PROJECT ÉVORA 3D: RESEARCH, METHODOLOGY, RECONSTRUCTION AND VISUALIZATION

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INTRODUCTION

The Évora 3D project was born from the collaboration between the Municipality and the University of Évora, through the two research centres of CIDEHUS[1] and CHAIA[2], with the objective of completing a virtual reconstruction of the city in a long-time frame. In the national and international context, the use of new technologies has led to the diversification of this type of proposal, both at the urban level and in the reconstruction of concrete spaces. The application of this same model to Évora, contemplating several chronological layers, seems to impose itself in a city that, in the medieval and modern periods, was one of the most important of the kingdom, as Court city, and that today is classified as World Heritage Site.

Évora's Municipality began this pioneering work with the proposal of the 3D model of the Islamic city (Yábura), finished in 2015 and that led to an archaeological exhibition (Figs. 1, 2, 3, 5). It is intended to continue the project, in a broader collaboration and in a broader chronological perspective. At the moment, the proposal explores the reconstruction of the medieval period, considering two chronological layers (14th

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and 15th century). The work methodology, which will be repeated for the other chronological periods, starts from a database, defined by the working group, and focused on the definition, characterization and location of properties (built and not built). For this purpose, a systematic survey of primary sources is carried out in Évora, which will later be complemented by the insertion of data related to the archaeological survey.

The project underlies the fundamental idea of a more in-depth knowledge of the city in the different time frames, implying a systematization of numerous studies already carried out, a methodical survey of primary sources and archaeological data, coupled with a spatial interpretation of the city itself. A double strand shapes it, as it was mentioned: the urban evolution and the socio-economic dynamics, connecting the people to the spaces. In this sense, and in the broader view of the project's design, the complementarity of resources and the combination of scientific and technical knowledge of the Municipality and the University, through its two centres, CIDEHUS and CHAIA, largely grounds the pursuit of the proposed objectives.

Fig. 1. Exhibition space of the Islamic city (Yábura), 2015

Fig. 2. Video of the reconstructed Islamic city in the main exhibition area

Fig. 3. Screenshot of the reconstructed environment of the Islamic city

RESEARCH METHODOLOGY: HOW CAN MEDIEVAL DOCUMENTS HELP URBAN 3D DIGITAL RECONSTRUCTION?

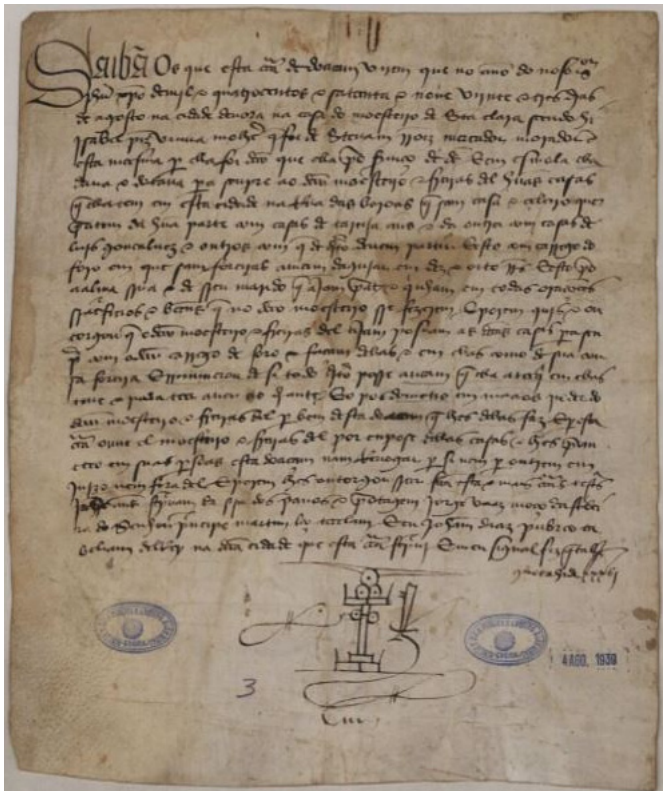

Fig. 4. Scan of one of the archival documents

Fig. 5. Screenshot of one of the houses of the Islamic period

For the medieval period, archival documents (Fig. 4) constitute the comprehensive basis of the research methodology intended to complement and broaden the archaeological and other data from the urban space. A systematic research was carried out in the archives of Évora, in the National Archive (Arquivo Nacional da Torre do Tombo, Lisbon) and in the collections of published primary sources. The elements were then inserted in a database outlined by the team of this project. The property and its owners/ /tenants were the focal point of the analysis. In this sense, a wide documentary typology was used, privileging notary documentation related to patrimony — rental contracts, deeds of property partition, sentences involving real estate disputes, donations — but also including wills and different records from the municipal and royal administration.

A sole contract (Fig. 6) provides a typology of the property (e.g. house, cellar, oil/ /wine press, stable, backyard…), its location and its confrontations, allowing the identification of several other assets that can be cross-checked with further documents and spatial references. It also provides the names and sometimes the social status or labour occupation of its owners, tenants and even neighbours.

Example 1

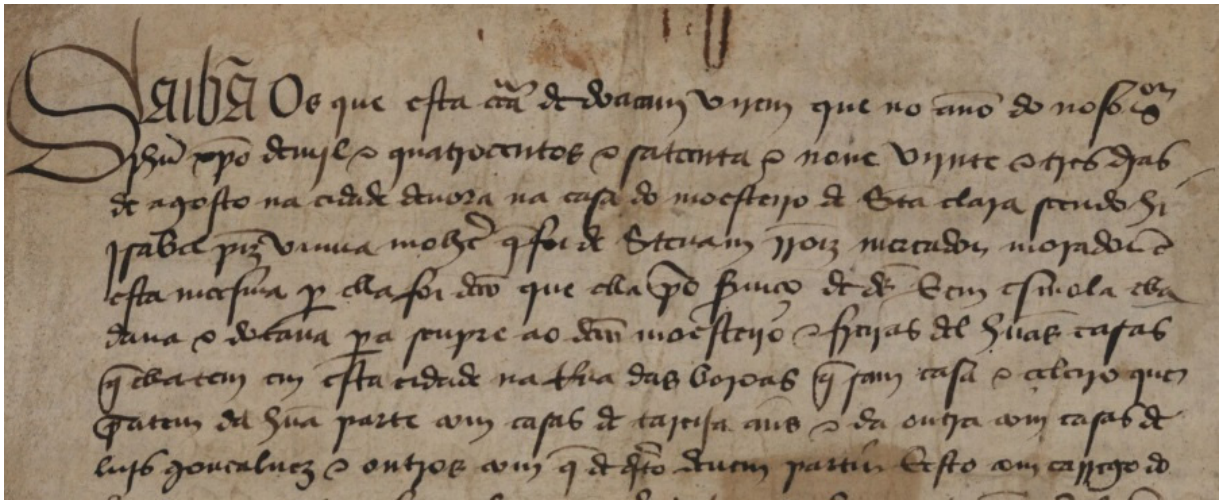

Fig. 6. Scan of a part of a sole contract that provides a typology of the property

Évora, 1479-08-23 — Biblioteca Pública de Évora, *Pergaminhos Avulsos*, pasta 14, doc. 79
Line 4: «Isabel Peres, widow from the merchant Stevam Rodrigues […]»
Lines 6-8: «houses/that she has in this city, in the Street of Boroas, which are house and barn that/are limited, from one side, with houses from Tareija Anes and, from the other, with houses of Luis Gonçalvez […]»

These elements were individualized into two major database sections: Document (identification, date, typology and abstract) and Property (typology, location — see

Example 2 [Tab. 1], dimensions, description — see Example 3 [Tab. 2] —, owner and tenant, with the reference of the respective social status or/and labour occupation — see Example 4 [Tab. 3]). In this relational database, the ID (primary key) of each property is linked to a pre-defined thesaurus related to zones, materials and architectonic elements to identify, as accurately as possible, the space and to enable a texture mapping of the virtual world (see below «Editability of architectonic elements»).

Example 2

Tipo estrutura	Localização
Casas	Rua de João Airas, à Porta do Moinho de Vento
Bens de raiz	Rua de João Airas, à Porta do Moinho de Vento
Bens de raiz	Rua de João Airas, à Porta do Moinho de Vento
Azinhaga	Rua de João Airas, à Porta do Moinho de Vento
Pardieiros	Bairro de São Mamede
Casas	Bairro de São Mamede

Example 3

Tipo estrutura	Localização	Dimensões	Descrição
Casas	Rua da Freiria	A casa dianteira mede 7 varas e terça de longo e 4 varas em ancho, tendo as mesmas medidas a casa de cima; o celeiro mede 5 varas e meia de longo e 4 varas escassas em ancho, tendo as mesmas medidas por cima	Casas derrubadas, na Rua da Freiria, foreiras ao Cabido, que partem de uma parte com casas de morada de Constança de Vila Lobos, da outra com quintal de Pêro Jusarte, por trás com casas do dito Pêro Jusarte. A casa dianteira deverá ter sido sobradada, pois tem uma escada de tijolo e uma chaminé redonda; o celeiro tem uma janela pequena para trás, sobre as casas que vão de trás

Example 4

Enfiteuta	Estatuto/Profissão
Judas Ruivo	Alfaiate, judeu
Isaac Braguel	Judeu
n/a	n/a
Gonçalo Vasques e Maria Afonso, sua mulher	Mercador
Gonçalo Afonso e Maria Martins, sua mulher	Hortelão
Diogo Gonçalves e Margarida Mendes, sua mulher	Escudeiro
João de Vilares e Margarida Lourenço, sua mulher	Almocreve
João Fernandes Ravasco e Leonor Eanes, sua mulher	Azeiteiro
Pedro Anes e Joana Martins, sua mulher	
n/a	Trombeta
n/a	n/a
Rodrigo Eanes	n/a
	Vendeiro

The primary written sources and the related database are therefore instrumental components to analyse the urban evolution and the socio-economic dynamics, connecting people to spaces. Digital models represent *memoryscapes*, since «it is not the disappeared cities which are recreated, but the memories retained from them through the available documentation and their present interpretations»[3]. So, the aim to recreate the memories of the urban fabric of Évora, minimizing the degree of hypothesis, goes side by side with the relation with the human element. It's intended, for example, to define and visualize the artisanal and/or commercial areas, the popular streets *vs*. the ones of the elite, the aristocratic zones and the minor quarter of the main landlords' patrimony (king, bishop, churches, monasteries, military orders, council, confraternities)[4]. Furthermore, the different stages of this 3D project, even for the Middle Ages, provide the evolution of both the urban space and the socio-economic dynamics.

Nonetheless there are limits and difficulties that require selection criteria. The city is an organic element — it grows and suffers constant transformation. Non-built spaces are transformed into buildings, the functionality of structures often changes, the itinerary of the streets is altered and new ones gradually take shape — among many other possible modifications. And all that can occur within a short period. To recreate a 3D urban environment is not only to crystallize the memories of a chosen moment but also to select sources within a credible, informed, critical, and logical framework that must be visible and understandable for his «readers». In short, historical methodology is as valid for this multidisciplinary approach as for in any other study of a strictly historical subject.

[3] MURTEIRA *et al.,* 2017: 79.

[4] These data will broaden and complement general studies previously published about the medieval city, namely BEIRANTE, 1995 and CARVALHO, 2004; CARVALHO, 2007.

DIGITAL RECONSTRUCTION

In terms of the approach to the modelling part of the project, the different time frames lead to different strategies, also dependable on the amount of knowledge available regarding a specific urban space or time frame.

As such, what defined the Islamic city of Évora is not what is considering, in its micro scale, when modelling its Roman counterpart, let alone its medieval layers. For these last ones, the attempt was to minimize the degree of hypothesis, accepted in its majority for the centuries that preceded it. However, the overall research enabled the imperative of the fixed points, or historical focal points (Fig. 7) in the urban space, such as the medieval walls or the structure of the Roman Temple. Like all virtual reconstructions, the tools to provide an accurate (as best as possible) model need to confront archaeological information, document data and establish a series of comparative analyses, to enable a visual correspondence to other known sites.

Fig. 7. Historical focal point

A new workflow includes the reconstruction of the city in a modular manner such as that the first imprints of the building will be modelled with traditional 3D tools, however different architectonic elements will also be modelled separately so that they can be used and swapped when more research is made.

Despite the aim being the full-scale reconstruction, to provide the sense of the sequential growth and adaptation of the urban space of Évora throughout time, the specific areas in which the knowledge can provide a greater detail to the model, the team decided to enhance certain areas, not only for visual concerns, but also in a pedagogical form.

It was always understood that there will be «blank areas», in which the information possessed is close to none. When in that, the applied imagination requires a solid basis

for proposal of an urban setting, without removing the hypothesis from the context in which it lies (Fig. 8).

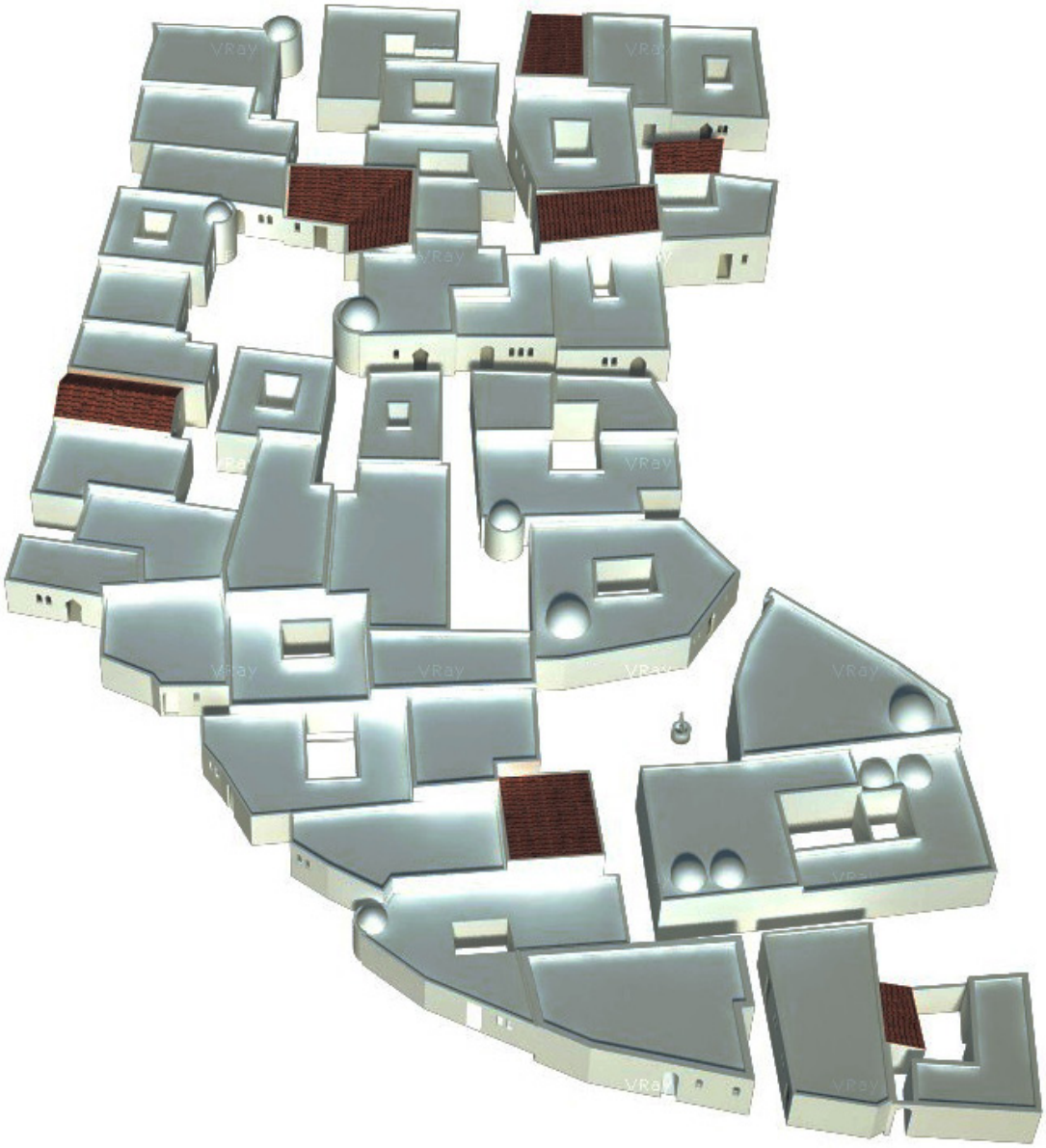

Fig. 8. Screenshot of the modular approach for modelling the houses

Apart from the raw modelling parts, the project also involves a solid texture mapping of the virtual world, gathering the information available about old techniques, not only in terms of roofing and stucco, but also in the fields of limestone pigmentation, types of wood used, and especially the survey regarding mural paintings, particularly important when considering the time frames from the 15th century onwards.

As such, it is particularly interesting to understand that despite the attempt to connect all the different models, within their specific time frames, it is also mutable the visual aspect of its own representation.

The final model of the Islamic city is rather different than the one of the Roman city (Fig. 9), and the first attempts to model the medieval city also lead to different decisions in terms of visual tools.

The amount of software required to achieve the desired effect that can also lead peacefully to the divulgation strategies, compiles an all-around project, in terms of the modelling phase. To counterbalance the «blank spaces» and the decision to allow space for some creativity and imagination, one of the team's strategies is to adopt the Archaeological and Historical Evidence Scale, developed by César Figueiredo and Pablo Aparicio Resco (Fig. 10), in which a colour scale is attributed to the totality of the model, to show the degree of knowledge about each specific area. This can be considered a visual response to the guidelines proposed in the London Charter[5] and the Seville Principles[6].

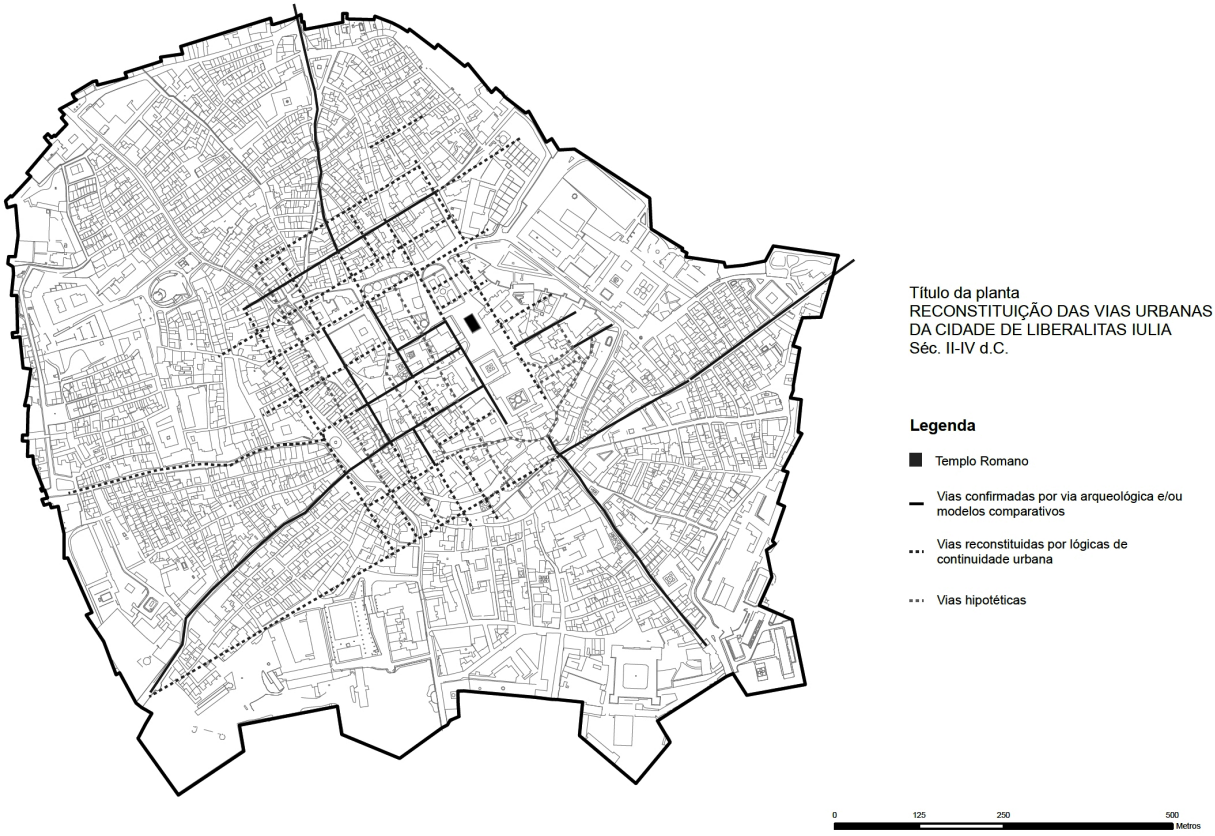

Fig. 9. Map of the difference in the layout between the Medieval and the Roman city

[5] *Londoncharter for the Computer-Based Visualization of Cultural Heritage*, 2014.
[6] *Principle of Seville*, 2011.

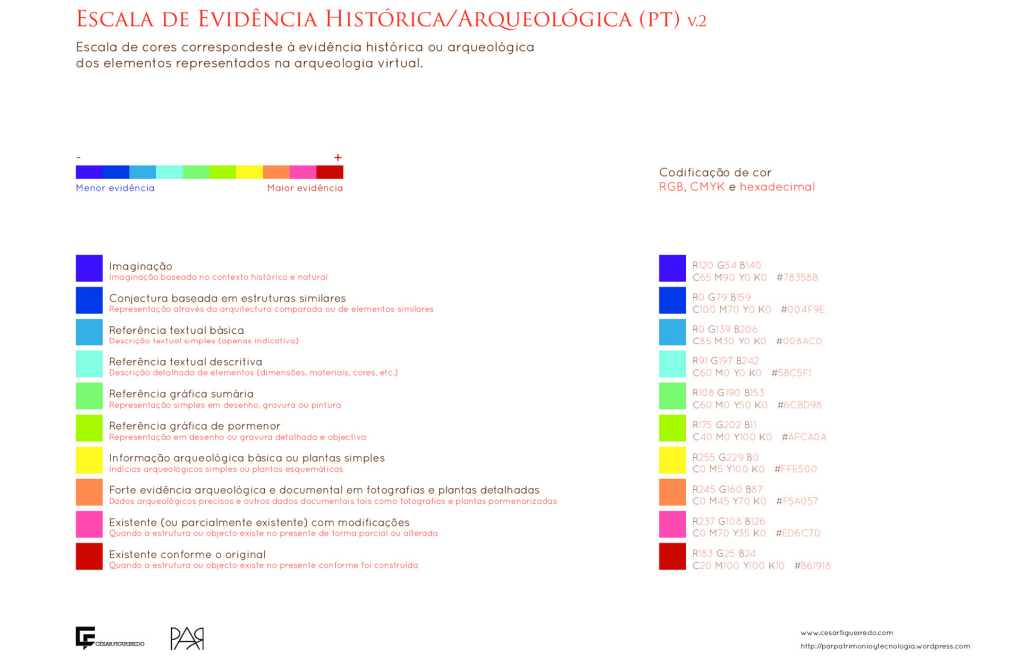

Fig. 10. Archaeological and historical evidence scale

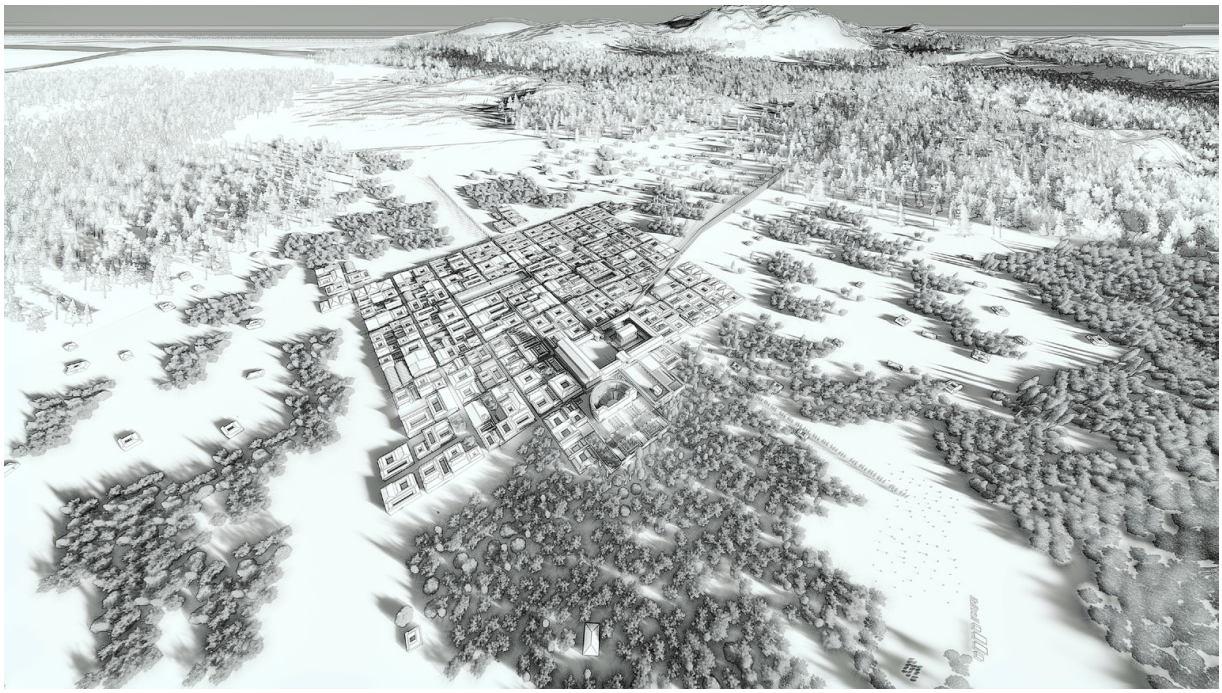

Fig. 11. Screenshot of the recreated Roman city

VISUALIZATION & DIVULGATION

In the last decade, the production of 3D visualizations in heritage for public dissemination has grown exponentially. The rises and the evolution of many different tools, for the documentation, the creation and the publication of this type of contents, has helped the production stage of many projects that otherwise would remain entangled in a more academic environment. This has certainly brought a positive public response in the educational field of cultural digital heritage. For example, more appreciation by a younger audience due to the use of a familiar visual language found also in commercial videogames[7] (Fig. 11). However, 3D visualization and VR environments in Cultural Heritage have also brought some issues such as the use of excessive spectacularization pointed out by Daverio[8]. When dealing with cultural heritage virtual environments a distinction must be made: although virtual archaeology is certainly an important tool for scientific research, when translated into CGI and real-time applications for the public, it needs to be addressed not only with scientific methods but also with new specific visual languages[9]. On the other end, to sustain the final product for a long period of time the constructed model must also be sustainable. By rendering only a single virtual tour or even several, this remains difficult, expensive, unsustainable and most of all can only show one perspective, the one of the person that composed the shots sequence. In most

[7] MALONE & LEPPER, 1987 *apud* ANDERSON *et al.*, 2010: 255-275.
[8] DAVERIO, 2013: 14.
[9] SCHIAVOTTIELLO *et al.*, 2016.

of the cases this factor accentuates the emotional effects if done properly, like in a film or first-person modern videogame sequence. However, it does not leave too much space for public interpretation, updatable contents and scientific debate.

In this research, we aim to overcome this problem by proposing a new methodology for the final publication of the cultural virtual space. We aim to achieve this by proposing a method that makes use of modern 3D interactive techniques found in commercial videogames but adapted to specific needs for virtual heritage environments.

Project Évora 3D has been chosen as a case study for the experimentation of this new type of workflow that will be implemented once the full 3D reconstruction of the medieval city is completed.

As a container of the final hybrid model we will use a virtual interactive environment, built with traditional videogames engines such as Unity 3D. However, at this stage, an extra layer will be added on top of the final application. This layer can only be accessed by special users such as museum curators, historian and academic content creators. These types of users cannot modify the basic underline structure of the city, such as for example the position of the houses and their dimension, however they will be able to access many other editing capabilities. The platform will explore the implementation of different basic features, such as the possibility of tuning the natural environment by changing the weather, the time of the day and the background sound. However most of the work is concentred in developing three major features that will permit the inheritance of updatability and sustainability of the virtual environment. These are: rapid historical contents creation, editable architectonic elements, and virtual tours to propose an emotional experience as well as scientifically valid.

Historic content creation for the public

VR environments are mere doomsday like environment without its corresponding historic contents, at the best we can say that are tools of wander[10]. To appreciate their value and to gain some knowledge about the topic that they propose, the final user must be able to query all the existing elements that are present within the historical 3D reconstruction. We recognize, of course, that attaching information to each single element is a difficult task when dealing with project deadlines and uncertainties. Therefore, we think that leaving this task to the experts such as historians, archaeologists, museum curators and the academic editors rather than the designers is probably the best possible solution. This is very difficult to achieve when the creation tools are specifically designed for a technical user. With our added new layer on top of the final application the non-specialist user will be able to insert contents directly attached to a certain visual element. This can show up in three different manners: as textual descriptions at

[10] FARAGO, 2017.

the bottom of the main application's window, as an audio overlay and finally by using a virtual character that can describe the chosen element and count its history when the public interacts with him/her. The choice of these three different forms will be left to the content creator and not the designer of the application.

Editability of architectonic elements

This feature will be implemented with a textual interface that will permit to swap the architectonic elements and their intrinsic features (such as colours and textures) by choosing them from a pre-built-up thesaurus. This pre-compiled dictionary, which will be specific to this project, is linked to an XML-schema that describes the architectonic elements themselves. The choice of an element will be pursued directly within the textual description by tagging words, the file will be saved in a XML format that the 3D application will be able to read and show instantaneously.

For example, we can say: «The house had a rooftop». The word house can be tagged with the element description that characterizes a house with a rooftop. Or we can also say, for example: «The house had a terrace top». This time around the word house will be tagged with an element description that characterizes the house with a terrace top (Fig. 12).

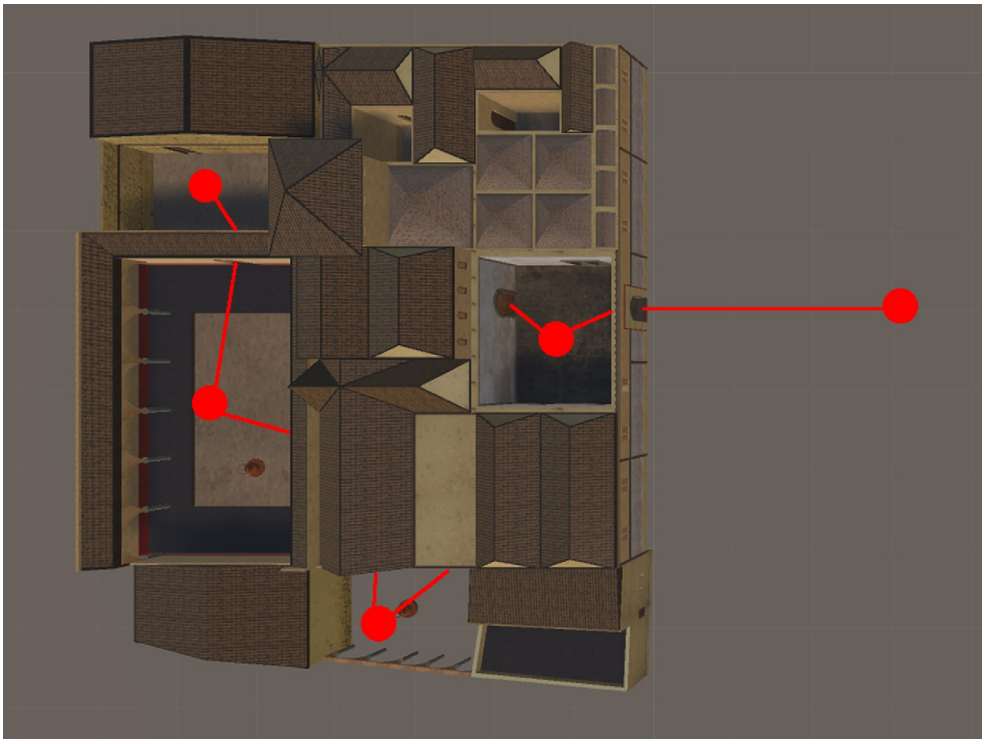

Fig. 12. Screenshot of tours creation tool

This process can be repeated for many other features of the house such as colour and texture and therefore for the whole model of the city. This is easily done by maintaining

a unique identifier number for all the elements introduced when importing the first hybrid model and for all the hidden elements that need to be swapped if necessary. The number of existing swappable elements is decided by the constructors of the city and can be incremented whenever more research is added to the project, thus giving the possibility of maintaining an open and infinitely updatable solution.

Virtual tours

Although virtual non-playable interactive environments have been extensively used for the communication of cultural heritage contents, they can deviate from their purpose if not accurately planned[11]. For example, young audiences usually seek a quest or a game when presented with a game-like environment; they don't know why but they just play[12]. Moreover, full interactive environments are not always the key for all types of audience: there are people that want to experience a virtual exhibition without having to decide what to explore. In this case we added the option of creating virtual tours (Fig. 13). These tours can be totally guided, where contents are presented in a linear fashion such as when viewing a movie, but with the added possibility to look around similar to a VR rendered application; or partially interactive, where the contents are presented with a certain linearity but the audience can also choose where to go from the last visited point within the city. The user can also decide if visiting or not some related suggestion given at the end of each short story description previously presented. Of course, the tours can and must be created by the same content creators that introduce historic information. At the end, we hope to create a strong binomial bound between the content creators and the final audience in such a way that the final application will result in a scientifically open collaborative platform for the content creators and an emotional and attractive experience for the final user.

[11] Arqueología Virtual, 2011.
[12] GOUVEIA, 2010: 11.

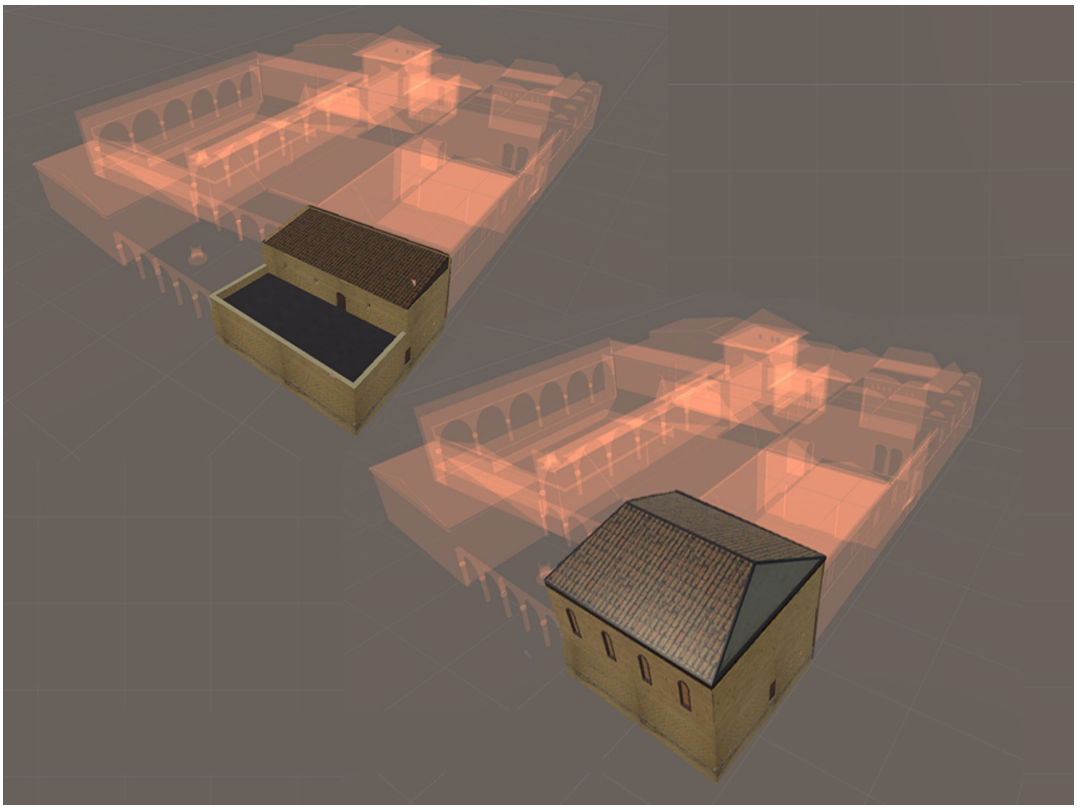

Fig. 13. Screenshot of the module swapping building tool

Lastly, we must remember that 3D real-time applications as well as rendered scenes can also result in a non-sustainable solution. Therefore, we aim to introduce the concept of persistency, where the created virtual environment will always exist online. This will give the opportunity to access this space at any given point of production and execution. Here the editors will have the possibility of updating the contents at any time while the public will experience the changing and the enhancements almost instantaneously.

CONCLUSIONS

The project Évora 3D has explored the possibility of recreating a city in various historic periods. In this occasion, after the completion of the Islamic town in 2015 and the Roman one yet to be published, we have presented an innovative solution to rebuild the Medieval period. However, this time around, in order to understand the complexity of the building's layout, it was necessary to recover ancient documents that describe the memory of the place and the time frame. We tackle different issues that are present when using virtual environments for the reconstruction of ancient cityscapes. In this specific case, we have argued that it is possible to recreate an historic place by using ancient documents as a primary source of our interpretation. The virtual reconstruction, although it is the central element for the final interpretation, will not be the objective of our study but rather the means to understand the first impression of a possible layout. Our model

will remain open and throughout a new type of collaborative 3D platform will propose a new way of composing and updating 3D elements, historic contents and virtual tours. By doing so, we aim to propose a new method of presenting to the public an historic virtual reconstruction which is open, scientifically valid and always accessible.

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