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Integrated digital survey methodologies for the knowledge and enhancement of the ancient city walls. The "Curtain" of *Santa Chiara* in Cagliari (Italy)

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***Abstract* –The contribution shows some results of a multidisciplinary research in which architectural surveying and representation methods are supported by archival documents analysis.**
The procedure is applied in a limited area of the ancient walls of Cagliari (Sardinia, Italy).
The sector consists in the meet point between the sixteenth century bastion called "Curtain" of *Santa Chiara* realized in the period 1575-1578 by the military engineer Giorgio Paleari and the curtain of de Cardona commissioned by the Viceroy in the 30s of the same century.
The historical documents indicates the presence of medieval structures, vaulted chamber and passages designed and built during this period.
This source, supported by the knowledge of construction techniques indicated in the military treaties, allows a first graphic representation of the sixteenth century bastion, of which today we can only recognize a part of the vaulted gun chamber positioned along the curtain of de Cardona.

I. INTRODUCTION

The survey of the urban historical heritage represents the necessary preliminary step for the identification of the best intervention and planning strategies.

Once the acquisition and analysis of drawings and archival information is complete, the primary objective to be achieved is the organization of a digital database that allows to represent the complexity of the studied system.

In the case study, the analysis of archival documents integrated with an architectural survey of the existing parts of the military architecture allows the formulation of some hypothesis on the presence of medieval and modern city walls; with this aim the construction of a digital model becomes a useful tool for represent and understand the stratified urban landscape of *Castello* district in Cagliari, a sector characterized by the presence of civil, military and religious architecture built starting from the medieval era.

Following a line of research on Sardinian's fortification [1] recently integrated with geophysics surveys methods [2], the paper shows some hypothesis about the presence of vaulted passage and vaulted gun chamber (casamate) in the sixteenth century *Cortina di Santa Chiara* (fig.1)

II. THE "CURTAIN OF SANTA CHIARA" IN THE ARCHIVAL DOCUMENTS

Some interesting documents describe the study area and its transformation.

Starting from the sixteenth century, drawings, technical reports and permission provide useful information for the knowledge of the ancient city walls of Cagliari.

Among these, a view of the city published in 1550 (fig.2) by Sebastian Munster in the cartographic collection "*Cosmographia Universalis"*, the project for the modern fortifications of Cagliari realized by the military engineer as Rocco Capellino in the 1552, Giorgio Paleari in the 1573, 1575 and 1578, and the drawing of Giuseppe Viana in the eighteenth-century.

The first two documents (1552, 1573) show the existing city wall and its planned growth but don't offer detailed information on existing buildings and medieval defensive line, unlike the subsequent drawings.

The project for the *Cortina di Santa Chiara*, proposed by Giorgio Paleari in 1575 and approved by his brother Jacopo, is aimed at building a bastion that advances the existing defensive line for half its length as indicated in the drawing (fig.3). The design "involves the demolition of the 8 houses leaning against the medieval wall, although the same engineer advises against demolishing these buildings and suggests to bring out for half the length the existing defensive line to cross the artillery fire with the flank of the bastion of *Balice*" [3].

The indication "for half of the length" -that can be deduced through a graphical analysis of the drawing- is not confirmed after a comparison with the eighteenth-century drawing of Giuseppe Viana and an instrumental survey also shows an increase in length if compared to the initial project of Giorgio Paleari.

The drawing of the engineer, supported by a metric scale that adopt *palmi romani* and *trabucchi* [4], indicates the position of the houses to build between the new bastion and the tower of the Elephant; these buildings will have to be edified following the profile of the medieval walls that -placed on a solid rocky base- is separated from the "Curtain" of de Cardona by an embankment (made with *tierra y faxina*, as reported in the archival document).

The subsequent drawing of 1578 (fig.4) shows the final solution assigned to the bastion equipped with artillery fire and the vaulted gun chamber as represented by Giuseppe Viana in 1776 (fig.5).

The shape of the military architecture is also modified; the angle between the face and the flank of the bastion becomes from rectum to obtuse with the aim to allow the construction of vaulted structures and casemate.

Fig. 1. Aerial view (http://www.sardegnageoportale.it).

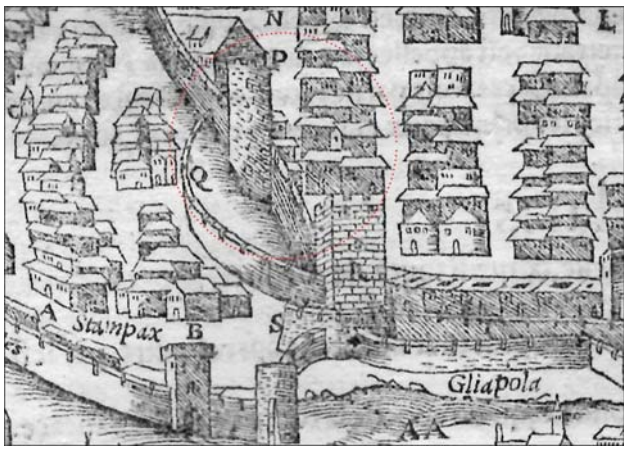

Fig. 2. The study sector represented in the 1550's map.

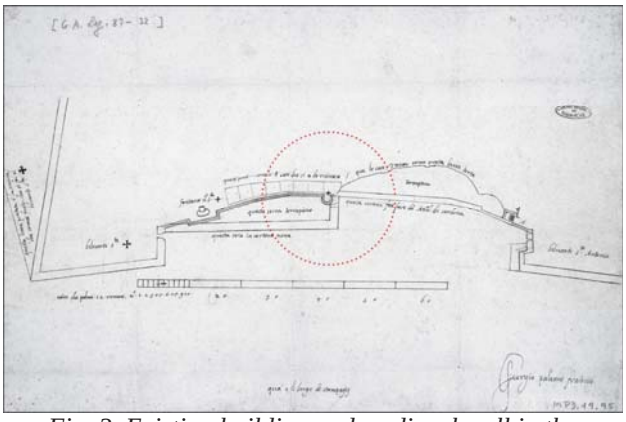

Fig. 3. Existing building and medieval wall in the drawing of 1575 (AGS, Archivo General de Simancas, Spain).

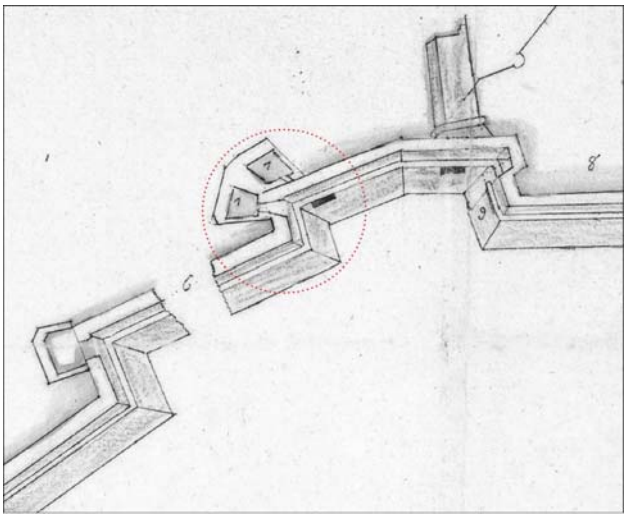

Fig. 4. Drawing by Giorgio Paleari that shows the gunboat built between 1575-1578 and indicated with the number 7 (AGS, Archivo General de Simancas, Spain).

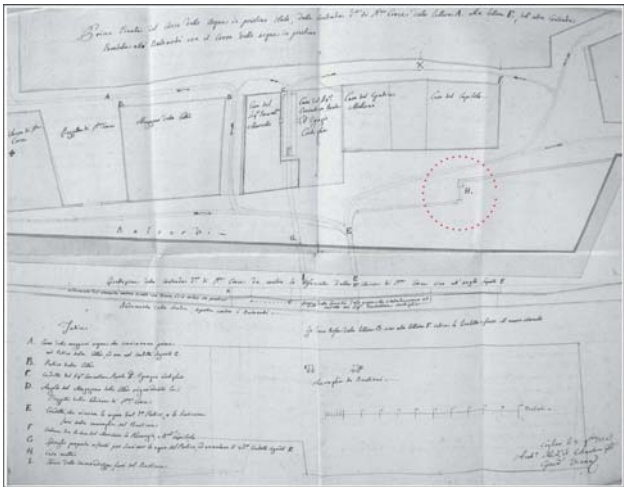

Fig. 5. Drawing by Giuseppe Viana that indicates the "Casa matta" (vaulted gun chamber) with the letter "H" (ASCa, Archivio di Stato di Cagliari).

The historical research also offers an interesting contribution as some documents dated 1537 that refer the use, by a Jewish merchant, of a tower -called *la Mordent*- located in the alley of *Santa Croce* or Orifany, nearby the tower of the Elephant. The merchant took possession of the building and obtained to be able to build in the adjacent area some structures as high as the tower, with the faculty of being able to build even above the walls.
Luys Sabater, instead built a staircase and other housing structures adorned with windows that overlooked the street of Orifany, close to the tower of *la Mordent* and the wallwalk [5].
The references clearly indicate that the tower represented in the 1575 is the one mentioned in the documents and one of the 8 houses that will be destroyed. These information -together with the knowledge of construction techniques (figg.6-9) and design models [6] adopted by military engineers- guides the identification of the elements of the bastion hidden below the street level as already happened in the strongholds of Alghero [7].

Fig. 6. Sixteenth century bastion in the Spanish stronghold of Alghero in Sardinia (photo by A.Pirinu).

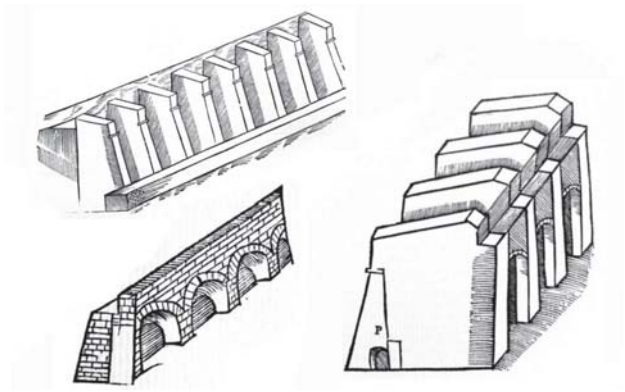

Fig. 7. Drawings from the sixteenth century military treaty of Girolamo Maggi and Jacopo Fusto Castriotto.

Fig. 8. External coating of the vaulted gun chamber in the bastion of Santa Croce in Cagliari (photo by A.Pirinu).

Fig. 9. Vaulted passage realized by Giorgio Paleari in the stronghold of Cagliari (photo by A.Pirinu).

III. DIGITAL SURVEY AND VIRTUAL RECONSTRUCTION OF THE MILITARY ARCHITECTURE

The aim to define a three-dimensional representation of the sixteenth century bastion it is been obtained through an integrated (photogrammetric and instrumental) survey.

The digital database become the “container” in which to transfer the information deduced from the analysis of the archival documents and measurement of the still existing parts of the fortification.

Therefore, gunboats, protected communication path, walls and towers documented, have been located in their most probable position.

Fig. 10. The meet point between the "Curtain" of Santa Chiara and the "Curtain" of de Cardona (photo by A.Pirinu).

The analysis of documents and the knowledge of historical construction techniques could lead to different options –in particular- about the location of the round tower. Two hypothesis are proposed in figg.11,12.
The first one is the result of the overlapping between archival documents and a urban survey in which the tower is placed far from the meet point between the "Curtain" of Santa Chiara ad the "Curtain" of de Cardona, the medieval houses are below the present block and the buttress of the "Curtain" of de Cardona would be below the current road level, suggesting an upcoming survey with geophysical methods.
The second hypothesis takes into account the modification made to the initial project and the conformation of the rocky slope represented in fig. 3.
In both solutions the path that leads to the vaulted gun chamber is initially parallel to the current road (called *via Santa Croce*) and then follows the shape of the new bastion. Starting from these hypothesis it is been elaborated a 3d digital representation (fig.14,15).
The outcomes obtained is not conclusive and the model - created to be implemented and modified by new acquisitions- during the research becomes the place in which visualizes hypotheses, makes choices on dimension, position and functionality of single part of the military architecture.
Therefore, the elaboration path of the digital model acquires the role of a tool for understanding the design motivations of every new element added.

Fig. 11. First hypothesis. The round tower is placed far from the meet point between the vaulted gun chamber and the buttresses of the "Curtain" of de Cardona are below the today's street level (drawing by A.Pirinu).

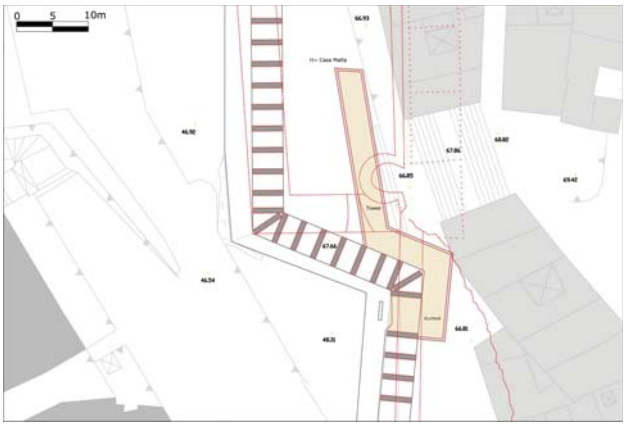

Fig. 12. Second hypothesis (drawing by A.Pirinu).

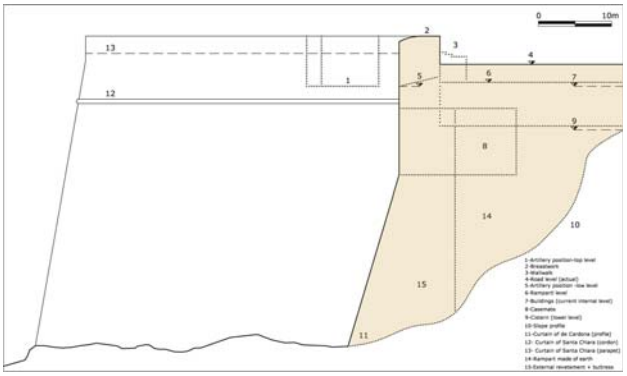

Fig. 13. Cross section that reconstructs the functional scheme of the sixteenth century bastion and suggest the application of different geophysical methods (drawing by A.Pirinu)

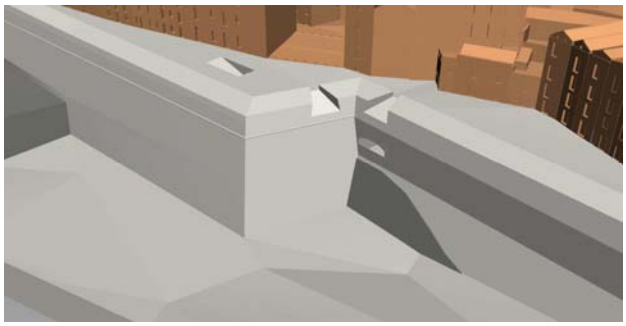

Fig. 14. Hypothesis with vaulted gun chamber and two embrasures that allow artillery to fire (graphic elaboration by M.Utzeri).

Fig. 15. Protected communication path that lead to the vaulted gun chamber and the other parts of the bastion as the banquet and the embrasures (graphic elaboration by M.Utzeri).

IV. RESULTS ACHIEVED AND FURTHER INVESTIGATION

The comparison between the archival documents, historical measurement units, construction technique and design models employed in the sixteenth century Spanish Mediterranean fortifications and a digital integrated survey of the "Curtain" of *Santa Chiara* allowed to define a first digital representation of a part of the west sector of walled city of Cagliari.

In particular, the analysis of documents and the knowledge of the sixteenth military architecture, could lead to different options; this will soon find confirmation or further elements of discussion within a broader research that welcomes the contribution of geophysical surveys methods.

The application of GPR (ground penetrating radar) and of seismic/refraction tomography methods -already been successfully applied in other sectors of the west defensive line of *Castello* district- guarantee an interesting contribution if correctly employed [8,9].

This further step can offer -without carrying out invasive interventions not allowed in a multi-layered site as the surveyed area- additional useful information related to the historical construction system and to the presence of vaulted passages once necessary to the military use of the bastion.

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