

Coastal towers between Spain and Sardinia

Proposals for a documentation strategy

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Abstract: Spain and Sardinia, all along their Mediterranean coasts, offer a suggestive sequence of towers, this system is integrated and presented in the landscape for a surveillance and defence purpose and represented an articulated military system for a long period. Since the sixteenth century, there was the need to protect a territory otherwise easy to be attacked by pirates. At the end of this historical period, once defeated the pirates in the "Mare Nostrum", the coastal towers system lost its defensive function, but remained as a testimony of history. The study of the towers, their positions and their different types, suggest the creation of a multimedia catalog, which provides research and knowledge of these towers beyond a virtual connection between them, almost an attempt to revive the routes marked by history. The study and determination of a methodology is fundamental to approach any research project. In addition, in our case, taking the architectural elevation as a fundamental means for the analysis and study of a building corpus, it is even more important since the casuistry of each of the towers can be completely different. We started with the necessary preliminary inspection that led us to adapt the methodology used in each case, for each tower, ending up with a combination of various technologies that are being incorporated to the project. The whole work will be based on historical documentation retrieval and digitalization, 3D digital survey (using 3D laser scanner and terrestrial/aerial photogrammetry), 3D modeling. With all this we will be in a position to disseminate the results at the two levels contemplated in the project: a scientific level, with complete data and high-resolution models; and for the general public, with lighter models manageable by smartphones or tablets, with the selection of the necessary data for its understanding.

Keywords: Towers, Mediterranean, multimedia, 3D model

Introduction

The sixteenth century was a period of confluence never seen in Valencian Coast, where a complex social - political context and technological development produced the birth of military architecture in this territory. In 1557, Felipe II became King, and he began an ambitious project that it had already traced the Duke of Maqueda, and consisted on building a network of watchtowers and defenses of the coast that they have the mission of alerting to neighborhood towns, of the frequent pirate attacks, and in addition to be the first line of defense. The Spanish king decided to entrust the ambitious network of watchtowers and defense of the east coast to Giovanni Battista Antonelli "Il Vecchio" which will be followed by other members of his own family who designed and constructed during the sixteenth and seventeenth centuries. The older Antonelli had a particular view on the concept of defense of the country, comparing the coast with the front of a wall, where cities and towns were the doors, the villages were the bastions and watchtowers were the battlements.

Nowadays all these towers form an important architectural heritage that they have lost their main feature, the unit. They were built as a part a unique defense project. Currently, we find them abandoned both physically and in terms of research effort for its value (RODRÍGUEZ-NAVARRO et al. 2015).

This contribution was made in the frame of the R & D project entitled "Surveillance and Defense Towers of the Valencian Coast. Metadata generation and 3D models for interpretation and effective enhancement" reference HAR2013-41859-P, whose principal investigator is Pablo Rodríguez-Navarro. The project is funded by the National Program for Fostering Excellence in Scientific and Technical Research, National Sub-Program for Knowledge Generation, Ministry of Economy and Competitiveness (Government of Spain).

The overall goal of the project is to generate metadata and three-dimensional models of watchtowers based on historical, geometric and constructive study. For this study, we propose the use of 3D photo-realistic models with the inclusion of their full data, and we can use them from any geographic location through the proposed dissemination. The opportunity of the study is to multiply the visibility of these cultural assets in the Eastern coast, providing data and high scientific level models that can also reach the general public through a new system of operating performance in "light" computing platforms such as Smart-Phones or PDAs (Apps augmented reality). For the implementation we will contact cultural management companies and local governments.

Historical approach

In 1453 Constantinople was conquered by the army of Sultan Mehmed II and this fact supposed the beginning of the fight to control de Mediterranean Coast. The Turkish attack supposed the Ottoman domain in Mediterranean coast. The quantity of pirate attacks augmented and this fact produced the Conquest of Argel in 1516 by Arrouj Barbarrosa (Red Beard). Pirate attacks in the middle of Sixteenth century increased and expanded around the coast through sacking and campaign of robbery (GARCÍA and MARTÍNEZ-MEDINA 2015). In Spain, Felipe II found an uncertain situation in the Northern of Africa and a reduction of Spanish fleet to resist Barbary attacks.

Under this situation, the engineer Giovanni Battista was employed in 1563 to develop a new defensive system in the Spanish Coast to get a double goal: looking after the outer sea and controlling the inner territory. The designed system consisted on developing watchtowers along Valencian coast using existing towers and building the necessary ones to control the coastal front.

The general situation of the coastal fortifications is a testimony about the dispute between Barbary pirates and Christian coasts.

Valencian Coast

The Valencian coast is characterized by mixing rough areas with sandy lands and lightly slopes. The defense in every type of land consisted on tower systems where a specific army was located to control and protect the coastal defense.

Locations of every tower followed under tactical criteria, getting the higher view of the coast and control the possibility of landing to attack or obtaining provisions. The rough coasts with a big quantity of geographic

features were suitable for pirate activities (POBLET 2013) and towers were located to control this type of seacoast. However, the higher points of flat lands were used to get the most capacity of viewing the seacoast. Depending on the localization of every tower, a defensive group was setting to control seacoast, to reject any possibility of landing and to warn neighborhood towns about the proximity of any kind of boat. In 1554, “Las ordenanzas de la Guardia Marítima del reino de Valencia” (The laws about navy guard in the Kingdom of Valencia) was published to organize the defensive system of Valencian coast and to describe the army organization that every tower needed: Guards were responsible of looking after the coast and warning in case of danger, and “Atajadores” were responsible of communicating news between towers. The final goal was to obtain a military coast using towers and organizing through army equipped with light artillery to control and defend the seacoast.

Typology of Valencian towers

The typologies of towers in the Valencian coast have gone developing during centuries and they have been adapted to new necessities and technological developments of attack systems. From the architectural point of view, architectural typologies changed their morphology throughout fifteenth and sixteenth centuries (Fig. 1). We recognize three stages according Poblet (POBLET 2015):

Stage 1: This phase happened from the end of the fifteenth century to the beginning of sixteenth century.

Towers are prismatics with square or circle base, very simple that they only answer to the function of visual control of territory.

Stage 2: This phase happened between 1520–1560. The towers are pre-bastioned which have singular elements as alambres and esperontes.

Stage 3: This period finished in seventeenth century. Towers have important variations regarding previous phases. They used conical forms that let them a higher strength against artillery weapons. The hexagonal shaped appeared to solve a not only a visual control but offensive functions.

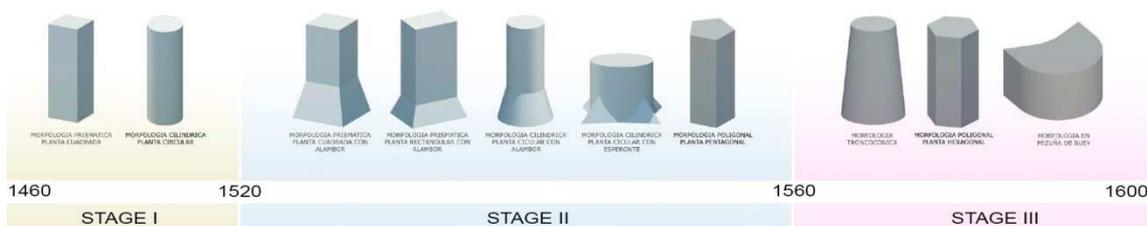


Fig. 1 – The evolution of the Towers typology (Copyright: Poblet)

Towers were composed by three parts, foundation, tower base and main body. Every part had a structural and defensive function. The diameter of foundation generally was bigger than tower base and it was adapted to land. Base reaches a third of the total height and its function was to avoid accessing to the tower and rejecting artillery through alambor and esperonte (sloping and screeding system). The main part includes watching area and interior was built through vaulted system.

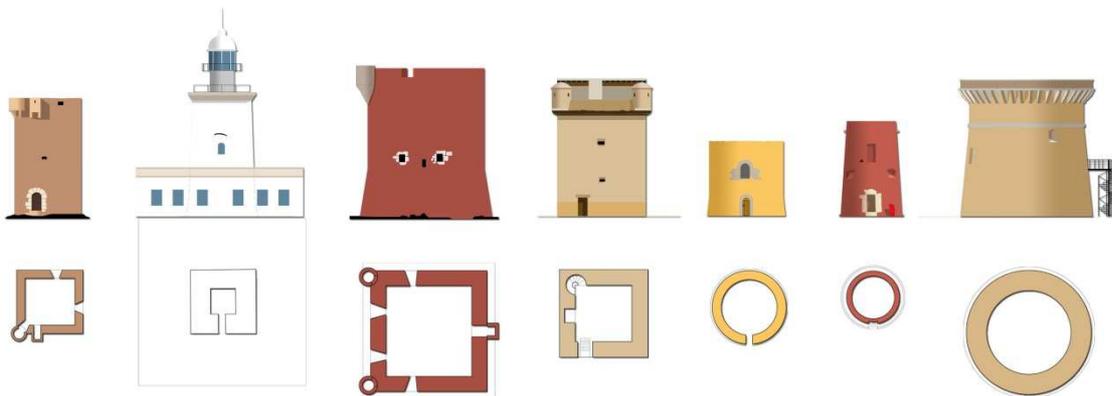


Fig. 2 – Valencian types (Copyright: Atzeni, Naldini and Rodríguez-Navarro)

The own elements of these typologies were: the elevated access through ladder, holes on the shaft of the tower, loopholes, machicolations around tower. All these elements gave to the tower all necessary functions to defend and control.

Sardinian Coats

The Coast of Sardinia doesn't allow an easy landing due to high erosion of the sea. The coast is showed as a natural defense against invaders and it has suitable conditions to build watchtowers. This coast is high and rocky and it forms a natural defense against the pirate attacks of the Berberis. The emplacement of the tower in this orography is because of occupation of high place and the control the most quantity of length of the coast and keeping visual connexions between nearest towers (ATZENI and NALDINI 2015).

Typology of Sardinian towers

The kingdom of Sardinia built a big quantity of coastal towers in sixteenth and seventeenth century. The most quantity of towers had circular base. Their functions were control and defense, and they had a garrison completely established there with their artillery system.

The localization of towers depended on visual control of the coast and their necessity to be seen by nearest towers. This is the way to create a continuous system of communication.

From the point of formal view we identified four types of towers in Sardinian Coast:

1º Cylindrical shaped towers: There were towers that they could be inscribed in a cube of width equal to the height.

2º Cylindrical shaped towers: The tower is inscribed in a parallelepiped of double height than the diameter

3º Conical frustum shaped towers: The diameter of the minor base is approximately 1/3 of the height and the diameter of the major base is 2/3 of the height.

4º Cylindrical towers of conical frustum base: The height of the conic frustum is smaller than the height of the cylindrical side.



Fig. 3 – Sardines types (Copyright: Atzeni and Naldini)

The entrances to the towers were located 5 or 6 meters height. This elevated entrance avoided any possibility of accessing by pirate attack. All towers had a deposit and pipes to store and carry rain water. Towers had a room to store gunpowder and ammunition.

The high of the towers depended on the localization in the coast. The goal is to have the longest view possible. There are towers 4 meters height because they are built above a cliff three hundred meters height over the sea level. There are towers of eighteen point twenty five meters height and located over the sea level.

Design of the 3D models

For years we have approached the architectural heritage through the traditional drawings, based on data collection taken from sketches and point to point measurement. However, today we can rely on different systems as photogrammetric surveys (2D correction, 3D restitution), 3D laser scans, drones, photographs, spherical panoramic photographs, video, etc. We use every methodology depending on formal features, geographical locations and the dimensions and materials used.

The towers of Spain's eastern coast have a clear historical and architectural identity, but a comprehensive study of them is still pending. It is precisely with the study of the constructions themselves where we can make further progress in their knowledge, and the best way to more deeply comprehend their relevance is by drawing them. The overall objective of the present work is to provide a methodology for the graphic documentation of this architectural heritage, which addresses all the existent problems in the different constructions, so that we are able to generate the metadata and three-dimensional models of the watch and defense towers of the Valencian coast for their interpretation and effective worth.

For this study, we propose using the most advanced technical means available in the area of graphical representation, employing a flexible methodology as appropriate, trying to simplify processes and optimize resources while maintaining maximum reliability and quality of results. In addition, these same results can be adapted for use in the cultural field aimed at the general public.

Previous documentation

Prior to the first visit we have to gather all the information possible in order to capitalize our onsite visits. The basic pre-visit information needed is established in the following items:

- Location: town and access to the tower.

- Cartographic map of the area.
- Ownership: public or private. Permissions needed.
- In case of current occupation, contact managers; Tourist Office, dealership, ...
- Contact with local technicians: archaeologist, architect, engineer, ...
- Access to the interior of the tower. If it is possible to access to the interior we must determine if it is opened or we have to request its opening.

Photo and first sketches

We always bring a camera to our first visit to any of these towers and basic tools for first freehand notes, which will consist of the main measurements. For the realization of the photographs we must proceed very orderly, taking notes in a schematic sketch, numbering the pictures taken in the exterior, interior by floors, cover, etc, so that later on we find no difficulty in identification.

- Location:
 - On plain or mountain.
 - Exempt or within a urban área.
 - Visible or not around its entire perimeter.
- Form:
 - Polygonal.
 - Rounded.
- Flown elements. Shape.
- Dimensions:
 - Height.
 - Number of floors.
 - Number of rooms per floor.
- Stairway:
 - Size.
 - Shape.
- Cover; accessible or not.
- Has movable objects inside.
- Has annexed buildings.
- Presence of vegetation.
- Other features.

Topographic support

The topographic support is reduced for obtaining the coordinates (x, y, z) of the targets, need to locate a specific spatial position and be able to scale the model. The methodology carried out in elevation is based on the generation of a closed polygonal mesh around the tower, in which vertices we have located the basis of the topographic survey measurements. The method used in establishing this closed polygon will allow us to minimize possible measurement errors and to compensate where appropriate. For the interior, we establish an itinerary that attached to the outer polygon will constitute the support mesh.

3D Photogrammetry. Photomodeling

In recent years, photomodeling advances have been remarkable, mainly due to the development of new algorithms that have facilitated the production of three-dimensional models using the method called SfM (Structure from Motion). This method is based on the use of conventional images, made in principle with any camera, from any point of view, but keeping with the maxim that all parts of the model are visible at least from three different points of view.

When working with this type of software, the first thing that needs to be done is the alignment of the pictures that will be used to rebuild the model. The procedure is based on the use of each pixel of the image as a point, looking for homologous points in all the pictures and thereby the relative positions of each camera. The set of camera positions, along with the pictures themselves, are used for the next phase which is the construction of the model's geometry, ie, the construction of a 3D polygon mesh defining the model's surface. Finally, we can automatically create the photorealistic texture for the 3D model where to get the orthographic views (Fig.4).

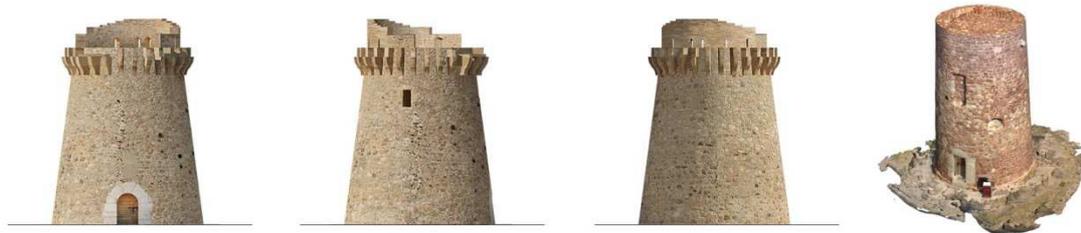


Fig. 4 – Elevation of the Piles Tower. Textured Model (Copyright: Roberto Atzeni, Valentina Naldini, Giorgio Verdiani and Pablo Rodríguez-Navarro)

UAV (Drone)

Using a drone for shooting the photographs solves the first two accessibility problems listed above. Aerial photographs allow us the freedom of movement needed to take pictures from every point of view. If we use the same camera for a terrestrial photographic sequence, we can proceed to do photomodeling without masking the sky (Fig.5).



Fig. 5 – Elevation of the Piles Tower. Textured Model (Copyright: Roberto Atzeni, Valentina Naldini, Giorgio Verdiani and Pablo Rodríguez-Navarro)

The combination of UAV and terrestrial photogrammetry is very easy; has we said, we use always the same photographic camera, and use the images from aerial and terrestrial, all together, for the SfM reconstruction.

Scanner 3D

For more complex structures, the use of 3D laser-scanning technology is necessary, solving the problem posed by photomodeling of interiors, whether for lighting reasons or for a question of space and complexity. Scanning is much more laborious, both for data acquisition and subsequent processing (registration of clouds, mesh, surfaces, textures, ...), but ensures correct data acquisition under any circumstances (Fig.6).

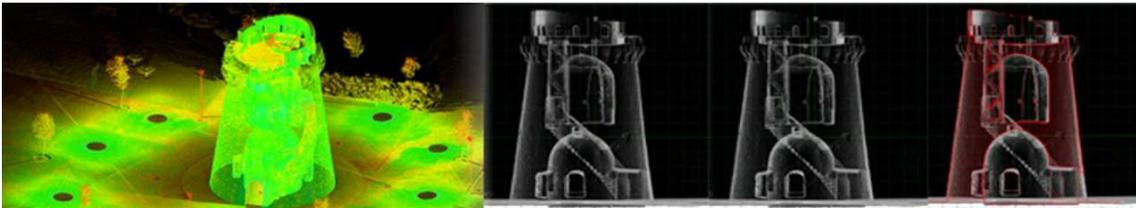


Fig. 6 – 3D laser-scanning. Piles tower. (Copyright: Giorgio Verdiani, Roberto Atzeni, Valentina Naldini and Pablo Rodriguez-Navarro)

Multimedia Catalog

The goal of the project is the creation of a multimedia catalog about the heritage of the defense of the coast. This knowledge will be shown as defensive element of the knowledge and tourism campaign of the Mediterranean coast (Fig. 7).

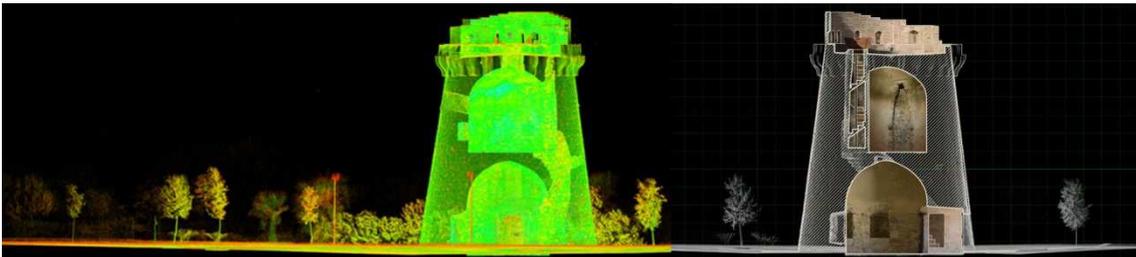


Fig. 7 – 3D laser-scanning and textured section. Piles tower. (Copyright: Giorgio Verdiani, Roberto Atzeni, Valentina Naldini and Pablo Rodriguez-Navarro)

Information contained in the catalog will be:

- Geographical area
- Historic context
- Written and graphic fonts
- Architectural measurements
- Constructive Analysis
- Typological analysis
- Conclusions

The dissemination of the information will be carried out through app program using mobile devices that they will access through wifi systems or Internet. This system will connect to the information about territory, the

history of the tower through interactive schemes. Multimedia information allows us to be aware about systems of towers, that there are along Mediterranean coast for defending against Barbary attacks.



Fig. 8 – Web information about Marenyet Tower. 3D interactive model. (Copyright: Pablo Rodríguez-Navarro)

The information will be hosted on web for easy access. 3D models are hosted in the Skechfab.com repository, while metadata are hosted directly in a web. Both, Skechfab as the web, can provide the link between 3D data and metadata, although the idea is that management will be carried out from an specific App.

Conclusions

Watchtowers located in Mediterranean coast are heritage with a high value because they are a historical document about the defensive system in Spain East coast and Sardinian coast in sixteenth and seventeenth century. The goal is to transmit this knowledge to people through advanced data collection techniques as photomodeling and scanner 3D.

In sixteenth century the Mediterranean coast was constantly attacked by Barbary pirates. Engineers proposed a watchtower system to control the coast and reject any pirate attack. Towers warned to nearest towns about some Barbary landings.

In Valencian coast, the towers were located in places where pirates could land and there were good view among them. Nevertheless, in Sardinian coast, towers were located to control the most quantity of length of the coast. In both cases, new military systems of artillery modified the design of them.

The goal is to extend the knowledge about this big and rich heritage. We propose to use an advanced data collection techniques using 3D technology. We have to carry out an accurate reconstruction of buildings to have a correct interpretation about every studied tower. All documents collected will be analyzed to have a correct valuation and explanation to people interested in this defensive system. These technologies allow us to explain people the defensive system along Mediterranean coast, from Valencian coast to Sardinian coast. We

will obtain an idea about tower systems with high historical and patrimonial interest that they cross over borders.

References

ATZENI, R., NALDINI, V. (2015) *Guardando il tempo da una torre sul mare*. unpublished. Tesi di Laurea, directed by Giorgio Verdiani and Pablo Rodríguez-Navarro. Firenze: Dipartimento di Architecture. Università degli studi Firenze.

BOIRA J.V. (2007) *Las torres del litoral valenciano*. Valencia: Consellería de Infraestructuras y transporte.

GARCÍA A., MARTÍNEZ-MEDINA, A. (2015) "La frontera marítima fortificada: de la vigilancia a la señalización (XVI-XIX)", in *Defensive Architecture of the Mediterranean. XV to XVIII Centuries*, vol. 1, p.p. 61-68. Valencia: Universitat Politècnica de València.

POBLET GONZÁLEZ, P. (2013). Torres vigía y defensa del litoral Valenciano (VII): De la torre del Cap d'Or a la torre bombardada. Published final degree, directed by Pablo Rodríguez-Navarro. Valencia: Universitat Politècnica de València.

RODRÍGUEZ-NAVARRO, P. (2012) "Automated Digital photogrammetry versus the systems based on active 3D sensors", in *Revista EGA*, nº20, p.p. 100-111. Valencia: Universitat Politècnica de València.

RODRÍGUEZ-NAVARRO, P., VERDIANI, G., GIL PIQUERAS, T. (2015) "Comprehensive methodology for Documenting the Defense Towers of the Valencian Coast (Spain)", in *Defensive Architecture of the Mediterranean. XV to XVIII Centuries*, vol. 1, p.p. 321-328. Valencia: Universitat Politècnica de València.

VERDIANI, G. (2011) *Il ritorno all'immagine. Nuove procedure image based per il cultural Heritage*, in Lulu.com.

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