, in addition to other military buildings such as observation posts (Cala Regina, Nuraghe Diana, Fortress) and the "C165 Capitana" and "Faldi" batteries at "Torre Mortorio" [Grioni, Carro 2014], organized into 19 strongholds. These strongholds comprise different design models and armaments based on their control tasks. The survey of existing structures has so far revealed a predominant abandonment of this architectural heritage, which nonetheless shows a fair state of conservation.

This contribution focuses particularly on a portion of the containment arc, specifically the strongholds located near Lake Simbirizzi, overseeing some access routes to the city of Quartu Sant'Elena. This sector has not been affected by the extensive urbanization that has characterized the Quartu countryside in recent decades and presents significant landscape interest. The investigation included a sequence of operations, such as the analysis of historical cartography and the survey of existing structures to acquire their dimensional, constructive, and landscape characteristics. This allowed for the completion of the cataloguing and comparison with archival drawings. Maps based on 1:25,000 scale IGM cartography constitute an important documentary source preceding field operation. A preliminary reading of the maps shows that the protection of Quartu Sant'Elena was entrusted to a network of small bunkers adapted to tactical and camouflage needs. This latter requirement led to the creation of unique design solutions and specific research interest.
Rural houses, tanks, and small religious buildings are some of the uses found in the countryside near Lake Simbirizzi and along the communication routes between the urban center and the cultivated fields to the east (fig. 1). The models constructed along the coast, ready to oppose an Allied landing, propose simpler designs that combine circular or quadrangular shapes (sometimes different from those indicated in archival documents), with the only exception of particular

Fig. 4. Aerial view that allows to distinguish 3 of the 4 bunkers belonging to the XIV "Licata" (photo by Nicola Paba).

Fig. 5. Aerial view of the fourth bunker belonging to the "Licata" and located near the shore of Simbirizzi Lake (photo by Nicola Paba).

interest being the reuse of the ancient Carcangiolas tower on Poetto beach and the Nuraghe Diana in the Is Mortorius area. The variety of formal solutions and adaptations to the site's topography, and their grouping into strongholds, determines the field operations and the creation of different areas of investigation. The first area (figs. 2, 3) is located between the coastline, the hill of Pitz'e Serra, and Lake Simbirizzi, consisting of the strongholds named "Licata", "Corleone", "Caltanissetta", "Castroreale" and "Carcangiolas", dedicated to controlling the numerous connecting routes between the Cagliari area and the territory. Most of these strongholds appear to be preserved, except for the "Caltanissetta" stronghold, which is obscured by recent construction.

Integrated Survey for the Study of the Military Landscape. The "Licata" stronghold

The "Licata" stronghold (figs. 4, 5), located not far from the urban center of Quartu Sant'Elena, consists of four bunkers, three of which are partially buried and positioned along the southeastern slope of a small hill overlooking Lake Simbirizzi. The fourth bunker is currently situated near the lake shore and is inaccessible as it is within private property. The study of this sector, as anticipated in the general discussion, requires the application of integrated methodologies at different scales of analysis.

Fig. 6. Strongholds XIV "Licata". Orthophoto obtained from the photogrammetric survey [Pirinu et al. 2022, p. 51].

After the analysis of the IGM map and an initial site inspection, the work program included a sequence of survey operations aimed at acquiring a comprehensive database that encompasses the architectural, technical-constructive, and landscape characteristics of the investigated sector. To this end, the execution of sketches and landscape readings through live drawing were combined with laser scanner scans, useful for recording the interior spaces of individual structures, and photogrammetric applications using a drone, necessary for acquiring the external 'skin' of a stratified landscape. Laser scanner surveying and UAV application specifically allowed the connection of internal and external metric and spatial information of the individual bunkers, as well as an understanding of the adaptation of the design to the site's morphology, thus the intersection between nature and artifice. The obtained data thus enabled a deeper understanding of the current state of the sites but, more importantly, facilitated the recognition and comprehension of the design choices defined from the graphic schemes present in the manuals prepared by the Italian Military Engineering Corps.

From an operational perspective and with reference to the tools used, the instrumental survey was conducted using a Faro Focus M70 laser scanner, specific for short-range applications, with a resolution of 12mm at 10m, sufficient for the intended objectives, i.e., architectural scale surveying. The reconnaissance was completed using 16 stations, 13 internal and 3 external, the latter necessary to connect the laser scanner survey to the photogrammetric survey.

Data acquisition for photogrammetric purposes was conducted with a DJI Spark drone, equipped with a 12.4 Mpx camera with a 4:3 aspect ratio and a 4.49 mm f/2.6 lens, equivalent to 25 mm on a Full Frame (35 mm) format. To achieve at least 1 cm of GSD, nadir shots were taken at a constant flight altitude of 15 m from the ground, while oblique photos were taken at 10 m from the surfaces. Once field operations were completed, the data was processed using Agisoft Metashape Professional software. With the SfM (Structure from

Motion) process, recognizable elements (Key Points) and matching points (Connecting Points) were identified, and then a Sparse Cloud was defined, processed to correctly align all images in the process. The data processing produced a Sparse Cloud of 650.000 points and a Dense Cloud of 24.000.000. The Dense Cloud was then processed with Cloud Compare software using subsampling, noise reduction, and SOR filter tools. The digital model thus obtained allowed the production of various outputs, including orthophotos, axonometric and perspective views, and environmental sections (figs. 6, 7) representative of the individual bunkers and their context. However, this initial series of models still does not allow a comprehensive reading of the military landscape. The completion of the investigation indeed occurs with the integration of the two processes attributable to instrumental and photogrammetric surveying.
Now the data acquisition is complete but the further objective of a representation capable of communicating results, through 'simplified' graphical models, to a wide range of users has not yet been achieved; this is achieved through the 'hybrid' drawing, which helps reduce the complexity of the digital survey and offers a mosaic of reasoned summaries that express and communicate the characteristics of the site.

Representing and Communicating the Military Landscape

Upon completing field operations and reprocessing the acquired data, we have a high-quality digital database capable of providing detailed information on individual bunkers and the landscape context, as well as creating a mosaic of graphic models useful for narrating the military landscape. These representations illustrate the shapes, internal and external volumes, and the materiality of these industrial objects set in the natural environment or anthropized landscape, and essentially, analyze the design at various scales of interpretation.

Fig. 7. Digital models of the Bunker N. 25 belonging to stronghold XIV "Licata" (graphic elaboration by Nicola Paba).

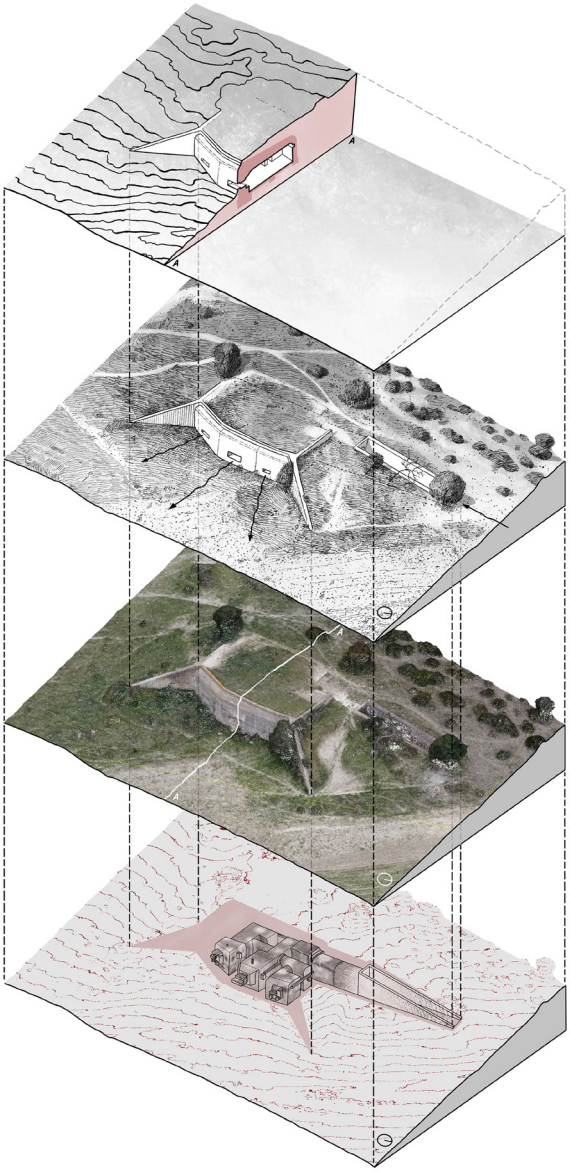


Fig. 8. Representation of the military landscape. Stronghold XIV "Licata" (graphic elaboration by Giancarlo Sanna).

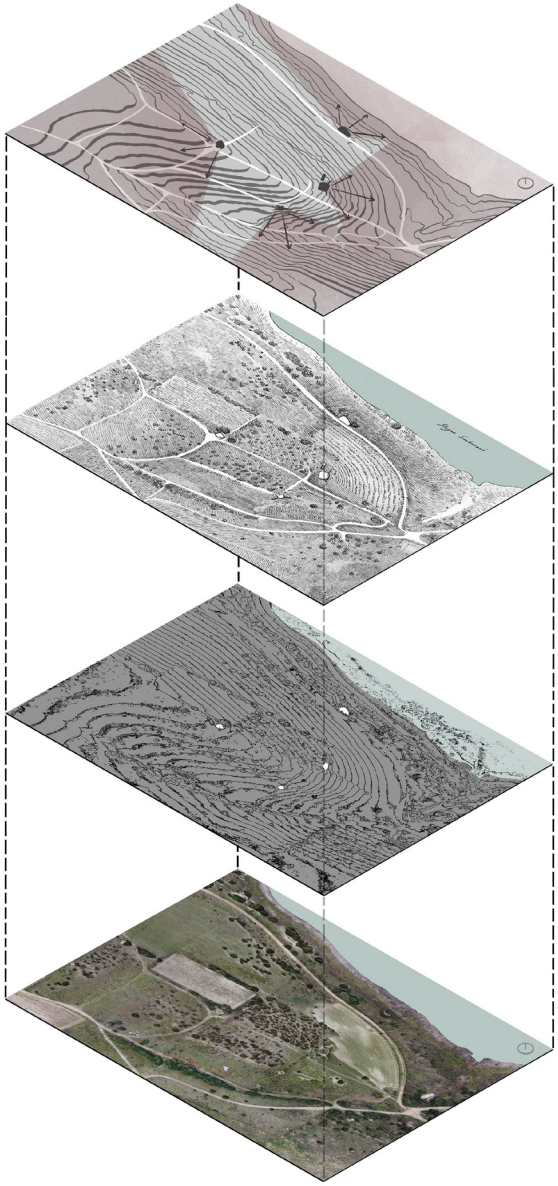
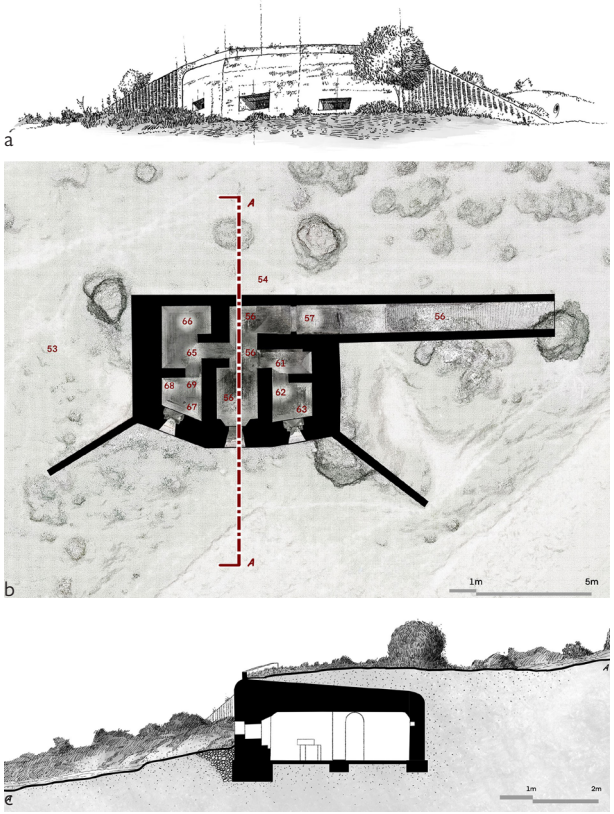


Fig. 9. Representation of the military landscape. Stronghold XIV "Licata", Bunker n.25 (graphic elaboration by Giancarlo Sanna).

A further step promotes the understanding and sharing of the results. This involves the decomposition and recompositing through the redrawing of digital models according to separate thematic reading planes, each represented individually (figs. 7, 8) to facilitate understanding the relationships that link the individual themes and each to the whole, according to the principles of the structuralist current [Docci, Chiavoni 2017]. The very nature of digital surveying allows isolating different informational levels and integrating them with graphic forms attributable to traditional drawing. The result is a 'hybrid' representation that combines the metric reliability of digital surveying systems with the communicative power of freehand drawing. In the proposed case study, the digital model of the entire stronghold XIV "Licata" (fig. 8) was 'dismantled' and highlighted the site's morphological characteristics, the road network, land use, and the positions of the individual bunkers and their visual cones, one of which was built entirely above ground. In this case, the redrawing with an IPAD using the Procreate application resulted in a grayscale synthesis, where the marks of cultivated fields and uncultivated areas are interspersed with a dense network of paths connecting the small concrete structures. A further elaboration produced an image that replicates a 'three-dimensional' map, strongly reminiscent of a model, a tool still widely used by designers today, showing the position of the bunkers within the entire sector. Through a similar process of decomposition and intersection of graphic models, an architectural scale sequence of informational planes (fig. 9) was created to examine the direct relationship of the structure with the terrain, also integrated by traditional drawings (fig. 10a). The insertion of the model, obtained from the combination of instrumental and photogrammetric surveying, allowed to observe the composition and the constructive/functional scheme of the internal spaces of bunker no. 25 belonging to the stronghold (fig. 10b).
Finally, a sectional operation (fig. 10c) highlighted the correspondence, in terms of shapes, thicknesses, and site positioning, between the built work and what was prescribed in the archival documents (fig. 11). These distinct readings, but in constant dialogue with each other, can be compared to panels in a comic strip. Taken in isolation, they have individual value; however, it is in their sequence and comparison that they gain strength, much like the panels that, put together in a storytelling, narrate a story with greater coherence, richness, and communicative capacity. This method is perfectly suited, even though diachronic readings, to the representation of a system in continuous modification such as the landscape.

Fig. 10. Bunker n. 25: a) sketch from life; b) plan with indication of the instrument stations; c) section and landscape context (graphic elaboration by Giancarlo Sanna).



Conclusion

The military heritage of World War II in Sardinia represents an important historical, cultural, architectural, and landscape legacy. Its preservation requires, first and foremost, a thorough understanding of the existing heritage; this action, in turn, requires the use of integrated

procedures for surveying and representing architecture extended to the landscape scale. The investigation protocol applied to the study of Compartment XIV "Licata", part of the Containment Arc of Quartu Sant'Elena, a town not far from the island's capital, highlighted the reliability of digital surveying in terms of data acquisition capabilities and the potential of a 'hybrid' drawing, which integrates digital and traditional techniques, for communicating a multi-layered, complex, and continuously changing system. The forms of representation and the outputs extractable at various scales of interpretation from the knowledge database, in comparison with archival documentation, have also allowed for a deeper understanding of the current state of the sites and the design characteristics of the defensive compartments and individual bunkers, a necessary step to promote recovery and enhancement actions, even within cultural itineraries.

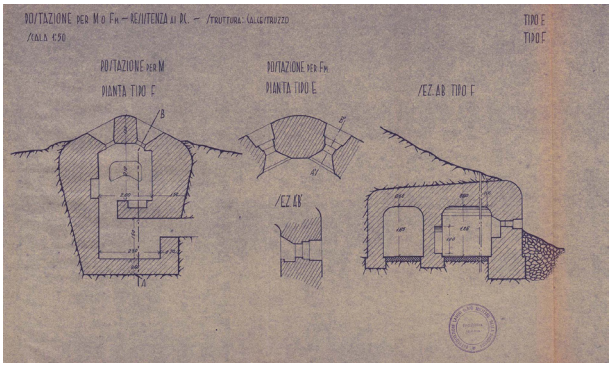


Fig. 11. Archive document showing a fully buried solution with only two artillery openings facing the landscape to be checked (Archive of the Infrastructure Department of the Army of Cagliari).

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