

Developing and Maintaining of the Long-term 3D Visualization Projects Caričin Grad – Justiniana Prima

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For more than two decades software for multimedia allows experts of various fields to dive into re-creation of the disappeared historical places and various monuments of the past. The quality of work has been in all times thoroughly scrutinized by the audience, especially by the scientific community which is righteously sensitive about everything regarding approach to the work, elaboration according to the scientifically data at disposal and finally result from which an proper perception of the monument depends. In that way there is no hiding place for the expert(s) whose knowledge and skills are exposed in 3D Restitution of the architecture, either as an individual edifice or as an urban agglomeration. The question of acceptable quantity of “intelligent assumption” and percentage of “hypothetical ideas” will remain omnipresent, meaning that it could not be generalized by numbers but rather reconsidered from project to project, from one monument to another.

The experiences gathered in five successive projects conceptualized as 3D architectural studies for the late-antique city of Caričin Grad –Justiniana Prima in Serbia and achieved from 2002 to 2018 within the Institute of Archaeology in Belgrade, have embodied several premises that could serve well or at least contribute as a guidance in further development of digitization of ancient architecture as a hybrid archaeological and architectural discipline. These premises varies from case to case, depending of the researching concepts, if work on 3D re-creation follows the archaeological investigations or not, or if the project of 3D visualization is conceived as a tentative study of different possibilities based on so far achieved data or as an attempt in comparative architectural analyses, etc.

As summarized 3D Architectural study, the project for Caričin Grad demonstrates a changing methodology in approach which has evolved in the last fifteen years, following new archaeological findings and progress achieved through interdisciplinary researches.

Key words:

History of Architecture, 3D visualisation, Digital reconstruction (Archaeology), Heritage.

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CONCEIVING OF THE PROJECT OF THE CAPITAL 3D ARCHITECTURAL STUDY OF CARIČIN GRAD ARCHAEOLOGICAL SITE

The term digitization usually refers to two main engagements: works on the rendition of monuments can refer to the creation of a digital image of the existing structure or as incomparably more complex efforts to reach a scientifically valid perception of a monument that no longer exists or is severely damaged. The recording of existing structures is a more technical procedure which primarily documents the state of the monument while the creation of a study in three dimensions tries to reconstruct the emergence of non-existing structures in the digital media. The complexity of three-dimensional studies is reflected in the necessity of mastering both the architectural knowledge and the history of the site and the archaeological research of the monuments as a whole.

Such interdisciplinary knowledge indicates further the need for cooperation between several experts or at least those from two key disciplines: archaeology and architecture. Also the production of serious studies can be accessed on the basis of the published material, but in this case the author must not only master the architectural knowledge

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acquired during schooling but also a special corpus in the field of architecture and construction technology, which is a precondition that also fills a smaller number of experts. Therefore, it is not surprising a long-run odium that less successful projects of 3D restitution of archaeological sites caused among the academic community in the first decade of application of 3D software in promotional projects of the heritage. At the beginning of the 21st century there appeared several projects with some successful works that are often accomplished within the archaeological teams gathered around individual sites, but these projects still do not contribute to the correct perception of the monument they promote, mostly due to the complete omission of architectural studies. The rapidly and often quite incompetent interpretation of architecture creates a counter effect that negatively affects the perception of the monument in public, and calls into question the seriousness of the work of the overall scientific team.

Early phase of the Project – shaping of the working methodology

The first scientifically well-established project of 3D Architectural study in Serbia was the re-creation of the Acropolis at Caričin Grad in 2002 (Fig. 1), initiated and conveyed within the Archaeological Institute in Belgrade¹. The project was aimed to creating a detailed 3D Architectural study of the walls of the Acropolis of Caričin Grad – Justiniana Prima and all the buildings that once made the “Episkopeion” (Episcopal palace and Cathedral basilica with Baptisterium).within them. The selection of the site and the theme was made in light of the fact that the archaeological site Caričin Grad had at that time disposal of the best survey and planimetric documentation as well as a collection of scientific documentation of several generations of researchers.

From the very beginning, the basic premise in the approaching methodology was carefully scrutinizing of the already existing documentation, primarily architectural planimetry realized by earlier research architects for all fully explored buildings on Caričin Grad.

In this sense, the work on the Acropolis of Caričin Grad with the fully investigated palace and church complex of the Archbishopry of Justiniana Prima (Fig. 2), imposed itself as a clearly defined structural entity, suitable for thoroughly learning and dealing with the architecture of the epoch and the creation of a detailed 3D studies, elaborating them in old 3ds R4 for DOS (1994, Version 4) and Autodesk 3ds Max (Discreet 3dsmax 5). As the archaeological site Caričin Grad was explored with minor interruptions for almost a century (the centennial was marked in 2012), in this significant period of time some portions of the city within the ramparts have been completely researched, like the Acropolis itself – Episkopeion, the zones around the imperial square, the block with the principia, the residential quarter in the Lower Town and the eastern street of the Lower Town with two important churches. Such a degree of research that enabled almost complete ambient perception of certain zones in the urban core of the city, contributed to the conducting of a series of 3D restitution projects that thematically emerged from each other only to fit into the final 3D architectural study of the city.

The character of Caričin Grad as one-layer site and its great significance for historical disciplines, archaeology and history of architecture, from the first project of the Acropolis 2002, indicated the necessity to process the appearance of almost every building in this late-antique city in a thoroughly studied manner, according to all the principles of architectural practices from initial analysis of proportions and design geometry, through the study of the primary structure and volume to the final materialization of the building.

In this process, as well as during the preparation of the planimetric 2D studies, during building of 3D reconstruction, the most effort was invested into elaboration of the monumental sacral architecture along its characteristic cross sections so that the interior of these buildings, as well as their constructive frame, could be convincingly demonstrated.

¹ Project for the Acropolis 2002 was based on an archaeological documentation presented in Duval and Popović [1984a]



Fig. 1. Project chronology plan for Caričin Grad – Justiniana prima 3D Architectural Study, achieved in 2001-2018: **2002/3** Caričin Grad – Acropolis Project (main subject Episcopium of Justiniana Prima); **2004/5** Caričin Grad Study of the fortification works (overall fortification with aqueduct line); **2006/7** Caričin Grad – Architectura Justinianica, Public Edifices (four churches intra muros, principia and the public bath extra muros); **2007/9** Caričin Grad Urban equipment and researched structures (all streets with porticoes, researched settlement in Lower Town and individual buildings); **2012** Caričin Grad – Justiniana Prima Scientific film (landscape and scenery assembling with overall texturizing); **2017** Caričin Grad – Northern slope settlement (complete Architectural Study of the newly researched settlement with horreum and public building); **2018** Caričin Grad – New Skylines: two churches extra muros, outer defense line with river dam and castellum on St Elijah hill. (Drawing V. Zdravković 2018)



Fig. 2. Caričin Grad Acropolis Project. Volumetric 3D Rendition (left) and fully materialized 3D reconstruction (right) of the Episcopseion (Episcopal palace and Cathedral basilica with Baptisterium). (V. Zdravković, M. Urošević, 2002)



Fig. 3. Caričin Grad Acropolis Project – Elevations of the Cathedral basilica with volumetric and accomplished perspective rendition of the Acropolis from west. (V. Zdravković, M. Urošević, 2002)

In each project adopted working premises were conveyed, which proved to be unavoidable in the process of finding scientifically correct solutions for buildings of different purposes but which shared common architectural pattern of the epoch in which they were created. Guidelines for maintaining the working process during making of the architectural study are:

- Preparation of planimetric and 2D studies according to the architectural principles and on the basis of archaeological research,
- Producing of volumetric 3D documentation,
- Creation of a complete 3D architectural study according to the principles of architectural practice, and
- Complete materialization of 3D reconstruction.

Resulting 3D Caričin Grad database

In this way, the most objective scientific documentation is realized, based on the argued analyses of the constructive structure and materialization of the building by the participation of several competent experts. This process of reviewing the correctness of the perception of architecture lasts throughout the entire working process:

- Preparation of planimetric and 2D architectural studies involves the development of complete architectural project documentation, elevations and display of details of the building that has being studied before building the 3D reconstruction of its appearance. In this step, the greatest number of problems related to the proportionality and the primary constructive frame of the building has been solved, as well as the guidelines for its further materialization in 3D. At this stage, accurate blueprints have also been made for architectural sculpture - capitals, cornices and other tertiary plastics, without which any reconstruction of monumental sacral and palatial architecture loses its credibility.²

- Volumetric analysis in 3D refers to the making of the preliminary volume representations of the structure, proportioned and based according to the 2D studies. This was the first spatial visualization of planimetric documentation, and for the first time one could see the relations of certain construction portions and the correctness of the calculated relationships. This step in the 3D study is grateful for demonstrating the primary structure of an individual building but also for spatial analysis of the entire urban agglomeration and its relation to topographical conditions, hydrological situation and morphology of the terrain. Also, at this stage, many final solutions to the appearance of architecture have not yet been fully demonstrated, and the demonstration of primary volumes may at some point be considered scientifically "abstained".

- Further development of volumetric 3D documentation refers to the creation of a detailed structure in 3D³, with a complete demonstration of the overall constructive assembly and final processing of architectural sculpture and profiled elements (Fig. 3). For most of the scientific projects within which scientific conclusions and solutions are demonstrated, this degree of processing is of most benefits, before accomplishing of the final materialization of the 3D Reconstruction (Fig. 4).

- Complete materialization of 3D reconstruction refers to the creation and application of convincing and scientifically acceptable textures that achieve not only the reality of the rendition of the elaborated building but demonstrates the technology of building and knowledge of the architecture of the epoch. There are many examples that successful 3D reconstructions in its final processing are degraded by the producing and applying bad or incorrect textures, which again causes a poor perception of the monument and rejection in scientific circles.

² Where it is possible, of course, it is always of great benefit to involve some of very new scan-digitization techniques, laser scan or photogrammetry or a combination of the digital and analogue technology as it was successfully applied in the work of Athanasios Styliadis [2007].

³ A good example of elaborated volumetric 3D re-creation of the architecture would be the volumetric spatial model of the interior of the church of Hagia Sophia, built for the purpose of lighting analysis and demonstration of Justinianic liturgy. [Stichel and Svenshon 2008].

CARIČIN GRAD PROJECTS 2006-2008 – ASSEMBLING OF THE TOWN IN 3D: DEVELOPING OF THE MASSIVE 3D STUDY OF THE 6TH CENTURY URBAN AGGLOMERATION

Of course, 3D reconstructions can be elaborated to different levels of detail and expertise which again depends on the character of the monument, its significance in science, and the attitude and ambitions of the scientific team. The 3D architectural study project for Caričin Grad has been composed from the very beginning as a long-term composite study, which primarily provides detailed 3D architectural documentation of the already thoroughly studied parts of the site and in the next steps the newly investigated portions of the ancient town.

As the first in a series of projects, the 3D study of the Acropolis in 2002⁴ marked the direction in which the construction of the overall 3D study of the site will go. During the realization of this project, the guidelines which must be respected in order to achieve scientifically valid and prestigious 3D material have occurred as well.



Fig. 4. Caričin Grad – Study of the fortification 2004/5. Volumetric rendition with elevations (left) and cross-sections of the fortification of Upper Town and Water tower (right). (V. Zdravcović, 2004/5)

This primarily refers to the scrutinizing of the architectural and urbanism solution of the late antique site, where a step forward was made in correcting then current perception of the appearances of the Caričin Grad architecture as rather medieval into early Byzantine. Profound studies of the investigated architecture of the site, with their own appearances gained in 3D reconstruction projects, also have provided certain contributions to today's widely accepted picture of this endowment city of Emperor Justinian I as a late antique metropolis erected *de novo*, with the seat of the archbishop and the martyrial complex within the ramparts. A large number of various church buildings⁵ within the urbanized core in the walls (ten churches and a small bath adapted at a later stage in the eleventh church building), required a particularly studious approach primarily in studying the typology of early Christian church architecture, and then in the elaboration of churches in 3D, because almost every church building on Caričin Grad was equipped with its own sculptural program. More edifices from the public works corpus are also extremely important from the point of view of the history of architecture and have been subject of detailed study in the process of making of their planimetry and study analyses.

⁴ 3D Architectural Study of the Acropolis 2002 was presented at Exhibition at French Cultural Centre in Belgrade in 2003 and 2008. [Bavant and Ivanišević 2003; Ivanišević 2008].

⁵ The results of excavations and further analyses of the most important church ensembles within Acropolis walls are gathered within [Duval and Popović 1984].

As a completely justified step after the 3D study of the Acropolis of 2002, the next project for Caričin Grad 2006-7 was conducted (Fig. 5), with urban portions of the town as not processed as a whole, but with individual buildings chosen instead, from the group of public works (*principia* and large *thermae*)⁶ together with four church buildings, each different by their architecture design. With this project (Architectura Justinianica), a significant step forward was made in dealing with the late-antique architecture of Caričin Grad, because the entire process of developing of individual 3D architectural studies was based on previously detailed planimetric analyzes and designs. Together with the project for Acropolis, the 2006-7 project brought for the first time detailed 3D studies of the monumental architecture of church-sacral buildings, hydraulic structures and examples of the military architecture of the epoch of Justinian I, designed and materialized as an Imperial project on the soil of central Illyricum at the beginning of the sixth century. The collection of all structures elaborated in the form of a study in 3D from 2002 to 2008 was done during the project for Caričin Grad 2008, when for the first time all individual steps were integrated into a massive 3D study of the city as a whole. Caričin Grad is not a large-scale settlement, but its 3D study became a massive 3D scientific material file⁷ because, apart from the exterior of their architecture, all important objects of the late-antique metropolis are elaborated in detail as well as the interior with the accompanying architectural sculptures. (Fig. 7) It is indicative that the sculptural irregular form of a richly decorated capital processed as a 3D model, occupies almost identical technical capacities - the number of bits equal to the 3D model of the building without incorporated sculptural plastics.



Fig. 5. Caričin Grad – Architectura Justinianica, Public edifices EAR 2006/7. Planimetry and different stages of the volumetric 3D rendition of the Cruciform church. (V. Zdravković, M. Urošević, M. Nožić)

The project of the final 3D study of Caričin Grad 2008 was completed without the final materialization of the appearance of the 3D reconstruction, more precisely without the application of correct and studied textures for buildings and topography of the environment.⁸

⁶For project 2006 a basic archaeological documentation was given by Bavant et al. [1990].

⁷Managing and preserving of this digital database refers to the next level of the long term arranging achieved documentation in 3D which comprehends data classification along some basic categories and principles, some of which (semantic and geometric enrichment) have been suggested within [Beets et al. 2016].

⁸As assembled 3D Architectural Study Caričin Grad was for the first time presented at the Exhibition "Byzantium-Splendor and Everyday life", Bonn Art & Exhibition Hall, Bonn 2010.

The complete materialization of the 3D study was carried out in a special project of Caričin Grad - Justiniana Prima 2012, which was designed not only to improve and complete the realistic appearance of 3D studies, but also to produce a scientific film in the form of an animated rendition.⁹ The last city quarter, which has been fully elaborated and as a whole was incorporated into the final 3D study of the Caričin Grad, is a project of the 3D architectural study of the settlement on the northern slope of 2017. A display of this city district, located on a slope north of the Acropolis and around the *horreum*, demonstrates the results of several years of archaeological excavations by which not only the urban appearance of this part of the city was completed, but also an insight into a distinctive and unexpected type of housing and arrangement of residential areas within the walls of the protected area of the Upper Town, was provided as well.



Fig. 7. Caričin Grad – Architectura Justinianica, Public edifices EAR 2006/7. Planimetry, volumetric and final rendition of the capital – architectural sculpture. (V. Zdravcović, M. Novčić)

The massive 3D repository (Fig. 8) the final 3D study of Caričin Grad –Justiniana Prima in the past one and a half decade has grown to, is an example of the assembling of the scientifically scrutinized and validated resource of materials elaborated in 3D, eligible for multipurpose use in the most diverse scientific endeavors related to the Caričin Grad site itself or to support projects related to the epoch of late antiquity and the early Byzantium.¹⁰

CONCLUSIONS

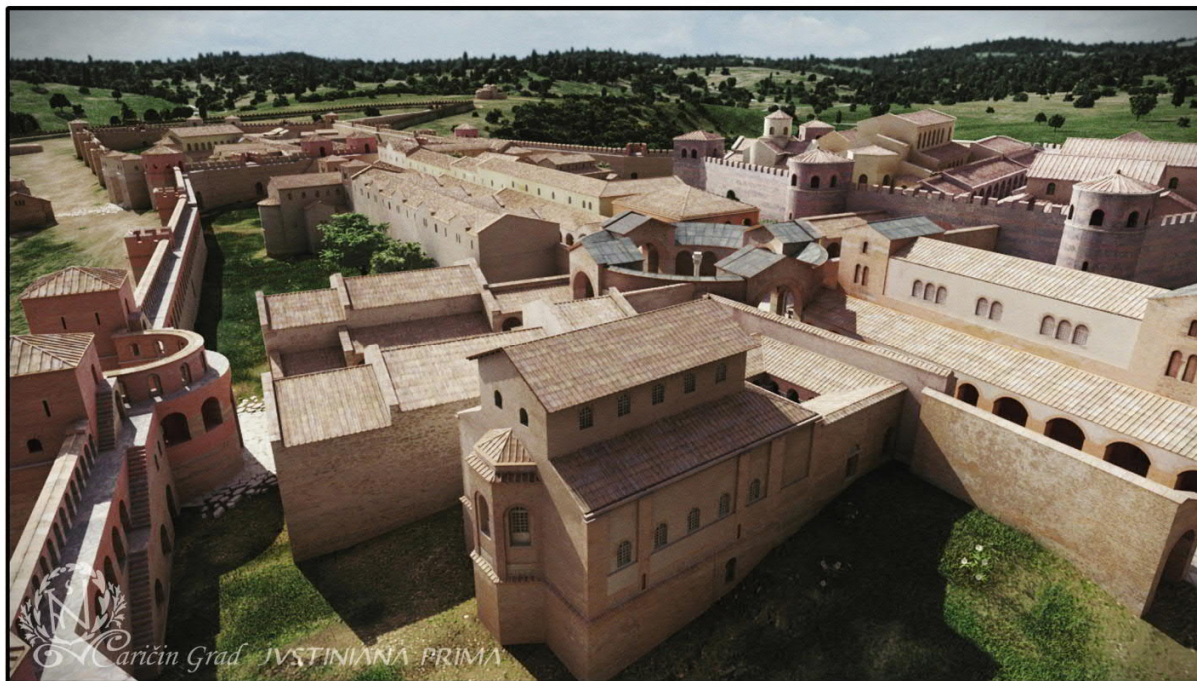
Dealing with architecture of historical heritage in 3D is a hybrid scientific engagement based on the expertise of two basic disciplines - archaeology and architecture. In this sense, on the one hand, development of multimedia technologies (mm) and, on the other hand, experience in this field over the past two decades, points to the necessity of adopting new terminologies or better definitions of already wide spread terms defining the nature and purpose of such projects.¹¹ First of all, this refers to the delineation of scientific projects from the

⁹An improved study of the town from 2010 was achieved in a separate project 2012 and presented at the Exhibition of „Golden Byzantium and Orient“, Schallaburg Castle, Lower Austria, April-November 2012. Producing of the scientific film for 3D Caričin Grad 2010 and 2012 was provided and supported by the Römisch-Germanisches Zentralmuseum (RGZM) in Mainz.

¹⁰As more actual than ever before, the issue of long term maintaining 3D database appears to be a matter of the current debates among scholars. One approach to the problem is exposed in: [Paquet and Viktor 2005].

¹¹For terminology articulation and semantic database see Kuroczyński et al. [2013-16].

widespread popular semi-scientific or quite arbitrary works that are mostly represented in the global media and which can be properly grouped under the term visualization.



*Fig. 8. Caričin Grad – Justiniana Prima Scientific film 2012. An overview toward the south perimeter of the town.
(V. Zdravković, M. Urošević, M. Novčić, V. Ranđelović)*

Visualization¹² would mark in the 3D world what the illustration (better or worse) would be in the world of books, therefore without pretensions to have a serious project format but good enough to illustrate selected topics in the public media and popular publishing. Scientific projects for treating historical monuments in 3D should range from architectural restitution to even more serious, scientifically most valid, 3D reconstructions. Architectural restitutions may also vary depending on the available knowledge of the monument, from completely hypothetical and tentative to study restitution. In their reach, these projects aim to introduce new views of monuments in scientific discussions or to test certain scientific ideas about the elaborated topic. Architectural restitutions are therefore preliminary studied views of architecture that can relatively quickly change according to the new knowledge.

In contrast, the architectural 3D reconstruction of the monument is the most solid presentation of the chosen structure, which is based on long-lasting and deeply studied scientific work, as well as on the results of the architectural study, which implies its long presence in an unchanged form in the official scientific flow. Similar to the categorization of projects in 3D, a difference in the work process can be deducted, as well. For planimetric or 2D studies, we can talk about drafting and drawing while working on the elaboration in 3D is truly "building" of architectural displays, because the author is all the time focused on thinking and solving volume in three-dimensional space.

All of this documentation could be realized in various multimedia software for 3D modelling. In the Caričin Grad project the basic software was Autodesk's 3ds R4 for DOS (1994, Version 4) and Autodesk 3ds Max (Discreet 3dsmax 5 - Autodesk 3ds Max 2012). All textures were elaborated in Adobe Photoshop (Adobe Photoshop 8.0, CS 2 – CC 2015). The primary goal of the project was the exchange of ideas among scholars therefore purely academically with no intentions to exploit the results in wide range promotion of the monument. Nevertheless, achieved quantity and scientific quality of the material opens the question of further upgrading or using it for the

¹² Visualization could be achieved via various technologies and could refer either to the simple archive document or rendition and scans of smaller artifacts as well [Gonizzi Barsanti et al. 2015].

projects of Virtual and Augmented Reality, which again could bring another level of experience of the architecture already elaborated in 3D.

Each of these documents has its own individually purpose while unified gives a total massive architectural study of the monument considered. For the sake of scientific approach and control of the work process, it is necessary to adapt the degree of documentation processing to the knowledge about the monument and its significance for science and the public. In this sense, for the most devastated monuments or for those structures for which there is insufficient information, it is enough at least from a scientific point of view, to reach volumetric presentation and rendering with somewhat more elaborate structures for which there is more data. All other more complex, more significant and better explored or sufficiently documented monuments deserves a serious scientific approach with the gradual developing and production of scientific 2D and 3D studies. Reconstructing the past purely in words is a challenging and difficult task by itself. The reconstruction of the appearance of the extinct monument with all its accompanying argumentation often turns into the work of several generations of experts, because it entails the responsibility of presenting historical and monumental heritage in the most valid and objective way to the general public. In the light of the increasingly progressive and inspirational works in the field of architecture history, new questions arise about the institutionalization of these achievements to the benefit of science and the generations of followers of this noble discipline.

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