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VIRTUAL AND DIDACTIC APPROACH TO THE DEFENSIVE HERITAGE OF THE 16TH CENTURY FORT OF THE TRINITAT (ROSES, GIRONA)

APROXIMACIÓN VIRTUAL Y DIDÁCTICA AL PATRIMONIO DEFENSIVO DE LA FORTALEZA DEL SIGLO XVI DE LA TRINITAT (ROSAS, GIRONA)

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Highlights:

- The Fort of the Trinitat, built in the mid-16th century, is an extraordinary poliorcetic piece, conceived as an artillery machine, whose mission was to protect the natural port of Roses (Girona, Spain).
- Between 2019 and 2021, an ambitious reconstruction of virtual archaeology has been carried out, developing didactic iconography aimed at broad-spectrum visitors and formal education students.
- The didactic iconography proposal developed in the Fort of the Trinitat does not try to compete with the large market productions, but it does try to explore sustainable intervention models to make the past and its heritage known.

Abstract:

The Trinitat Fort, built in the mid-16th century, is an extraordinary example of European military architecture from the mid-16th century, conceived as an artillery machine, whose mission was to protect the natural port of Roses (Girona, Spain). The fortification had a long history of warfare that ended with the Peninsular War or Spanish War of independence (1808–1814), which turned it into ruins. In 2002, the Roses city council planned an ambitious architectural intervention to recover the fortification. The works restored the overall exterior volumetry, with current construction materials. The large interior spaces resulting from the intervention had little in common with the original structures. Starting in 2016, the museum projected to open the fort to the public. The strategy focused on 3D works, which were used to plan museographic proposals and to make an interior space understandable, with an aspect which was very distant from that of the original construction. It entailed extensive fieldwork, analyzing the sources and structural remains that were preserved and surmising the possible architectural solutions the fortress originally contained. Based on evidence and hypotheses, a reconstruction from virtual archaeology was carried out, together with the development of a didactic iconography to explain the artefact to a broad spectrum of visitors and students. This iconography was applied on the panels, in the scenography and audiovisuals of the museum, and in the dissemination materials. Museography was implemented between 2019 and 2021. Considering the variables and comprehension needs for a wide range of users and visitors, the authors completed the virtual archaeology proposal based on realistic criteria, giving importance in 3D to textures and colours. The proposal incorporated all anthropic and movable factors through matte painting techniques and images obtained with the support of re-enactment groups.

Keywords: virtual archaeology; poliorcetic; 3D matte painting; re-enactment; fortification

Resumen:

El Fuerte de la Trinitat, construido a mediados del siglo XVI, es un extraordinario ejemplo de arquitectura militar europea de mediados del siglo XVI, concebido como una máquina de artillería, y con la misión de proteger el puerto natural de Roses (Girona, España). La fortificación tuvo dilatado historial bélico que terminó durante la Guerra de la Independencia (1808-1814), convirtiéndose en un montón de ruinas. En 2002, el ayuntamiento de Roses planificó una ambiciosa intervención arquitectónica para recuperar la fortificación. Las obras restauraron la volumetría exterior en su conjunto, con materiales de construcción actuales. Los grandes espacios interiores resultantes de la intervención tenían poco en común con las estructuras originales. A partir de 2016, se inició el proyecto de museografía con el objetivo de abrir el fuerte al público. La estrategia se centró en la realización de un 3D, utilizado para planificar propuestas museográficas y hacer comprensible un espacio interior que presentaba un aspecto muy distante al de la construcción original. Se procedió a la realización de un laborioso trabajo de campo, analizando las fuentes y los restos estructurales que se conservaban, y aventurando las posibles soluciones arquitectónicas que en su día tuvo la fortaleza. A partir de las evidencias y las hipótesis se procedió a realizar una reconstrucción de arqueología virtual y se desarrolló una

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iconografía didáctica para explicar el fuerte a un público visitante de amplio espectro, y a estudiantes de enseñanza reglada. La museografía comenzó a implementarse entre los años 2019 y 2021. Teniendo en cuenta variables y necesidades comprensivas de los usuarios y visitantes la propuesta de arqueología virtual se planteó a partir de criterios realistas, basándose en el 3D, en las texturas y en los colores. El factor humano y mueble se incorpora a partir de técnicas *matte painting* con el apoyo de grupos de recreación histórica.

Palabras clave: arqueología virtual; poliorcética; ilustraciones 3D; patrimonio del conflict; fortificación

1. Introduction

1.1. A complex military history

Emperor Charles V intervened in many conflicts on a world scale, including the Mediterranean. The rise of Turkish power in North Africa, in factual alliance with the kingdom of France, sowed uncertainty and terror in the coastal areas linked to the Empire, especially in the territories of the Crown of Aragon. To ward off threats, Carlos V, and later Felipe II developed a broad poliorcetic proposal aimed at building a "maritime border", based on fortifications, to protect their territories (Burch, Palahí, 2019; Cámara, 2005; Aguiló, 2006). In Catalonia, it gave special importance to the natural port of Roses, which allowed large fleets to anchor (Fig. 1).

Figure 1: Aerial photo of Cap de Creus. The box indicates the natural port of Roses (Girona).

Luis Pizaño, engineer and general captain of artillery, planned, in 1543, the defence of the port enclave of Roses (de Sojo, 1927). He built a fort on a mound off the coast that had artillery options over the port. The place had a medieval observation tower known by the name of "The Holy Trinity". He provided the medieval town of Roses with a set of new and powerful walls (Tarrus, Martin, Nieto, 1989). Pizaño could not finish his projects, however, and it was Benedetto de Ravenna who continued the work of the Trinitat. The main body of the fort was finished in 1546. The engineer Gianbattista Calvi began the construction of the new walls of the town of Roses in 1552. Both fortifications (separated by 2500 m in a straight line) were part of the mission to safeguard the port using artillery. La Trinitat was a strictly military establishment of relatively small dimensions. It was not a large fortress; yet, Roses became a great stronghold of a civil and military nature (de la Fuente; 1992, 1994, 2002, 2005).

The fortification played a major role during the War of Separation (1640–1659) and in the border conflicts of the late 17th century (Baig, 1988; Ainaud, 1965). At the end of the 18th century, the revolutionary army of the French Republic bombed and partially ruined the fortification. During the Peninsular War, the French army besieged the Trinitat fort in December 1808 (Díaz, Pedler, Reay, 2008). The famous British naval captain Lord Thomas Cochrane. The enclave was heavily bombarded, and upon leaving the position, Cochrane blew up the fort, rendering it useless. During the withdrawal of the French, in 1814, new destructions were carried out (Díaz, 1991; Benito, 1926). The Trinitat fort was completely abandoned and became ruins until 2002, the work to remove rubble and partially restore its spaces began (Figs. 2 and 3).

Figure 2: Photograph from the beginning of the 20th century that shows the state of ruin of the fortification (Photo: Josep salvany – Fons Salvany, Biblioteca de Catalunya, 1912).

Figure 3: The fort. Interior (Photo Josep Salvany – Fons Salvany, Biblioteca de Catalunya, 1912).

1.2. An artillery platform

Luis Pizaño conceived the Trinitat fort with innovative criteria in order to optimize the use of the new pyroballistic technology. From the end of the 15th century, engineers struggled to develop fortifications that could withstand artillery and be used for defensive

purposes. On the Catalan border, other defences had been tried, such as the Salses castle, built by the Aragonese engineer Francisco Ramírez at the initiative of King Ferdinand II (Ferran el Catòlic) (Cobos, 2004, Hernàndez, 2021). They configured the Trinitat fort as an authentic machine designed to use the artillery of the moment.

The Trinitat fort was designed around an old medieval watchtower, on a secondary and free elevation of the Puig Rom Mountain, fortified since Visigoth times. The mound rose about 70 m from the shoreline. The fortification was adapted to the morphology of the relief, based on a four-pointed star shape, defined by four triangular bastions (de la Fuente, 1998). The fort had a large open-air platform facing the sea, which comfortably housed up to four culverins. Culverins were heavy pieces of bronze, among the largest at the time (Duffy, 1997). They fired spherical iron bullets that due to the elevated position of the Trinitat could reach the centre of the port located less than 2 km away.

They organized the defence of the walls with falconets (with a smaller calibre than culverins), and with portable weapons (arquebuses, muskets, and pistols). The dihedrals formed by the triangular bastions had open loopholes in the lower areas of the walls to be able to shoot with falconets and light weapons from the underground of the fortress against anyone who approached the base of the fortification. La Trinitat was an extraordinary and innovative fortification, but as the effectiveness of artillery grew in the following centuries, the fort became an obsolete artefact (Hughes, 1976).

The fort was architecturally merged between 2002 and 2010, following the project of the architects Miquel Capdevila Bassols and Neus Roca Cambra (Capdevila and Roca, 2013). The result was a work with a powerful personality and advanced design, which was not without harsh criticism. The volumetry and the exterior appearance were restored by the use of reinforced concrete; the interior was emptied and new internal walls were defined that configured large spaces (Figs. 4 and 5).

Between 2016 and 2021, the DIDPATRI research group faced the problem of proposing a functional museography inside and outside the complex. The intervention hypotheses and the decisions were difficult since musealisation could not have original pieces or documents, as they were nonexistent. The conditions of the additional spaces defined by the restoration did not allow the application of traditional museum solutions, either. It was understood that the only functional museum options were a combination of scenography, ambitious audiovisual proposals, and the use of didactic iconography. It was necessary to opt for a museography based on images that made the artefact understandable and this required a powerful development of virtual archaeology from a 3D reconstruction that could help to interpret the fortification and its circumstances (Hernàndez, Sospedra, 2018; Liarokapis, Voulodimos, Doulamis, Doulamis, 2020).

Figure 4:The fort after the reconstruction carried out between 2002 and 2010 (Arxiu Didpatri-UB).

Figure 5: The fort. Interior. Current state and details of the walls that show the presence of different levels, arches, etc.: a) First floor; b) basement -1 (Arxiu Didpatri-UB).

2. Methodology

2.1. General objectives

DIDPATRI had to develop a viable museum and museum project for the Trinitat. The task was complex since the interior spaces had little in common with the original structures, which were a veritable maze of rooms and narrow corridors. The possibilities of using photogrammetry or a scanner were of very limited interest. We discarded their use in favour of direct observation and the planimetry carried out during the restoration to produce a 3D image of the building. The documentary evidence on the fortification was limited to some general plans of the area, from the 17th and 18th centuries, with an imprecise approximation of its perimeter, and two more complete planimetries, one from 1717 and the other from 1792. The bibliography and previous historical–archaeological studies were also very limited (de la Fuente, 1998). The experiences of virtual archaeology on the poliorcetics of the XVI were scarce. Virtual proposals on defensive ensembles had been developed (López-Menchero, Maschner, Bart McLeod, du Vernay, Hervás Herrera, 2020;

Aparicio-Resco, García Álvarez-Busto, Muñiz-López, Fernández-Calderón, 2021), but they focused on the Middle Ages and were developed with the use of photogrammetry or a scanner.

The intervention was proposed, considering the empirical experience of the research group developed in other similar projects (Aparicio-Resco, 2021, Rahaman, Champion, 2019). The 3D reconstruction proposal had to contribute to identifying the key points and to developing a didactic iconography that could help to design various museographic proposals and didactic materials (panels, audiovisuals, guides, didactic dossiers, models, apps, etc.). The 3D image had to be in agreement with the concept of Virtual Archeology, developed in the London Charter of 2009, and in the Seville Principles of 2011 (ICOMOS 2017; López-Menchero, Grande, 2011; Aparicio-Resco, 2021). Our aim was to carry out a virtual reconstruction (based on existing evidence and studies) that would also serve as the basis for virtual recreations of different historical moments, incorporating material culture, environment, uses, and human presence. The reconstruction of virtual archaeology in 3D had to be versatile to meet various objectives:

1) Elaborate in 3D the situation of the fortification after the architectural intervention of 2002–2010, which would help understand the logic of the resulting spaces in relation to the historical spaces and enable the planning of the museum environments, the circulation of the public, complementary uses, etc. This 3D proposal had to start from the cartography of the architectural project available at the Roses Town Hall (Figure 6).

2) Elaborate a realistic and understandable 3D image of the interior and exterior spaces, based on rigorous and didactic fieldwork, of the Trinitat fort, as it was when its construction was completed (mid-16th century). The 3D reconstruction had to integrate the information from the structures and the polemoforms of the fortification. The little-known parts had to be hypothesized by applying logical solutions and parallel cases. The textures also needed to be realistic.

3) Use, in combination, various types of evidence in order to develop the virtual archaeology proposal. The construction of the proposal had to consider the plans and sections from 1717 and 1792 and all the information that could be deduced from direct observation of the preserved walls and structures.

4) Define a 3D proposal capable of various 2D developments, which could incorporate, functionally, movable and anthropic iconography in order to contextualize the different spaces, their appearance, and their uses. Develop a complementary iconographic program, based on matte painting and video techniques that could take advantage of the imagery generated by the 3D proposal as a background, to present specific moments and situations in the history of the complex (construction, equipment, combat, destruction, etc.), as well as the functions of the different spaces (logistics, combat chambers, kitchen, bedrooms, latrines, etc.).

5) Characterize 3D, and the iconography generated in its environment, as an instrument of communication and dissemination for the public, education, and productive environments (cultural industries, cultural tourism, etc.).

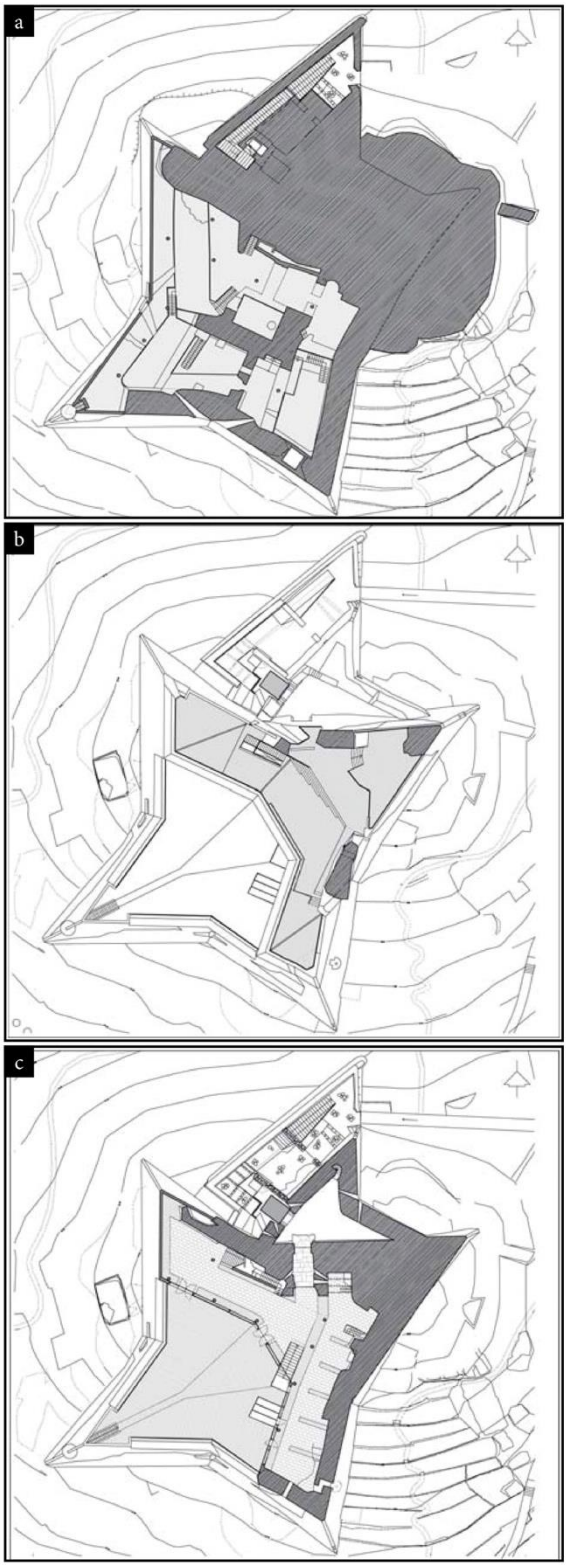

Figure 6: Planimetry of the restoration of the castle of La Trinitat (Roses). Project by Miquel Capdevila and Neus Roca (LAND Urbanisme and Projectes SLP. Execution of the work: 2002-2010: a) second platform or semi-basement floor; b) first platform; c) third platform.

2.2. Historical and archaeological information and virtual reconstruction

As much information as possible about the fortification was collected from primary and secondary sources. The localized cartography (in the General Archive of Simancas, in the *Institut Cartogràfic i Geològic de Catalunya*, and in the Biblioteque Nationale de Paris), was not very significant; vintage engravings and drawings only gave exterior and general views of the fortress on a much-reduced scale. The only useful cartographies, since they had section and plan representations, were made in France from 1714 to 1720 and in Spain from 1792. The French cartography showed the fortification in 1693 when it was conquered by the troops of Louis XIV (Hernando, 2000); the second plane, the Spanish one, was signed by Antonio López Sopeña (López, 1792), and probably executed with a view to the conflict with the French Republic. Both sources helped to interpret the spaces, but they were very imprecise and presented contradictions to each other (Figs. 7 and 8).

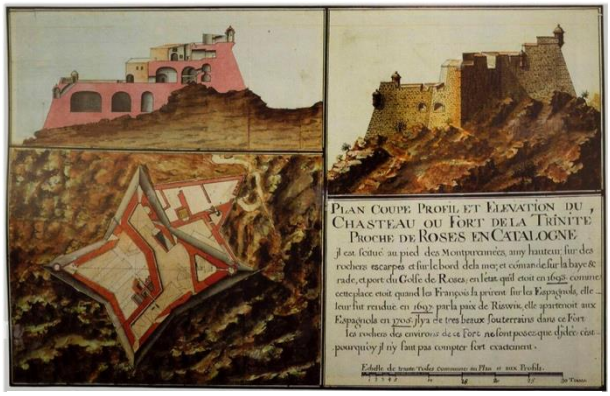

Figure 7: Map of Roses, elevation of Fortress Trinidad, 1714. In Claude Masse Atlas, compilation of maps made by the French intelligence services

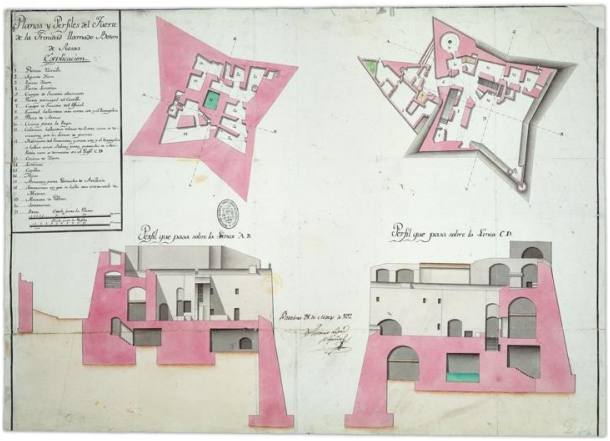

Figure 8: "Planos y perfiles del Fuerte de la Trinidad llamado Botón de Rosas", Antonio López Sopeña, 1792.

Archaeological information was scarce, and there were no plans. The work was not a systematic excavation, it only involved removing rubble from the sectors where it was necessary to intervene. However, the architects' plans were useful in raising the 3D planimetry of the monument in its current situation. This 3D development of the current building allowed us to understand the organization of a very complex space, which the architects had found destroyed and on which they had intervened without considering archaeological criteria. We used this 3D survey to develop simulations and presentations of the various museographic proposals (Flynn, 2007).

The most reliable source of documentation for making the 3D proposal was direct observation and fieldwork. The analysis of the existing remains, more or less fragmentary, involved a systematic display of options and hypothetical solutions to interpret the different spaces. The interior of the building, destroyed by the blasting, maintained many walls and structures that provided information. Everything was meticulously photographed and measured. The dividing walls, the openings corresponding to doors and embrasures, the remains of vaults and arches, the preserved stairs, the system of skylights to provide natural light to the interiors, the encasing of the beams that showed the existence of different levels, the layout of the latrines, and so forth, all created a puzzle that was slowly completed. In addition, when the planimetry and 3D proposals reflected the hypotheses, the problems and solutions were better outlined. The researchers of the DIDPATRI had some experience since, in 2002, they had musealized the walls of Dalt Vila (Eivissa), a work of the engineer Gianbattista Calvi (Hernàndez, 2005; Hernàndez, Rojo, 2012), and they had also collaborated in other projects such as that of the Renaissance walls of Ceuta and Melilla, the fortress of Sant Ferran de Figueres.

The lifting of the 3D base period was carried out in 2018 after this systematic fieldwork, and during 2019, improvements and corrections were carried out. Slowly, the virtual fortification came to life and was understood. As we have already shown, Pizaño conceived the fort as an artillery machine. Everything was designed based on the use of culverins, falconets, and arquebuses. Pizaño established the main floor connected to the access portal and the large shooting platform. This main floor was the heart of the fortress; it also housed the governor's residence, guard post, kitchen, and principal fireplace. Presumably, there was also a sleeping area for the gunners. The firing platform was directly connected to the governor's room and that of the troops. It had a curb to collect water from the cistern and a drain that collected rainwater from the main terrace and the upper terraces.

Two staircases began from the main floor. One accessed the two upper floors and the other the basements. The two upper floors created a shield for the fortification since the walls prevented others from firing on the main platform from the nearby slopes. They organized the upper floors from covered galleries and terraces built over the main platform. They had embrasures to locate light artillery (falconet type) or to shoot with arquebuses and protect the direct access points of the fortress. The subway had a labyrinthine structure as they adapted it to rock outcrops. There were rooms divided by wooden attics and freestanding rooms. It probably housed the tinderbox and warehouses in the deepest rooms. In the underground dihedrals of the triangular bastions, there were embrasures to beat the bases of the walls whether the enemy approached. There was also a large oven and, in a central position, the large cistern supplied with the rainwater collected from the upper terraces.

The central nucleus of the fortification, made up of the four triangular bastions, was protected by an annexed fortification, a type of powerfully fortified ravelin, which added three portals and which covered the path to the main entrance.

The criteria for governing the virtual reconstruction were adjusted to the transfer functions, and the most diverse experiences and options were considered (Brusaporci, 2010; Centofanti, Brusaporci, Lucchese, 2014; Carnevali, Cundari, 2010). The 3D project had to give a realistic image of the whole, and for this purpose, the textures and colours had to be clearly represented (Pujol, 2011). In these same years, these criteria were also applied to other virtual reconstructions of poliorcetic spaces from the 15th and 16th centuries (Cabezas, Montes, 2019; Barreau, Esnault, Foucher, Six, Le Faou, 2020). The 3D construction had to consider the exterior and interior views, suitably textured. The unknown areas had to be hypothesized from the parallel solutions and changed if the investigation provided more recent evidence. The 3D project had to generate the most diverse 2D points of view, on which we could superimpose anthropic or furniture elements, if necessary.

3. RESULTS

3.1. Sections and floors

We reconstructed sections and architectural plants from the accumulated information (Figs. 9 and 10). These sections were also considered with didactic criteria in case we decided on their use in museography, or in various transfer platforms (Fig. 11).

Regarding architectural plans, the options were complicated, since they did not build the fort from homogeneous floors. A multiplicity of floors and subfloors were adapted to the rock, with the added problem that many had wooden mezzanines and staircases. We represented the floors from a slightly oblique aerial view, and in some of them, showed some constructive characteristics such as the vaults. We designed 11 floors (Fig. 12) that allowed, from the highest to the lowest height (or vice versa) us to show the inner details of the building. This material enabled a whole series of possibilities and resources, especially for school visits: information, orientation, gamification, and location of spaces. It could also be used interchangeably and from a simple animation in apps, the internet, and audiovisuals.

Figure 9: Overhead view made with Autodesk 3D Studio Max 2020.
(JR. Casals/Arxiu Didpatri-UB)

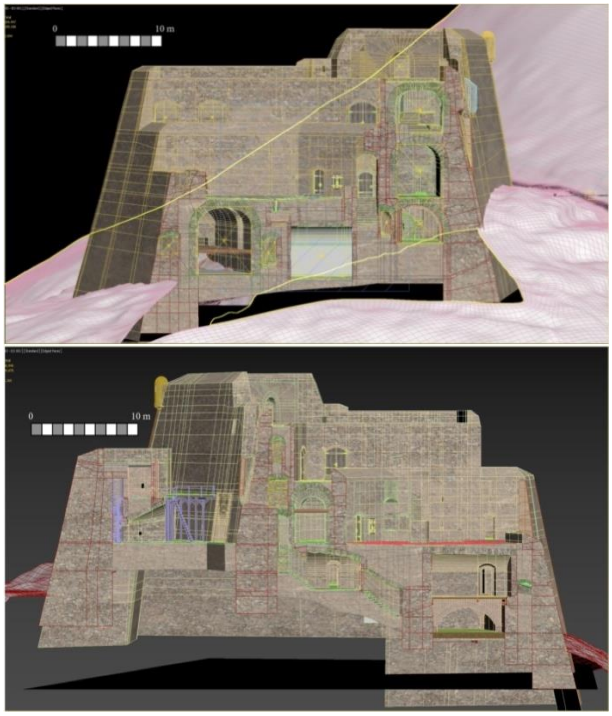

Figure 10: Sections of the fortification.
(JR. Casals/Arxiu Didpatri-UB)

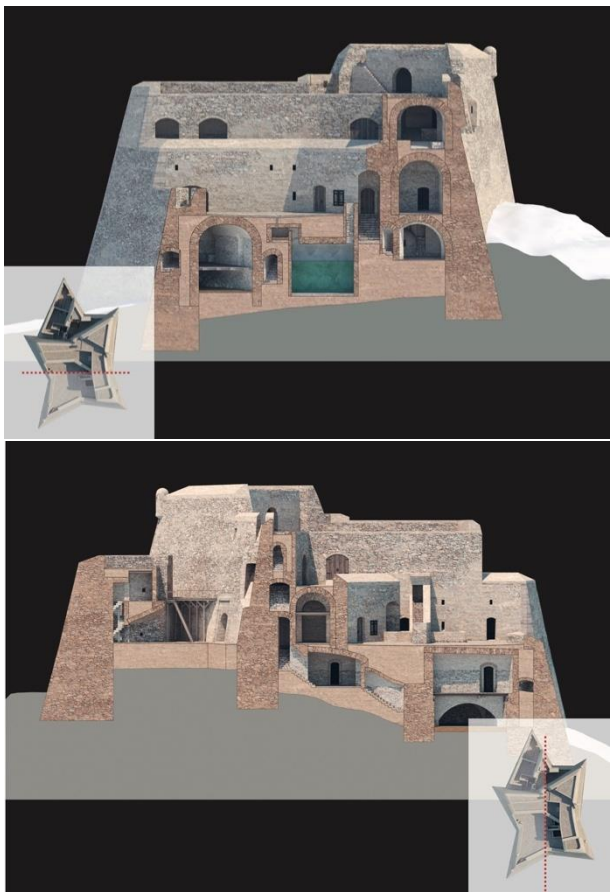

Figure 11: Sections of the fortification. Application of textures.
(JR. Casals/Arxiu Didpatri-UB)

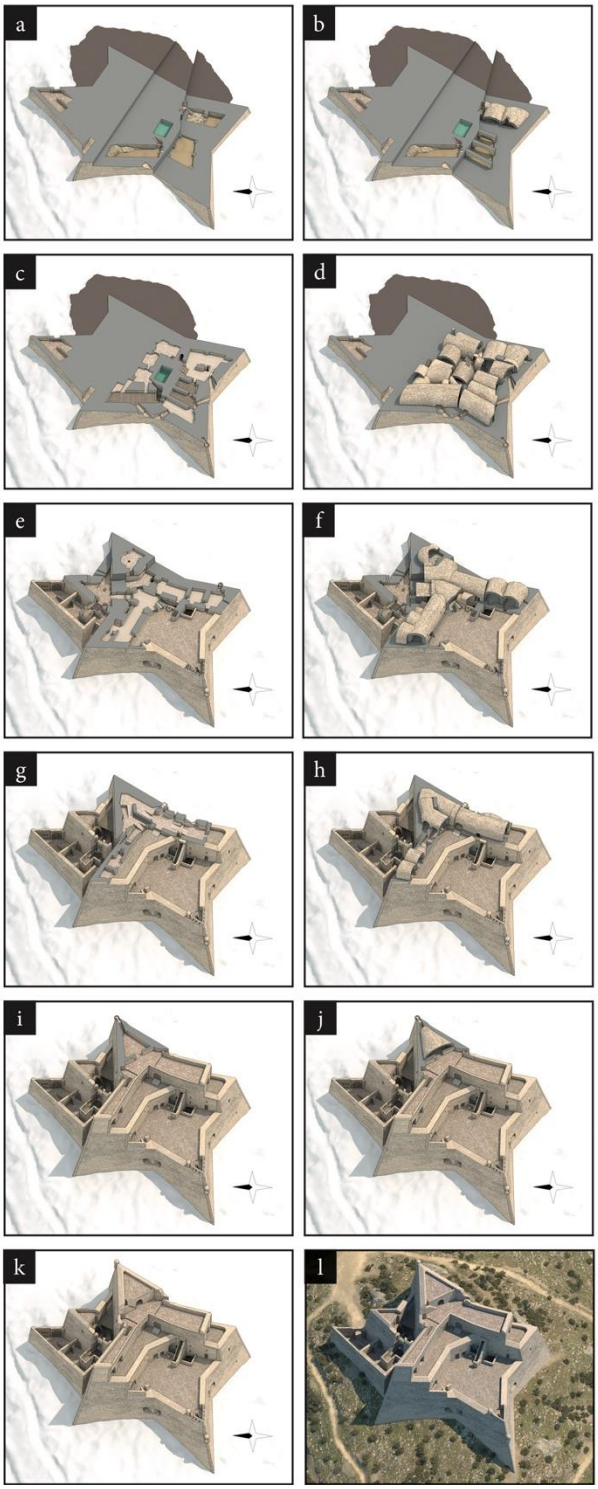

Figure 12: Volumetric reconstruction of the different floors of the fortification.
(JR. Casals/Arxiu Didpatri-UB)

3.2. Realization of the exterior 3D

The volumetry of the fortress was recreated from the outside. The process was complex, but the use of the logic of the original design of the 16th century engineers helped to restore it. To facilitate the understanding of the building, we used it as realistic criteria, and this implied working in-depth with all the textures and landscapes near the fort. The result showed the characteristics and functions of the fortress: the arrangement of the four bastions and the position of the ravelin, making access

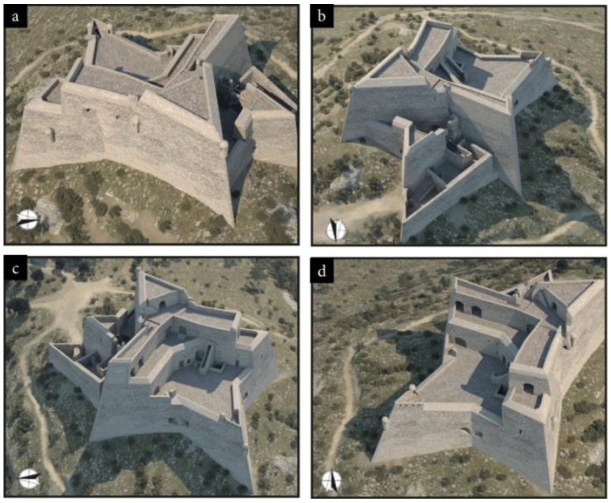

Figure 13: Volumetric reconstruction of the exterior of the fortification. Views: a) West-East; b) North-South; c) East-West; d) South-North. Reconstruction made with Autodesk 3D Studio Max 2020)
(JR. Casals/Arxiu Didpatri-UB)

Figure 14. Reconstruction of the landscape of the fortification. Views from the Bay of Roses: a) Southwest-Northeast direction view; b) West-East direction view; c) South-North direction view.
(JR. Casals/Arxiu Didpatri-UB)

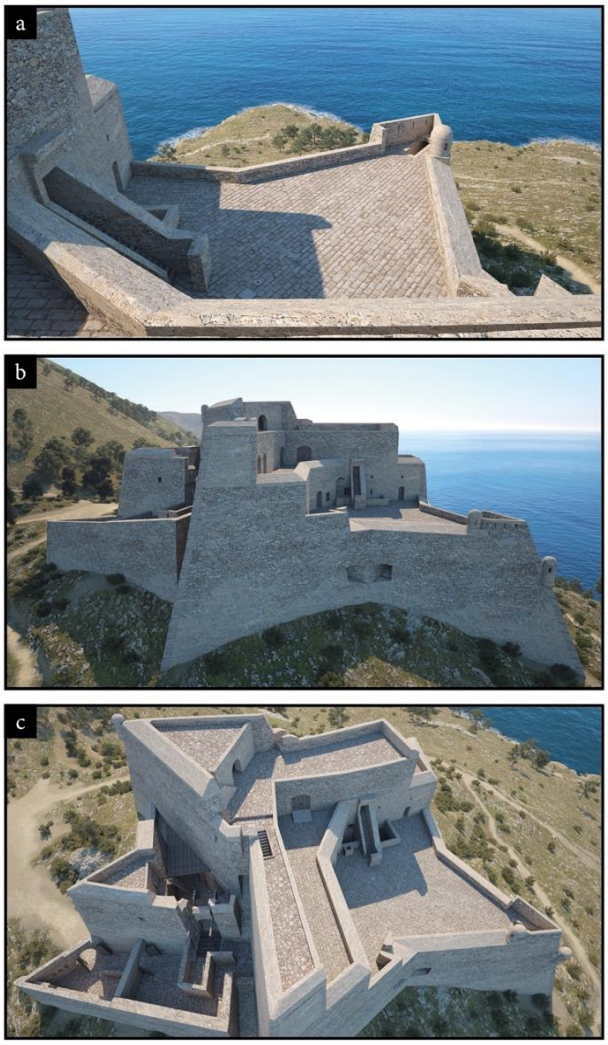

Figure 15: Reconstruction of the exterior of the fortification: a) Artillery platform; b) Artillery platform and embrasures for close defense; c) Views of the terraces and the protective ravelin at the entrance of the fort.
(JR. Casals/Arxiu Didpatri-UB)

to the entrance difficult. One of the most interesting aspects was the arrangement of the embrasures for firing with light artillery and arquebuses, an arrangement that denotes careful geometric planning, with various solutions, some of them with distinctly medieval tones. The work was performed in Autodesk 3ds Max 2020. The 3D virtual reconstruction allowed us a wide iconographic range to recognize and interpret the fortification from the most diverse points of view. The images could apply to various supports and functions and enabled the generation of oblique flights to facilitate the understanding of the morphology of the fortification (Figs. 13-15).

3.3. Realization of the interior 3D

We developed the interior in its entirety, in the same 3D model, as a global project to better understand the structure of the building and the thicknesses of the curtains, load-bearing walls, and vaults. The different rooms, doors, skylights and embrasures were carefully considered, recreated, or hypothesized. The work made it possible to propose interior, vertical, and horizontal routes, the operation of the underground artillery positions linked to the dihedrals, and the arrangement of the many wooden mezzanines supported by beams. The 3D project established the possibility of visiting the interior of the fortress from still images or animations, and it also generated options to develop apps and augmented reality from smartphones and tablets. As with the exteriors, the work was carried out in Autodesk 3ds Max, although in the final work approximations were tested by Blender v. 2.80 and Unreal v. 2.8.4 to study possible future applications of augmented reality AR/virtual reality (VR) (Fig. 16).

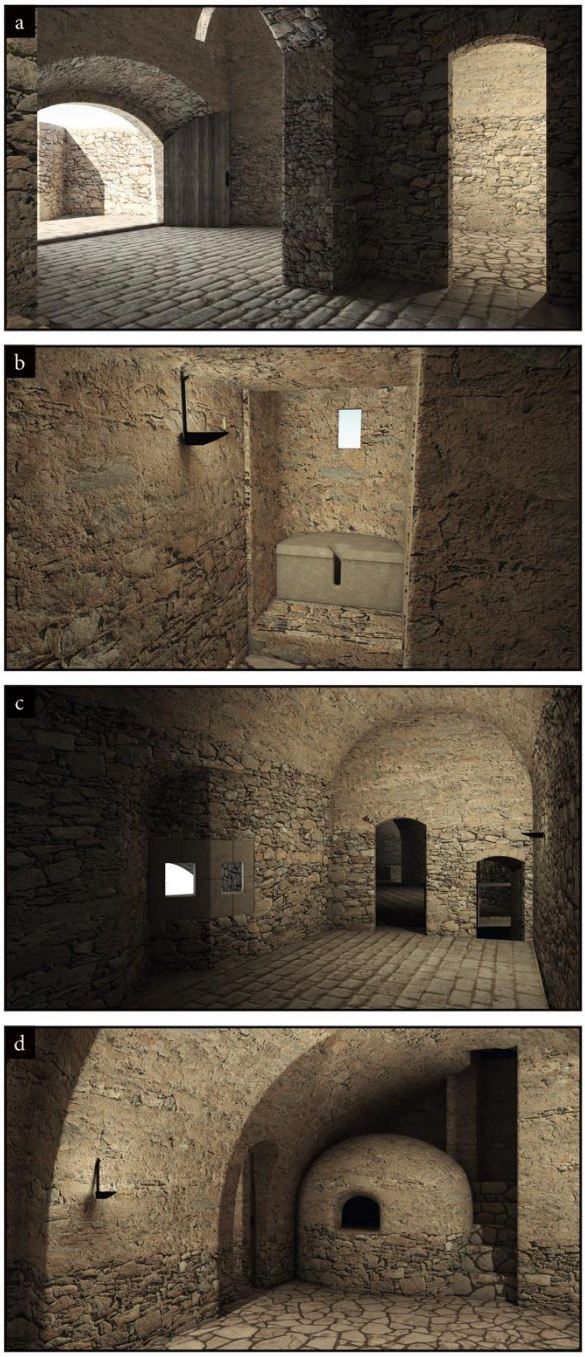

Figure 16: Reconstruction of the interior of the fortification. a) Accommodation of gunners; b) Governor's Latrine. c) Underground embrasures for light artillery. d) Bread oven, located in the basement.
(JR. Casals/Arxiu Didpatri-UB)

3.4. Developments of 3D proposals

The proposed 3D model had a strict architectural approach. The walls and floors had realistic patterns, but they did not include movable or human elements. These variables, essential to establish an understanding of the different spaces, were dealt with in two ways, static and kinetic. In the static, the movable and anthropic elements from the use of matte painting were placed on a certain vision of the building. It was not possible to incorporate a human figure modelled in 3D from software such as Blender or Daz 3d, but the dominant criterion in DIDPATRI (UB) was to add re-enactment images retouched with matte painting, which were more truthful and easier to produce. The development of contextualized didactic iconography implied the production of many plates or scenes, some of which were mounted on 2D backgrounds selected from 3D. The iconography stood out for its realistic effect, which integrated spaces, humans and furniture, and for its versatility in that someone could interchangeably use the plates in various museum options. The second strategy used, of a kinetic nature, consisted of historical recreation, recording characters on a green screen and superimposing them on the relevant 2D backgrounds.

Figure 17: Illustration process with matte painting technique using backgrounds generated from the generation of 3D views: a)Image generated from 3D; b) Making off; c) Chosen image of the making off; d) Final composition (made with: Autodesk 3D Studio Max 2020/Adobe Premiere Pro 2020/ Adobe Photoshop 2020) (JR. Casals/Arxiu Didpatri-UB).

The most important value of these images, fixed or kinetic, was their summative didactic character, where they could include all the elements of interest that were necessary to explain a situation: furniture, characters, dresses, pets, lighting, food, etc., as long as it was justified and harmonious.

We can summarize the didactic iconography proposal developed as an interaction between various techniques to represent a certain space. Three-dimensional modelling was used to create spaces, and the spaces were typified and contextualized from matte painting or video, using images generated by historical recreation groups (Figs. 17 and 18).

Figure 18: Illustration process with matte painting technique using backgrounds generated from the generation of 3D views: a) Image generated from 3D; b-c) Making off; d) Final composition (JR. Casals/Arxiu Didpatri-UB).

4. DISCUSSION

The didactic iconography works (illustration) carried out in the Fort Trinitat were part of a museum proposal, as subsidiaries. They served a very specific aim: to make understandable a fortification that was destroyed, and that was later rebuilt with current materials and non-historicist criteria. In this sense, the iconographic proposal faced the double difficulty of understanding the destroyed remains and the reconstructed remains. The iconographic reconstruction was conceived, in this context, as a bridge that would allow mediation in the

face of a fragmentary reality. All the iconographic works had to be didactic. We inscribed the basic proposal within the parameters of so-called “Virtual Archeology” (Forte, 1997) and “Digital Archeology” (Evans and Daly, 2006, McManamon, 2014), and within the concepts of "virtual reconstruction" and "virtual recreation" defined in the Seville Principles.

The 3D reconstruction option was clear and necessary, as it could facilitate the understanding of the ruins propped up with concrete structures and generate elements of museum application. The 3D reconstruction fulfilled the first premise. It required slow rigorous work to fit the various remains and preserve evidence, and hypothesize about the disappeared. It was necessary to put the 3D result on the correct platforms so that people could access the information and contrast current remains with their hypothetical appearance (Georgopoulos, 2014; Hermon and Kalisperis, 2011). From there, we moved to museographic options that could show the proposal, and here 3D demonstrated its versatility, since animation plays a leading role on screens, the web and apps. Further, from still images, it fulfilled its role in panels, publications, gamifications, and didactic materials (Parry, 2013; Geroimenko, 2021). In addition, it showed its effectiveness as a background on which anthropic elements could be sensed, placed, or even attempted virtual reality.

Including anthropic elements and furniture in the representation of a certain space or place is essential to contextualize its uses. Ultimately, an anthropic space cannot be understood apart from considering its uses and relationship with the human element. From a museum's perspective, any iconographic approach to an archaeological or historical space requires the representation of humans and their artefacts. These presences, from the didactic point of view, must be concrete and realistic. They can be raised from 3D modelling, but it is a complex solution. It is likely that, in the future, the development of programs such as Metahumans (Epic Games) will allow for easy inclusion of the human figure in didactic iconography. However, at the time of writing this paper, including quality human models requires high professional specialization, time, and dedication. The costs are high and the developments uneven. In museum environments with discrete resources, it is much faster, cheaper, and easier to include the human factor from matte painting and photographic or kinetic documentation from re-enactment. Using re-enactors to obtain still or animated images recreate credible images of the past (Hernández-Cardona; Feliu; Sospedra-Roca; González; Wilson, 2019).

5. CONCLUSIONS

Didactic iconography (comprehensive illustration) creates an excellent museum resource. It is especially useful in heritage spaces with limited possibilities for museography due to the absence of objects and documents. In these cases, iconographic options help to build a story about the place or the events to be explained (storytelling). In recent decades, digital iconography, in archaeology and history environments, has reached high levels of development linked mainly to the rise of gamification proposals, films, and television series (de Groot, 2016; Elsaesser, 2019; von Lünen; Lewis; Litherland; Cullum; 2019). However, the software that crafts these products is complex and requires large investments to develop competitive products with a large impact on the market. Broad sectors of the public understand this high technological development as normal, and they underestimate the more limited digital products, those produced in the surroundings of museums and heritage centres.

The didactic iconography proposal developed in the Trinitat fort does not compete with the large market productions, but it tries to explore sustainable intervention models to make the past and its heritage known. It is sustainable because once it has carried out the pertinent historical archaeological investigations, the transfer processes can develop in a reasonable time. Sustainability is also justified by the use of affordable and less complex software. Finally, sustainability is also sought by using the resources of re-enactment, maintained by volunteers and with low-cost profiles, to obtain realistic, reliable, and credible static or kinetic images that are historically rigorous. The viability and sustainability will also be endorsed because we can update the digital didactic iconography to incorporate research novelties, and reapply it in different media: panels, apps, the internet, videos, games, etc. In summary, what it is sought to generate an understandable product, at a reasonable cost, of aesthetic and educational quality that can be applied in different environments and that is evolutionary and modifiable.

With the Trinitat fort, we attempted to develop this "doctrine" and it was successful. We implemented 3D from Autodesk 3ds Max, and we introduced hyperrealistic textures. From 3D, we developed various 2D images. In parallel, we generated a bank of photographs and video thanks to the use of re-enactment groups. Story sheets were implemented from 2D generated from 3D and incorporating anthropic elements and furniture from matte painting and re-enactment resources and, likewise, audiovisuals were produced from animations 3D and the recording, in chroma, of groups of re-enactors. The set, generated mainly by the initial 3D, made it possible to have a set of resources that helped to promote and explain the heritage element in the most diverse supports and contexts. In this sense, we can consider the experience as an interesting model to systematize to intervene in the promotion of the most diverse spaces of historical-archaeological interest. The new museography of the Trinitat fort, structured by virtual archaeology, was implemented as of 2019, and obtained notable public success despite the limitations imposed by COVID-19.

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