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Physical *in situ* and Digital/Virtual Reconstructions and the International Heritage Charters and Conventions: A Critical Overview

Abstract

Conservation and reconstruction policies reflect the evolution of cultural heritage (CH) concepts. It is also apparent that reconstructions should not be limited to buildings and infrastructures, but also refer to socio-economic conditions. Physical, *in situ* reconstruction has been one of the most debatable (CH) conservation techniques and methods as reconstruction of remains can have both positive and negative outcomes. In the last two decades, rapid technological and cultural development has permitted the diffusion of different digital applications (involving virtual reality, augmented reality, mixed reality, holograms, serious games, *etc.*) that can communicate about the past using three-dimensional content. As a result, virtual reconstructions have achieved significant realistic and aesthetic impacts. Today, we must acknowledge that digital and virtual (computer-based visualisation) reconstruction has become an established way of presenting the past. Various international heritage charters and conventions have clarified the physical *in situ* reconstruction issue and even emphasised the significant role of virtual reconstruction in building a comprehensive repository. Furthermore, due to the systematic argument for virtual reconstruction, several projects and documents meant to establish efficient guidelines and good practices in scientific visualisation have been recently realised, such as the London Charter (2009) and Seville Principles (2011). Through a critical overview of the international heritage charters and conventions, the reasoning for reconstructions, the pillars and principles of (CH) reconstructions, and the debate and dilemmas regarding physical in situ and digital/ virtual reconstructions within the heritage community, this paper attempts to sum up and illustrate the development of heritage

reconstructions. In addition, it attempts to discuss and show the concepts, flexibility, resilience, and practice of physical in situ and digital/virtual reconstructions from the early stages to today and to provide an insightful glimpse into the future of digital/virtual reconstruction.

Introduction and Scope

It makes sense to begin this discussion by defining the related terminology and to describe aspects of physical *in situ* and computerised visualisation or digital cultural heritage (CH) reconstruction. First, reconstruction has been one of the most arguable methods among conservation techniques. Today, reconstruction is sometimes appropriate, considering the numerous armed conflicts, earthquakes, and other disasters that affect properties and places recognised as heritage (Jokilehto 2013: 1). Second, the term "reconstruction" can seem too peremptory, and archaeology has long debated its use. Third, it is among the conservation techniques applied to entirely or partially ruined structures under certain conditions. In contrast to limitations in conservation theory, reconstruction practices have spread quickly and widely in recent decades. Fourth, architectural and archaeological reconstruction is complex but immature as a scholarly tool. As the archaeologist Simon James put it, "Every reconstruction is wrong. So, the only real question is, how wrong is it?" (Hageneuer 2015). To conclude, many academics have criticised the use of the term "reconstruction", as it could be misleading: it might convey a false sense of knowledge with the risk of mistaking for "truth" what is nothing more than a simulation, a hypothetical model of the past, or the result of subjective interpretations. In some virtual archaeology projects, the two concepts of virtual restoration and virtual reconstruction coexist (Pietroni and Ferdani 2021).

The term "reconstruction" can be defined as the rebuilding of a monument to its state at the time of its history chosen for that representation. To reconstruct means to construct anew. Reconstruction can also refer to "re-establishing or regenerating the social-economic condition of a place after a period of abandonment" (Jokilehto 2013: 1). The U.S. Secretary of the Interior's Standards for the Treatment of Historic Properties (1992) defined reconstruction as "[t]he act or process of depicting, by means of new construction, the form, features, and detailing of a non-surviving site, landscape, building, structure, or object for the purpose of replicating its appearance at a specific period of time and in its historic location" (Weeks and Grimmer 1995; Jokilehto 2013: 11; Adams 2018).

Reconstruction is generally identified as "returning a place to its earlier state and is distinguished from restoration by introducing new material into the fabric" (ICOMOS 2013: Burra Charter, Article 1.8). One representative example of physical *in situ* archaeological reconstruction is the Stoa of Attalos (115x20m) in the ancient agora in Athens, Greece (Sakka 2013) (FIG. 1). It was fully reconstructed by the American School of Classical Studies at Athens in the 1950s on the original foundations using the original materials found on site and made into the Ancient Agora Museum, with funding donated by the Rockefeller family (Vogeikoff-Brogan 2021). According to Maja Toshikj and Ákos Zsembery (2019: 378), in the entire reconstruction, the architectural approach is "the mimetic or assimilated way that tries to conjure the original appearance."

Anastylosis is the reassembly of existing but dismembered parts: using new materials should be recognisable.

However, there are questions that this short description does not address, *e.g.,* who is supposed to recognise the newly added elements, and how? For example, Rusnak (2021) asks if that is meant to apply to professionals, *i.e.,* architects, conservators, museologists, and archaeologists, who use advanced research equipment? Or to ordinary observers looking at such an object with the naked eye? Alternatively, both perspectives may be considered (Rusnak 2021; Bold 2018).

In a different approach, over the last two decades (CH) development and concerns combined with rapid technology have permitted the dissemination of different digital applications (including virtual reality, augmented reality, mixed reality, holograms, serious games, *etc.*) oriented toward communicating past human activities using three-dimensional content. Paul Reilly (1991) introduced the term "virtual archaeology" to describe computer-based simulations of archaeological excavations. According to Clark (2010), it would be better to use the terms "models, simulative models, or scientific models," as they are means for a clearer understanding of the past and not statements of reality. Baker (2012) prefers the term "visualisation" as an alternative to the reconstruction, as "the former does not pretend to show the real thing because what constitutes the real thing is open to far too much speculation."

Computerised visualisation means the process of graphic representation of information with the help of new technologies. Three-dimensional computer graphics (3D CG) are becoming more popular because they often visualise objects more comprehensively than real ones. 3D CG has drawn solid public attention in recent years for this reason. Many have tried to reconstruct ancient monuments with it; we must acknowledge that digital reconstruction has become an established way of dealing with past human activities, notably during the last two decades.

Virtual reconstruction includes using a virtual model to visually recover an edifice or object created by people at a given moment in the past from available physical evidence of these edifices or objects. However, it should be conducted using a methodically reasonable comparative inference and deal with all relevant studies carried out by archaeologists and other experts (London Charter 2009). Virtual anastylosis involves restructuring existing but dismembered parts in a virtual model. Therefore, we can state that physical restoration seeks the preservation of the materiality of the object and its cultural content. Meanwhile, virtual restoration aims to digitally preserve the information about this content, enhancing its legibility. Virtual reconstruction aims to valorise and disseminate the object, enhancing its meaning and function (Pietroni and Ferdani 2021).

This terminology overlap may depend on several factors. First, archaeology and restoration have varied disciplinary backgrounds. Although these disciplines frequently work together in the same contexts, they have their own theories and methodologies. The practice of virtual restoration is a natural development from physical restoration. It generously shares the goals related to image restitution and legibility. In archaeology, the term "reconstruction" seems more accurate, as this word emphasises the poor state in which monuments are generally found and, consequently, the need for a more extensive interpretation. The percentage of loss in archaeology often

exceeds what is preserved, and the data collected in the field are inadequate to define a comprehensive hypothesis or confirm legibility. To overcome the lack of data, dependence on other documents, testimonies, and comparisons from similar contexts is required. Various international heritage charters and conventions have emphasised physical reconstruction's outsized role regarding the criteria for evaluating reconstruction works and conservation charters. The (CH) conservation charters, which do not have legal enforcement, have a considerable guiding role in both physical and digital/virtual reconstruction practices. However, even though these guidelines and charters promote excellent documentation and presentation practices, they are often ignored.

This paper attempts to summarise and illustrate the development of the concepts, their flexibility, resilience, and practice, and the related issues of the physical in situ and digital reconstructions from the early stages to today and to give a glimpse into the future of digital/virtual reconstruction. This will be based on a critical overview of the international (CH) charters and conventions, a discussion of why we should have reconstructions of architectural and archaeological remains, the pillars and principles of (CH) reconstructions, and the current international debate and dilemmas regarding physical *in situ* and digital/virtual reconstruction within the heritage community. It will be mainly based on recent (ICOMOS) approaches to reconstructing World Heritage properties.

Why Reconstructions of Architectural and Archaeological Remains?

This section aims to understand the effects of reconstruction on the remains and the conservation issues at archaeological sites. Reconstructions are a common way of communicating the past to a broader audience, as observed in museums, magazines, documentaries, or even video games. Historic architecture and archaeology usually damage earlier sites, and excavated buildings are demolished down to their foundations. Thus, it can be hard for both specialists and people generally to have vivid images of how they looked in antiquity without the help of reconstruction drawings. By understanding and acknowledging the object's shape, form, and function in its existing broken and decayed state, the purpose is to estimate its shape, form, and function as it was when the object was new and undamaged (Pospíšil 2012: 3; Hageneuer 2020). Figure 2 shows the main architectural remains of the sanctuary of Eukleia in Vergina in northern Greece (the two temples, the western and southern stoas, the altar, and the three bases), with a graphical reconstruction of the Second Temple and its façade, and the western stoa and of the sanctuary.

In addition, reconstructions of ancient sites and finds can support us in realising the distant past for communication or educational reasons. For non-academics, reconstructions present a glimpse into past human activities, a visual accumulation of scientific research communicated through images, models, or even virtual reality. Its use in films, museums, and magazines illustrates the stories behind historical or archaeological facts. For archaeologists, reconstructions are essential to answer unsolved questions and even raise new ones (Hageneuer 2015; 2020). Other reasons for undertaking reconstruction are a desire to restore national identity or pride, improve interpretation, support education, and increase public attention, as in the case of Stoa of Atta-

lus as a symbol of reconciliation (Çetin *et al.* 2012).

However, the purpose of virtual heritage is not only to produce digital replicas. The concept that the object may have a more important value in its incomplete state than if it were to be reconstructed runs counter to this strong compulsion (Stanley-Price 2009). Nevertheless, the idea has been vital to the theory of conservation and restoration developed mainly in the western world and has consequently been distributed worldwide. The core of western conservation theory is epitomised in how far restoration should be taken.

Various justifications have been developed for reconstructing edifices known primarily through excavated evidence (Stanley-Price 2009). These include physical *in situ* and digital/virtual reconstruction. They can be summarised as follows:

- Site Preservation*:* Physical *in situ* reconstruction, showing that the site is being actively used, helps protect it from development pressures; alternatively, it may stabilise precarious ruined structures.
- National Symbolic Value*:* Physical *in situ* reconstruction of a structure that played a crucial role in the country's history or was related to a notable figure.
- Continuing Function or Reuse: The reconstructed physical *in situ* building can continue serving its initial function or allow for a new, different function.
- Education and Research: Both the physical *in situ* and digital/virtual reconstruction process can be a rewarding research project, and the finished building serves as an essential, instructive tool for visitors.
- Tourism Promotion: The physical *in situ* and digitally/virtually reconstructed structures can attract tourists, increasing income for the public or private authorities in charge of it.

A Brief History of the Evolution of Archaeological Reconstruction

There have been early attempts at reconstruction since at least medieval times. Artists created visual reconstructions drawn from the accounts of travellers, such as of the Tower of Babylon or Stonehenge. However, a weakness in the reconstruction process from past examples is the absence of precise reliability in the reconstructed model, due to the absolute disjunction between the modelers producing the final computer graphics, the archaeologist who created the reasonable reconstruction hypotheses, and the actual 3D data coming from the comprehensive survey (Guidi *et al.* 2013).

"Reconstruction has been part of archaeology since its beginnings" (Hageneuer 2020). In the 18th century it showed the general view of ancient objects, a rather antiquarian perspective. In the early stages, the focus was mainly on the artistic side rather than technical drawing. Until the late 19th century, when archaeology started to emerge as a fundamental scientific discipline, reconstruction of finds was created depicted from one side only. Later, just before the end of the 19th century, artistic focus still prevailed, but technical precision went along with it. Without proper measurements (using individual size-ratios instead), such drawings were replaced nearly exclusively by photography in the first half of the 20th century (Pospíšil 2012: 3). Figure 3 illustrates the progression of the early reconstructions. With the application of photography, new

issues arose. A photograph can capture the entire scene, but it does not interpret it. It can be distorted, or it can be taken badly, *e.g.,* out of focus or the scene can be poorly lit (Guidi *et al.* 2013; Pospíšil 2012: 4). However, some semblances of a norm started to appear in the second half of the 20th century. The number of drawings was again slowly increasing until they roughly equalled the number of photographs. It is not just drawing an artefact; it is drawing how it had been used in the past or how it had been made (Pospíšil 2012: 4).

The Three Pillars of the Reconstruction Process and (CH) Principles

Today we can see reconstructions that are life-sized physical models or virtual reality. However, how are they created? At least three actions from different cultural domains must be adequately interleaved to generate a positive cross-fertilisation in (CH) reconstruction. Every reconstruction process comprises three building blocks or pillars: primary sources, secondary sources, and guesswork (Hageneuer 2015).

The Primary Sources: The First Step Is a Good Visualisation

One must be aware of the archaeological data and the excavated remains: simply all that has survived and that we know about. Figure 4 illustrates the three types of primary sources for reconstruction. In some cases, we have much that survives, and often we have the basic ground plan (Hageneuer 2015). This can be integrated with the standard set of data supplied by historical sources, on which 3D reconstructions are typically based, with the proper 3D shape visible with up-to-date passive or active 3D capturing methods. This integration should be appropriate for providing an excellent initial theme for the reconstruction process; it is the first step that has not yet been exploited enough. However, recently, Dzwierzynska and Prokop (2022) described two entirely different methods for reconstructing the same structure and their comparison and evaluation. The first is from a single-photograph reconstruction method, while the other is laser scanning.

Secondary Sources: The Second Step Is to Fill the Gaps with Secondary Sources

Even when the primary sources are utilised, we often must fill the gaps with secondary sources. These are architectural parallels, ancient depictions, descriptions, or ethnoarchaeological data. We then must look at other buildings to find out how they were built. We also might look at contemporary architecture to understand how architecture functions and what specific architectural details might mean. Unfortunately, we do not have any depictions or textual evidence to help us with this example.

Final Guesswork/Hypothesis Decision: The Third Part of Each Reconstruction Is Simple Guesswork

After developing all the primary and secondary sources, we still need to fill in some gaps. The third component of every reconstruction process is making decisions about hypotheses or simple guesswork. Of course, we need to limit that part as much as possible, but there is continually some guesswork on the part of the team, no matter how much we research our building. For example, we might make an educated guess based on the estimated length and inclination of columns within the building. If we are lucky, we can apply several primary and secondary sources for that as well, but in the end, we need to make a subjective decision (Hageneuer 2015). First,

however, we need to consider the agreed upon (CH) principles in the reconstruction process or restoration activity (Pietroni and Ferdani 2021):

1. Respect for Cultural Significance: The cultural asset's meaning, history, and authenticity should be maintained.
2. Compatibility: It is necessary to understand the material of the cultural assets for a correct assessment of the intervention and compatible materials to be used.
3. Recognition of Intervention: The legibility of the authentic parts matters. Integrations should be recognisable as old and new.
4. Reversibility: Any material used should be removable to return the artwork to its original condition, allowing for future restoration.
5. Minimal Intervention: It is required to repair or conserve original parts rather than replace materials to maintain the historical value.

(CH) Reconstruction and International Heritage Charters and Conventions

As mentioned above, (CH) key principles such as reversibility, minimal intervention, and compatibility are at the heart of an ever-expanding library of codes of ethics, charters, and conventions. Nonetheless, no specific rules exist about when and how far reconstruction should go. Instead, each case is considered unique and judged on its own qualities. First, when should excavated or incomplete buildings be reconstructed to depict how they might have appeared in the past? Second, what are the widely accepted principles of reconstruction? Third, what is the justification for the practice of reconstruction? What are the counterarguments? Finally, what principles can be proposed to help guide reconstruction issues (Stanley-Price 2009)?

Many principles enshrined in conventions and charters in (CH) conservation have addressed the reconstruction of sites based on their archaeological remains. Immediately after World War II, the emphasis was on monuments, and it was mainly the state's task to protect them. Among the charters, the influential Venice Charter (1964) mentions reconstructing archaeological sites. Article 15 reads "All reconstruction work should, however, be ruled out. Only anastylosis, that is to say, the reassembling of existing but dismembered parts, can be permitted" (Stanley-Price 2009). It is clear that the Venice Charter handled the issue cautiously and dedicated an article that strictly ruled out all (CH) reconstruction, permitting only anastylosis and the reassembly of the existing members. The article also shows the necessity of avoiding (CH) reconstructions that focus attention on a few structures and disturb the balance of the site (Jokilehto 1995). In 1964, the Venice Charter favoured the conservation and restoration of (CH) and took a strong stand against reconstruction (Haddad *et al.* 2021).

Since the Venice Charter declared that restoration "must stop at the point where conjecture begins" (Chirici 1971), it may be argued that virtual archaeology begins where restoration stops. In fact, despite this apparent separation between restoration and virtual archaeology, the two fields are much closer than one might expect. The question can be raised as to whether the Venice Charter declaration on reconstruction is still relevant or more precise criteria should exist. It is also noted that digital reconstruction is possible today, which was not the case in the 1960s. However,

the language of the Venice Charter is inflexible in suggesting what constitutes appropriate reconstruction on archaeological sites and monuments ("the reassembling of existing but dismembered parts").

While the Venice Charter was almost entirely opposed to reconstruction, the field has not necessarily followed this principle in practice. Indeed, there are many different reconstructions in Europe and other continents. There have been attempts to limit the inscription of re-created properties to cases in the World (CH) context, such as Warsaw and Dresden. However, there has also been an amount of confusion about the applicable criteria in each case (Gabellone 2015).

(CH) reconstruction policy regarding historic areas destroyed by war was debated and adopted by the ICOMOS Symposium/Declaration in Dresden in November 1982, and the operational guidelines for implementing the World Heritage Convention (1983) (Stanley-Price 2009) revealed a slightly broader view. It introduces the concept that "[a]ny reconstruction should be undertaken if specific conditions were met," *i.e.,* cultural properties have to "meet the test of authenticity in design, materials, workmanship or setting" (the Committee emphasised that reconstruction is only acceptable if it is carried out based on comprehensive and detailed documents on the original and to no extent on conjecture) (Jokilehto 2013). Article 7 of The Charter for the Protection and Management of the Archaeological Heritage (ICOMOS 1990) recognizes the uses of reconstructions for experimental research and interpretation. It also states that reconstruction "should, however, be carried out with great caution, to avoid disturbing any surviving archaeological evidence, and they should take account of evidence from all sources to achieve authenticity. Where possible and appropriate, reconstructions should not be built immediately on the archaeological remains and should be identifiable as such" (Stanley-Price 2009; English Heritage 2001).

The basic tenet against reconstruction stated in the Operational Guidelines for the World Heritage Convention's Implementation and the Venice Charter is echoed in many following documents. Thus, the revised version (1999) of the Burra Charter of Australia ICOMOS describes reconstruction as returning a damaged building to a well-known earlier state by introducing new materials: "Reconstruction means returning a place to a known earlier state and is distinguished from restoration by introducing new material into the fabric" (Article 1.8); Article 17 states: "Reconstruction is appropriate where a place is incomplete through damage or alteration and where it is necessary for its survival or where it recovers the cultural significance of the place" (Jokilehto 2013). Article 18 states: "Reconstruction is limited to the completion of a depleted entity and should not constitute the majority of the fabric of a place"; Article 19 says that "[r]econstruction is limited to the reproduction of fabric, the form of which is known from physical and/or documentary evidence. It should be identifiable on close inspection as being new work" (https://gdrc.org/heritage/icomos-au.html; Stanley-Price 2009). Article 20.1 states: "Reconstruction is appropriate only where a place is incomplete through damage or alteration and only where there is sufficient evidence to reproduce an earlier state of the fabric. In rare cases, reconstruction may also be appropriate as part of use or practice that retains the cultural significance of the place." Article 20.2 states: "Recon-

struction should be identifiable on close inspection or through additional interpretation."

The Burra Charter interpretation of reconstruction (Article 1.8): as being "marked from restoration by the initiation of new material into the fabric" disagrees with the Venice Charter and widespread usage outside Australia. There must be few restorations that do not need the introduction of any new material (Haddad *et al.* 2021). If the Burra Charter meanings were widely accepted outside Australia for where they were developed, they could not fail to confuse. For example, the current long-term project on the Acropolis of Athens would have to be considered a reconstruction, a term that the Greek authorities would reject (Mallouchou-Tufano 2006).

Since the 1990s, there has been an ongoing increase in the understanding of heritage and the conservation charters correspondingly became more tolerant (Haddad *et al.* 2021). For example, the ICHAM Charter (1990) presented an encouraging but cautious approach, which stresses that reconstructions should be carried out with great caution to avoid disturbing any surviving archaeological evidence (Article 7). In addition to the Venice Charter and ICHAM Charter, some international and national charters have addressed the restoration and reconstruction of archaeological sites: The Secretary of the Interior's Standards for the Treatment of Historic Properties (1992) in the USA were inspired by the Venice Charter. However, reconstruction was part of the regular preservation or regeneration process. The goal is to "recreate the appearance of the non-surviving historic property in materials, design, colour, and texture." Therefore, reconstruction should be identified as a contemporary re-creation, and designs never executed historically should not be constructed (Weeks and Grimmer 1995; Jokilehto 2013: 11).

In 2000, various activities related to (CH) conservation were expressed in the International Conference on Conservation of Krakow Charter (2000). It is stated: "The reconstruction of whole parts 'in the building style' should be avoided. Reconstruction of minimal parts having architectural significance can be accepted as an exception because it is based on precise and indisputable documentation. If necessary, completing more extensive spatial and functional parts should reflect contemporary architecture for proper building use. Reconstruction of a whole building, destroyed by armed conflict or natural disaster, is only acceptable if there are exceptional social or cultural motives related to the entire community's identity" (Jokilehto 2013).

In the same year, another international initiative explicitly discussed the reconstruction issue. The resulting Riga Charter (2000) referred to several international doctrinal papers that established a presumption against (CH) reconstruction. It was, however, measured that exclusion can be made in "circumstances where reconstruction is necessary for the survival of the place; where a 'place' is incomplete through damage or alteration; where it recovers the cultural significance of a place; or in response to tragic loss through disasters whether of natural or human origin, and always providing that reconstruction can be carried out without conjecture or compromising existing in situ remains, and that any reconstruction is legible, reversible, and the least necessary for the conservation and presentation of the site" (Jokilehto 2013). The charter re-establishes the presumption against

reconstruction except in exceptional circumstances and reiterates that it must in no way be speculative.

In English Heritage 2001, the international and national guidance is that restoration or reconstruction of historic buildings and ruins must be approached cautiously and never carried out on a speculative basis. Any proposals for restoration or reconstruction must be acceptable regarding their impact on the site itself and its setting. They must be acceptable also in the context of the local planning authority's development plan. The international symposium in Beijing (2007) discussed the policies of conservation and reconstruction and decided that restricted reconstruction was acceptable when justified by the site's integrity, protection and/or stabilisation. Still, "It should not be undertaken if the site in its present form has acquired significance in its own right. In any case, all relevant issues should be discussed with the community concerned" (Jokilehto 2013: 6). In the ICOMOS Advisory Committee meeting in Costa Rica in 2013, the ICOMOS Scientific Committee on Interpretation and Presentation of Heritage Sites (ICIP) proposed enabling a debate on permissibility and standards for reconstructions of monuments and sites concerning the Venice Charter position.

Digital and Virtual (Computer-Based Visualisation) (CH) Reconstruction and International Heritage Charters and Conventions

Reconstructing ancient constructions from their remains has been one of the main applications of computer graphics in archaeology for its suggestive potential (FIG. 5). The evolution of technology has contributed significantly to many aspects of (CH) preservation and recording. Techniques like digital image processing, digital orthophoto production, photogrammetry, laser scanning techniques, and 3D model processing have enabled such alternative products. The process for computer uses in 3D reconstruction and 3D modelling for reconstruction and projection mapping can be roughly divided into three stages or categories:

- Gathering ideas and sketching: 3D image data acquisition; the process of obtaining a 3D model of reality; 3D scanning; Photogrammetry, Manual modelling (3D Studio Max, Cinema 4D, Maya etc.).
- Digitisation of historical building: Data analysis and automated 3D reconstruction.
- Creating the digital 3D image of historical buildings: 3D data visualisation and presentation.
- The scheme presented in Figure 6 describes the suggested sequence of 3D visual documentation from the planning phase to the project design and reconstruction phase.

Virtual reconstructions have achieved results of significant realistic and aesthetic impact (FIG. 5). UNESCO also mandates using digital technologies to preserve and curate (CH). With the Charter on the Preservation of Digital Heritage (UNESCO 2003), this global organisation proclaims the basic principles of digital (CH) for all civilised countries of the world. Numerous international projects are underway with the scope to digitise all aspects of (CH). Many examples of (CH) computer-based visualisation encourage using these technologies to develop interpretation, preservation, and communication strategies for heritage assets (Bentkowska-Kafel *et al.* 2012). Work on significant monuments, tangible artefacts, and even

intangible articles of the world's various legal international heritage charters and conventions has emphasised virtual reality reconstruction's outsized role. International charters have also regarded VR as a method for communicating and preserving (CH). Because of the scientific debate on virtual reconstruction, many projects and documents targeted at creating practical guidelines and good practices in scientific visualisation have been applied over the years, as in the case of the London Charter (2009) and Seville Principles (2011). However, although these two charters/principles are still under discussion by the scientific and heritage community, their introduction provides a fascinating basis for a vital reflection on specific issues related to virtual archaeology.

The London Charter guarantees "[i]ntellectual and technical integrity, reliability, documentation, sustainability, and accessibility" (Pietroni and Ferdani 2021). It points out the significance of structuring and recording the sources used and their metadata and the interpretive process to achieve visual representation. This aspect is essential when dealing with virtual recon-struction. "Sufficient information should be recorded and circulated to allow computer-based visualisation techniques and results to be understood and assessed about the contexts and purposes for which they are deployed" (London Charter 2009). Section 4.4 highlights the value of the knowledge claim. It confirms that any computer-based visualisation of heritage should declare its identity (*e.g.*, 3D models of the present state, evidence-based restorations, or hypothetical reconstructions) and the extent and nature of any factual uncertainty.

The principle of Seville offers booklets and recommendations that follow the guidelines recognised by the London Charter, considering the specific nature of virtual archaeology. Increasing the London Charter's applicability conditions and improving its implementation, specifically in archaeological heritage, is critical. These principles aim to increase the situations of applicability of the London Charter in order to expand its application in archaeological and industrial archaeological heritage. In addition, it is abridging and organising its bases sequentially, proposing new recommendations considering the specific nature of archaeology and (CH). They also promote virtual archaeology as a mature discipline founded on scientifically valid and widely shared methods. Gabellone (2015) focused on problems related to transparency and scientific accuracy in virtual archaeology projects through a critical discussion of Principle number 7 of the Seville Charter. Principle 7.1 on "Scientific Transparency" concentrates on the importance of the documentation to create all reconstructions in such a way that they are testable by other researchers or professionals. To accomplish "scientific and academic rigour in virtual archaeology projects, it is vital to prepare documentary bases in which to gather and present the entire work process transparently."

The Seville Charter introduced the definition of virtual archaeology and virtual restoration, anastylosis, reconstruction, and recreation to frame the anticipated outcomes of using VR methods in heritage conservation. The charter focuses primarily on setting up criteria and guidelines that ensure the effectiveness of virtual methods and encourage the use of new technologies for better conservation, management, and dissemination of cultural values. Enhancing public appreciation and engagement is also a main focus (Lopez-

Menchero and Grande 2011).

According to the Principles of Seville, virtual reconstruction is a digital process with the goal of creating a "virtual model to visually improve an edifice or object made by humans from the available physical evidence of these edifices or objects, scientifically-reasonable comparative inferences, and in general, all studies carried out by archaeologists and other specialists concerning archaeological and historical science." As a stylistic virtual restoration, virtual reconstruction involves the restoration of an artefact at the time of its creation or its consecutive phases of use. In the latter, the concept of "hypothesis" seems to play a significant role. However, "virtual restoration" (intended as a stylistic intervention) and "virtual reconstruction" are often synonymous, especially in built heritage. While the former is preferably employed in architectural restoration, the latter is more familiar in archaeology (Pietroni and Ferdani 2021).

Discussion: Current International Debate and Dilemmas Regarding Physical *In Situ* and Digital/Virtual Reconstruction in the Heritage Community

Generally, international charters and conventions are binding treaties once ratified by the states concerned, but they only slightly refer to reconstruction (English Heritage 2001). However, as has been mentioned, the philosophy of "conserve as found" has come into conflict with traditions that prefer the restoration of structures to maintain religious or other functions. It is currently more widely acknowledged that it is the preservation of the spiritual values of such edifices ("living heritage") that is more important than the conservation of their physical fabric alone (Stanley-Price 2009). However, reconstruction that respects the typical architectural characteristics has not been debated.

There are two faces to reconstructing (CH) remains; each can have positive and negative outcomes. The arguments against (CH) reconstruction are mostly related to a high level of physical intervention, the use of new material, and structural reintegration techniques, affecting the monument's authenticity and the site's significant values. Therefore, reconstruction with limited information and excessive interventions should be avoided. More specifically, the arguments against physical reconstruction are (Stanley-Price 2009):

- The difficulty (impossibility?) of accomplishing authenticity. Reconstructed edifices are de facto new buildings, tending to reveal the culture and times of their designers rather than being faithful reproductions of the original.
- The ethical concern of conveying erroneous data. Incorrect reconstructions can mislead the professional and lay public unless identified as such.
- The destruction of actual evidence. Several reconstructions have destroyed or rendered inaccessible the evidence on which they are based, to the detriment of future scientific research.
- The disruption of landscape values. A reconstructed structure in an otherwise ruined landscape distorts visual and spatial relationships.
- They distort site interpretation. The complexities of sites with an extended history are obscured if reconstructed to feature a single period.
- Cost. Reconstruction tasks tend to be very expensive and often can only be financed by the political authorities who insist they be undertaken.

Therefore, physical reconstruction can "frequently be more destructive of significant fabric or structures" (English Heritage 2001); meanwhile, the value of a ruined building if left as it is can be more evocative than if it were reconstructed.

One problem is that reconstruction is sometimes used to create fake history in tourist areas. Regarding this, the China Principles (2002) by China ICOMOS and the Getty Conservation Institute give the alert that a "building that no longer survives should not be reconstructed" (Jokilehto 2013) except in remarkable cases when clear evidence is confirmed by experts and permission is granted (Jokilehto 2013). However, according to Maja Toshikj and Ákos Zsembery (2019: 378–379), the question remains of what the rule for contemporary reconstructions will be in the future. Can reconstruction serve as a permanent conclusive solution to representing the past, or will it serve solely as a new layer on the monument's history, until something more advanced appears as a new prevailing solution?

On the other hand, at what point does a reconstruction of a historic structure surpass and overwhelm the original authentic building rather than complement and enlarge its impact? Reconstructing historic architectural styles can be tricky, especially in preventing the addition from looking dated or outshining nearby historic buildings. Sometimes, these new reconstructions successfully preserve the originals while bringing something fresh and new. At other times, they can fall on their faces or even send (knowingly or unknowingly) a fake message.

Some obstacles to physical reconstruction are the lack of trained professional staff, ignorance of reconstruction practical sciences and paradigms (Weeks and Grimmer 1995), lack of awareness of the consequences of such methods and techniques, lack of basic materials and tools required for restoration and reconstruction, and lack of supportive projects in reconstruction sciences at regional and local levels, especially in the Middle East region. There is also a lack of international aid and institutional support providing financial aid for surveys and reports. According to Pietroni and Ferdani (2021), the first applications for the 3D visualisation of archaeological data and reconstruction had several weaknesses regarding virtual reality concerns. First, many projects were more dedicated to technological exhibition and distribution than scientific research. Second, the first models were not "transparent" regarding their sources, and the reconstructions were presented as peremptory without offering alternative hypotheses. Third, a lack of interdisciplinary professionals linked the humanities with the computer science area.

However, the development of recovery and restoration raises a question of authenticity: How far can an authentic experience be re-created or conjured through the simulation of an absent original monument? It has been emphasised that reconstruction should be preceded by a thorough archaeological investigation based on the precise duplication of historic features and elements. Figure 7 shows the main architectural remains of Macedonian Tomb D from the site of Pella in northern Greece, with graphic and photographic documentation of the façade and a proper graphical reconstruction of the plan and the tomb façade with the axonometric 3D reconstruction of the tomb. Its purpose is to recreate the appearance of the non-surviving historic property in materials, design, colour, and texture, where available.

Reconstruction should be identified as a contemporary re-creation, and historically, designs that were never executed should not be constructed (Krakow Charter 2000). Equally, reconstruction can also be seen as a cultural act. Another question can be raised when reconstruction is used to reintegrate an urban area and when corrective measures are introduced in managing a landscape or a cultural landscape. The primary purpose of safeguarding heritage resources is maintaining their historical authenticity and credibility. However, the current debate places many situations on the table, ranging from (CH) sites to historic urban sites and vernacular cultural landscapes. Therefore, the primary decision returns to the critical cultural process of recognising something as (CH) and then planning how to conserve and manage that (CH). But, the question remains of who is going to do this recognition and by whom should something be recognised as heritage.

Digital reconstruction has many benefits in comparison. Traditional classical archaeological reconstruction deals with specific issues that are nonexistent or less severe in the digital medium. Working digitally accomplishes the same purpose in fewer steps, without the issues mentioned above. Archaeological drawings are frequently significant, but it is not easy to photograph them properly because of the size of illustrations/drawings. Such photographs require more processing to be printed reasonably and to correspond to the described objects. In addition, there is the difficulty of future changes and editing; these drawings have a limited ability to generate numerous variations of one reconstruction. Digital tools also permit cloning elements, separating layers of content, and adjustable changes. Storage space in digital files can be damaged just as paper can, but a hard drive takes up considerably less space than boxes full of drawings. Finally, backup in the cloud is an option for digital files.

In addition, when the past form and function of a structure are suggested virtually, many existing components are digitally restored (*e.g.*, paving mosaics and fragmented columns). The building is also integrated into a more comprehensive virtual reconstruction, intended to provide a general idea of the cultural context. This means that many "local" elements of digital restoration are included, with several levels of reliability that should be differently documented (Pietroni and Ferdani 2021). According to Pietroni and Ferdani (2021), Hermon complained in 2007 that the capability of 3D visualisation for scientific research was vastly undervalued, and the cause could have been that, at that time, few archaeological reports were presenting new results obtained using 3D. Debates in the 2000s were robust regarding the advantages and disadvantages of virtual archaeology and the application of computer-based visualisation in (CH). The debate regarding benefits and drawbacks and how virtual reconstructions of the past should be adequately generated and managed in research and communication is ongoing—the same concerns the use of terminology. For example, although criticised, the term "virtual reconstruction" is commonly utilised in digital heritage, with an increasing awareness of its meaning.

Consequently, the number of stakeholders has risen. This is evident from the Council of Europe Faro Convention of 2005, which introduced the concept of a "heritage community", increasingly recognised by UNESCO. Furthermore, in the session on the 40th anniversary of the World Heritage Convention, the

conference accepted the Kyoto Vision and underlined the importance of the role of community, stating: "Only through strengthened relations between people and heritage, founded on respect for cultural and biological diversity as a whole, joining in tangible and intangible aspects geared toward sustainable development, will the future we want become attainable."

Several scholars have made suggestions as to how the value of society's point of view in the process of explaining historical monuments might be increased (Rusnak 2021), asking whether reconstructions have been adequate in interpretative programs and whether the Venice Charter's position should still be relevant today (Jokilehto 2013). The debate on reconstruction is necessary, due in part to the much-changed cultural context of today versus the period after World War II.

Today, reconstruction is just as appropriate because the same problems remain, including many armed conflicts, earthquakes, and other disasters that affect properties and places recognised as heritage. In the case of World Heritage properties affected by disasters, the international community has often offered a helping hand (Jokilehto 2013). However, the question is different when deterioration occurred in the distant past. Partially, this may be due to the association of a particular ruined site's significance, which may be recognised for its historical integrity even as a ruin.

Such relationships should be grounded in a multi-disciplinary and participatory approach to conservation. Heritage conservation must be understood in its more general socio-economic framework. This is essential for any success in the long term. In areas that have been marginalised and are losing their traditional vitality, the reconstruction of social and economic frameworks can be of fundamental importance to re-establish their functional life and integrity and the empowerment of local communities (Riga Charter 2000; Jokilehto 2013).

Discovery by Reconstruction

In some cases, 3D reconstruction of historic buildings and thinking about their original typology, morphology, and interdependence can reveal exciting connections. Digital reconstructions can enhance understanding of archaeological details, spatial relationships, and cross-referencing with field data. In addition, they provide feedback for future field data collection. Olsen *et al.* (2004: 3) concluded that "[d]igital technologies can bring archaeology to a new era where it not only can assist archaeologists for scientific discovery, but it can also enrich the presentation of findings and enable the distributed scientific communication and discovery." Reconstruction can also aid archaeological investigations (Hageneuer 2015). It has been found that reconstruction work is beyond simple logical reasoning and crafting. Instead, many cognitive processes, such as assumptions and analogies, are involved in the reconstruction and play a significant role. However, unfortunately, those inverse physics processes are hidden as "experience" or ambient intelligence rather than existing as an exact science (Olsen *et al.* 2004; Pospíšil 2012: 6).

Virtual modelling also empowers the testing of conceptual, constructional, and environmental aspects prior to embarking on the *in situ* construction process. It has been demonstrated that seeing a reconstructed artefact in a realistic simulated context may permit new archaeological discoveries. Furthermore, visualising accurate shapes and their

geometrical associations within context—only explained verbally in a conventional approach—may trigger imagining narrative scenarios (Guidi *et al.* 2013).

Criteria and Guidelines for the Potential of Digital Reconstruction to Show Alternative Presentations

The criteria for evaluating reconstructions at archaeological sites and monuments through a review of current international and national conservation charters, considering the relation of scale and the size of the historical remains, can be summarised as follows: accuracy of the reconstruction, avoidance of physical damage, compatibility of materials and use, distinguishability of the interventions, availability of the interventions for future applications, reversibility, limits of the intervention, and retainability of the original characteristics of the site. Furthermore, the materials and activities used in the partial reconstruction must be compatible to the original, must not damage the original materials, and be distinguishable. The interventions that present recently obtained architectural information should be a basis for future studies and be reversible. Finally, the reconstruction does not falsify the original characteristics and the site's cultural significance but increases the ability to perceive it (Çetin *et al.* 2012).

Regarding the criteria related to the international references shaping the discipline, however, the stated principles are intended as guidelines and good practices, not norms. There is no standard solution to control and exemplify the typology of technologies and the complexity of records and interpretations engaged in virtual reconstruction or to represent the reliability/uncertainty of the aimed-for reconstruction. In the past few years, researchers have developed and adopted diverse solutions: segmentation methods according to "degree of certainty" based on "Level and Classes" or "Typologies"; a method borrowed from architectural restoration, based on the "data correspondence model"; quantitative methods where the validation of the models is calculated according to a numerical "index of reliability"; a method that uses structural equilibrium and constructive rules to validate architectural reconstruction; methods based on systemic simulations; formal languages based on stratigraphic approaches, and others. Even if solving this concern with a universal method is complicated, some different methods have been successfully applied (Pietroni and Ferdani 2021).

Regarding the "Legibility, Contextualisation, and Symbolic Meaning: Where and How Virtual Restorations and Reconstructions Intervene in the Communication Pipeline," as stated by Pietroni and Ferdani (2021, p. 5-6), in the special issue of *Information* on "Virtual Reality Technologies and Applications for Cultural Heritage," each artwork reflects the artist's opinions on his time's social, moral, cultural, ethical, or religious context. In other words, a (CH) object conveys a message from its creator and is addressed to a specific audience. Visitors will evolve their thinking capacity if the cultural data enhances connections. However, this is not always obvious because many cultural objects can no longer be recognised and understood. They come from a different cultural context or have been harmed by time. There are three requirements for cultural transmission to take place (Pietroni and Ferdani 2021):

1. Legibility: The object must be identifiable in its shape, content, and functionality; this condition falls

within physical and virtual restoration domains.

2. Contextualisation: The object must be linked to its original context (*e.g.*, a statue initially fitting to the decoration of a temple pediment; or a painting placed on an altar. It falls within the domain of virtual reconstruction. The criteria for visual reconstruction of a historical façade are:

    - The quality of projecting realistic images on the facades of the historical building.
    - The clarity, softness of the edges, and colour of the facades.
    - Adaptability and flexibility of images on the facades.
    - Quality of the facade display in different scales.

3. Narration: An object's function and symbolic, intangible value must be narrated. Here, the consideration is centred on identity. This condition falls within the storytelling domain, and virtual reconstructions are the visual background of such stories.

Concluding Comments

Reconstruction has been one of the most debatable methods among conservation techniques. By the beginning of the mid-19th century, systematic scientific reconstructions based on factual data were made using scientific archaeology. Unfortunately, these earlier visualisation efforts were more conjectural than those that came later due to the lack of comparable data. However, the politics of reconstruction go far beyond early aesthetic considerations.

What is common to all international conventions or charters produced by professionals is that physical *in situ* reconstruction constitutes an exceptional case and should be carried out only when sufficient primary evidence exists. One of the critical questions is whether sufficient information is available for this purpose. In international conventions, charters, and guidelines, the solution to whether incomplete buildings should be reconstructed is clear. Unfortunately, it is not very encouraging. As the World Heritage Guidelines state, reconstruction is "acceptable only based on complete and detailed documentation and to no extent on conjecture." Although guidelines and charters promote an excellent process of documentation and presentation, they are often ignored. The questions and answers about reconstructing the archaeological past presented in this paper can also be applied to modern architectural reconstructions.

On the other hand, virtual reconstructions have achieved significant realistic and aesthetic impacts. One of the fascinating applications of virtual worlds is the 3D reconstruction of archaeological sites and monuments. Three-dimensional reconstructions bring archaeology to life; meanwhile, virtual 3D reconstruction allows testing conceptual, constructional, and environmental features before embarking on the physical in situ reconstruction process. The virtual reconstruction approach in conservation can introduce many practical, educational, and entertaining dimensions for the public and visitors. Furthermore, 3D reconstruction effectively engages target audiences with a site or topic. This output provides suitable materials for public engagement with the ruins and their conservation.

Therefore, specialists must check each model produced regularly and scientifically to make sure the models follow new knowledge and investiga-

tions. Following recent trends in the cultural sector and future technological perspectives, 3D reconstructions can be essential components of the (CH) repository. Digital content from historical and cultural sources will be stored by cultural, educational, and research institutions and evaluated for historical accuracy and cultural and artistic quality by professionals coming from creative industries, used for its initial purpose and re-used for supplementary purposes, until the content reaches large audiences in various forms.

By exploring the use of computers in reconstruction and listing currently used techniques and methods, virtual tools can help scholars analyse, interpret, and advance different hypotheses. In addition, simulations in which the real and virtual work together can create an evolutionary and creative process in which social interaction translates into evolving knowledge. Physical in situ and virtual reconstructions should no longer be judged as opposed but as a continuum, together bringing value to the (CH) and human experience. They include the observer, who becomes an active participant with a leading role.

Digital technologies can help bring archaeology to a new era by assisting archaeologists in scientific discovery, enriching the presentation of findings, and enabling distribution of scientific discoveries. However, scientific transparency strengthens the value of the documentation by making all reconstructions testable by other researchers or professionals. Specialists must scientifically check each model produced and regularly update them to follow new knowledge and investigations. Therefore, virtual reconstruction has become a predominant method in heritage and conservation studies. To summarise:

- Virtual 3D modelling enables testing conceptual, constructional, and environmental aspects before embarking on the *in situ* reconstruction process. First, however, specialists must scientifically check each model and regularly update it to follow new knowledge and investigations.
- Virtual 3D reconstructions can be constantly enriched with more cultural content, new documentation on buildings/artefacts/events, and more depth.
- Creating interactive interfaces for buildings and their interiors and developing dynamic visual media would further enrich the user experience. At the same time, this could be a motive for revising already used 3D reconstructions to see "what is new".
- In future development, it would be remarkable to discover an improved degree of communication between the different historical and technological experts based on social networking instruments and annotations on renderings or directly on 3D models.
- A complex approach based on modern analysis is needed to reconstruct historical and architectural monuments.
- The reconstruction work at archaeological sites must be cautiously approached to prevent disturbing any surviving evidence.

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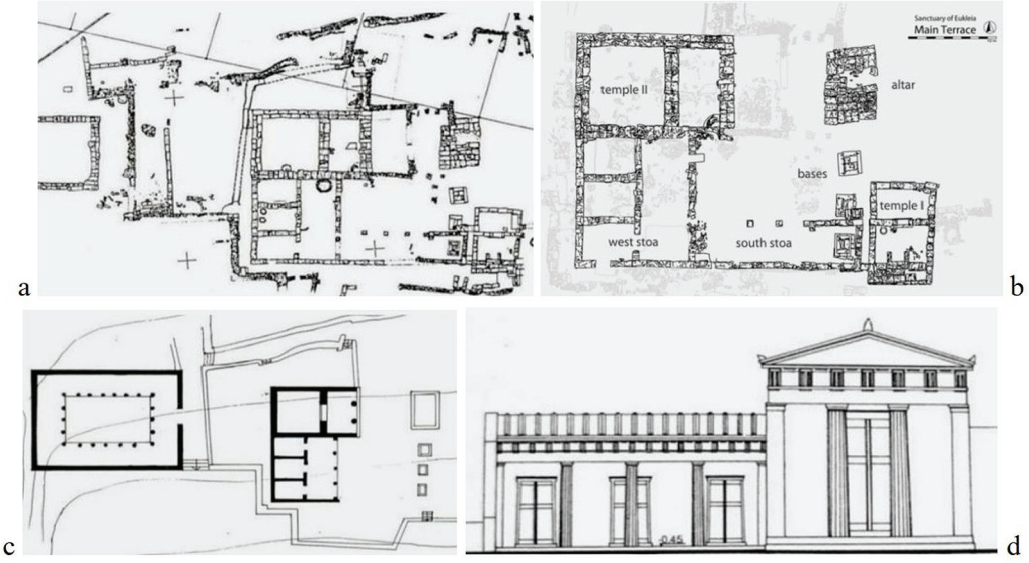
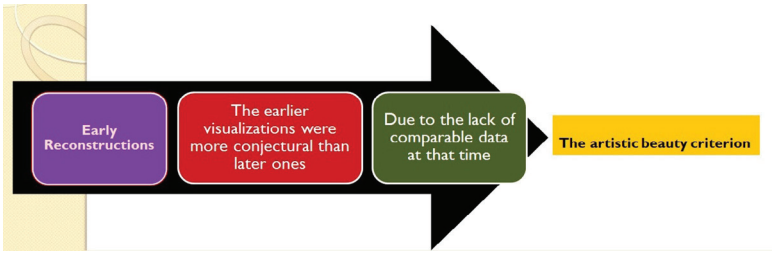
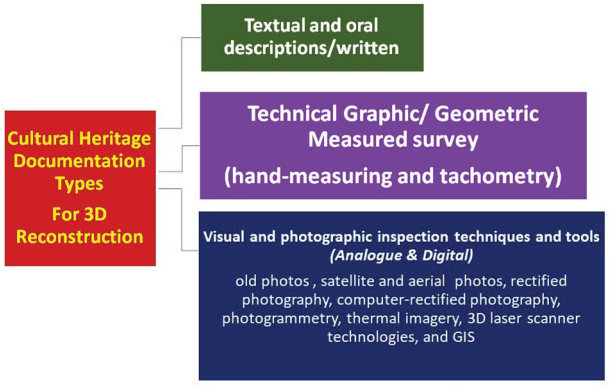
1. 1. a) The Stoa of Attalos before its reconstruction in 1952. ASCSA Agora Excavations. b) The Stoa of Attalos after its reconstruction in 1956 (after Vogeikoff-Brogan 2021).



2. a) The main architectural remains of the sanctuary of Eukleia in Vergina in northern Greece, showing the two temples, the western and the eastern stoas, the altar, and the three bases. b) Graphical reconstruction of the Second Temple and the western Stoa and of the sanctuary. c) Graphical reconstruction of the façade of the Second Temple and the western Stoa of the sanctuary (image by N. Haddad).

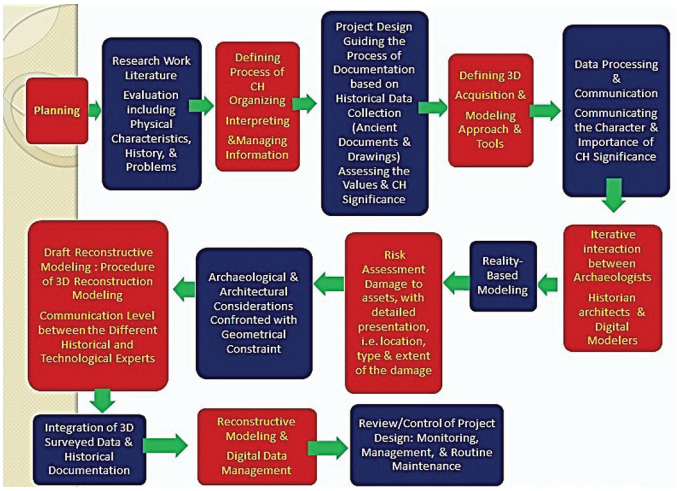


3. Progression of the early reconstruction (image by N. Haddad).

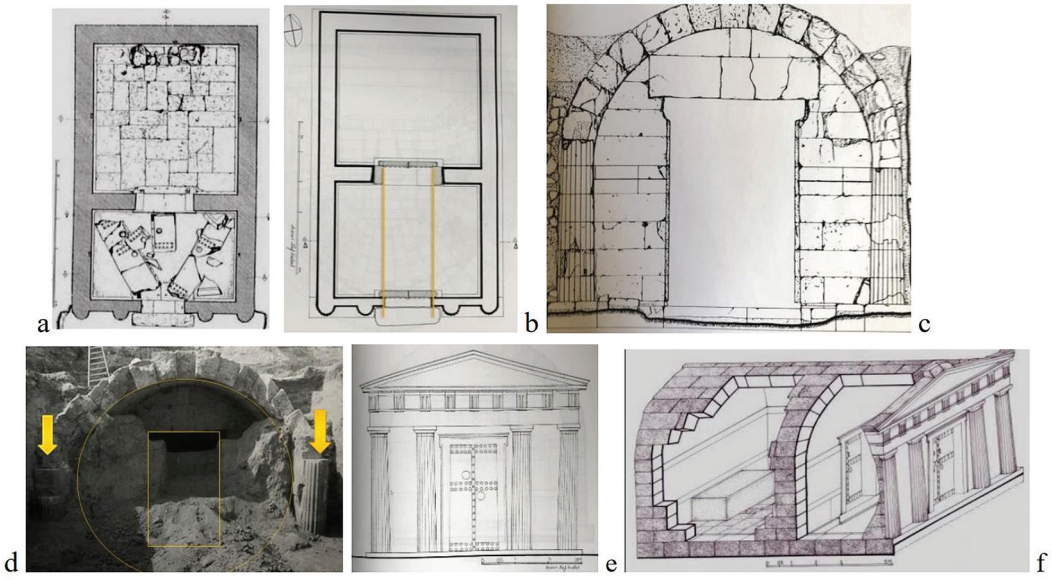


4. The three types of primary sources for the reconstruction (after N. Haddad 2022).

5. Two examples of virtual reconstructions of the classical-period Parthenon (447–432 BC) at the Acropolis of Athens (after "7 Ancient Monuments 3D Reconstruction" [https://www.youtube.com/watch?v=Yyrr645n7dc]).



6. Suggested sequence of the 3D visual documentation from the planning phase to the project design and reconstruction phase (after N Haddad 2022).



7. a) The main architectural remains of the Macedonian Tomb D at Pella in northern Greece. b) Graphical reconstruction of the plan of the tomb. c) Graphic documentation of the façade remains. d) Photographic documentation of the façade remains. e) Graphical reconstruction of the tomb façade. f) Axonometric 3D reconstruction of the tomb (image by N. Haddad).

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