

# BUILDING'S TWIN RECONSTRUCTION

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**ABSTRACT:** *The work shows a process that starts from the digitization of cultural heritage and through analysis arrives at the subsequent diachronic holographic representation. The object of the study was the creation of two holograms of historical buildings: the church of St. Maria in Sovana with an interesting subsoil and the ruin of church of St. Francesco, attributed to Sangallo il Giovane in Pitigliano. However, the theoretical setting of the research is placed at due distance from the twin term. It has implications and meaning that are not matched by producing a digital copy, even a very high resolution one. The use of different cognitive technologies and the assembly of the various inputs in a digital model can never be defined as a twin of the original. Bearing in mind what has just been specified, the work was organized according to different levels of acquisition of cognitive data. Obtained from the survey and from historical studies the shape of the original state, a historical narrative interweaving of digital models has been created. The hologram is a three-dimensional and dynamic representation, which in the case of the church of San Francesco shows the reconstruction of the ancient architectural complex, visualizing the evolution of the studies of historical documents, up to the vision of today's ruin. For the church of S. Maria, the underground area is reconstructed through the geoelectric analysis of the subsoil and of the urban composition. Use of high detection technologies (GPR and HVNSR). The holographic of the artifact, promotes scientific divulgation and its dissemination sharing experience, it is not realized through device indeed, but thanks a holographic display.*

**KEYWORDS:** *Digital twining of cultural heritage, hologram technology, scientific divulgation, dissemination - Diocesan Museum Palazzo Orsini of Pitigliano (GR).*

## 1. INTRODUCTION

The research activity concerning the case of the church of St. Maria in Sovana (GR) and the ruins of the church of St. Francesco in Pitigliano (GR) starts by questioning the real possibility of making a digital twin of any object or structure especially in relation to the concept of cultural heritage. Starting from the awareness that nothing can be perfectly reproduced, both in structure and texture, even more we find ourselves in the impossibility of being able to observe any artifact divorced from its concrete and real contextualization.

The highest resolution survey and the most advanced technologies can never produce the real in the sense of the twin as we would like it to be. Much less can digital reproductions be correlated with the originals of which they are a partial copy. The theoretical setting of the research thus identifies in the term *twin*, incongruence between signified and signifier; twins in fact have a usual nature, it would instead be more appropriate to speak of digital copies to already have in mind the intrinsic limitation of the action. The misunderstanding, evidently intended, may not seem foundational, but we think at the level of scientific setting it is.

To return to the question of architectural research having clarified the position, albeit in a consciously non-exhaustive way, the paper proposes a twin action of architectural study and composition. That is aimed at identifying the usual nature of the project idea starting from artifact, investigating it according to the compositional rules of architecture referring to different historical periods. Therefore, if the idea has a usual nature, we can research its premises according to the regulative logics of architectural design and here plausibly offer a digital twin of the project idea, which is then confronted with the nature of the artifact, or the cognitive process given by the physical survey and the historical documentary study. In this case then the result shifts to making the project visible from the object.

The structures that are virtually duplicated remain of the usual nature at the ontological level of idea, and the effect of this operation is an architectural image and form that mediates the direct study work on the object and the design process that preceded it. On the one hand, we are in the sphere of the late Renaissance, and we are confronted with a pragmatic architect by profession such as Antonio da Sangallo il Giovane, who in the service of the Medici family, engaged in urbanistic actions of profound transformation in that of Pitigliano, a contested episcopal city and a border town right between Rome and Florence. This area that today is called a minor interior area is characterized by castles, fortified towns and monasteries or convents, and the town of Sovana connected today with Sorano is one of these centers that supplied travertine and valuable mineral resources to Rome. The operation

carried out in Santa Maria Sovana is trying to represent an evolutionary diachronicity of a site that is resemantized within the urban grid.

## 2. THE DHOMUS PROJECT, MATERIALS AND METHODS

In the framework of the research described above, the DHoMus project, conducted in collaboration between the Department of Architecture (disciplinary scientific sector ICAR/17) of the University of Florence, the Diocese of Pitigliano-Sovana-Orbetello and the Diocesan Museum Palazzo Orsini in Pitigliano, began in March 2020. Action aimed at safeguarding cultural heritage and in line with the idea of a *diffuse museum* (Aiello, 2020b). Two relevant historical emergencies such as the church of the convent of St. Francesco in Pitigliano and the church of St. Maria in Sovana refer to the first museum pole in Pitigliano (Stefanini, et al. 2021).

### 2.1 The case study of St. Francesco church, Pitigliano

The Convent of St. Francesco, located outside the urban center of Pitigliano, is in a state of ruins today (fig. 01). In fact, the building, which was built in the XVI century to a design by Antonio da Sangallo il Giovane, was soon abandoned in the early years of the XVIII century under the pressure of the Napoleonic suppressions, leading to a gradual process of decay. In the second half of the 1900s the Diocese implemented a parceling out of the convent complex and remained the owner of only the church.

There are still many elements of interest of the ruin, in addition to its architectural definition, that lead us to focus attention on this building again.

The first phase of the study was to, as is customary, prepare an integrated survey project, which in 2019 approached a three-dimensional modeling of the actual state with care taken to keep the textural and chromatic data as faithful as possible to the actual appearance of the ruin (fig. 02) (Lecci et al. 2021). At the same time, research was carried out at the Uffizi *Gabinetto* of Drawings and Prints, a valuable fund for those interested in architectural design and the studies made by Renaissance architects.

Fortunately surviving the events of about half a millennium are two papers precisely concerning the San Francesco in Pitigliano, where the architect in the early period of his professional activity sketches two plans of the building. From some reconstructions of the activity and the placement of the drawings it is plausible to think that the church in 1522 was already definitely built.

The drawing depicts, on the recto of the page, the plan layout of the convent complex of St. Francesco, consisting of two cloisters around which the buildings are attested (fig. 03). Accompanying the project sketch is a legend indicating the function of the various buildings. What remains to this day of the entire convent is solely the church part. Church designed with a single nave with leaning against it on the long side three polygonal chapels extroflexed with internal apse. Note also that the church was planned to have a vestibule with three entrances from which to enter, now lost.

The study of Sangallo's drawing, given the differences in the church between the project and its present state, has guided the research toward a more thorough investigation of the project itself, taking an interest in how the building was conceived and how it should have looked in its original state (Aiello, 2020a).

The drawing seems to plan an overall idea and that the realization therefore according to the document could have been synchronic. The survey also provided us with a reading of the parts attributable to the original layout and thus compatible with the plan found in the Uffizi *Gabinetto* of Drawings and Prints.

The functional distribution of the architectural complex was identified directly from the legend of the original sketch. An initial graphic elaboration was carried out that could communicate this information more clearly and immediately, placing the 16<sup>th</sup> century design sketch at the center and explaining the dislocation of the rooms by highlighting them and their wording, as specified by the architect in the legend (fig. 04).

More extensive archival research identified designs that could be compared with that of St. Francesco in terms of characteristics and style, attempting to delineate the possible elevation thought up by the architect.



Fig. 1: Photo of the church of the convent of San Francesco in Pitigliano, GR.

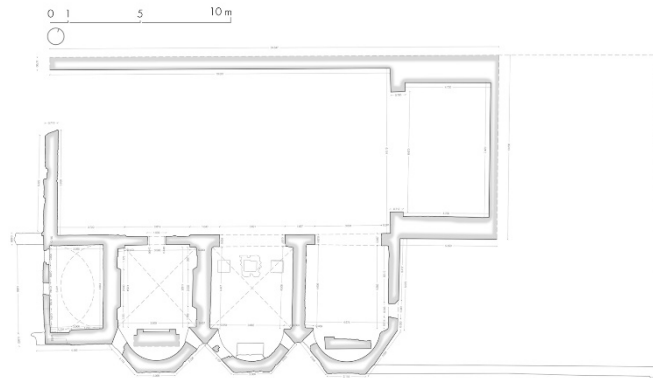


Fig. 2: Plan of the church of the convent of San Francesco in Pitigliano. Graphic elaboration obtained from the survey and developed by the arch. Luca Pasqualotti in his Architecture degree's *Abitare il Paesaggio Storico* (Pasqualotti, 2020).

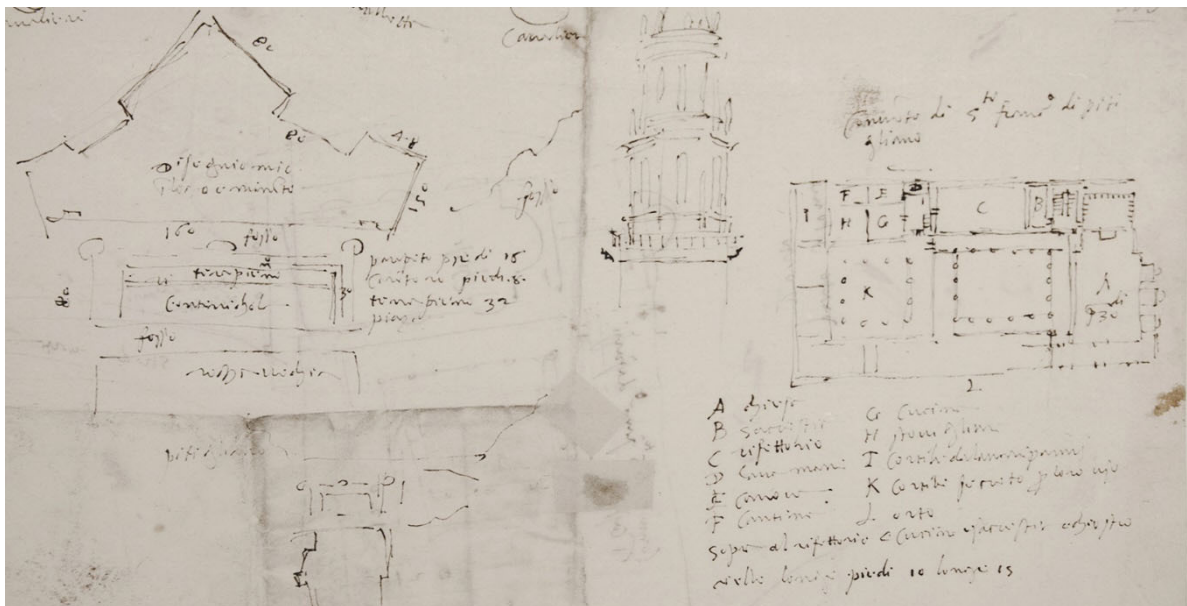


Fig. 3: Photo of page n°811 A, drawing by Antonio da Sangallo il Giovane showing the plan of the convent of San Francesco in Pitigliano. *Gabinetto* of Drawings and Prints in Uffizi, 16<sup>th</sup> century.

On the survey and the iconographic document, the metric-proportional study of the entire plan layout was carried out, with the aim of verifying whether the project, even if in the form of a sketch, had been conceived according to proportional ratios and/or according to specific mensural canons.

Such a possible positive finding would on the one hand have helped the reading of the architectural portion visible today and on the other hand would have added information about the figure of the architect himself, regarding his *modus operandi* as an architectural designer. The analysis was based on the planimetry, from which the design geometries were highlighted from the proportional diagrams of the two cloisters. These were then investigated for the existence of any measurement modules between them (fig. 05) (Pasqualotti, 2020). Analyzing the length and width ratios of the greater cloister revealed an internal scanning in squares of sides equal to the span of the intercolumn of the portico. This correspondence thus revealed the existence of a modularity that, aggregated in a ratio of 4:5, punctuates the entire composition of the cloister itself. The modular quantity derived from this ratio was extended to the entire plan development of the complex, bringing out the same correspondence between module and project, thus suggesting that the architect had a clear proportional geometric structure of reference (fig. 06) (Zerbini, 2022).

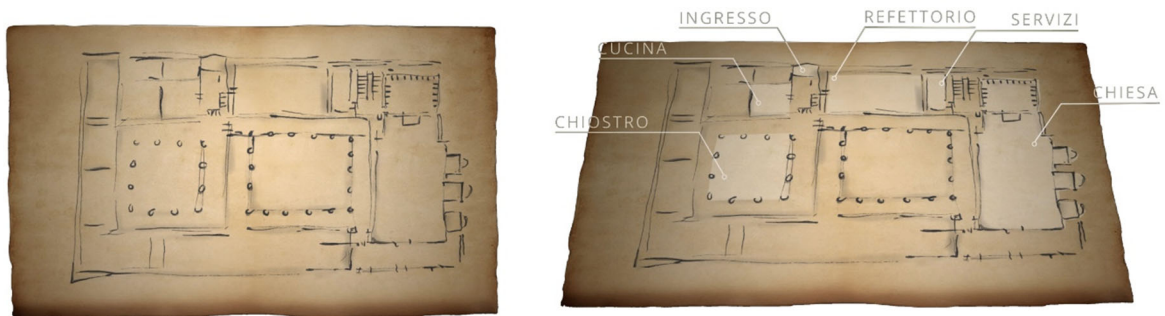


Fig. 4: On the left: Graphic reworking of the project sketch by Antonio da Sangallo il Giovane; on the right: visualization of the sketch showing the different functions of places.

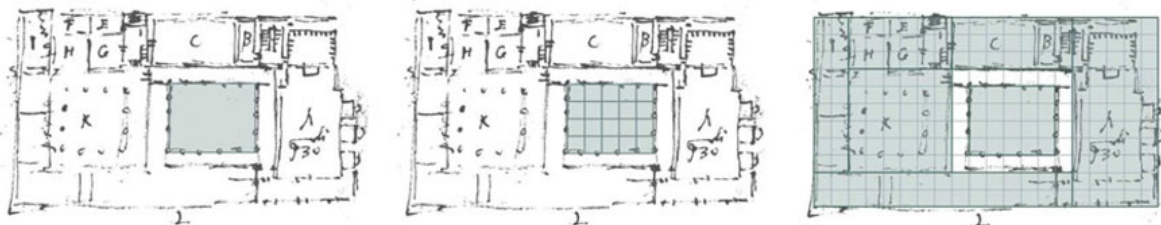


Fig. 5: Compositional-proportional studies performed on the project sketch of the plan of San Francesco's convent in Pitigliano.

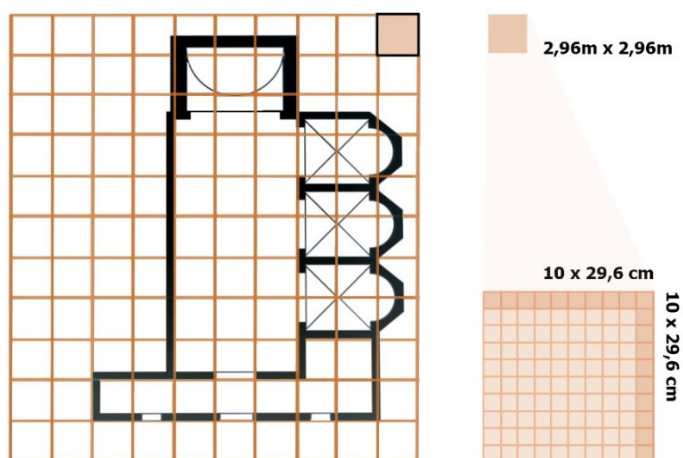


Fig. 6: Compositional-proportional study on the plan of the church through the modular grid obtained from the previous study.

The proportional geometric protocol then applied directly to the survey of the surviving structure revealed a direct match even in the elevations, which are still recognizable today. The building consistency, therefore, has been identified in its main characteristics of heights and distributions.

Missing at this point a stylistic reference to associate with the compositional one to trace the design idea. In this regard, compositional constraints of the surveyed structure were sought, such as portals, still recognizable facade openings, and traces of the ante-facade vestibule. It was then observed that the portals of access to the vestibule and the presence of a central rose window, would have conditioned the elevation of the vestibule itself, which was meant to allow direct light intake. For these reasons, the vestibule designed by Sangallo was assumed to be a single-register element, over which the gable of the church rises.

The result obtained was the subject of three-dimensional modeling, which from the plan design shows the construction of the building according to the proposed hypothesis and finally overlaps with the model inferred from the survey, of the church in its present state (fig. 07).

Two models of a different nature are thus obtained, the first is produced from a survey of the actual state, while the second is produced from a design model, constrained planimetrically and determined in elevations by the proportions introduced by the plans of the Sangallo il Giovane, and its analogous projects.

The final idea was to produce holographically, the superimposition of the two models and the representation of the document testifying to the design intention of the Sangallo il Giovane.

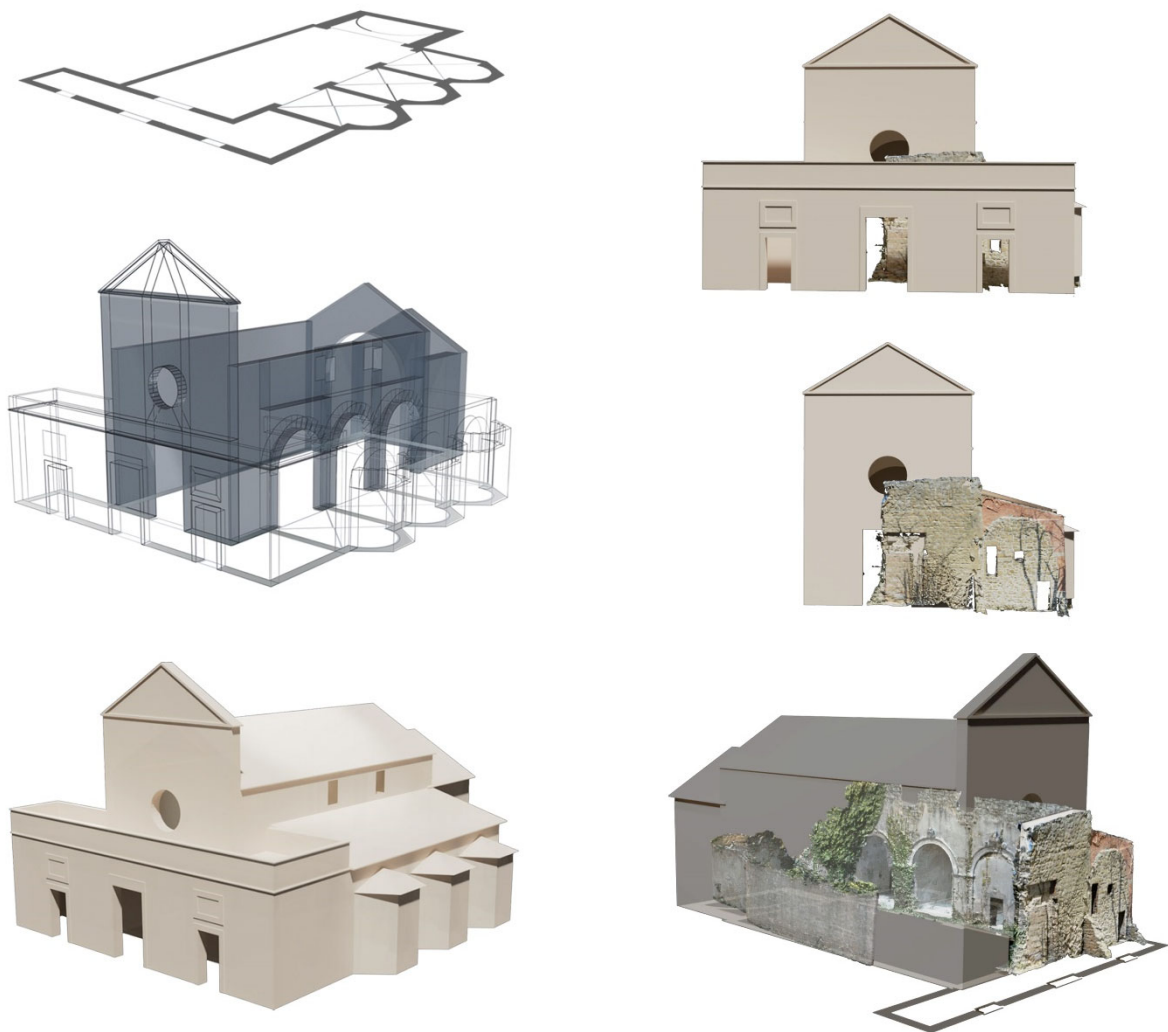


Fig. 7: Three-dimensional project of the hypothetical reconstruction of the church of San Francesco's convent according to the idea of Antonio da Sangallo il Giovane. And overlap of 3D model with the existing monument.

## 2.2 The case study of St. Maria church, Sovana

The small town of Sovana is characterized by the central Pretorio square and the ruins of the church of the patron saint San Mamiliano. It, believed to be the first church-cathedral of Sovana, is placed directly on the remains of an Etruscan and then Roman building almost bordering the Pretorio square whose northern edge is defined by the side of the church of Santa Maria.

It perhaps to be identified as that Santa Maria, which is consecrated by Bishop Ranieri of Tuscania in 1208, is certainly mentioned already in the will of Count Ildebrandino Aldobrandeschi, called *il Rosso*, of 1284, and recorded in the Decimari of 1296. In 1321-24, it was looted and possibly damaged by the Sieneze in 1410 and by the people of Pitigliano in 1434. Around 1558, the construction, on the initiative of Grand Duke Cosimo I de' Medici, of the Loggia with archive building, later to become Palazzo Burbon del Monte, deprived it of its facade, limiting access to only the side portal, open to the square (fig. 08).

The interior of the church is of the basilica type, with three naves divided by polygonal pillars supporting wide round arches. The nave is divided into three bays by Gothic transverse arches, on which the wooden trusses of the roof are set. In the center of the presbytery, raised on a few steps, is the famous ciborium (VIII-IX century), the only example of its type in Tuscany, referable to the pre-Romanesque period (fig. 09) (Rivetti, 2018).

In the work being presented, it is interesting to consider the urbanistic placement of the church in relation to the whole plan the plant. The latter consists of the square and a series of water distribution infrastructures that affect the last terracing where the entire city is set. The church, therefore, is in line with the oldest route that leads directly to the site of the present cathedral. Along this route, in the proximity of the apse of St. Maria's itself is the Public Fountain, currently facing the square, and a wash house at a lower level than the Fountain, adjacent, however, to the extroversion of the church's apse. In further analyzing the archival documents in the Technical Report of the Superintendence for the consolidation works of the church in 1984 it appears that in the apse outside during the excavation an empty archway was found, probably a possible ancient water access route connected to the water system described above (fig. 10).

The continuing problems inherent in rising damp that affected the interior of the church induced to investigate what kind of water structure was present of the area at the time before the church was built. In 2021, thanks to the INGV (National Institute of Geophysics and Volcanology) of the CNR in Florence, it was possible to resort to a geophysical exploration inside and outside the church by means of an electromagnetic radar technique (Ground Penetrating Radar, GPR) survey at 300 MHz and 800 MHz. This made it possible to investigate the stratigraphic conformation and the presence of any structures in the subsurface. The results obtained indicate that there is a depressed area under the church with a compluvial development at the bottom, probably backfilled with material similar (tuffaceous elements) to that of church construction. The compluvium appears to be directly in axis with the apse and its opening to the outside described above, still present today, and a collector placed in the direction of the present wash houses (fig. 11).

The water line, therefore, running from the cathedral to the main square, suggested the possibility that it was a permanence of water system of the classical period, also given the baths of the villa under San Mamiliano. The geophysical survey, moreover, returned a different density of material between the area of the aisles and the central nave of the church opposite the apse, delineating a well-defined rectangular area that ends in conjunction with the two rows of pillars. Opposite the present chancel, a very large apsidal form can be discerned that opens and extends the entire length of the church. This materializes a kind of double-apsidal plan with a central basin and an inflow channel that were placed in axis with the entire external water system (fig. 12).

Regarding the problem of continuous rising damp that still affects the structure today, it is shown that water continues to pass through by capillarity. It is noted how the level of humidity is distributed on the floor forming a hemicycle opposite to that of the apsidal basin of the church. These results gave the possibility to advance hypotheses about the previous use of the area by focusing on possible references to nymphaea of urban areas of Roman cities or classical in general, tried to connect the various outcrops of water adduction.

To make visible all that the instrumentation identified and highlighted, the choice was made not to make a copy of the church itself as such, but to structure a possible evolution from the Classical hypogeum layout to a conversion of the structure into a religious site of the early medieval period. The choice of 3D reconstruction is emphasized by the choice of the use of holographic representation, which through moving scenes, comprehensively depicts the steps in the history of the city of Sovana (Stefanini, et al. 2022).



Fig. 8: Photo of the church of S. Maria in Sovana, GR.

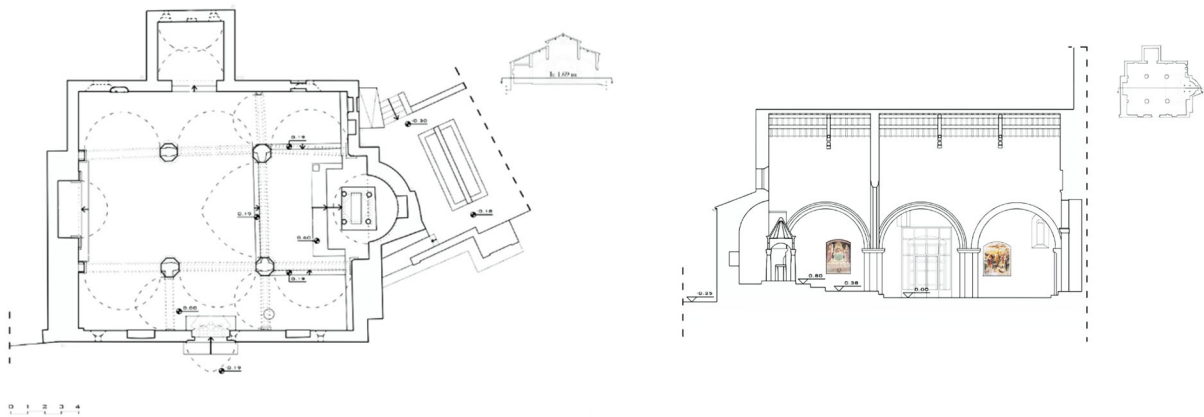


Fig. 9: Graphic elaboration obtained from the survey and developed by the arch. Domenico Rivetti in his Architecture degree's *Il battistero di S. Maria nella profondità della sua storia*, 2018.

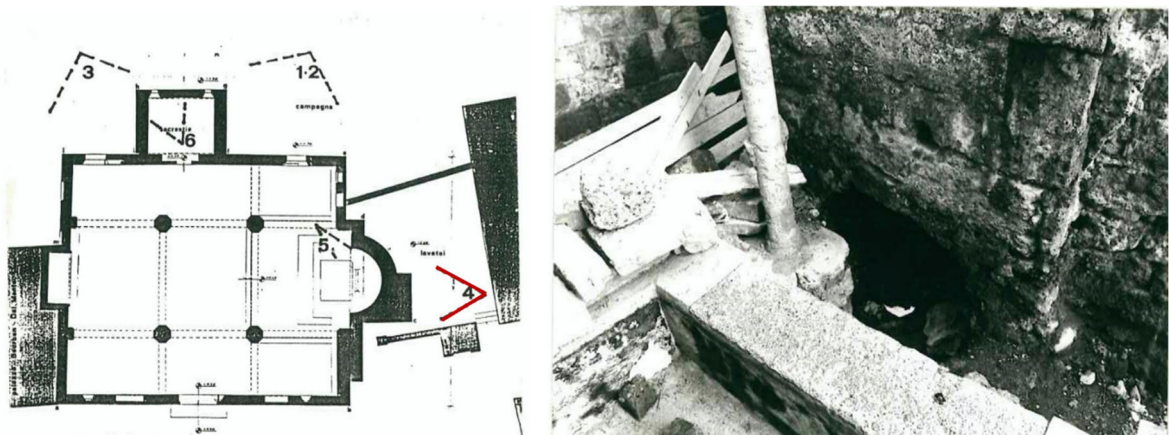


Fig. 10: Technical Report of the Superintendence, 1984. Detail of the empty archway found in the apse outside during the excavation.

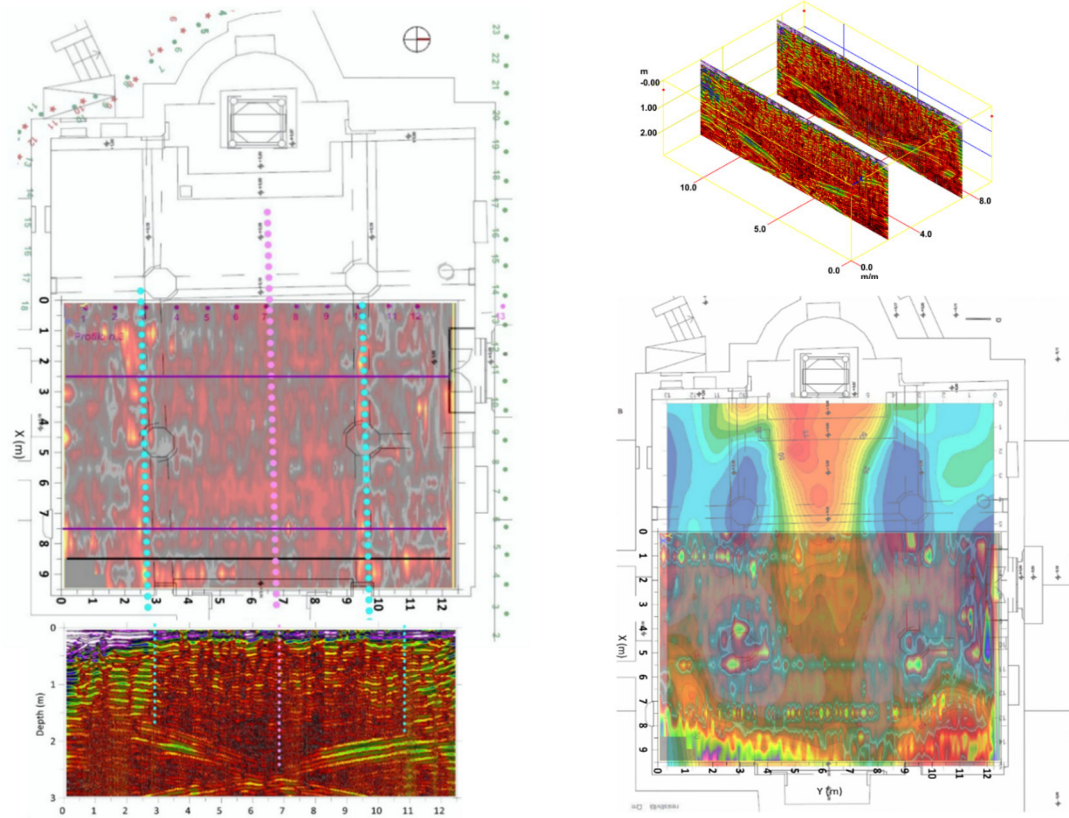


Fig. 11: Geophysical survey, 2021. INGV of CNR of Florence. On the left: internal section of the church GPR 300 MHz ( $z=190\text{cm}$ ) - Line 8.5m. On the right: overlay of EMP 400 and GPR 800 MHz comparative analysis.

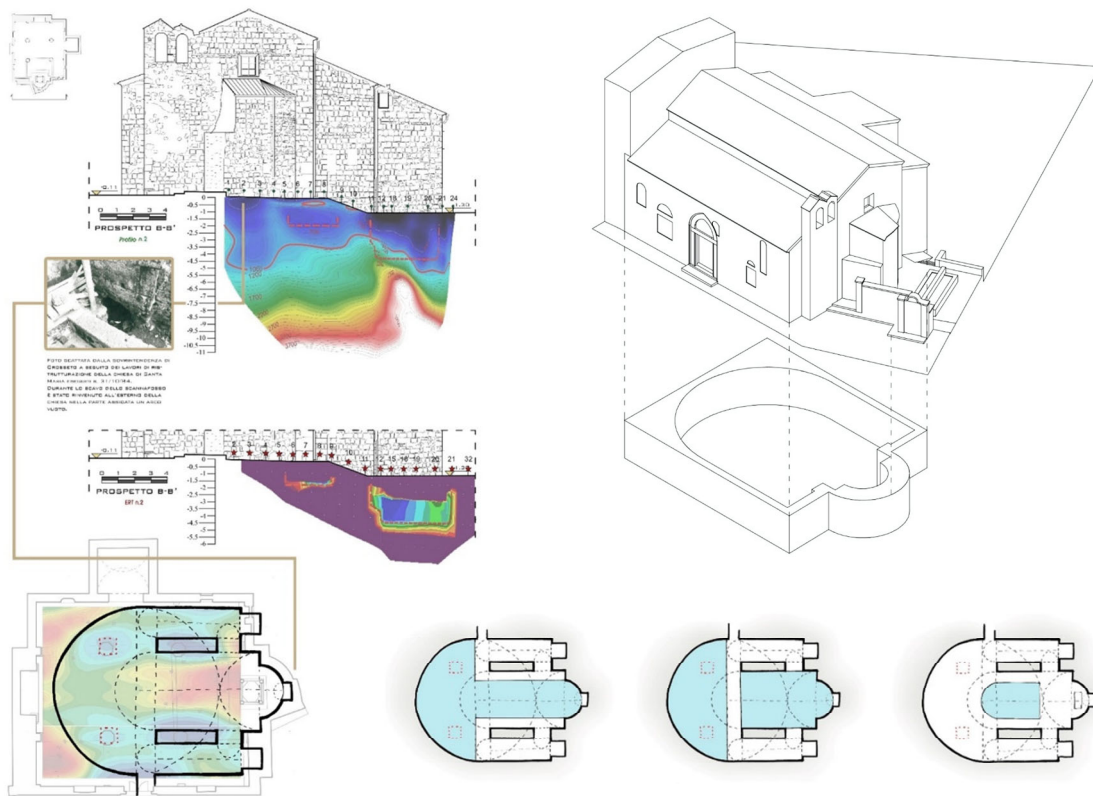


Fig. 12: Reconstructive hypothesis of nymphaeum types present in the hypogeum of the church of St. Maria. Arch. Domenico Rivetti in his Architecture degree's, 2018.



### 3. RESULTS

Operationally, the holographic representation, is actualized through the support of the holographic showcase, an instrument formed by a monitor that contains the images or video to be projected. They are reflected on the glass faces of a hollow pyramid trunk and recomposed in the center. The operation is based on the theoretical principle of projective geometry, whereby the image, or video, contained in the monitor is projected onto the transparent surfaces inclined at 45° of the prism, directly applying the principles of projectivity (homology) (Lecci, et al. 2019).

Interestingly, at a strictly operational and technical stage, a properly theoretical principle is being materialized into a result provided by theory. The principles of projective geometry make it possible to faithfully recreate an image or video animation of digitally made objects that appear via optical effect, in a three-dimensional view at the center of the pyramid (Yamanouchi, et al. 2016). To create the holographic projection, it was necessary to make a video that would show all the stages of the research previously described and be able to communicate the story of the building clearly and directly. The work involved writing a storyboard of the research contents and making them the protagonists of the images to be produced, structuring a storytelling to be included in the holographic showcase. To do this, the 2D and 3D material obtained from the survey was used, with which a real narrative plot was developed for the creation of the video animation (Gabellone, 2014).

The storyboard made it possible to sequence all the steps to be told, hierarchizing the information and, at the same time, managing its timing, effects, and steps. In the case of the church of St. Francesco, the paper document becomes the protagonist of a three-dimensional reconstruction of the project that then gradually reifies into the remaining structure of that architectural idea of which we have the trace sketched as a starting point. Geometric analysis of the plan follows until the building is made visible according to the architect's compositional ideas, finally arriving of what remains of the walls of the present ruin (fig. 13).

In the case of the church of St. Maria, on the other hand, the narrative starts from the dissolving of the interior and exterior walls of the church until it arrives at the level of the floor, beyond which the reconstructive hypothesis of that hypogeous environment, known only through the studies carried out on the subsoil, is depicted. Thus, what is not visible is made visible, leaving an idea, a curiosity about what is hidden under the thick walls of the Sovana church that we still see today (fig.14).

#### 3.1 The choice of hologram projection

Using high technology and new methods of digital representation such as holography, we expect to develop more explanatory and engaging narratives (Luschi, et al. 2023). Holograms become a form of interactive and educational visualization, closer to reality by distancing themselves from the use of the support of visors (VR) that isolate from the outside world.

With the implementation of the above-described videos in the holographic showcases inside the Diocesan Museum of Palazzo Orsini in Pitigliano, it was possible to give visibility to the museum and its inaccessible external archaeological sites, making them virtually visitable (figs.15,16).

The museum reality has the purpose of both musealization and being able to have effective communication with visitors. The goal is to present new forms of communication that allow the dissemination of knowledge about the historical-archaeological heritage. Allowing the involvement of increasingly diverse user targets, offering a complete and satisfying visit (Lecci, et al. 2022).

### 4. CONCLUSIONS

The results that have emerged from the two approaches and experiences are of different tenors. The first that of the church of St. Francesco is the attempt to pursue an idea that leaves its trace from the beginning for the conception of the drawing, to its realization. In between these two major terms is an activity of logical reconstitutions of the project idea that is verified in parallel, both by the drawing and the preliminary sketch, and by the result whereby the extreme terms make the intermediate procedure more and more plausible.

The second experience, on the other hand, there is an evolution to be made visible, still, and partly inaccessible. The technology used puts us in a position to extrapolate a drawing. This drawing is a fact that, however, must be compared with the actual drawing of the church of St. Maria.

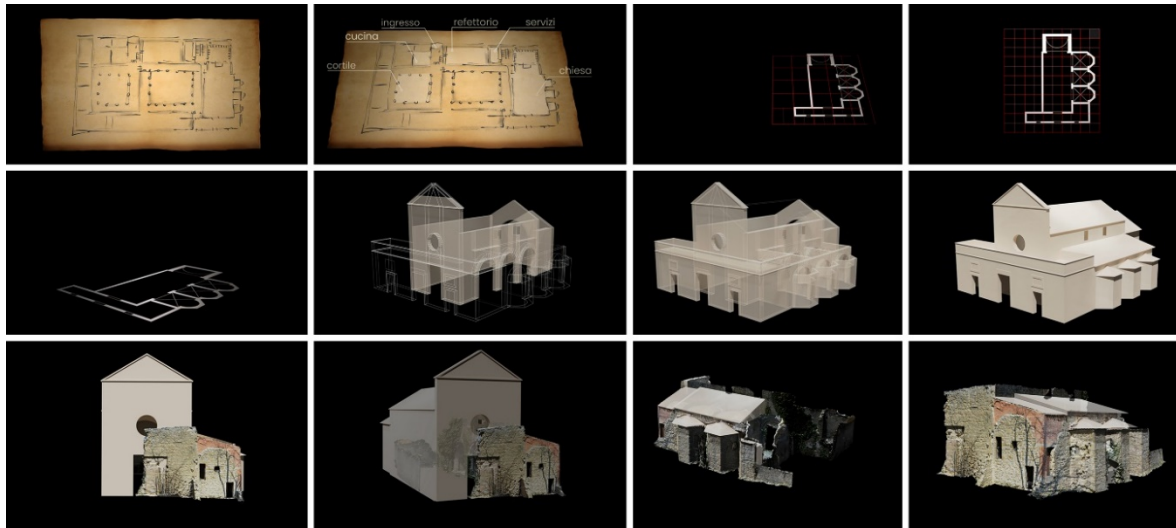


Fig. 13: Some frames in sequence of the video elaboration of St. Francesco's convent in Pitigliano, created to be projected inside the holographic showcase.

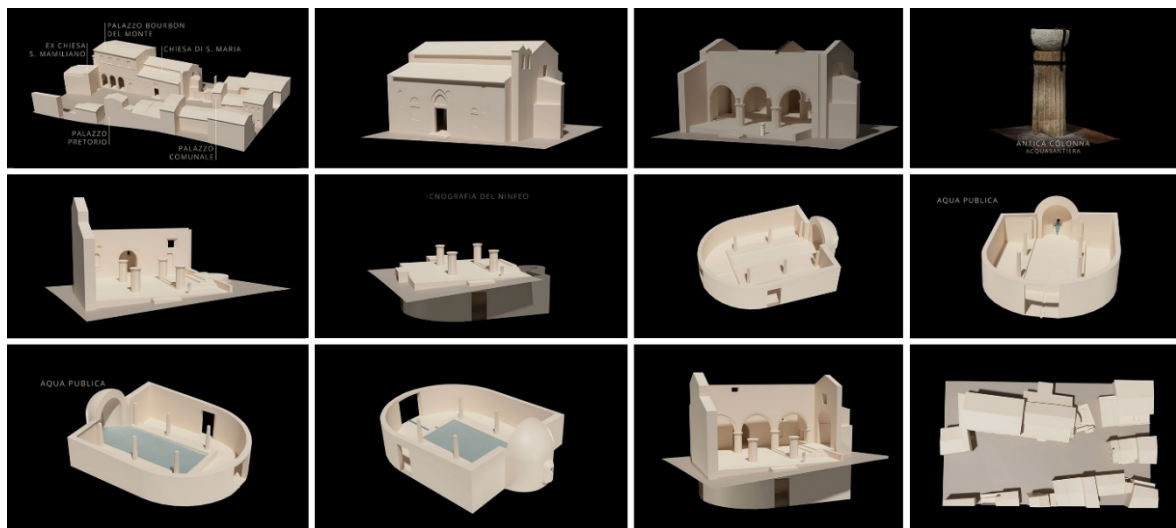


Fig. 14: Some frames in sequence of the video elaboration of St. Maria in Sovana, created to be projected inside the holographic showcase.

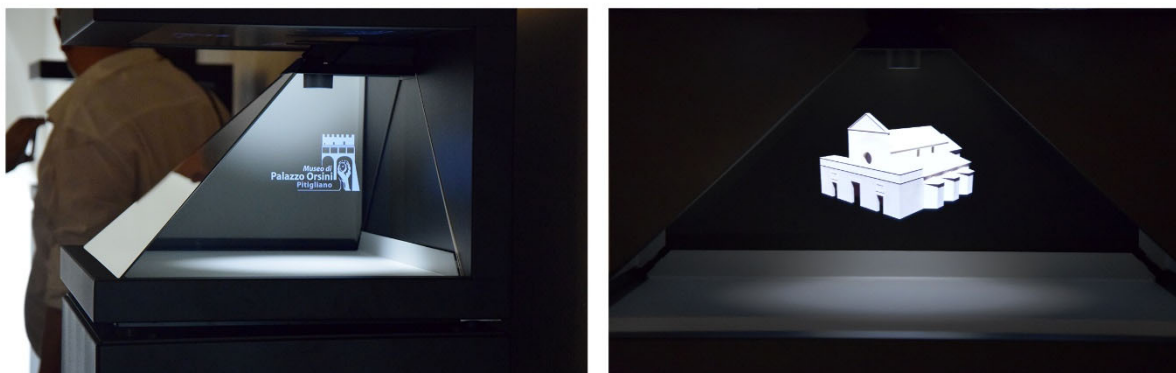


Fig. 15: The showcase shows the holographic projection of the video, as indicated by the sequence of frames.

Here it is that between these two moments a logic must intervene introduced precisely by a digital model that mediates the positions, the hypotheses and makes them visible in a becoming understandable and consistent with

what are the scientific data placed at the end of it.

So, if in the first case there is a drawing of a project and then a verification of that data through a model, in the second case we have two survey models of a different nature working together and helping to verify the evolutionary stages of a site. Focusing not on the representation of the object itself but of an evolution of an idea and a resemantization of urban spaces.

The digital copies, then, managed to show the effectiveness of a research and its different moments of in-depth reconstruction of hypotheses, returning a unicum that is coherent and somehow re-presenting the becoming of these architectures, in the passage of time.



Fig. 16: Photos of the holographic showcases with their projections, inside the Museo Diocesano of Palazzo Orsini in Pitigliano, on the inauguration day, year 2021.

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