

Photogrammetric data analysis for fortified architecture. Survey of currently disused structures

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Keywords: Photogrammetry, Survey, Analysis, Model, Albania

Abstract

The research presents the results of the analysis of coastal cities in Albania, characterised by military bunkers for defensive purposes. The work is divided into an analysis of the researched territories, two-dimensional surveys of the bunkers and their classification into XS, S, M, L, XL with regard to their size, and an applicative conclusion of digital technologies for digital modelling and graphic visualisation of the spaces. These architectures are located along the coastline on steep slopes or, at this time, in the private gardens of summer residences, and this location has greatly influenced the survey campaigns, determining the state of the sites, often in a state of complete abandonment. Some underground structures, such as the one located in the bay of Porto Palermo, are currently in use by the navy for the safekeeping of ships and their maintenance. The final task of the research work is to propose a graphic knowledge of the coastal sites between Vlora and Saranda, which have been the subject of uncontrolled construction of buildings for seaside tourism in the last decade, documenting the state of the sites of defence architecture.

1. Introduction (LC)

The Albanian territory is dotted with around 750,000 bunkers built to defend the coasts and borders. A substantial number of defensive structures were built under the dictatorial reign of Enver Hoxha from 1945 to 1985 and still today they cover hills, cultivated fields, beaches and roadsides. Construction was further increased during the Cold War in order to provide Albania with complete protection from Eastern invasions, following the previous Ottoman rule, and control over the Mediterranean coastline.

The sources analysed, the documents in the Central Archives in Tirana, show that a single bunker was provided for every four inhabitants at the time, in addition to the defence structures characterised by a single military post and artillery depot. In order to delineate the spaces characterised by defence architecture, it is useful to analyse the landscape and morphological characteristics of the coastal area between the towns of Vlora and Saranda. A 125 kilometre coastal route that connects the Albanian sites of Vlora, Orikum, Dhermi, Himare, Qeparo, Borsh and Saranda united by narrow valleys that open into pebbly bays towards the southern Adriatic.

The territory is separated by Llogara Park, which splits the Albanian waterfront in two and determines its characteristics and differences. The towns of Vlora and Orikum overlook a stretch of sandy beach sheltered to the south by the Llogara mountain and facing northwest. This geographical configuration is more exposed to the north winds but uses the mountain behind to protect itself from attack. It is, in fact, the Llogara pass that determines the difference in elevation between the beach and the more than one thousand metres separating the southern shore of the Albanian coast.

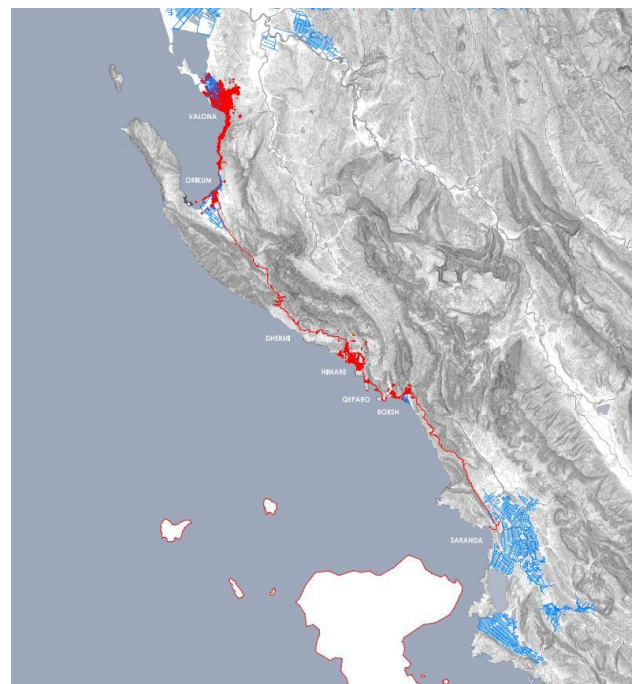


Figure 1. Planimetric identification of the Albanian coastal stretch from Vlora to Saranda. Subject of the search and identification of bunkers

The city of Vlora is included in the current research itinerary as a historical stronghold to the north to embark on that journey southwards through a steep climb and a series of hairpin bends between the towns of Dhermi, Himare, Qeparo and Borsh. The four municipalities along the coastline are now summer resort towns and retain the historical nature of places devoted to pastoralism and fishing. The wild new constructions of the last decade have disrupted the original layout consisting of a T-shape with an axis perpendicular to the waterfront that climbs into the valley behind. There are numerous architectural and archaeological sites in the coastal municipalities and their state of neglect and decay does not currently allow the establishment of thematic cultural tourism itineraries. Particularly interesting are the fortified and monastic architectures caused by the Ottoman invasion and the subsequent flight to the coast and the neighbouring island of Corfu. Traces remain of these buildings, characterised by fine constructions in local stone and with painting cycles of great interest, and currently dedicated to the construction of the waterfront for the crowds of tourists. The itinerary concludes with the town of Saranda, a bay north of the UNESCO site of Butrint and characterised by a series of tall, slender buildings surrounding the port connecting with Italy and Greece. Today's constructions have overturned the project plans made in the early 20th century, where analysis of historical documentation in Tirana's Central Archives reveals a desire to have large green spaces to protect the coast and the nearby mountains. The city of Saranda is built along the slope of the mountain that separates the Girokastra valley from the coastline. The interventions of the last few years have profoundly changed the coastal cities: Vlora and Saranda have undergone waterfront restyling in line with Albanian political directions that include the need to bring nature into the city through green areas and a waterfront with ample space for events and lush green areas. This modification activity was a major factor of interference between the surveying activities and the progress of the work, as profound differences were evident in the succession of surveys and verifications of the surveying phases. The result shows a series of planimetric drawings and the differences between the historical images and the current conditions. The main routes and ascents in the valleys are also identified to represent the main connection routes between the city and the surrounding area.



Figure 2. XS-type bunkers. State of the art view

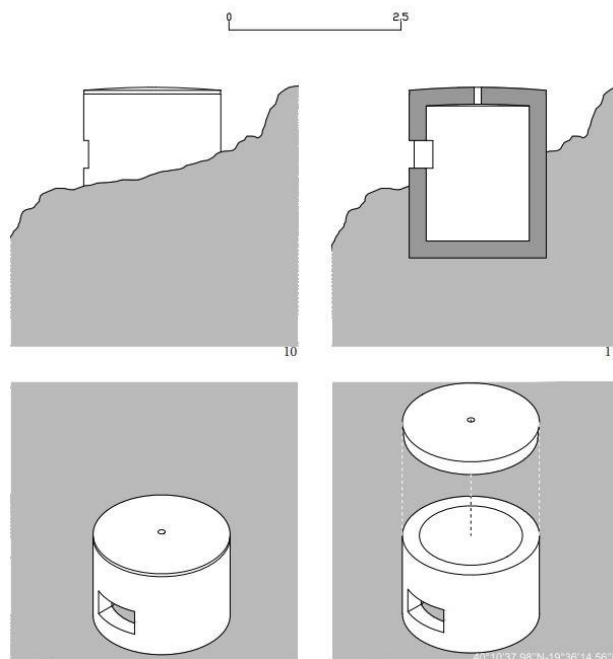


Figure 3. XS-type bunkers. Survey

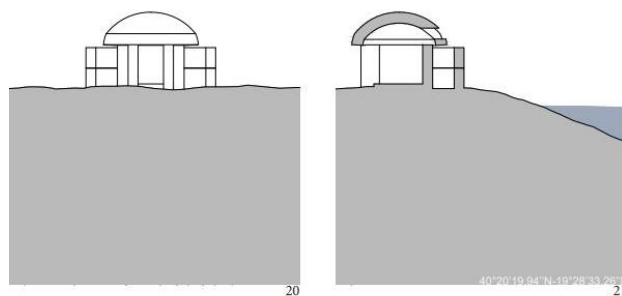


Figure 4. Bunker type S. Survey and view of the state of the art

2. The phases of research (GG)

An initial bibliographical and iconographical survey, at Albanian archives and libraries, produced few results as there is only a classification by size, but there are no surveys of the current state of either the individual structures or their planimetric positioning. This survey revealed the need to approach the territory, the Albanian coastline where the bunkers are located, in order to conceive the relationship between the architecture and the landscape in relation to the cities.

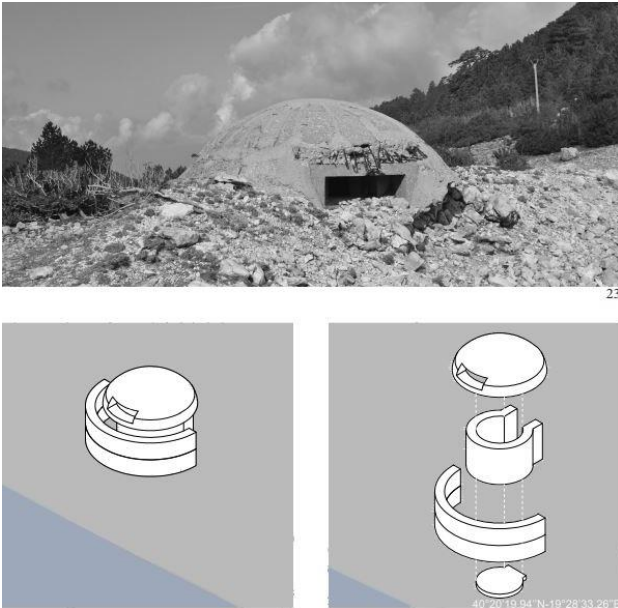


Figure 5. Bunker type S. Survey and view of the state of the art



Figure 6. Bunker type S aggregate. State view

These structures are positioned at a fixed distance from each other to allow the lookouts to easily exchange without leaving their position uncovered for a long period. The territorial study was conducted through a series of plans, reproduced from original drawings of the territories, created in the 1920s and 1930s by Italian architects on a mission in Albania. This documentation was of considerable interest as they are the only documents from which the historical evolution of the Albanian territory can be traced and graphically mapped. The second phase involved the investigation of bunkers, defence structures capable of housing one to several people and capable of attacking the enemy from the sea. These elements, an unspecified number (around 750,000), have been present since 1945 all over Albania to protect its borders. They are positioned from the border with Greece to the flat spaces near Montenegro, from the Albanian Alps they share with Kosovo to Lake Orid in Macedonia. The investigation, however, stopped at the coastal

stretch in order to locate the largest number of bunkers and the different types. In fact, the coastal stretch from Vlora to Saranda also hosts an XL bunker and its location, sheltered from the winds, carved into the rock and difficult for enemies to access, determined the choice of the stretch under investigation. The last part of the research deals with the use of spaces through 3D modelling and visualisation. This topic is developed in order to compare the two-dimensional activities carried out previously with the digital software currently in use, but above all, to enable the remote use of defence architectures in the Albanian territory. As previously illustrated, these structures are not entirely usable due to both their location and the current use and ownership of the land on which they stand. The modelling phases involved both the pure geometric forms, the towers and mushroom structures, and the large tunnels excavated in the rock. Very interesting was the post-production phase of the graphics with the textualisation of the structures in order to make the graphic rendering realistic. The final aim of the research work is to propose a graphic knowledge of the coastal sites between Vlora and Saranda, which have been the subject of uncontrolled construction of buildings for seaside tourism in the last decade, documenting the state of the sites of defence architecture.

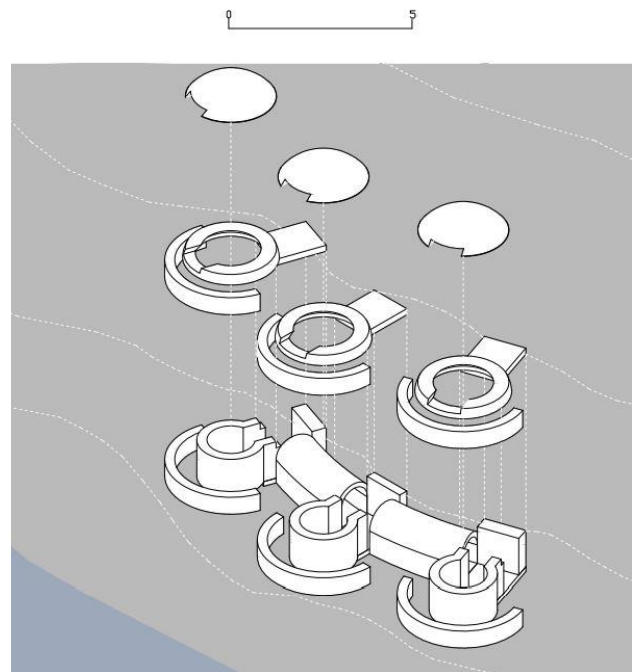


Figure 7. Bunker type S aggregate. Survey

3. Photogrammetric survey and data analysis (LC)

The survey and subsequent digital modelling activities covered the five categories listed above. The field surveys, in line with the disciplinary methodologies, were developed with manual methodology and terrestrial photogrammetry. This methodological choice was determined by the location of the structures and the rights of the soils where the bunkers reside. The knowledge activities were carried out with field surveys characterised by preliminary inspections to plan the work to be carried out and a subsequent phase with terrestrial and aerial photogrammetry. The research was developed, in the initial part, with photographic documentation, in order to create an



Figure 8. Type M bunkers State of the art view



Figure 10. Type L bunkers State of the art view

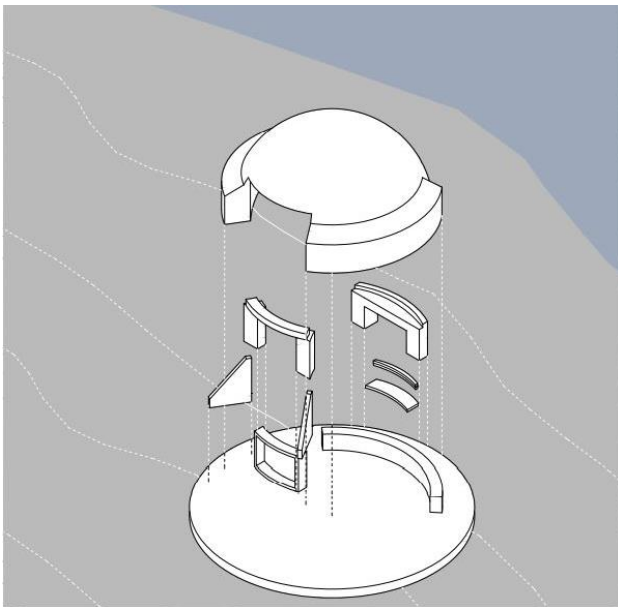


Figure 9. Bunker Type M. Axonometric Exploded View

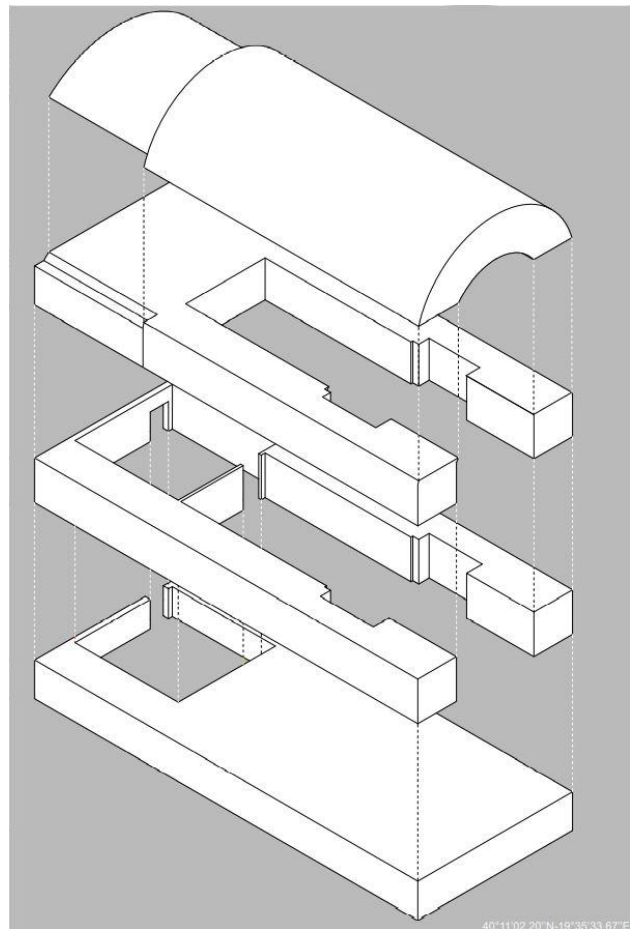


Figure 11. Bunker Type L. Axonometric Exploded View

adequate illustrative campaign to document the artefacts; in a second phase, an on-site survey of the bunkers was carried out. The photogrammetric survey phase, which mainly concerned the larger buildings, was carried out with a DJI four-wheel drone and subsequent data processing using Agisoft Metashape software. From the graphic restitution, following the survey phase, it was possible to determine the main dimensions and compare the war architectures. Bunker XS, a small structure, was placed as the element containing the military lookout for observation of the territory. Its main characteristic is its ability to camouflage itself in the surrounding environment; in fact, its position is often immersed in rocks or sufficiently hidden places. They are watchtower structures, cylindrical shaped with a diameter at the base of 1.20 m, produced with prefabricated elements and assembled on site. They are characterised by a single opening in the main part and a hole in the roof to allow

air circulation. Their function was relegated solely to territorial control.

S bunkers were designed to accommodate a soldier with his rifle in a total area of 2.45 m². The difference with the XS structures



Figure 12. Type XL bunkers State of the art view

concerns function: in fact, the S bunkers were armed and ready to fire. They are prefabricated concrete elements made in industry, transported and assembled on-site. They consist of a three-metre wide cover hemisphere with a single, double or triple opening used to position the gun. The lower part is cylindrical shaped, hollow inside and often buried for half its height, with 60 cm thick side parts. Such bunkers are the most widespread in the country as they are easy to construct and suitable for the various conditions of the Albanian territory. M bunkers, or rather medium-sized bunkers), were originally designed to house small artillery or a group of soldiers. Some larger ones are capable of housing artillery and heavy weaponry or groups of more than 10 soldiers. They consist of reinforced concrete segments (weighing between 8 and 9 tonnes) to make up the hemispherical roof structure. The floor area is 28.8 m², while the thickness of the walls could vary from 60 cm to 1 m, depending on the type of artillery to be deployed within the structure. The entrance is characterised by a reinforced steel double door 3 m wide by 1.5 m high. On the opposite wall of the base cylinder was the firing port, where there was a 180° view allowing the soldier a wide view of the entire area.

L-bunkers, on the other hand, are special structures comprising regular and anti-atomic tunnels designed and built for various military purposes such as military bases for submariners, aircraft, heavy artillery and homes for political and military leaders. This typology presents a unique form, but is adapted to the orographic conformations of the terrain.

The examples examined are the underground structures located in the southern part of the Gulf of Port Palermo, such as the Gjadër airfield and the aircraft tunnel south of Shkodër. As is well known, the Aircraft Tunnel was built inside the mountain behind it overlooking the sea, it had the capacity to accommodate around 50 aircraft plus personnel and featured an airport with a 600 m long runway. Another interesting feature, which emerged during the survey phases, is the thickness of the outer lining, made of reinforced concrete, never less than 1.5 m.

4. Conclusions (GG)

The final aim of the research work is to propose a graphical understanding of the coastal sites between Vlora and Saranda, which have been the subject of uncontrolled construction of buildings for seaside tourism over the last decade, and to document the state of the sites of defence architecture.

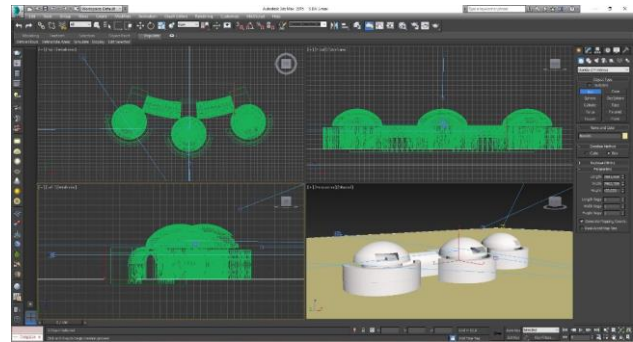


Figure 13. Parametric modelling processes of survey data

The final result can be seen in the modelling phases, which involved both pure geometric shapes, the turrets and mushroom-shaped structures, and the large tunnels dug into the rock. Very interesting was the post-production phase of the graphics with the textualisation of the structures in order to make the graphic rendering realistic.

A digital graphic documentation of architecture built for a war that never came and that still today constitutes an architectural landmark in the cities and landscape of Albania.

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