International Congress for Heritage Digital Technologies and Tourism Management
June 20th – 21st, 2024. Valencia, Spain
Doi: https://doi.org/10.4995/HEDIT2024.2024.17727

Integration of Historical Sources, HGIS and HBIM for Cultural Heritage Sites: The Digital Reconstruction of the Islands in the Venice Lagoon

Federico Panarotto[a], Ludovica Galeazzo[b] and Gianlorenzo Dellabartola[c]

Department of Cultural Heritage, University of Padua, [a], federico.panarotto@unipd.it; [b], ludovica.galeazzo@unipd.it and [c], gianlorenzo.dellabartola@unipd.it.

How to cite: Panarotto, F., Galeazzo L. & Dellabartola G. (2024). Integration of Historical Sources, HGIS and HBIM for Cultural Heritage Sites: The Digital Reconstruction of the Islands in the Venice Lagoon. In *International Congress proceedings: International Congress for Heritage Digital Technologies and Tourism Management HEDIT 2024*. June 20th - 21st, 2024. Valencia, Spain. https://doi.org/10.4995/HEDIT2024.2024.17727

Abstract

Starting from the 16th century, when the city of Venice began to systematically structure its water territory, the over sixty islands that shape the lagoon became an integral and fundamental component of its urban space. Today, much of this heritage site has disappeared or, in some cases, is in a state of complete abandonment. This situation prevents citizens or visitors from fully understanding the history and major events that characterised the lagoon's complex past, as well as the reasons for its current decline. Venice's Nissology *(VeNiss) is a project aimed at representing this peculiar urban context through an interactive 3D web map in which users can virtually explore the water-bound settlements and their transformations over time, from the sixteenth century onwards. The development of this online geospatial platform involves an articulated methodological process that includes an heterogeneous group of scholars, such as architectural and art historians, as well as experts in digital surveying, GIS (Geographic Information System) and BIM (Building Information Modelling). Building on the analysis of historical documents – specifically maps, iconographic sources, and textual documents – alongside survey data, either already existing or newly obtained through measurement campaigns, the project aims to create interoperable bi- and three-dimensional digital models of thirty islands over the centuries, allowing for the visualisation of their urban and architectural transformations in relation to relevant historical information. 3D models are created through a process of data re-elaboration and interpretation aimed at vectorialising the considerable and varied amount of existing iconographic sources and visualising the relationships between them. The ultimate goal of the project is to implement these virtual models in a geospatial structure that ensures users can gain a conscious understanding of the events that involved these places and the transformations that led to their current state.*

Keywords: *HBIM, HGIS, 3D models, Venetian lagoon, digital tools, VeNiss.*

1. Introduction

The ERC project *Venice's Nissology. Reframing the Lagoon City as an Archipelago* (VeNiss) digitally reconstructs the history and urban transformations of the hitherto neglected cluster of over sixty islands of varying sizes that, scattered across the Venetian lagoon, compose the archipelago of Venice. Today, this unique environment is in a state of severe disrepair, as most of its islands have been razed to the ground over the past two centuries and they now lie abandoned and detached – physically and conceptually – from the city centre (Galeazzo, 2024).

The origins of the gradual dissolution of the bond between Venice and its *aquascape* lie in the aftermath of the fall of the Republic in 1797. The suppression of ecclesiastical orders by Napoleon and the islands' conversion to accommodate warehouses, military hospitals, and barracks led to radical changes. These events not only transformed the islands' geography but also altered the perception of the articulated network of relationships that once sustained the archipelago's life. Nineteenth- and twentieth-century interventions erased the visual and historical memory of major buildings and architectural complexes, as well as an entire system of interdependent urban places that constituted the liquid outskirts of Venice, namely its whole periphery.

More than just an ornamental frame, from the early middle ages, the lagoon embodied an integrated system of calculated politic, socio-economic, and cultural interactions between the city and its water margins and islands functioned as capillary structures for the interests of the capital. Like pieces on a skilled player's chessboard, at various moments these urban settlements addressed the different needs of Venice's urban framework. Starting from the eighteenth century and for almost the entire following millennium, the lagoon islands opened their doors to almost all the main Christian religious orders, which played major roles as active patrons of pioneering works of art and architecture. These islands also served as connective centres called upon to sustain the social and economic life of Venice. In particular, they fulfilled the capital's need for food by producing, processing, and providing foodstuffs for their inhabitants as well as for the whole city. The tiny strips of lands were no less essential socially, as they housed infrastructures that served the daily needs of the larger Venetian community, such as public boathouses, guest houses, inns, and gunpowder magazines as well as a series of military structures that helped preserve the State's invulnerability over the centuries. Likewise, they proved to be crucial for the public health facilities of the city. Two islands – the Lazzaretto Vecchio and Lazzaretto Nuovo – were permanently used as lazarettos to quarantine people and goods during the plague, while a number of other sites operated as supplementary shelters in times of crisis. The aqueous environment was finally the stage set on which the Republic promoted the glory and power of the State through ostentatious ceremonies and events contested on water and offered bespoke state lodging services to visiting foreign dignitaries.

The assimilation of the many lagoon settlements into a single archipelagic network was the result of a complex socio-political but also conceptual construction process systematically developed by the Republic over the centuries, encapsulating the city's rising consciousness of its geographically and functionally granular identity. Their demolition irrevocably interrupted the centuries-old network of relationships that connected the islands with each other and with the city centre, transforming a robust and organic sprawling urban environment into a stark assemblage of isolated islands.

With a view of reconstructing the urban history of the lagoon and reassessing Venice as a whole archipelago, the project VeNiss aims to reconstruct the broader social and geographical inclusiveness of Venice's water landscape by visualising and interpreting the islands' transformations and their supporting functions for the capital in an interactive online platform. This combines digital reconstructions of almost thirty islands – out of sixty – over time with their pertinent historical data. This platform is meant to help users understand not only the lagoon's ancient morphology over the past five hundred years but also how this operated and conceived itself as an integrated network.

Developed at the Department of Cultural Heritage of the University of Padua in partnership with the Harvard University centre of I Tatti and the Department of Architecture of the University of Florence, this research was granted an ERC Starting Grant by the European Research Council for five years (2023-2027).

2. Reconceptualise Venice as an archipelago through a geospatial infrastructure

The demolition of entire lagoon complexes, monasteries, convents, and architectural monuments offers a compelling gauge for experimenting with new techniques of digital visualisation applied to urban history research. The first objective of the project Venice's Nissology is therefore the reconstruction of the ancient urban and architectural configuration of the Venetian archipelago throughout time in order to determine the nature and extent of its transformation, thus enabling the exploration of a nearly lost cultural heritage. In addition, VeNiss aims to delve into the social, political-economic, and cultural dynamics that shaped the historical organisation of the lagoon archipelago over the centuries.

To fill a crucial knowledge gap, the project proposes an online geospatial and time-based semantic infrastructure that allows users to digitally navigate the historic lagoon while discovering its ancient appearance and socio-urban framework. Leveraging on the capabilities of digital surveys, HGIS mapping, HBIM modelling, and semantic technologies, the infrastructure enables the intersection of 2D and 3D models of the many islands over time with pertaining historical data. These are disseminated across a profuse number of textual and iconographic documents, ranging from descriptions, rental contracts, and notarial deeds to maps and drawings, paintings and, for more recent times, accurate surveys, aerial photographs, and orthophotos. This extensive documentation, in myriad formats, is classified on the platform into four main categories or "entities": the sources (primary and secondary), the events recalled in the historical documentation, the actors involved in these sequences of actions, and the built works themselves, marked as buildings, islands, open spaces, and waterways (Galeazzo et al., 2024).

As a sort of "Google maps of the past", the geospatial infrastructure invites users on a journey through time and space, revealing the many urban processes that shaped Venice. The platform displays a map of the whole lagoon with overlaid two- or three-dimensional models – which are the results of HGIS and HBIM reconstructions – representing the water basin's ancient landscapes. These visualisations are superimposed on the base map and constrained by both a timeline and the zoom level. The time slider allows users to select a specific point in time, displaying the 2D or 3D historical features that correspond to that year. Thus, by moving across the decades and exploring different corners of the lagoon, the ancient islets come to life in their physical appearance and spatial arrangement. Additionally, the platform enables users to navigate between sources that served as the foundation of the research. All entities related to features displayed on the map at a specific time are listed on a sidebar, called the navigator. These include archival and iconographic sources, bibliographic items, but also actors, architectural and socio-economic events, and places that, at any time, can be filtered by type and displayed as either entry-level information or in-depth metadata (Figure 1).

To make the process of digital reconstruction visible to the public – and therefore open to discussion –, the infrastructure also allows the overlay of georeferenced images on the base map, which served as the basis for drawing the geospatial features. Users can drag and drop images or modify their transparency to compare different maps and their pertaining visualisations.

Robust search and faceting components also allow for fine-tuned visualisation of archival sources and geospatial features. By applying filters and manipulating features' colours and labels, users can effectively visualise information about the various functions (private/public), uses (religious, military, healthcare, etc), typologies (church, monastery, warehouse, gunpowder tower, etc), architects, patrons, owners, and tenants related to the many islands over the centuries.

These complex spatial analyses are intended to support the interpretation of the archipelago's changes over time in terms of urban space, social activities, state/private jurisdictions, and interactions between different actors involved in the place-making process. At the same time, the ability to navigate the ancient archipelago through 2D and 3D virtual models of disappeared places and visually contextualise historical documents allows comparisons of architectural solutions, spatial typologies, materials, and building techniques. This exploration reveals the agency of many actors in the circulation of architectural and artistic models between the islands, the city, and the Italian Peninsula.

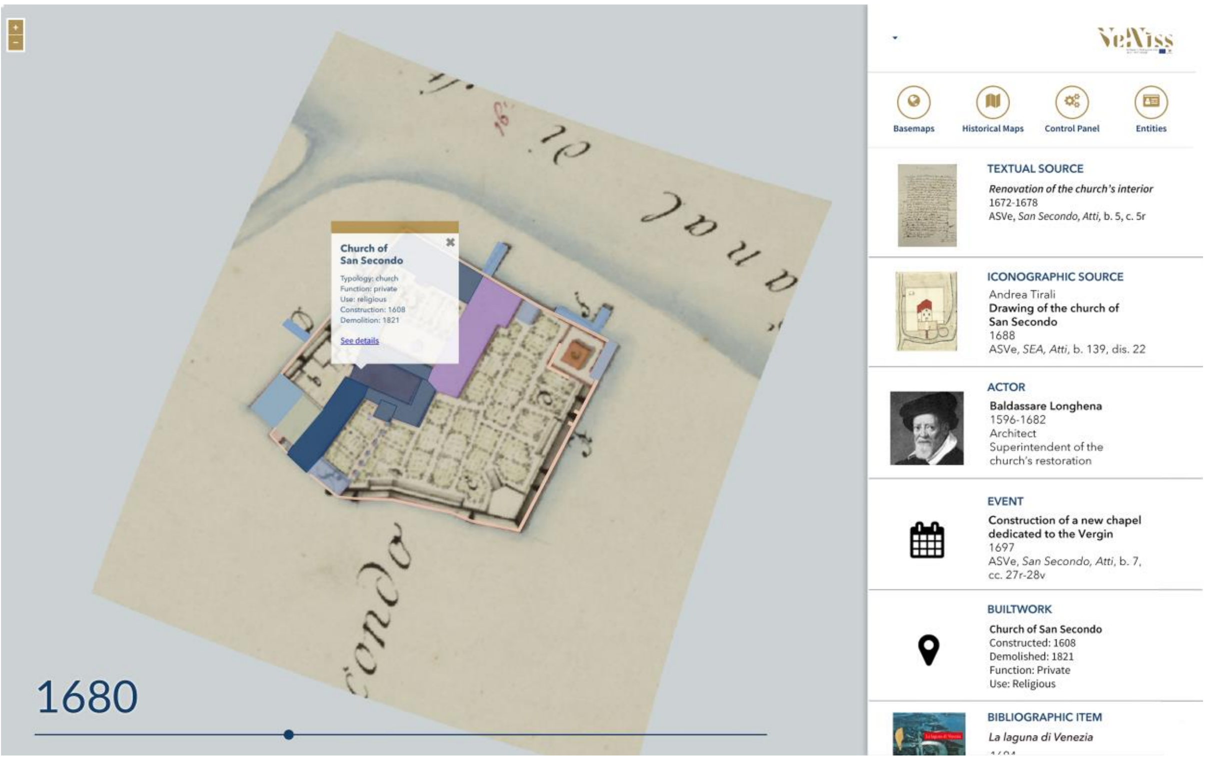

Figure 1. Layout of the VeNiss geospatial infrastructure.

By providing the possibility to visualise and interrogate historical information and archival data directly on the pertinent digital reconstructions, the infrastructure not only helps rediscover a cultural heritage that has almost completely disappeared but it also re-evaluates the city's borderlines as sites of incessant synergistic cultural, social, and economic dynamics, thus helping to move the discourse away from the typical schema of "centre-to-periphery".

3. Digital surveys for the definition of HGIS geospatial geometric references

A fundamental step in understanding the history and structure of the lagoon islands, with a particular reference to their current morphology and architectural condition, involves acquiring measurement data through digital surveys. These integrated surveys aim to provide reliable, georeferenced, and updated cartographic elaborations, which are crucial for georeferencing historical maps and drawings that describe the islets' former shapes. The newly acquired measurements are extremely significant as they constitute the base map for the georeferencing processes that complement outdated or often non-existent data.

The methodology adopted by the joint research teams of the University of Florence and Padua, responsible for the survey campaign, was highly sophisticated. Given the unconventional environments of the island settings, this involved using various types of instruments, preferring a static approach over a dynamic one according to need. It comprised fixed (TLS) and mobile (MLS) laser scanning systems for fast survey operations (Dell'Amico, 2021), integrated with photogrammetric databases from ground, drone (UAV), and underwater acquisitions. Additionally, spatial data were accompanied by morphological information expressed as GPS points, subsequently integrated into point clouds. The complexity of the selected case studies is evident from the need to use different survey instruments with the aim of collecting as much comprehensive data as possible. Equally complex was the data processing phase, which required the analysis and discretisation of a large amount of collected materials, subsequently uploaded into an integrated database. This database constitutes the indispensable basis for representing the current and historical configuration of the islands. To these extents, a new graphical language was defined through representation, in which reality is simplified in favour of selective information communication:

the drawing explicates descriptive needs operating through graphical synthesis and information transmission (Parrinello & Picchio, 2023).

To connect the information and graphical elaborations obtained from the digital surveys with both the database and the historical-archival documentation, the project VeNiss adopted a geographical information system for historical cartography (HGIS). This tool not only allows the acquisition, management, analysis, and visualisation of geospatial data, thus enriching the graphical data derived from the survey – vector drawings – with metadata, but it also enables the generation of dynamic and interoperable databases.

With the aim of representing the various transformative phases of the Venetian islands over the centuries, the process implies a backward reconstruction procedure. This begins with documenting the current state of the lagoon and then moves back in time to reconstruct changes through comparisons with historical maps and other archival materials (textual or iconographic). Within this methodology, historical documents – detailed maps, drawings, and large-scale plans – play an essential role in analysing spatial alterations, because they allow scholars to compare the current morphology of the lagoon settlements with numerous historical representations of ancient islands, thus facilitating the identification of urban and architectural transformations as well as the presence of buildings that have been modified over time (Galeazzo, 2024). This process of comparison involves identifying a series of reference points (ground control points) on historical maps that are still visible in the existing settlements and are necessary for georeferencing the iconographic documentation. These well-identifiable elements can be represented by geographic points, significant buildings, coastlines, or other urban and architectural components that scholars consider stable links between past and present environments (Picuno et al., 2019).

Once a series of ground control points is selected, historical maps are georeferenced through polynomial operations of roto-translation and scale variation, in order to adapt them to the current graphical elaborations. This process forms the foundation for the vectorisation activities that imply both drawing each urban and architectural element of a given island and reconstructing its many changes over time. In the GIS space, the resulting polygonal features are represented by four informational levels or "layers": canals, islands, open areas, and built works. These vector representations are integrated within the GIS environment with information regarding the temporal phase of each feature (namely its presence/absence in a given historical map) catalogued within specific attribute tables connected to the specific layers.

Both the georeferenced cartography and the vector features obtained in the GIS system are then implemented in the VeNiss online infrastructure. Here, they can be viewed and explored by users through a timeline and integrated into the BIM environment for constructing three-dimensional models that will also be loaded into the geospatial infrastructure.

4. From HGIS to HBIM: An interoperable methodology

The aim to describe an extensive area such as the Venetian lagoon through a sort of "4D geographic internet service" implies creating georeferenced graphical representations derived from the relationship between geographic/territorial data, managed within an HGIS system, and urban/architectural data, obtained within an HBIM (Historic Building Information Modeling) environment (Dore & Murphy, 2012). Additionally, the utilisation of extensive historical documents, crucial for depicting the islands' transformations spanning over more than five centuries, necessitates a robust management database.

In this framework, GIS serves primarily for georeferencing existing surveys or complex historical cartographic documentation in raster format, as well as for generating two-dimensional features associated with specific information. Building upon GIS features, the BIM methodology is employed to produce three-dimensional models using REVIT software. When focusing on built heritage, the term HBIM is certainly more appropriate (Murphy et al., 2009). This methodology, widely adopted in recent years, has significantly influenced the operations of documentation and monitoring of cultural assets (Diara, 2022) HBIM is in fact an advanced approach that combines the principles of Building Information Modelling with aspects related to the conservation and management of historic buildings and cultural heritage. This approach involves a series of specific activities aimed at creating digital models of historic buildings to enable a better understanding, conservation, and management of transformations of a given building throughout its whole lifecycle. In the VeNiss project, these capabilities are even more evident as we are dealing with a nearly lost cultural heritage site, where integrated 3D models serve as the only means to uncover the appearance and intricate history of significant ancient buildings and architectural complexes.

The creation of three-dimensional models in this research relies on close and continuous collaboration between architectural/art historians and BIM operators, but this is also greatly facilitated by the use of interoperable tools. To these extents, an elaborate protocol has been developed to manage information exchange among team members, outlined in a diagram known as Process Map (PM) (Figure 2). The PM, developed using the standard Business Process Modeling Notation (BPMN) approach (OMG, 2013), delineates all activities performed by the team, categorised by disciplines (referred to as Tasks), and the Exchange Requirements. These requirements are encapsulated in documents called Exchange Models, which define the information to be exchanged. This section highlights the activities undertaken by HBIM modellers and the corresponding data exchanged with GIS experts and art/architectural historians.

Drawing upon the conventional HBIM methodology integrated with customised processes tailored to the case study, the practice of constructing 3D models is structured into the following phases:

- Creation of the model representing the current building (Task 1.3);
- Definition of temporal phases and integration of historical data into the model (Task 2.2);
- Modelling of historical phases and assignment of temporal parameters (Task 3.2).

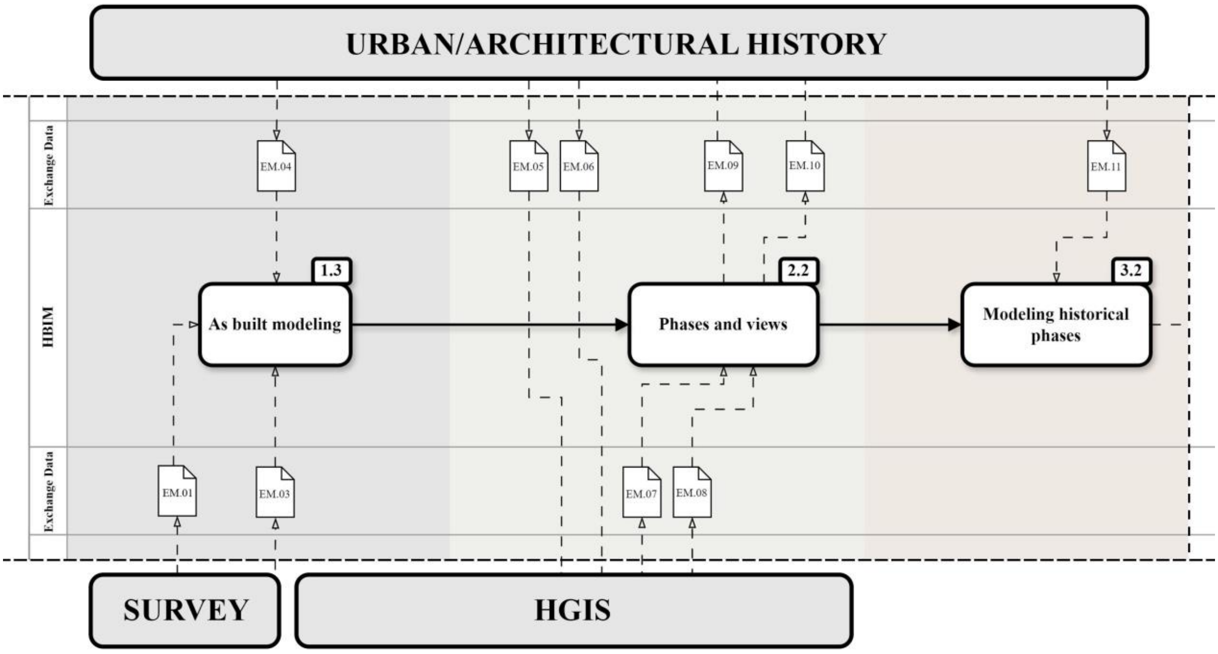

Figure 2. Process Map where the adopted workflow is schematically represented.

4.1. Creating as-built models

The initial phase of 3D reconstruction activities entails crafting BIM models reflecting the as-built state. Each building (or larger complex comprising multiple structures) is managed in separate files, which are then linked in a federated file based on a system of shared coordinates. The decision to divide the architectural space into multiple components is influenced by both constructional factors (such as the necessity to link specific parts of a building like common floor plans, etc.) and historical considerations (such as the uniformity of the construction period or functional relationships). In addition to the files representing architectural, construction, and civil works, a dedicated file for the topographic component of the island is created, which includes information about both its terrain and the vegetation.

3D models depicting the current state are developed by using input data derived from either existing surveys or new survey campaigns. In the first case, data typically consist of general floor plans, site maps, elevations, and sections, which, often not spatially located, require georeferencing in a GIS environment. Conversely, new digital surveys include georeferenced point clouds that, once processed, allow for the creation of BIM models using the standard Scan to BIM procedure (Banfi, 2020).

Given the multitude and heterogeneity of input data, harmonisation operations are necessary to ensure standardised modelling results. Regardless of the precision degree reported in available surveys (which is assigned a reliability score), the final result maintains a standardised level of detail. The Level of Information Need (LOIN) used during the modelling phase aligns with a Level of Detail (LOD) of 200/300 for the as-built state and 100/200 for historical phase modelling (Figure 3). Because the main purposes of the models are the visualisation and valorisation of the built heritage, the theme of LOD and Level of Reliability (Bianchini & Nicastro, 2018) is conditioned by the quality of the acquired original data. Models related to the current state may be reused for future purposes, necessitating increased level of detail. These purposes may include structural analysis, environmental simulations, surveys, assessments of degradation, etc., crucial for building conservation, maintenance, and restoration over time.

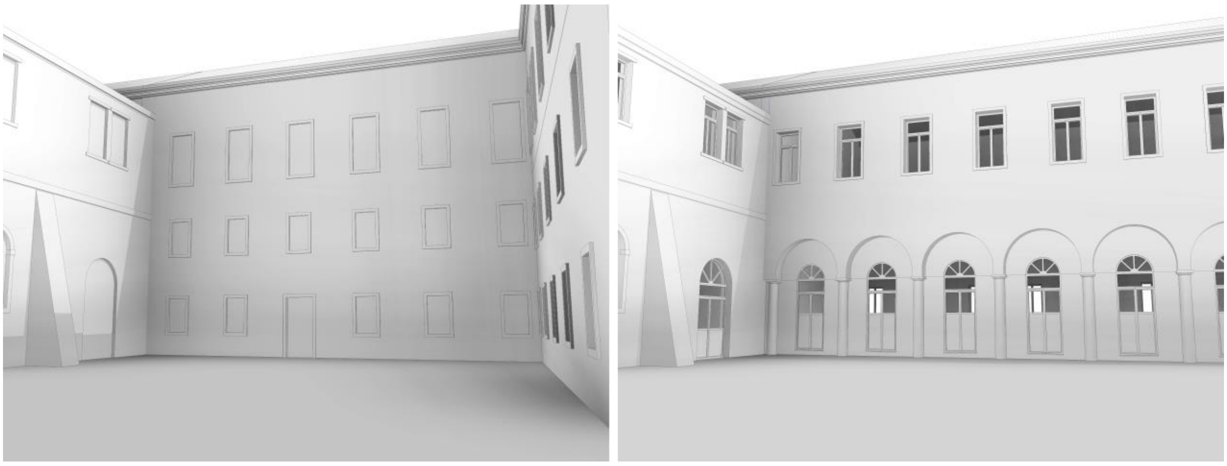

Figure 3. Image showing the difference, referred to the same portion of the building, that sometimes occurs between the level of detail of the as-built model (on the right) and the model representing historical phases (on the left).

4.2. Historical data integration

Mainly working on textual sources (both primary and secondary) and iconographic sources (historical maps, drawings, engravings, frescoes, paintings, views, and photographs), researchers of the VeNiss project need to constantly share historical information with GIS and 3D modelling experts. This approach requires a well-define and iterative collaboration process. Historical data comprise the number of “temporal phases” of a built work that need to be reconstructed (namely the temporal period located in between two starting/ending moments of a building structure) as well as iconographic sources that constitute the building blocks for the creation of the virtual instances. This material encompasses historical maps, plans, and drawings developed using GIS tools, along with other iconographic sources useful for HBIM model development. In this phase, HGIS is employed for the collection and integration of geographic data, but also because it stores drawn features in a PostgreSQL database running the PostGIS module (Galeazzo et al., 2024).

With regards to the GIS methodology, for each shapefile, an Identity number (ID) is assigned, and, using a boolean method (true/false), its presence or absence within the attribute table is indicated through a series of columns that refer to the dates of the historical maps used in the georeferencing process. The next step involves linking the historical metadata with the actual GIS functionalities. In order to implement this process, we decided that it was beneficial for scholars to integrate information about various aspects of a built work directly into the infrastructure so that they can work in a single environment and they do not need to access the GIS system. These include:

- Date parameters (construction / demolition);
- Functions (private / public);
- Uses (religious, military, healthcare, …);
- Typologies (church, guesthouse, refectory, …);
- People (architects, patrons, owners, …);
- Events (social, economic, urban, …);
- Artworks (paintings, sculptures, artefacts, …).

These data embedded in the platform, which consist of two-dimensional features and their associated attributes, are also transferred into the BIM modelling platform to create three-dimensional models (Figure 4). Additionally, all iconographic sources are integrated into the BIM environment through an XML (Extensible Markup Language) table. This contains the URLs (Uniform Resource Locators) of the original scanned documents gathered in a shared cloud storage.

To enhance interoperability between systems, each BIM object is assigned the same identifying code as the GIS features, enabling team members to easily identify the built work in both environments. Furthermore, the ID number is crucial as it ensures the subsequent transfer and management of 3D models within the VeNiss platform. Once GIS features, along with their pertinent temporal phases, are imported into the software REVIT, views are created and a display filter allows the visualisation of only BIM objects present in a given phase. These procedures are executed using scripts created with VPL (Visual Programming Language), which automate specific tasks that are not covered by the modelling software or would otherwise be repetitive.

4.3. Modelling the historical phases of a built work

Once the temporal phases of a historical building are defined and GIS data, including georeferenced historical maps, are imported into the REVIT environment, the process of modelling the historical phases can begin. This involves the creation or deletion of new buildings and the transformation or modification of existing units. During this phase, it is crucial to assign temporal parameters of construction and demolition to each individual BIM object, as the built works on the islands have been significantly transformed or altered over the centuries. As mentioned, the level of detail for 3D models representing historical transformations is LOD 100/200, where virtual instances are depicted with a depth of information related to the acquired historical data. Specifically, only documented historical evidence justifies the modelling of specific technical or decorative apparatuses; otherwise, a simplified schematic modelling approach is adopted (Giordano et al., 2023). The use of two different levels of details not only reflects the philological approach of the project but also enables users to understand the varying degrees of information derived from historical iconography (Bevilacqua et al., 2022).

Furthermore, we resolved to use parametric modelling procedures since BIM models, by their nature, allow for the agile update of object geometry directly through the modification of their dimensional attributes (Sacks et al., 2018). This capability is crucial as it facilitates the easy and rapid modification of 3D models in response to new discoveries or different interpretations developed by scholars during their research. To this extent, once produced, the models are shared in an online BIM management software, usBIM by ACCA Software, in which historians involved in the project can share their opinions and comments on the modelling results. In particular, through a user-friendly interface, they can explore the 3D models and provide feedback and annotations directly on them. This procedure creates an iterative process in which the BIM operator can incorporate changes and updates directly into the 3D reconstructions until a high-quality result is achieved. However, the use of this external platform is only temporary. In the future, when the VeNiss infrastructure is fully developed, this process will be carried out internally.

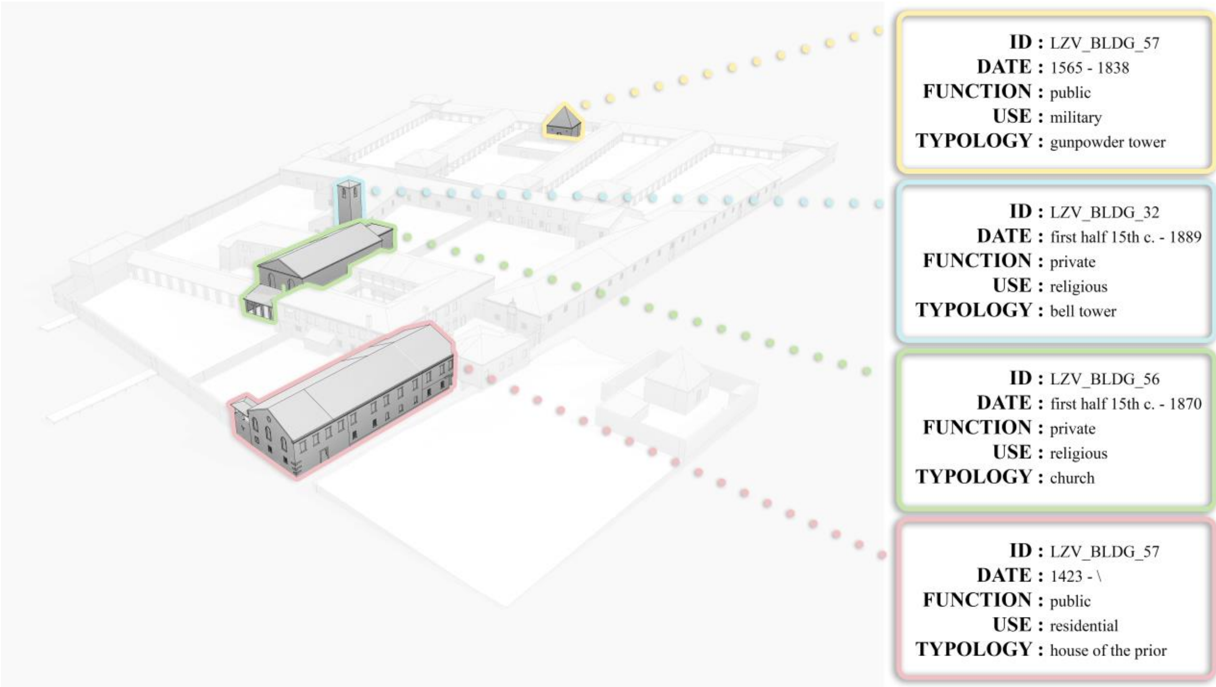

Figure 4. In the image, some of the data associated with building entities are graphically represented.

5. Results

The described process has been applied to two initial case studies: the islands of San Servolo and the Lazzaretto Vecchio. Both located a few hundred metres south of St Mark's basin, they were chosen for the immediate availability of existing surveys and for their complexity. Following the typical BIM methodological process, 3D models were created and organised in complex hierarchical structures. At the top of this hierarchy is the Project entity, followed by, in progressive order: Site, Building, Level, Room, BIM object. Models are linked in a federated coordination file that coincides with the export model in the Industry Foundation Classes format (IFC), which allows the transfer of file into the VeNiss platform (Figure 5). Each file is identified by a specific name consisting of:

- Project code (VNS);
- Island identification code (SSV, LZV, …);
- Model type (M, T o F);
- Unique code (001, 002, … , 00N);
- Level (GF, 01, 02, ZZ, …);
- File type (M3 = 3D Model);
- Discipline (A, S, E, …).

According to this schema, for instance, a file containing a 3D model of a building located on the island of the Lazzaretto Vecchio, comprising multiple levels and referring to a given architectural feature, would be named VNS_LZV_M_003_ZZ_M3_A. The same coding is applied to other related entities, such as Level, Room, and BIM objects. Virtual models are created starting from the current state and then, moving backward in time, they extend to the 16th century to reconstruct the more ancient phases based on large-scale maps or detailed historical drawings. Planimetric documents are also integrated with other types of sources that describe the buildings' heights, such as sections and elevations. However, these documents are quite rare, especially for peripheral urban contexts like Venice's lagoon. Consequently, it is often necessary to refer to other kinds of sources, including engravings, views, paintings, and photographs. These documents are processed using perspective restitution techniques that allow for the internal and absolute orientation of the pictorial or photographic frame. In this process, the necessary condition for absolute orientation is that the depicted scenario shows a demolished building along with still-existing architectural structures, or at least a portion of the building needs to still be standing (Panarotto, in press).

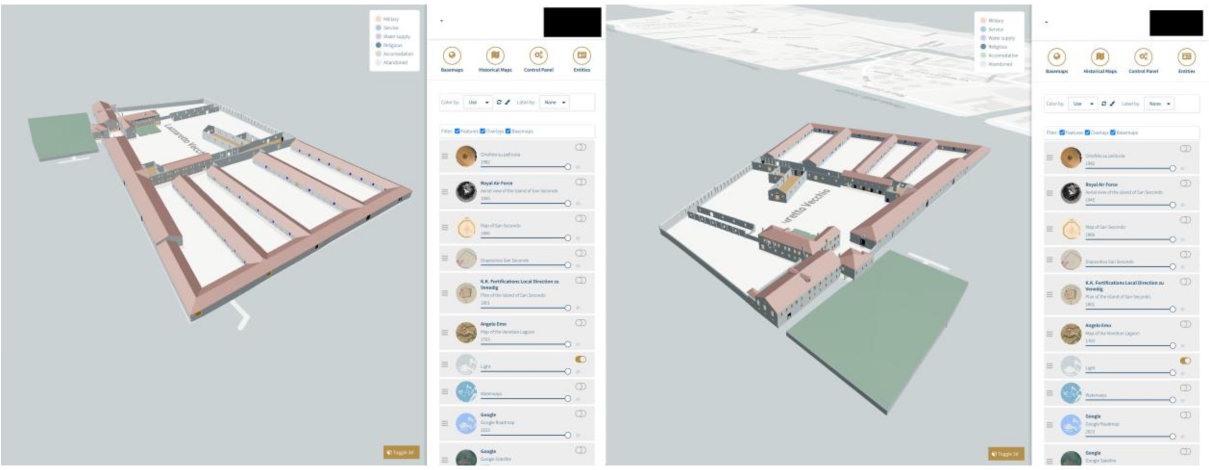

Figure 5. The image shows the initial approaches to integrating IFC files within the platform.

The operations described above have enabled the creation of HBIM models for the two islands under consideration. In summary, the virtual model of San Servolo consists of 78 entities, divided into 16 files, spanning from 1809 to the present day (Figure 6). The HBIM model for the Lazzaretto Vecchio, on the other hand, consists of 106 entities divided into 15 files, covering a temporal period from 1737 to the present day (Figure 7).

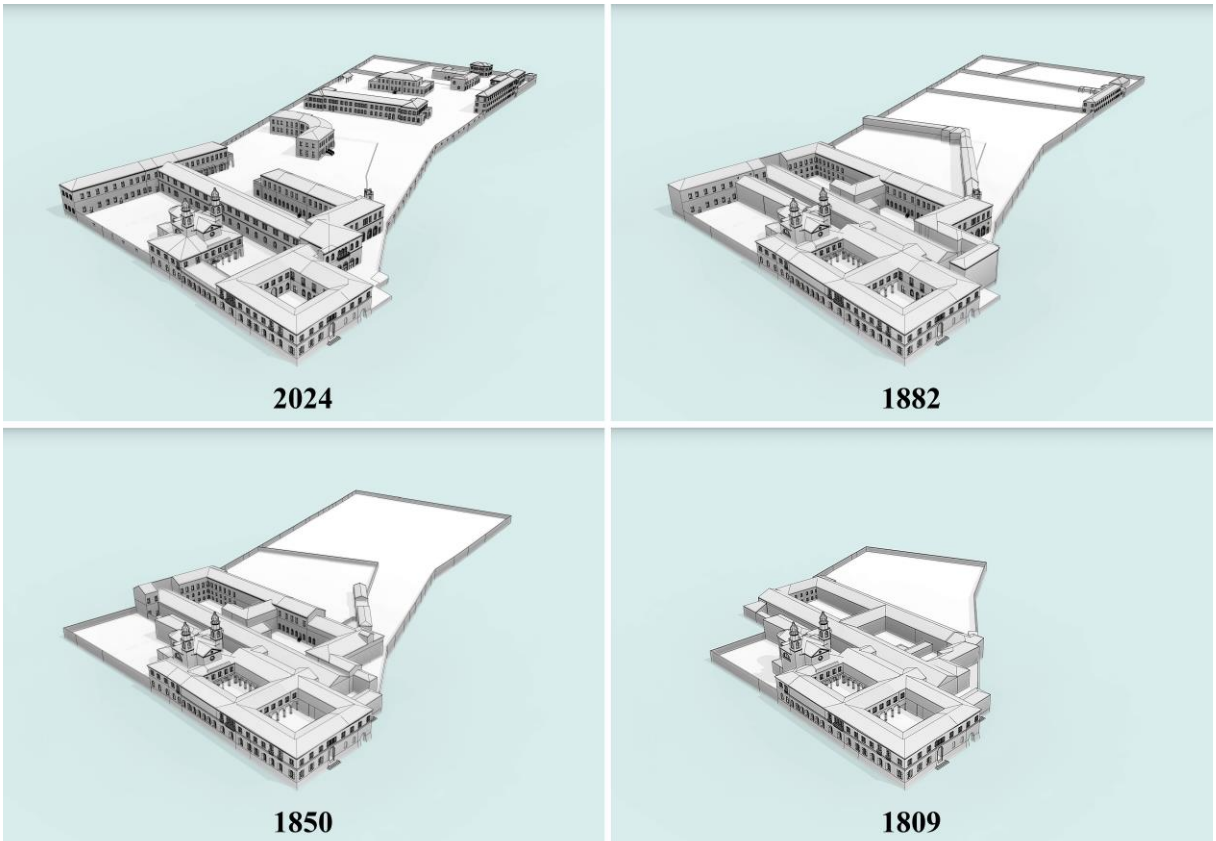

Figure 6. The image illustrates some of the main phases related to the San Servolo model.

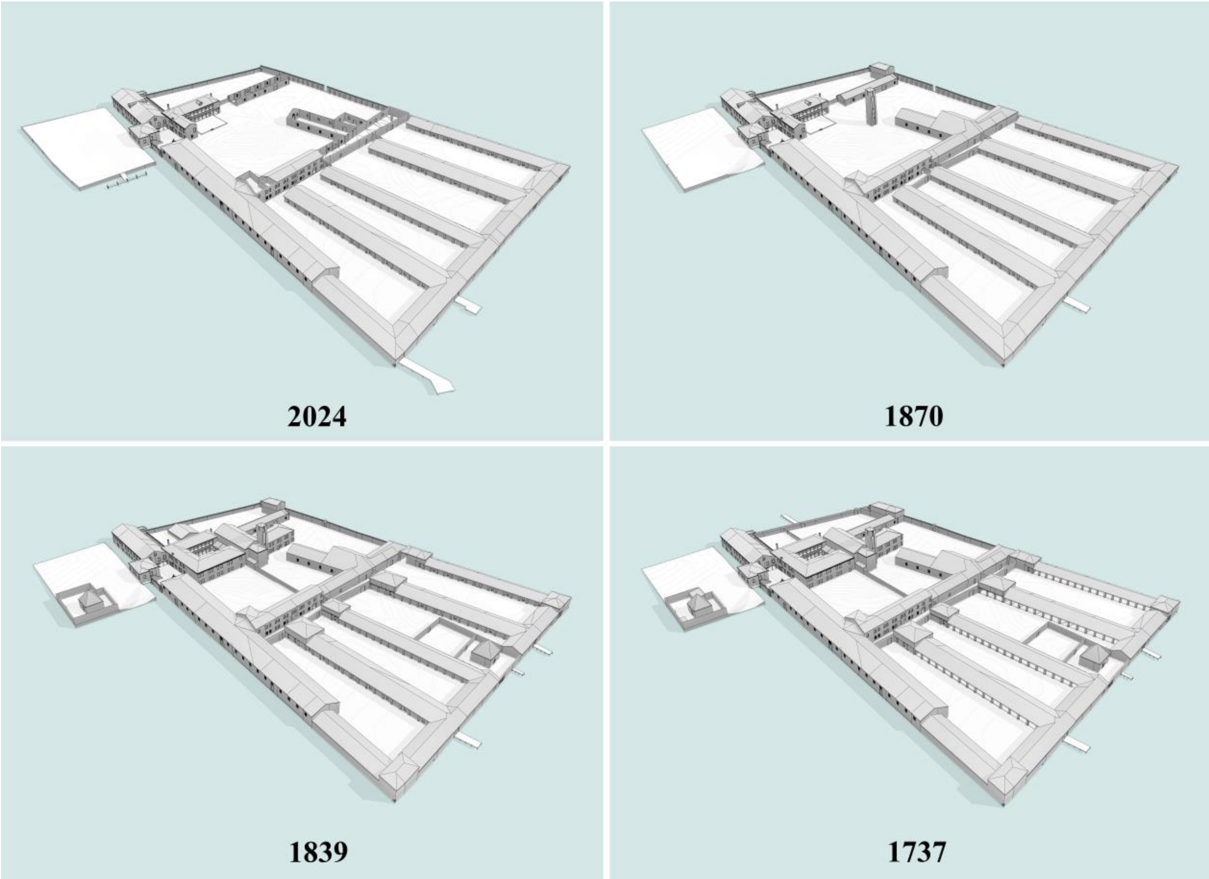

Figure 7. The image illustrates some of the main phases related to the Lazzaretto Vecchio model.

6. Conclusions

Given the interdisciplinary nature of the project, the methodological approach adopted was developed to address the specific needs of different professionals involved in the research, focusing on the peculiarities of the two pilot cases treated during the first year. The data refer to the results obtained through a study and in-depth analysis based on philological interpretations of certain and indisputable documents. The immediate future goal of the project is to focus on historical documents related to more ancient temporal phases, which are not only fewer in quantity but also less accurate graphically. This requires a stronger effort of interpretation and, conversely, a higher level of simplification of details in the modelling procedure. For this purpose, the 3D model representing the oldest version of a building or complex serves as a critical investigative basis through which various interpretative hypotheses related to earlier phases can be examined.

The VeNiss platform is designed to explore the historical lagoon backwards in time, covering a temporal range from the 16th century to the present day, with a granularity of a single year. On the contrary, in the BIM modelling software, objects are embedded in a specific temporal phase that is determined by the available cartography, representing a snapshot of a particular moment in time. To allow scholars to refine the granularity of the temporal range by assigning specific dates of construction or demolition to each built work, 3D BIM models are exported as single architectural-territorial entities. This enables scholars to attribute individual date parameters to each entity, transitioning from a "layers" structure to a time-based geospatial reconstruction. The described methodology allows historians to update by themselves temporal data directly within the VeNiss platform according to their discoveries based on new documents and sources, thus increasing their autonomy.

Another crucial aspect we are currently considering and plan to further develop in the next steps of the project is the representation of vegetation. Greenery is not only a fundamental component of today's lagoon environment due to the state of disrepair of the current islands, but it was also an integral element of the societal framework of the ancient islands, whose spaces were largely used for agricultural activities. This condition is particularly important in a series of cases that will be addressed in the near future, such as the islands of San Secondo, Poveglia, and San Giorgio in Alga. Accurately representing greenery will provide users with a more realistic depiction of the complexity of the Venetian islands' framework over time.

7. Funding

Funded by the European Union (ERC-2021-StG, ERC Programme Horizon Europe, VeNiss, G.A. 101040474). Views and opinions expressed are however those of the author only and do not necessarily reflect those of the European Union or the European Research Council Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

8. Acknowledgements

This paper arises from collaborative efforts among the authors. L.G. authored paragraphs 1 and 2, G.D. wrote paragraphs 3, and F.P. was responsible for paragraphs 4, 5 and 6.

9. References

Banfi, F. (2020). HBIM, 3D drawing and virtual reality for archaeological sites and ancient ruins. *Virtual Archaeology Review*, *11*(23), 16–33. https://doi.org/10.4995/var.2020.12416

Bevilacqua, M.G., Russo, M., Giordano, A., & Spallone, R. (2022). 3D Reconstruction, Digital Twinning, and Virtual Reality: Architectural Heritage Applications. *2022 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, 92–96. https://doi.org/10.1109/VRW55335.2022.00031

Bianchini, C., & Nicastro, S. (2018). The definition of the Level of Reliability : a contribution to the transparency of Heritage-BIM processes. *3D Modeling & BIM*, *Nuove Frontiere*. *2*(2018), 45–59.

Dell'Amico, A. (2021). Mobile laser scanner mapping system's for the efficiency of the survey and representation processes. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLVI-M-1–2021*(M-1–2021), 199–205. https://doi.org/10.5194/isprs-archives-XLVI-M-1-2021-199-2021

Diara, F. (2022). HBIM Open Source: A Review. In *ISPRS International Journal of Geo-Information*, *11*(9). MDPI. https://doi.org/10.3390/ijgi11090472

Dore, C., & Murphy, M. (2012). Integration of Historic Building Information Modeling (HBIM) and 3D GIS for recording and managing cultural heritage sites. *2012 18th International Conference on Virtual Systems and Multimedia*, 369–376. https://doi.org/10.1109/VSMM.2012.6365947

Galeazzo, L. (2024). Venice's Nissology. Mapping and Modelling Venice's Aquascape in a Historical Perspective. *STORIA URBANA*, *173*, 31–45. https://doi.org/10.3280/SU2022-173003

Galeazzo, L., Grillo, R., & Spinaci, G. (2024). A Geospatial and Time-based Reconstruction of the Venetian Lagoon in a 3D Web Semantic Infrastructure. In *CEUR Workshop Proceedings*, *3643*, 212–225.

Giordano, A., Monteleone, C., Friso, I., & Huffman, K. (2023). Visualizing Cities: Methodologies and Modalities for Cultural Heritage Transformations. In M. Balzani, S. Bertocci, F. Maietti, & L. Rossato (Eds.), *Research Innovation and Internationalisation: National and international experiences in Cultural Heritage digitisation* (pp. 125–136). Maggioli Editore.

Murphy, M., Mcgovern, E., & Pavia, S. (2009). Historic building information modelling (HBIM). *Structural Survey*, *27*(4), 311–327. https://doi.org/10.1108/02630800910985108

OMG. (2013). *Business Process Model and Notation (BPMN) Version 2.0.2*. https://www.omg.org/spec/BPMN/2.0.2/PDF

Panarotto, F. (in press). *Measurement and Representation of Lost Historical-Architectural Heritage: The Venetian Lagoon Archipelago* [Paper presentation]. 45° International Conference of Representation Disciplines Teachers, Congress of Unione Italiana per il Disegno, UID 2024 (Padova – Venezia, September 12-13-14, 2024).

Parrinello, S., & Picchio, F. (2023). Digital Strategies to Enhance Cultural Heritage Routes: From Integrated Survey to Digital Twins of Different European Architectural Scenarios. *Drones*, *7*(9), 1–23. https://doi.org/10.3390/drones7090576

Picuno, P., Cillis, G., & Statuto, D. (2019). Investigating the time evolution of a rural landscape: How historical maps may provide environmental information when processed using a GIS. *Ecological Engineering*, *139*, 1–16. https://doi.org/10.1016/j.ecoleng.2019.08.010

Sacks, R., Eastman, C., Lee, G., & Teicholz, P. (2018). BIM Handbook. In *BIM Handbook* (3rd ed.). John Wiley & Sons, Inc. https://doi.org/10.1002/9781119287568