DEFENSIVE ARCHITECTURE OF THE MEDITERRANEAN
XV to XVIII Centuries

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Digital tools for documentation and interpretation of the fortification system of Elba: the Giove Fort as a connection point between ancient routes and visual targets.

Giulia Baldi\textsuperscript{a}, Mirco Pucci\textsuperscript{b}, Giorgio Verdiani\textsuperscript{c}
\textsuperscript{a}Dipartimento di Architettura, Florence, Italy, giuliabaldi87@gmail.com
\textsuperscript{b}Dipartimento di Architettura, Florence, Italy, mirco.pucci@gmail.com
\textsuperscript{c}Dipartimento di Architettura, Florence, Italy, giorgio.verdiani@unifi.it

Abstract
Elba territory presents a dense network of forts and outposts created by the various dynasties and conquerors that ruled the Island through the centuries. This defensive apparatus was connected by ancient paths, routes and visual systems, as it is possible to notice from the landscape, showing the various watch towers located on hills. The visibility among these archaeological evidences can still be observed as no changes has been made to their context. The most important fortresses are: Giove Fort, Volterraio Castle and St. Giovanni Tower, which are located on strategic areas to control the whole perimeter of the Island and of the Mediterranean Sea. They represent a potential visual line on heights, which all coastal fortification systems referred to. The use of digital tools, 3d laser scanner technologies and photogrammetric survey, make possible to understand the evolution of this military apparatus and the communication method between the Giove Fort and the other main outposts. The acquired data aim to a better knowledge of the Giove Fort and the role it played in the past. The final documentation can provide an improvement of the bibliography, promoting a kind of virtual tourism. By the use of multimedia applications and web sites, visitors can interact with digital and physical 3D-models of the archaeological complex, avoiding accessibility obstacles. The paper proposed here will show the description and the analysis of this documentation and dissemination project.

Keywords: Fortification System, Elba, Archaeology, Digital Survey, Landscape.

1. Introduction

Elba shows an articulated defensive fortification system, quite well preserved and therefore still visible. Fort Giove, built by the Appiani during the 16th century, represents the most important strategic and logistic fortification among all the others along the Tyrrenian coasts.

1.1. Territorial dynamics

Elba is the largest remaining stretch of land from the ancient tract that once connected the Italian peninsula to Corsica. The northern coasts face the Ligurian Sea, the eastern coasts the Piombino Channel, the southern ones the Tyrrenian Sea, and the western coasts face directly the neighbour Corsica. The history of the human settlements on the island covers a very wide chronologic period, and developed around its mineral resources and strategic position in the Mediterranean Sea. The iron resources on the island guaranteed one of the most important traffic in the Middle Age and also assured trade relations with all countries in the Mediterranean Sea, Sardinia, Corsica, Spain, France, Sicily and all the other island of the
archipelago, down to North Africa. The firsts to arrive at Elba looking for copper were the Neolithic navigators, followed by Etruscan first and Romans afterwards. These conquests led inevitably to the formation of a defensive fortified system: towers, castles and fortresses arouse all over the island. This defensive system reached its most important period with the Maritime Republic, when Pisa and Genova contended for the rule of the mediterranean sea and the Church increased its role on the island sending monks and encouraging the realization of churches and hermitages. However the diffusion of the military apparatus reached its maximum period of glory under the Appiani dynasty first, and under the Medici family then. The following centuries saw the decadence of this defending system during the Spanish monarchy and the Napoleonic period. The military defence system was dismantled little by little during the French domination and after the insurrections of the Elba people. Today only few traces of these architectural remain, but are fundamental for a deep study of the fortification system and a better understanding of the story of this territory.

2. Ancient routes and visual targets

The defensive outposts rise on specific places according to the conformation of the ground: usually built on heights to have full control of the seas, and along the coasts to defend the inland valleys and the most important tin mining sites of the island. Besides fortresses on heights there is a network of archaeological structures, as towers, fortified villages, fortified churches, and sighting sites on halfway from the coasts and the mountains, or near valleys and rivers. The majority of the military outposts are positioned in the western and central part of the isle where the morphology of the ground offers strategic sites on heights, difficult to be conquered in case of siege and with a wide view on the archipelago, on the inside trade and on the other outposts. This defensive network, however, developed also in the eastern part of the isle where the richest iron reserves are concentrated. The necessity to protect the most productive mining areas together with the shortage of landing points, determined the location for the sight and defense points and also for human settlements and villages (examples are Monte Giove and the Giove Fortress, the nearby and almost disappeared Grassera, Capoliveri, Porto Azzurro and the coast of Cavo). As already seen, the defensive system is closely related to the vicissitudes of the territory and to the various dominations when the outposts were strengthened according to the needs of their times. Some scholar believe that most of the fortifications were built on the isle at the end of XIII century, when the Genoese thread became more and more dangerous until it culminated with the occupation of the island in 1290. However not all the fortified outposts built on Elba during the century had a military nature: Volterraio Castle and Fort Giove had a defensive character as they could accommodate the population in the event of a siege. At the same time, with the intensification of Turkish raids during the whole XVI century, some small fortified villages and Comuni grew up, characterized by ecclesiastical-military structures, as shelters for the inhabitants and able to defend the territory (see San Piero, Volterraio Castle, Marciana, Rio nell’Elba and the old medieval village of Grassera, at the base of Mount Giove). Architects and military engineers, most of them italian, contributed to the design and realization of these sight and defence points. This articulated sighting system between fortress on top of hills and outposts along the coast allowed, visual connection to each other, a better control over the inner valleys, all along the coasts and on the Tuscan Archipelago, beside a quick and safe propagation of warning and other information with fire signals. The analysis of the communication system used by these fortresses points out a main visual axis (east to west) formed by the Giove Fort, Volterraio Fortress, St. Giovanni Tower, all situated on promontories overlooking the coasts and the Mediterranean Sea and connected to other secondary visual systems.
The complex of Volterraio with the etruscan fortress and the Church of San Leonardo, is the main centre of this important visual axis. The complex is situated on Mount Veltraio at 394 mt above sea level in the central part of the island near Portoferraio. The sighting system develops from here both to the west for about 15.7 km towards St. Giovanni Tower (300 mt above sea level) overlooking the Gulf of Marina di Campo - built in the XI century under the dominion of Pisa – and for 4.5 km towards the eastern part of the island, rich in iron mines, dominated by Giove Fort (Mount Giove 352 mt above sea level), and from here towards the Tyrrhenian Coast. The use of digital tools, the analysis and experimental methods for management and postproduction of the data, allow to hypothesize the presence of other outposts between the longest distances: probably small wooden forts destroyed in the course of time, never rebuilt or reinforced and of which we have no evidence remained.

The potential visual axis on heights and the ancient routes connecting the whole network of outposts are still visible today as the original landscape has not changed and there are no buildings or architectures to stop the perception of visual targets.

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**Fig. 2- The Volterraio Castle seen from Giove Fort (Mirco Pucci, 2017)**
3. The Giove Fort

The use of digital tools, 3d laser scanner technologies and photogrammetric survey, make possible to understand the evolution of this military apparatus and the communication method between the Giove Fort and the other main outposts. Infact this research focuses on the role that Giove Fort played in the past.

The importance of this fortification can be found in the position and the location that held on the territory: it is, and it was, infact the only connection point between Elba Island, the inland valleys, Piombino channel and the mainland coasts. The Fort completes that system of visual connections and paths that assured an efficient and safe control over the island during the evolution of political, economic and cultural events of the Mediterranean Sea. The fort rises on the eastern part of the island which is also the richest and most precious part of the Island, characterized by one of the greatest iron reserve in the mediterranean sea. It was built in 1459 on the top of Mount Giove (352 meters above sea level) by Jacopo III Appiani to reinforce his dominion over the Island. Appiani Dynasty was one of the most important family in the history of the Island because, as ruler of Elba in the Renaissance, it incremented the power and reinforced the defense of Elba keeping on an articulated militarization (started in the medieval era), placing watch towers and outposts all over the territory. Example of the evidence of the Appiani family on Elba can be found in many relevant architecture: the construction of Rio Marina Tower, Marciana Marina Watch Tower and the enlargement of the Volterraio Castle and the Marciana Fortress. The watchtower, according to a legend was built on the ancient ruins of a Temple dedicated to Jupiter, but other sources assert the presence of etruscan remains. The building had a dual function: military control of the territory and the sea, and safe place and shelter for the nearby population of Grassera village. Infact the inhabitants of Grassera found asylum in the fort during the first turkish invasion in 1534, when the pirate Barbarossa invaded the Island. In this occasion the Giove Fort remained still and unconquered, and it was only years later, in 1553 that the castle was besieged by the Ottoman pirate Dragut who enslaved the refugees. From that moment the history of the fort follows the events related to the occupation of the Island by the Spanish monarchy, passing through a series of attacks that inevitably lead to the slow decay of the complex. It was then definitely dismantled and abandoned in the XVIII sec. by the french army. Today this massive structure is in great part collapsed and submerged by vegetation.

As demonstrated by the studies, the digital and photographic surveys done for this research, this huge defensive architecture is composed by a quadrangular central body on two vaulted floors provided with bank walls and toroidal band course. The central body is surrounded by walls and a moat all around. The walls on the western side collapsed (probably during the '700), while are still visible on the eastern and southern sides and provided with a bank. The main entrance to the watchtower is on the northern side and it was probably provided with a stone bridge. The building is very articulated especially for the various materials used for the construction: local stone (verrucano) bricks and tuff. The architecture of Giove Fort does not undergo substantial changes during the centuries apart from the material used (for example wood is replaced with stone), and the perimeter walls are higher to offer a major defence especially after the gunpowder invention introduced in Europe around the XVI century.
4. Digital tools for comprehension and documentation

The digital and photogrammetric survey produced a detailed analysis of the dimensions and of the surrounding area. The documentation obtained, based and verified on two-dimensional drawings and three-dimensional models, is a necessary tool to have a correct idea of the shape and of the importance of this fortified complex, its architecture and its role both as defensive shelter and crucial site of the sighting system on the island. The study and the reading of this ancient architectural heritage was carried out using 3D Laser Scanner technologies based on phase-shift measuring solution: Zoller+Fröhlich Imager 5006h. This kind of device assure fast operations and a good accuracy of the data. The working scale of this instrument ranges from 0.4 to 79 meters (according to the technical specification of the manufacturer).

The positioning of the scan stations was decided according to the shape and to the specific conditions of the terrain and of the remains. The survey were completed taking 133 stations (about 654 million points have been registered), all of them operated in full panoramic mode, and exploiting the characteristics of the 3D laser scanner in use, which was capable of scanning 360° on the vertical axis and 310° on the horizontal axis. A so high number of stations is due to avoid shadow spots created by the vegetation close to the tower walls.

The digital survey operated by a team from the Department of Architecture (DiDA) of the Florence University in April 2017, produced a detailed description of the complex, essential to catalogue the single buildings. The documentation was implemented and completed with material and chromatic data thanks to an additional photographic and photogrammetric survey. The combination of these surveys allow to obtain a wider view of the entire complex for a better realization of a 3D digital model and to produce a metric database and analysis of the area. Sequential scans were taken beginning from the northern side at the ancient gate in front of the drawbridge beyond the castle's moat. Scans moved afterwards clockwise towards east under the ramparts. In this section the vegetation close to the wall made it necessary to place targets to obtain a more accurate data production. The south part is the most damaged: the ground is covered by the ruins fallen down from the external walls. The last external part surveyed was the west one. After a first round around the complex, a second group of scans was taken in the inside of the Giove Fort and focused the part of the massive structure still intact. The photogrammetric survey was operated only in the inside, the most scenographic part, and was used to compare it to the laser scanner data, combining them when necessary and specifically to obtain a one final 3D low poly textured model, necessary for analysis and further studies. The high density point cloud generated by the lasercanner data resulted contaminated by high-growth vegetation close to the massive, so it has been accurately cleared of all the unnecessary data in order to obtain a clear view of the complex, its moat and walls and the higher part of the fortress.

All the 2D drawings and 3D graphic elaborations were obtained following a series of steps of post-processing:

- Mesh generation from laser scanner data; (hi-poly mesh): a mesh of about five millions of polygons was produced in this phase. Parts of the remaining vegetation has been removed, some points closed and correct the surfaces where necessary;

- Creation of a 3D low density digital model for multimedia use: through an appropriate high-poly-mesh decimation it was possible to generate a lighter mesh of 500.000 triangles (or polygons); therefore the necessary mesh corrections have been made;
Unwrapping and baking operations: the UV map was carried out through the Luxology Modo solution, trying to solve overlapping issues, to make a more harmonious and homogeneous UV map and more simplified further operations of chromatic texture editing. After these operations it was possible to make the high poly mesh baking, creating an appropriate normal map;

Texturing by photogrammetric data: a complete photogrammetric survey of the architecture produced a series of data that was edited and analysed using SFM software (structure from motion), calibrating the shots and generating a rough 3D digital model. By the importing of the low density model on Agisoft Photoscan software it was possible to create an appropriate chromatic texture of the architecture;

Revision of the textured model, final model: final operations of balancing and texture editing necessary for the final 3D digital model.

5. Promotion of a cultural and architectural heritage part of the history of the Island

This research enables to understand limits and potentialities of these architectures, the bound that join all the various forts together and the importance and the role played through the centuries. The accuracy and the speed of the laser scanner technology allow to analyze the fortification system with a degree of detail far superior to the classic techniques of survey. The use of new methodologies together with advanced drawing softwares lead to the creation of 2D and 3D digital models. The 3D digital models obtained will improve the documentation and the dissemination of informations about the fortification system of the Mediterranean Sea, especially using web solutions easily accessible online by computers, smartphones and tablets. This research aims also to develop and implement a completely free multimedia application dedicated to the fortification System of the Mediterranean Sea, in particular to Elba. The app gives all the updated informations about this military apparatus, focusing on the crucial points and highlighting on ancient routes, paths and visual targets.
Fig. 6- FortElba App for computers, smartphones and tablets (Mirco Pucci, Giulia Baldi 2017)

Using interactive, didactic and ludic features, the user can explore the 3D virtual models and the hypothetical reconstructions of the architectures, learn informations and take advantage of direct links, share data, locations (google maps or similar) tags, images and topics. This kind of web solution its a tool that can be used at any time and anywhere either by exploring the interactive map or by using geolocation services, in order to locate any nearby buildings and get informations about how to reach them. The app can also connect by browser with internet platforms like Sketchfab, where all the 3D digital models object of these studies are already catalogued. Elba is today mainly visited by seaside and naturalistic tourism, but these architectural and cultural emergencies, witnesses of the troubled history of the island, are quite evident. The Tuscan Archipelago National Park started in the past years a promotion of these buildings beginning from the restoration of the Volterraio Fortress and the organization of guided tours: a multimedia proposal such as the one described in this research can be an efficient device to help such activities, stimulating and arousing the curiosity of the visitors. The steep slopes and the vegetation surrounding the arduous paths leading to the archaeological sites are a limit to the visit and the exploration of these architectures: this issue of accessibility and possibility to visit the most of the fortresses of the Island is a problem that can find a solution in this kind of application. The proposal of a virtual tourism wants to ensure the opportunity for a wider audience to visit such important places: visitors will be allowed to interact with a virtual system of 3D digital models that will replace or integrate a real visit to the site creating an ideal connection between the public and the landscape around. Together with the app, 3D physical printed models will be realized in chalk powder and will be gathered in strategic places like museums, accessible to everyone. It will allow a better comprehension of this ancient defensive system in an alternative and dynamic way.

Fig. 7- The Volterraio Castle seen from Giove Fort (Giorgio Verdiani, 2017)

All the studies of this research will try to improve the promotion and the valorization of the original elements, visual targets and routes, together with an enhancement of the documentation about this important archaeological remains, unique evidence of our past in our today civilization.
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