



Digital Twins. HBIM information repositories to centralize knowledge and interdisciplinary management of architectural heritage

Luis Cortés Meseguer*, Jorge García Valdecabres

Universitat Politècnica de València, Spain.

*Email: luicorme@upv.es

Abstract: It is obvious that the primary document will always be the building itself, but within the field of conservation, restoration or maintenance it is necessary to have a large documentary archive where the interventions are recorded. The older the monument is, the greater the knowledge of the built element must be before any intervention and this requires a lot of time in prior research and which can develop prior studies, in addition to the economic cost that it entails. This is why with the advancement of technology and digital repositories, digital platforms can be created within Heritage Building Information Modeling (HBIM). This article reflects the experience of an eight-century-old monument, San Juan of Hospital of Valencia (Spain), in which a virtual twin has been made with software and specific web platforms in facility management such as Archibus®, EcoDomus®, Zutec® that allow the integration of information from BIM models and data acquired through sensors. With this work, although it is economically expensive and requires a lot of time for people specialized in the required programs, is improving the efficiency of facility management. and maintenance planning for large buildings and infrastructure.

Keywords: HBIM; San Juan of Hospital; Archibus; EcoDomus; Zutecn.

1. Introduction

Heritage assets contain the legacy of the history of the towns who shaped the culture and civilization in which we live. Making information related to these assets available to the scientific community and society facilitates knowledge of the history of society and the people who inhabited it.

Heritage is defined by UNESCO Webb C. (2023), as our inheritance from the past, our current assets and what we bequeath to future generations. The value of heritage also refers to what a particular group or community considers transcendent. As time goes by, new types of heritage emerge or are supported by digital technology for their knowledge and conservation. This has been verified in a novel and purposeful way as a powerful tool on the frontier of knowledge, through forms as diverse as Web sites, relational databases, models and information simulators, that is, computer materials at the serving the needs of a community of users.

Heritage projects, in accordance with scientific practice and literature, are based on multidisciplinary documentation and cataloging processes from different professional fields such as historians, archaeologists, art historians, architects, restorers and biologists, among others. All of these disciplines contribute, exchange and interpret complex information about the heritage asset to understand its value and meaning (Historic England, 2017). As the COTAC BIM4C report (Maxwell, 2016) points out, the quality of this information as a multidisciplinary knowledge base is crucial for adequate decision-making on the intervention, conservation and management of heritage assets.

Traditionally, information about historic buildings is made up of a collection of individual documents, reports, drawings, 2D or 3D CAD files and various data sets provided by different professionals, each working with their own tools and standards. This information is typically dispersed across multiple locations (electronic data repositories, databases, and physical files) and in multiple formats (paper and electronic). For this reason, in many cases, there is no single reliable source of the heritage asset, which can lead to errors in decision-making and negatively affect the conservation of the asset (Historic England, 2017). The potential that Building Information Modeling (BIM) has, through the generation of 3D models with associated alphanumeric data, is proposed as an effective tool and resource to this conflict since it is a collaborative work methodology, which allows unifying, coordinating and share the information generated by the different disciplines involved in a construction process, thus achieving more efficient management (Volk et al., 2014).

During the last 11 years, there has been a growing interest in investigating the capabilities of BIM for the conservation of architectural heritage, called Heritage Building Information Modeling (HBIM) as well as a methodology capable of generating visual twins, as set out in the preceding chapter, on the state of the art of the HBIM models developed by the team led by Bulgarelli-Bolaños of the Technological Institute of Costa Rica (TEC). (Hernández-Salazar, & Bulgarelli-Bolaños, 2023).

The published case studies demonstrate that the use of HBIM allows for more efficient management of information on heritage assets as they generate more efficient methods to document, project, maintain and manage their use throughout their entire life cycle, while Just as it happens in the new construction sector. Numerous studies show the benefits of HBIM to record and document the current state of the heritage asset and its construction evolution Castellano and Pinto 2019; (Santoni et al., 2020).

Given that in the international context the use of BIM is almost a general requirement, guiding documents such as guides and protocols are being developed to facilitate the progressive and coordinated implementation of the HBIM system among professionals in the heritage sector, such as the BIM for Heritage guide (Historic England, 2017), the uBIM guide (BuildingSMART Spanish Chapter, 2018), the HBIM Protocol developed by Jordán et al. (2018) previously named Bulgarelli-Bolaños, Malavassi-Aguilar, Hernández-Salazar and Salazar-Ceciliano and the innovative HBIM Protocol for the management of public use of heritage developed by Salvador-García (2020) as a result of his doctoral thesis.

The lines of research related to the application of 3D HBIM models for heritage management are choosing to develop HBIM web platforms in a collaborative work environment that allow the unification and exchange of information from HBIM models and databases and facilitate remote access of the agents involved in the conservation of built heritage (Lo Turco et al., 2017).

The development of new software and specific web platforms in facility management such as Archibus®, EcoDomus®, Zutec® that allow the integration of information from BIM models and data acquired through sensors, are improving the efficiency of facility management. and maintenance planning for large buildings and infrastructure. As an example of practical implementation, the Sydney Opera House (Australia) (Sánchez et al., 2015) is using the Ecodomus® web platform to link the HBIM model with existing engineering and maintenance documentation and building control and management systems. On the other hand, Fassi et al. (2015) have

developed a web platform called BIM3DSG, to manage the maintenance tasks of the Milan Cathedral (Italy). Also Fregonese et al. (2015) have used the BIM3DSG platform to investigate the possibilities offered by HBIM models for the design and management of a preventive maintenance plan, using the Galvagnina church in Pegognaga (Italy) as a case study.

However, the review of the scientific literature has not revealed studies that propose a work platform to document and synchronize with the HBIM model the information generated by non-technical agents who do not use BIM software such as the historian or the managing Institution, among others.

Once the gap in knowledge or need in the management of this type of assets has been located, we are at the starting point to address this contribution: This is part of the set of studies carried out HAR2013-41614-R financed by the Ministry of Economy and Competitiveness of Spain 2013 (García-Valldecabres et al., 2016), as well as, in which we have been developing around the European project called “PROMETHEUS” PROtocols for information Models libraries Tested on HEritage of Upper Kama Sites, together with other Routes and Sites led by Sandro Parrinello (2019), whose objective is to build collaborative intersectoral protocols for a low-cost methodology to develop reliable 3D databases and Architectural Heritage Information Models. And, all of this, through an integrated methodology, combining traditional and innovative methods to evaluate the current state and condition of historical architectural complexes, and develop management and conservation plans to generate a Common Resource System. (Parrinello et al., 2019) and Parrinello, and Dell’Amico (2019).

In this context, the Digital Twin of a historic building is defined as the model or representation of 3D information of the current state of the building and its nearby urban environment in a systematic, detailed, reliable and real-time manner. In such a way that it contains information, both graphic and alphanumeric, on the phases of the life cycle, the construction periods and the ability to predict sustainable behavior according to the use to which it is intended. That is, a 3D model - HBIM with automated information through cameras and sensors installed in the building on the one hand and the information provided by the agents involved on the other.

Thus, the main objective of this contribution is to describe the process of generating a web platform that allows managing information from an external database and developing a synchronization plugin with the HBIM

model that thus becomes a Digital Twin of a heritage building in the nearby urban environment using the GIS platform.

2. Metodological approach

The methodological approach followed in this research has been based on social sciences, according to the proposals of Neuman (2003) and Yin (2009) based on case studies. Also, they were based on direct documentary sources from different groups of BIM experts, managing entities and agents from the different disciplines that work on cultural heritage.

An analytical study of the agents’ ways of working and roles was carried out through interviews and their own experience in order to recognize the type of documentation from which they started and how they used it, as well as the type of information that they generated and the workflows that they maintained with the rest of the agents involved.

From this analysis, some cards were developed to catalog the monument and its most significant elements. To define the graphic and textual information of the cards, the criteria of the catalogs and inventories used by the Administration were followed (Valencia City Council 2010); (Muñoz Cosme, 2014). The sheets were prepared using Access© software.

The development of the web Platform and the connection plugin was carried out in collaboration with the Institute of Information Technology of the Polytechnic University of Valencia.

The system architecture was composed of: a WebApi, a SQLServer database, a plugin, a web portal and the Revit Core. The WebApi is an application programming interface published on the web server. The plugin connects to this WebApi to exchange information. The SQLServer database is based on a relational model and allows working in client-server mode. It stores information in the cloud, supports millions of records and has no user limitation. The plugin consists of an api of the Revit© SDK. This plugin retrieves information from the Revit© model and consumes the WebApi to synchronize the data from the SQL server with the BIM file. The web portal facilitates the introduction, editing and consultation of data mainly for professional profiles that do not work in a BIM environment. Revit Core is a DLL library package that is responsible for managing the business layer and data access.

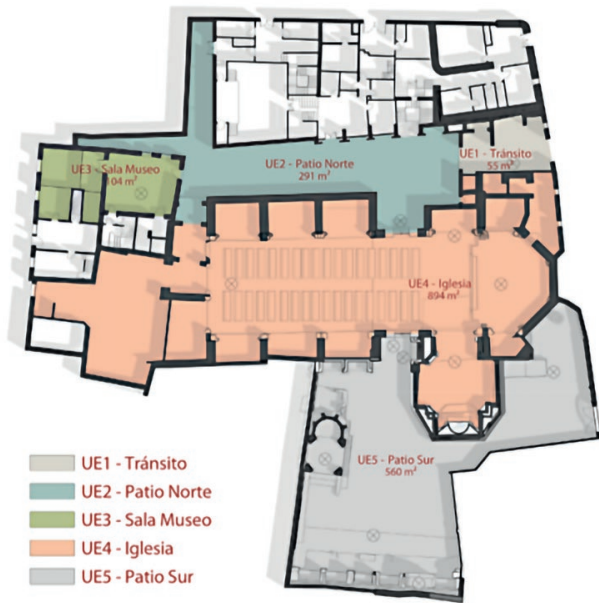


Figure 1 | Floor plan of the San Juan of the Hospital complex of Valencia..

Currently the Web Platform is in the experimental phase and is hosted on a private server that is not publicly accessible.

The case study chosen as the experimentation laboratory for the web platform was the medieval complex of San Juan del Hospital (Figure 1), which is located in the historic center of the city of Valencia, close to the Cathedral and next to the old gate of the Arab wall called Xerea.

It is made up of the North Patio and the attached buildings that surround it, the church and the South Patio, where the remains of the structures of the old medieval cemetery are located. The temple is an excellent example of Mediterranean Gothic and preserves important vestiges of the medieval cemetery such as the funerary chapel, the group of arcosolia, funerary steles and the crypt of Saint Barbara (Figure 2).

Numerous research works had been carried out around this monument, enhancement, drawing of plans, stratigraphic studies of walls, historiography, etc. that served for the drafting of the Temple Master Plan (2000). Once these works were completed, in 2002 we were commissioned to recover the South Patio. In this way, extensive experience was acquired in the management of the monument.

Thus, it was documented documentary evidence that in the San Juan del Hospital grounds there were remains of structures of great historical and social interest

belonging to the various cultures that had been building the city of Valencia: Roman, Visigothic, Arab, medieval Christian, modern. and contemporary.

The complex was declared a national Historic-Artistic Monument on April 5, 1943 (BOE 04/16/1943) and the entire complex was configured as the “Museum of the San Juan Hospital Complex” in February 1997 (B.O.E. April 16, 1997).

3. Results

This section shows the main results of the research, which have been: 1) the preparation of a card catalog of the heritage elements and 2) the design of the web platform and the development of the connection plugin with the HBIM model.

Firstly, some cards were developed to catalog the monument and in detail its most significant architectural and archaeological elements (Figure 3). These files were prepared with the Access© software and contained the specific fields of a cataloging file, such as the general data of the element, the description, the state of conservation, the history of interventions carried out and the bibliography, among others. The fields of the cards were introduced as new parameters in the HBIM model of the San Juan Complex of the Hospital de Valencia made with the Revit© software (Figure 4).

Subsequently, in order to work collaboratively with HBIM, a Common Data Environment was generated, as recommended by the BIM for Heritage guide (Historic England 2017). In this Common Data Environment, the information on the heritage asset was contained in two databases: the HBIM model, which is itself a database, and in another external database that was located outside the model. The information from both databases was mapped and synchronized using the plugin called GDHeritage. From the combination of both databases, deliverable documents could be generated, such as plans, tables, 3D views, etc. The information in the database could be managed from the web platform also called GDHeritage and (Figure 4). In this way, professional profiles that worked in a BIM environment such as architect, engineer, etc. They could manage the information from the HBIM model and the professional profiles that did not work in a BIM environment, such as the historian, or the Managing Institution, could manage the data from the web platform, leaving all the multidisciplinary information of the asset unified and coordinated (Figure 5).



Figure 2 | Church and old medieval cemetery of the San Juan of the Hospital Complex of Valencia.

The workflow for using the Web Platform and synchronizing information with the HBIM model is detailed below.

The access page to the Platform has a public part that allows you to freely consult the catalog of monuments contained and a private part that requires authenticated access from the user (Figure 6).

To register a new monument, the user logs in with their credentials, makes the registration request and the platform administrator authorizes or denies that request. If the request is accepted, that user is registered with the role of monument manager. The platform administrator uses the ID that is generated with the registration request to create the monument folder on the server where the HBIM models will be hosted.

From that moment, the manager can invite the rest of the professionals who participate and assign the different roles according to the disciplines: architect, technical

architect, engineer, archaeologist, historian and cultural manager. When professionals agree to participate, their user is automatically created with the assigned role. Each role is assigned permissions for processing information. Roles that will use the HBIM model can download the GDHeritage plugin in the BIM section of the web platform (Figure 7).

Once the plugin has been downloaded and installed, when you open the Revit© program the GDHeritage login appears (Figure 8). Validating the account generates a new network drive that contains a folder directory of the monuments in which that user participates. Each folder contains all the information about the monument: the HBIM model, the GDHeritage database and other documents such as memories, reports, photographs, historical documentation, copies of files, plans, drawings, engravings, etc.

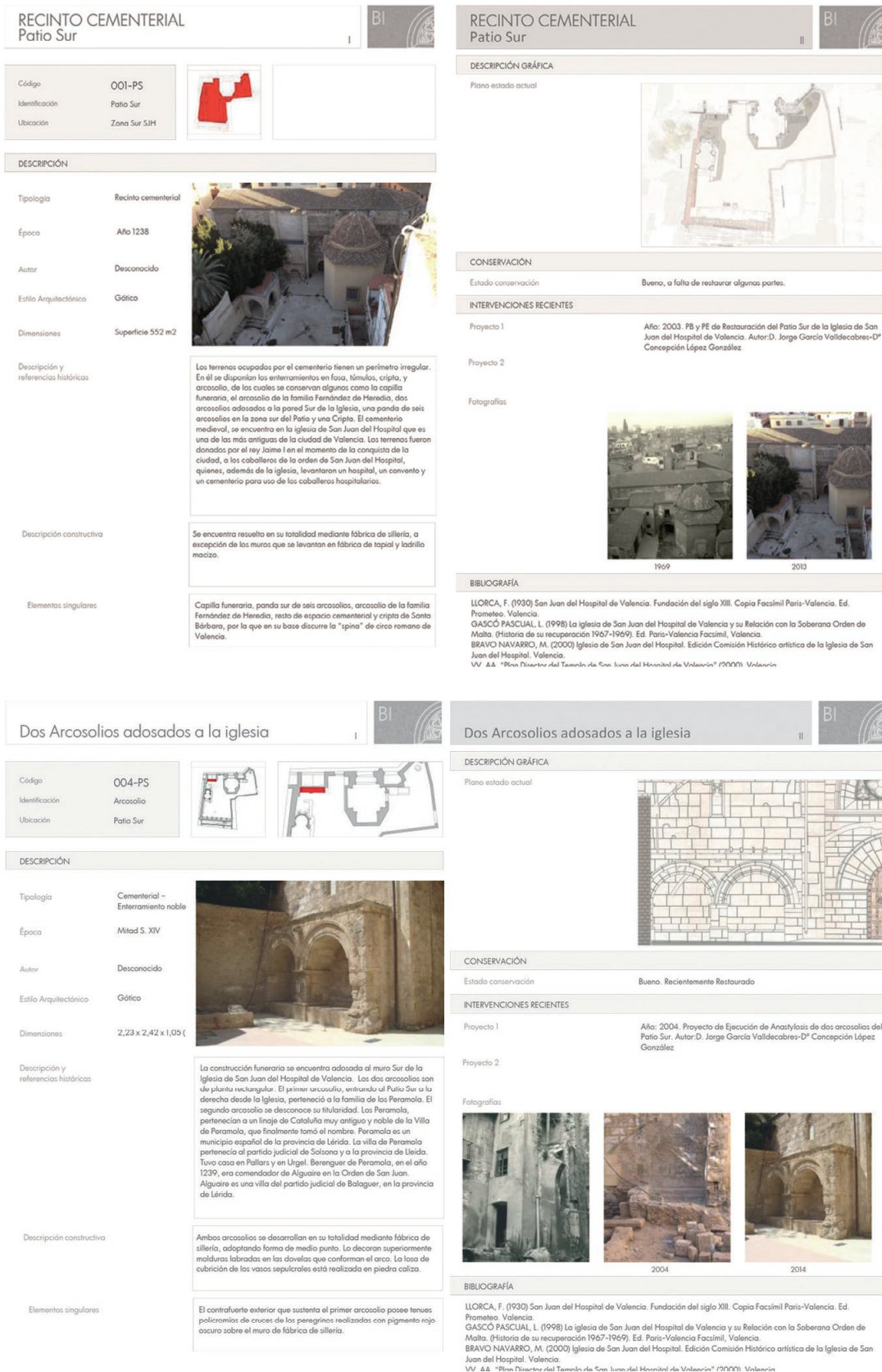


Figure 3 | Cataloging files of the San Juan of the Hospital Complex of Valencia, (García-Valldecabres et al., 2016).

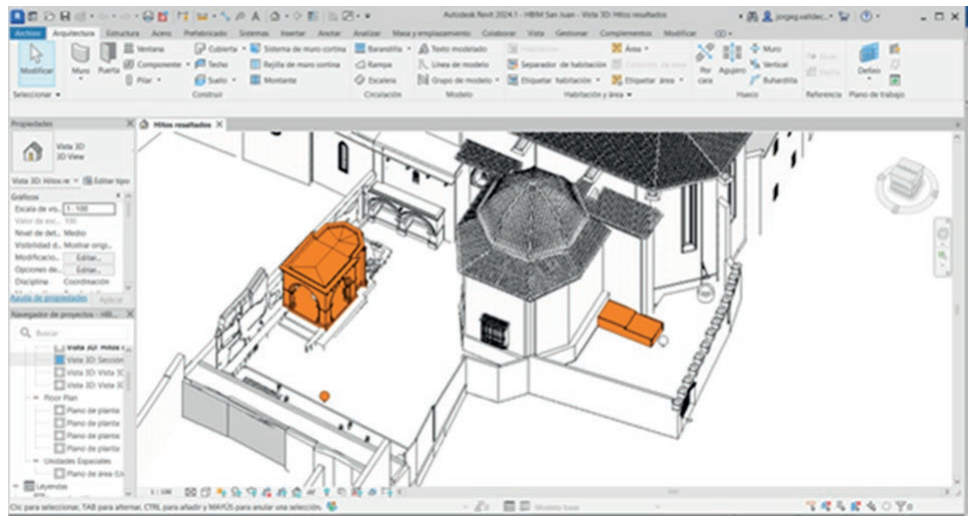


Figure 4 | HBIM model of the South Courtyard in San Juan of the Hospital Complex of Valencia made with Revit© software (García-Valldecabres et al., 2016).

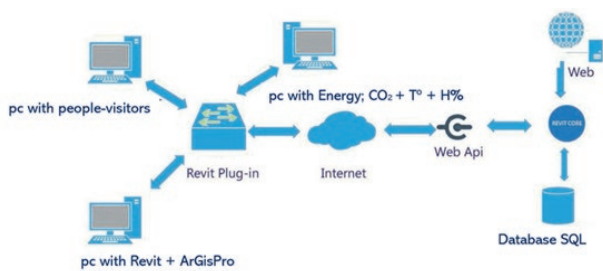


Figure 5 | Diagram of the organization of teams for GDHeritage Web management in a Common Data Environment.

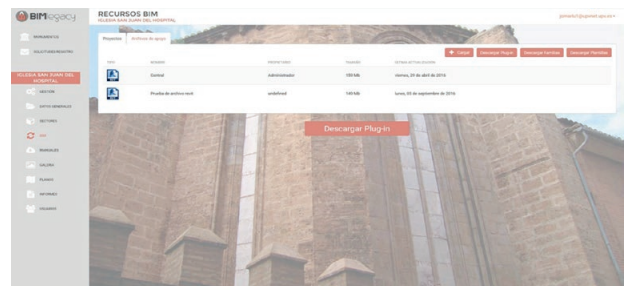


Figure 7 | GDHeritage plugin download page, 2016 (García-Valldecabres, 2016).

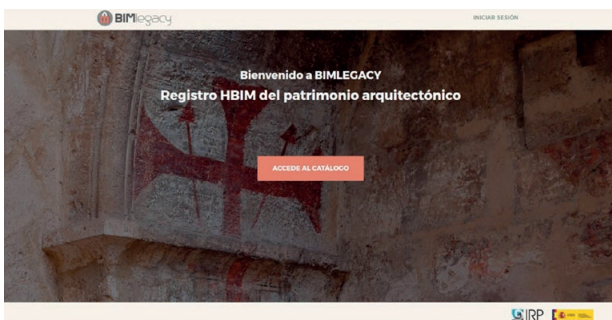


Figure 6 | Main website of the GDHeritage platform, 2016 (García-Valldecabres, 2016).



Figure 8 | GDHeritage login in Revit© software, 2016 (García-Valldecabres, 2016).

On the other hand, the GDHeritage synchronization plugin is located in the Revit© Plugins tab (Figure 9). The synchronization options offered are: upload changes and download changes, both for the monument and the elements, unlink monument and unlink element. To perform the synchronization, you must first select the monument that you want to link with the HBIM model.

To synchronize the data of the monument or elements, a list of all the fields that can be synchronized and two columns with the value of that field appear both in the HBIM model and in the database. In this way the values of the two databases can be compared (Figure 10).

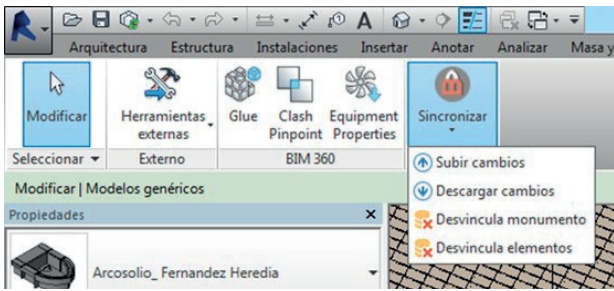


Figure 9 | GDHeritage synchronization plugin in Revit© software, 2016 (García-Valdecabres, 2016).

Likewise, if we unlink the monument, the link between the HBIM model is eliminated and the information from the monument and all the contained elements is unlinked. If, on the other hand, we unlink elements, only the associated elements are unlinked.

Finally, it should be mentioned that the application allows you to host and view metadata such as photos, videos, plans, etc. To facilitate the installation and management of the web platform, a GDHeritage User Manual was written.

BIM models have been integrated into GIS through the ArcGIS online platform, which makes it easy to combine 2D and 3D map models from various sources within an intuitive interface. At the same time, it allows the visualization, analysis, image processing, data management and integration of the information generated by the parties involved. A preliminary prototype 3D-GIS model has been developed, incorporating the first HBIM LoD-200 models of the three buildings, together with information on the itineraries of the surrounding urban environments (Figure 11 and 12).

4. Discussion of results

A new type of repository was created that allows containing all the information related to the heritage property under study for consultation and dissemination in a simple, direct, useful and operational way at the same time. In this way, the problem posed in heritage management is solved simultaneously since it improves the workflow, increases productivity, minimizes errors and facilitates decision making in the case of intervention aimed at the conservation of the heritage asset.

New digital documents have been generated for knowledge, memory and protection of the property, according to the recommendations of the Charter on the preservation of digital heritage (UNESCO, 2009). The

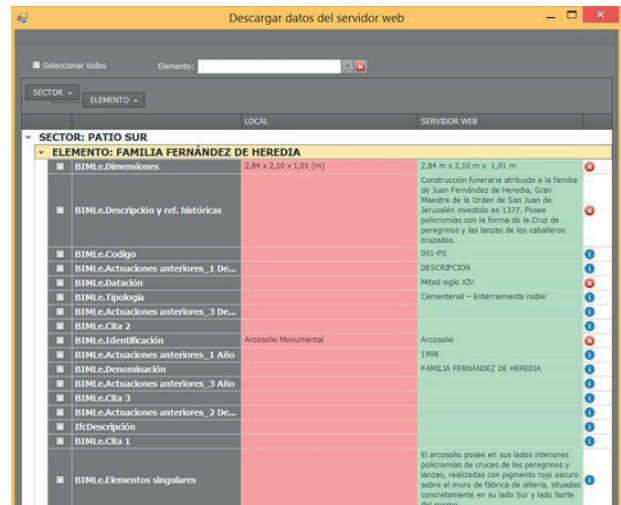


Figure 10 | Database fields and values and the HBIM model, 2016 (García-Valdecabres, 2016).

experts who validated the GDHeritage website suggested that it would be interesting to incorporate a 3D-HBIM model viewer for non-technical agents, so that they could also view and navigate the virtual model of the building while consulting the information.

Furthermore, it is evident that Autodesk Revit software allows integrating Digital Twins generated by HBIM with geometric and semantic information generated by the actors involved in maintenance planning and management. At the same time, it offers reliable support for decision-making in conservation design and management. Also, the Digital Twin prevents us from possible inappropriate management action before they materialize, reducing risks, time and cost invested to achieve more sustainable management.

5. Conclusions

The prototype obtained is a BIM model with an external database and a generic design that was tested with a group of experts to verify its feasibility and the possibilities it offers. After this initial stage, in order for the model to enter the market and provide improvements to the sector with its impact, interviews with monument users are needed to determine the most detailed aspects thoroughly.

The main innovation of this prototype is its specific methodology, based on considering the needs of a monument for its management, not only for use management but also for enhancement,

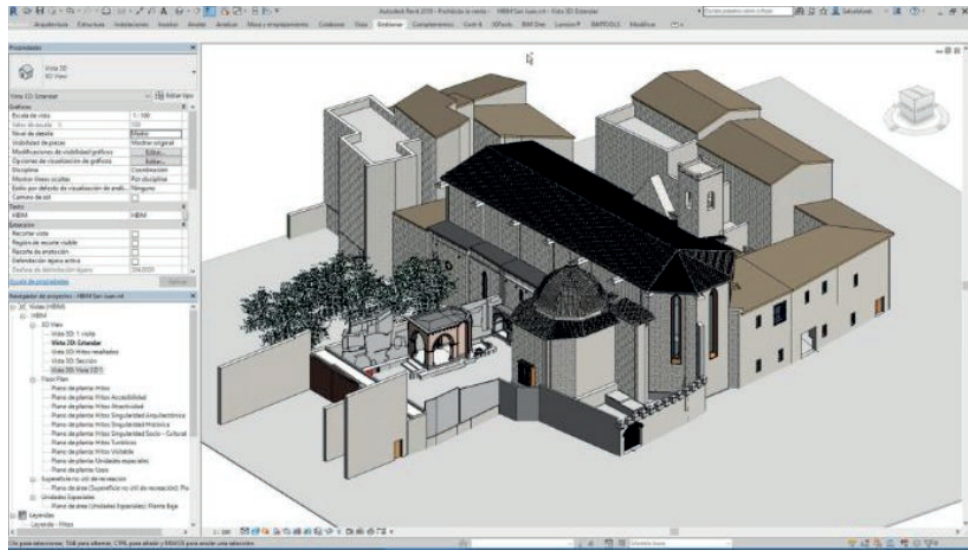


Figure 11 | The HBIM model is a complete model of the Church of Sant Juan del Hospital that is available in Revit.



Figure 12 | Complete model of the Church of San Juan del Hospital inserted in the GIS Platform.

dissemination, and maintenance to link databases, with the flexibility to complete these databases. It is a virtual twin personalised for each user. The database can be read in various computer formats, including smartphones or tablets.

The work developed to obtain Digital Twins through the HBIM methodology has turned out to be a valid and integrative method of documentation since: 1) it allows the introduction of a large amount of both geometric and documentary information; 2) links databases; 3) facilitates the design of management strategies.

Thanks to this GDHeritage obtained from a Common Data Environment, the agents who intervene in the conservation of heritage, but do not use BIM software, such as the historian, will be able to manage their information and in this way, all the information about the property will be unified in a single Digital Twin repository.

The decision-making and management process followed by the technical team has been based on the criteria of enhancing the value of the property, the historical-artistic significance and protection through a critical and analytical approach. Likewise, the repository of information generated is available for future actions on the property.

Not only will the scientific community have access to the information prepared by the different professionals involved in the process of studying a heritage

asset, but the entire society in general will be able to benefit from the use of this work methodology by having direct access to the information stored, which will encourage the establishment of a society prone and open to innovation that welcomes the development and adoption of new ideas and their incorporation into new processes, products and services as intended by the Spanish Strategy for Science, Technology and Innovation (2012).

This study demonstrates the potential of Digital Twins obtained from HBIM and GIS tools to assess the condition of historic buildings, as well as efficient asset management and linkage with urban spaces. By integrating these tools and promoting their interoperability, we can effectively manage the public use of heritage buildings and contribute to preventive maintenance and conservation management.

And, finally, the set of these results can well be implemented in monuments with similar characteristics. However, if we only stuck to the use of a technological product, we could run the risk of obsolescence of the work due to the rapid evolution of applications over time. Therefore, given that the results are based on a methodological model, it will not fall into a mere utilitarian tool.

Acknowledgments

This article is a result of the European research project “PROMETHEUS” PROtocols for information Models libraries Tested on HERitage of Upper Kama Site.

References

- Antonopoulou, S., Bryan (2017). *Historic England. BIM for Heritage. Developing a Historic Building Information Model*. <https://historicengland.org.uk/advice/technical-advice/recording-heritage/>
- Ayuntamiento de Valencia, (2010). *Catálogo de Bienes y Espacios Protegidos*. [URL] www.valencia.es/ayuntamiento/urbanismo/inicio (accessed 25 January 2009)
- British Standards Institution (2014). PAS1192-3:2014. Specification for information management for the operational phase of assets using building information modelling. [URL]. <https://bim-level2.org/standards/> (accessed 25 January 2009)
- Buildingsmart Spanish Chapter, (2018). Guía de usuarios BIM aplicado al Patrimonio Cultural. [URL] <https://www.buildingsmart.es/bim/guías-ubim/> (accessed 25 January 2009)
- BuildingSMART Spanish Chapter, nº 14. (2018).
- Bulgarelli-Bolaños, J.P., Malavassi-Aguilar, R.E., Hernández-Salazar, I., Salazar Ceciliano, E., Valverde-Solano, M. del C., & Pinto Puerto, F. (2022). Propuesta de protocolo para la formulación de Planes de Conservación Programada en Costa Rica, *Loggia, Arquitectura & Restauración*, (35), pp. 28–39. <https://doi.org/10.4995/loggia.2022.16320>
- Castellano-Román, M., & Pinto-Puerto, F. (2019). Dimensions and Levels of Knowledge in Heritage Building Information Modelling, HBIM: The model of the Charterhouse of Jerez (Cádiz, Spain). *Digital Applications in Archaeology and Cultural Heritage*, 14, e00110. <https://doi.org/10.1016/j.daach.2019.e00110>

- Fassi, F., Achille, C., Mandelli, A., Rechichi, F., & Parri, S. (2015). A New idea of bim system for visualization, web sharing and using huge complex 3d models for facility management. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, 40(5W4), 359-366. <https://doi.org/10.5194/isprsarchives-XL-5-W4-359-2015>
- Fregonese, L., Achille, C., Adami, A., Fassi, F., Spezzoni, A., & Taffurelli, L. (2015). BIM: an integrated model for planned and preventive maintenance of architectural heritage. *Digital Heritage. Granada: IEEE*, 51-54. <https://doi.org/10.1109/DigitalHeritage.2015.7413832>
- García-Valldecabres, J.L., López-González, M.C., Salvador-García, E., March, R., & Jordán-Palomar, I. (2016). El diseño de una base de datos, modelo para la gestión de la información y del conocimiento del Patrimonio Arquitectónico. Unpublished.
- Hernández-Salazar, I., & Bulgarelli-Bolaños, J.P. (2023). Identification and characterization of the foyer of the national theater of Costa Rica as part of the methodological strategy for the three-dimensional modeling of the future Digital Twin. *The International Archives of the Photogrammetry Remote Sensing and Spatial Information Sciences*. XLVIII-M-2-2023:709-719. <https://doi.org/10.5194/isprs-archives-XLVIII-M-2-2023-709-2023>
- Jordán-Palomar, I., Tzortzopoulos, P., García-Valldecabres, J., & Pellicer E., (2018). Protocol to Manage Heritage-Building Interventions Using Heritage Building Information Modelling (HBIM). *Sustainability*, 10(908), 1-19. <https://doi.org/10.3390/su10040908>
- Lo Turco, M., Mattone, M., & Rinaudo, F. (2017). Metric survey and BIM technologies to record decay conditions. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, 42(5W1), 261-268. <https://doi.org/10.5194/isprs-archives-XLII-5-W1-261-2017>
- López-Menchero Bendicho, V.M. (2011). Propuesta para profundizar en La Carta de Londres y mejorar su aplicabilidad en el campo del patrimonio arqueológico. *Virtual Archaeology Review*, 2(4), 65-69. <https://doi.org/10.4995/var.2011.4557>
- Maxwell, I. (2016). *COTAC BIM4C Integrating Report Part 1: Conservation Parameters*.
- Ministerio de Economía y Competitividad de España, (2012). *Estrategia española de ciencia y tecnología y de innovación 2013-2020*.
- Muñoz Cosme, A. (2014). *Catálogos e inventarios del Patrimonio en España*. E-rph, 14, 15-37.
- Neuman, W.L., & Kreuger, L. (2003). *Social work research methods: Qualitative and quantitative approaches*. Allyn and Bacon.
- Parrinello, S., Dell'Amico, A. (2019). "Experience of Documentation for the Accessibility of Widespread Cultural Heritage" *Heritage*, 2, no. 1: 1032-1044. <https://doi.org/10.3390/heritage2010067>
- Parrinello, S., Picchio, F., De Marco, R., & Dell'Amico, A. Documentando las rutas del patrimonio cultural. la creación de modelos informativos de las iglesias históricas rusas en la región superior de Kama, *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, XLII-2/W15, 887-894. <https://doi.org/10.5194/isprs-archives-XLII-2-W15-887-2019>, 2019
- Salvador-García, E. (2020). *Protocolo HBIM para una gestión eficiente del uso público del patrimonio arquitectónico*. Universitat Politècnica de València, València. PhD Tesis. Master thesis. <https://riUNET.upv.es/handle/10251/146811>
- Salvador-García, E. (2015). *Nuevas propuestas de puesta en valor para la visita pública interpretativa del Conjunto de San Juan del Hospital de Valencia*. TFM. Unpublished.
- Santoni, A., Martín-Talaverano, R., Quattrini, R., & Murillo-Fragero, J. (2020). HBIM approach to implement the historical and constructive knowledge. The case of the Real Colegiata of San Isidoro (León, Spain). *Virtual Archaeology Review*, 12, 24. pp. 49-65. <https://doi.org/10.4995/var.2021.13661>
- Sánchez, A., Hampson, K.D. & Sherif, M. (2015). Sydney Opera House. Case study report. 2015. *Sustainable Built Environment*. National Research Centre.
- UNESCO (2009). *Carta sobre la preservación del patrimonio digital*. [URL] <https://unesdoc.unesco.org/ark:/48223/pf0000179529.page=2>
- Volk, R., Stengel, J., & Schultmann, F. (2014). Building Information Modeling (BIM) for existing buildings-Literature review and future needs. *Automation in construction*, 38, 109-127. <https://doi.org/10.1016/j.autcon.2013.10.023>
- VV.AA., (2000). Plan Director del Templo de San Juan del Hospital de Valencia.
- Webb, C., coord. 2003. Directrices para la preservación del patrimonio digital. Biblioteca Nacional Australia. División Sociedad de la Información. UNESCO. CI-2003/WS/3. <https://www.researchgate.net/publication/277267631>
- Yin, R.K., (2009). *Case Study Research: Design and Methods*. Los Ángeles. California: SAGE Publications.