

Investigation of Heritage Building Information Modeling Possibilities in Lithuania

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Abstract – The paper discusses the possibilities of HBIM usage in foreign countries and Lithuania. Methods used in the paper are analysis of the literary sources, review of legal documents relating to the digitization of buildings, and analysis of case studies in foreign countries. The aim of the paper is to present the main stages of HBIM process for the historical buildings renovation. Nowadays HBIM process in Lithuania focuses on scanning heritage sites and reproducing realistic images and the attribute data for cultural heritage sites and incorporating them into HBIM models. The process is in the initial stage.

Keywords – BIM, cultural heritage, HBIM, management, protection.

INTRODUCTION

Nowadays architectural heritage is increasingly threatened by natural disasters or human invasive actions. For example, high-intensity earthquakes, such as Emilia Romagna (Italy) in 2012, have caused a heavy damage to the worldwide cultural heritage; or Notre Dame Cathedral, one of the most significant architectural symbols of Paris, was destroyed by a huge fire on 15 April 2019. The cultural heritage monument that has been built for several hundred years was destroyed in just a few minutes. Not only natural disasters or accidental human actions could be the reasons of damage of historical buildings or sites. Case of Syrian Civil War during which damage has been caused to numerous historic buildings when destructive effects to heritage of the conflict were caused by shelling, looting and rebel occupation. However, not only management and conservation are essential steps in the life cycle of historic buildings but also preservation from disasters. Unfortunately, the complexity of conservation practices and the lack of knowledge of historic buildings are often the cause of poor quality of building restoration and loss.

In order to ensure a qualitative change in heritage objects, it is necessary to move on to the development of historical building information models using HBIM technologies. The main function of building information modelling is to create and use a virtual (digital) model of building or engineering structure, which would not only simulate the design of a building but would be used to improve the processes of construction and building use. The essential benefit of BIM's application is the precise reduction of design and construction costs, elimination of errors and conflicts between different building elements, efficient time and cost management, high-quality and timely communication between the participants in the construction project (designers, manufacturers, builders, estimates, etc.) and many more. Heritage protection strategy documents are currently focused on the digitization of heritage objects. However, in Lithuania digitization of heritage is perceived as a creation of a database containing

only existing “paper” information, photo-pictures, drawings, etc. Meanwhile, in Europe, the digitization of heritage objects has been well advanced, with objects scanned and stored in digital format. An effective strategy for preserving historical data is the well-known construction information modelling (BIM), creating a static model that contains information on constructions, materiality, etc. In the Italian, Spanish, Irish heritage protection system, BIM measures are used to model the modelling and management of historical structures.

The aim of the paper is to discuss the possibilities of integrating BIM into the heritage protection system in Lithuania.

I. BIM AND HBIM USE FOR THE CULTURAL HERITAGE OBJECTS PRESERVATION IN FOREIGN COUNTRIES

European countries are developing and implementing policies that encourage or require the use of Information Modelling (BIM) for buildings in restructuring strategies in the sectors of architecture, engineering and construction (AEC). The main function of BIM is to create and use a virtual (digital) building or engineering model that not only simulates the construction of the building, but also serves to improve the design, construction and use of building processes. An essential advantage of BIM is the reduction of design and construction costs, elimination of errors and conflicts between different elements, efficient time and cost management, high quality and timely communication between the construction project participants (architects, designers, manufacturers, builders, etc.).

Stephen Fai et al. in the paper “Building information modelling and heritage documentation” describe the expanded role for BIM in the documentation and conservation of architectural heritage [1]. According to Stephen Fai, BIM could be used not only for new buildings but also for heritage buildings, such as the 19th century heritage buildings in the urban core of Toronto, Canada; a 600-hectare village in rural, and south-eastern Ontario with significant modern heritage value. Authors propose web-centred BIM database for materials and construction methods suitable to heritage conservation.

Historic Building Information Modelling (HBIM) is a new approach for modelling historic buildings. The method of preserving historical buildings has been developed in the Dublin Institute of Technology by Murphy M. and others (2009) [2]. The HBIM process [3] examines existing structures using remote sensing, after which the objects of the parameters and information are displayed in a geometric system based on remote sensing data. The purpose of HBIM research is to describe in detail the procedures for remote data acquisition by laser (scanning) and subsequent processing to create complete engineering drawings

(orthographic and 3D models) and historical structures from laser scanning and image analysis data. The HBIM process begins with remote data collection using a terrestrial laser reader with digital cameras. Various software images and scan data are then used. The “Mind View” mapping tool is used for communication planning / rendering, “Autodesk Revit” is used as a central BIM tool for Sketch Up, Pro is used in the survey. “Sigma” is for use in “Vico” and “Solibri”, “Revit” plugins are installed and used in BIM environments. HBIM tools can be used as a complete set of data, especially for building restoration. The resultant HBIM can then be used to automatically produce conservation documentation and to analyse the historic structures in addition to visualization [4], [5].

Murphy M. in his PHD Thesis describes HBIM stages: “... collection and processing of laser scanning survey data, identifying historic detail from architectural pattern books, building a library of parametric historic components/objects, mapping of parametric objects onto scan data and the final production of conservation documentation” [6].

Researching the works of foreign countries scientists in HBIM field it was noticed that this method is mostly used in the following cases:

- In the case of **renovation of existing historical buildings** – when the certain existing building should have a renovation of the structure or architecture details. Within the field of renovation of existing historical buildings HBIM was studied by researchers Murphy, M. et al. (2013, 2015, 2017), Dore, C. et al. (2014, 2015), and Nieto, J. E. et al 2016 [7].
- In the case of a **virtual reconstruction of historical building** – when a certain building does not exist and a new function has been assigned to the property, a physical reconstruction no longer makes sense. However, the existence of such building is important to the public, albeit in a non-physical manner [8]. Within the field of Virtual Cultural Heritage, HBIM was studied by researchers Chevrier, C. et al. (2010), De Luca, L. (2012), Boeykens, S. et al. (2012).

According the Boeykens, S. et al. “... The possibility of BIM to manage a model that can serve different outcomes is one of the biggest strengths of this approach. The same model can be used for the generation of drawings, 3D representations, but also for a listing of objects or materials and dedicated filtered views, e.g. the core structural system or a spatial model. A 2D drawing can instantly be seen in 3D and vice versa” [8]. For example, in 2015, architectural historian Andrew Tallon created a precise image of Notre Dame Cathedral in digital format by using a 3D laser scanner. A detailed scan, called a point cloud, can show exactly what the building looked like — inside and outside. Using this digital data, it is possible that after the 2019 fire Notre Dame Cathedral could be rebuilt as it has been [9].

In Europe, researchers are using a new modelling workflow and integrating a BIM management system to connect HBIM elements and historical knowledge. An example of such work

could be the St-Pierre-le-Jeune Church in Strasbourg, France, to expand HBIM’s new functions [10].

II. DIGITIZATION OF CULTURAL HERITAGE IN LITHUANIA

The goal of digitizing Lithuanian cultural heritage is to transfer unique and valuable cultural heritage objects into digital form. Digitization enables the opening up of cultural values protected by the public and access to them through remote access. Digitization activities in national memory institutions are coordinated by digitalization centres of excellence. These are national centres – Martynas Mazvydas National Library of Lithuania, Lithuanian Art Museum, Lithuanian Chief Archivist, Lithuanian Central State Archive, regional – National M. K. Ciurlionis Art Museum, Lithuanian Maritime Museum, Siauliai Ausra Museum, County Public Libraries, sectoral – Vilnius University Library, Vrublevskis Library of the Lithuanian Academy of Sciences, and public institution “Lithuanian National Radio and Television”. Computers, scanners, cameras and other photographic equipment, computer calibrators, audio guides, printers are used for digitizing heritage.

In Lithuania, digitization of heritage is currently perceived as a creation of a database containing scanned drawings, photographs and drawings. Heritage objects are scanned and stored in digital format. An effective means of preserving historical building data is the well-known Heritage Building Information Modeling (HBIM), i.e. a static object model is created, which contains information about the geometric expression of the building, structural elements, valuable properties, etc. In the Italian, Spanish, and Irish heritage protection system, HBIM tools are used for modelling and managing historical structures. HBIM has not yet been included in the Lithuanian cultural heritage preservation system, although this tool would help preserve heritage objects, design historic buildings and manage their valuable elements.

The policy of digitization of Lithuanian cultural heritage is implemented on the basis of the concept of digitization of Lithuanian cultural heritage, the strategy of digitization of Lithuanian cultural heritage, the strategy of digital content preservation and access and the program of digitalization and preservation of cultural heritage for 2015–2020. The purpose of this program is to define the main directions for the development of the virtual cultural heritage space in order to develop a unified system of digitization and dissemination of Lithuanian cultural heritage, content long-term preservation system, as well as establish common virtual cultural heritage and the principles of spatial development [11]. The program identified three main objectives for which implementing measures were envisaged: 1) to enhance the integrity and sustainability of the virtual cultural heritage space; 2) to create a national digital cultural heritage long-term retention system; and 3) to create a rich virtual culture that meets the needs of society heritage space. For the implementation of initiatives for digitization of cultural heritage in the period 2009–2013, almost 70 million Litas was allocated, of which over 54 million Litas were from the European Union Structural

Funds and co-financing. These investments have created a national cultural heritage a digitization infrastructure that provides a solid basis for further investment in this area [11].

The Ministry of Culture co-ordinates the implementation of this policy with the Ministry of Education and Science, the Ministry of Transport and Communications and the Office of the Chief Archivist of Lithuania. The Lithuanian Council for the Digitization of Cultural Heritage performs the functions of an expert and consultant in solving issues related to the formation, implementation and supervision of digitization policy.

The Law of the Republic of Lithuania on Management of Information Resources, 11/10/2016 (amendments) – the purpose of this law is to ensure proper development, management, management, use, maintenance, interoperability, planning, financing and security of state information resources [12]. Article 11 of this law establishes the rights and obligations of the Authority in the development and management of state information resources, which is also important for institutions engaged in digitization of cultural heritage objects and management of information bases.

The laws, related to the digitization of heritage objects in Lithuania are as follows: Cyber Security Law, 12.12.2014; Law of the Republic of Lithuania on Copyright and Related Rights, 21.12.2011 (amendments); Law of the Republic of Lithuania Management of Information Resources, 2011.12.15; Law on Information Society Services, 25.05.2006; Orders of the Minister of Culture approving the description of the procedure for monitoring the digitization of cultural heritage and the report on the monitoring of cultural heritage digitization monitoring statistics, 08.09.2016. These documents are linked to international legal instruments valid in all countries of the European Union, such as Directive of the European Parliament and of the Council on Copyright in the Digital Single Market, 2016.09.16; European Digital Single Market Strategy, Brussels, 06.05.2015; Conclusions of the Council of the European Union on the Digitization and Online Accessibility of Cultural Material and Digital Preservation, 10.05.2012; Conclusions of the Council of the European Union on the European Digital Library EUROPEANA, 2008.11.20.

On 9 April 2019, 26 EU Member States signed a Declaration of Cooperation on the Progress of Digitization of Cultural Heritage. The main aim of this declaration is to make more effective use of cutting-edge digital technologies in cooperation among EU Member States, addressing the challenges facing European cultural heritage, encouraging citizens' involvement, and increasing the use and visibility of cultural heritage. Key aspects of the Declaration are the following: a global initiative to digitize European cultural heritage sites, monuments and sites; re-use of digital cultural resources to promote citizens engagement and innovative use of cultural heritage; strengthening of the digital cultural heritage sector [13].

III. HBIM INTEGRATION POSSIBILITIES IN HERITAGE PROTECTION SYSTEM IN LITHUANIA

According to the International HBIM theoretical models, it is possible to distinguish several models of formation and use steps:

pre-BIM that is covered by design process; idealized/optimized BIM that is consisting of construction stages; post-BIM that has an operational lifecycle stage (integrated database paradigm) [14].

In Lithuania, HBIM processes take place mainly at theoretical level. In practice, the creation of heritage-based digital models with integrated attribute information therein is only at an elementary level.

As examples of the use of digital technologies in Lithuania could be mentioned the renovation projects of the Vilnius St. Archangel Rapol Church and St. Anne Church, and the Bernardine Monastery. During the renovation project, all problems have been solved by using complex laser scanning techniques and high-resolution photogrammetry [15].

The project preparation stages of cultural heritage buildings include historical object analysis, protection requirements analysis, pre-design proposals, technical project preparation, and project implementation stage. In this case, data collection (historic data, building parametric objects library, and so on) is the most important stage in digitalization process of cultural heritage objects, especially for historical buildings (Fig. 1).

Analysis of the current situation. The analysis of the current state is based on the evaluation of the valuable properties and physical condition of the objects of real cultural heritage, as well as the analysis of historical data and the establishment of protective measures. Currently, the Lithuanian Heritage Protection System collects these data in the register of values providing descriptive information. There are no digital 3D models with heritage status data, so this system would enable the transition to digital data models.

Building scanning process consists of photogrammetry or 3D laser scanning. Photogrammetry method is based on measurements of photographic images, where we can determine the shape, size, position of different objects on the surface, and make plans and maps. Managing objects with this method in virtual reality is much more convenient, giving users unlimited possibilities to do various simulations (move objects, cut them, etc.) on their computer screens, make measurements and make necessary calculations. 3D laser scanning, accurate 3D geometry of the measured cultural heritage object is captured. Scanning also produces digital high-quality photos that are combined with a cloud of dots. This gives the exact 3D object model. When scanning, all scanning positions are integrated into a single system ensuring the accuracy of the planned position and height. This creates a digital twin of the heritage object or site, which is important for preserving the digital model of the heritage site.

Physical representation of the 3D model of the building. At this stage, the relationship between the physical and modelled components is established and created, creating a realistic view of the building.

Collection and creation of attribute information and parametric objects library. Objects are associated with information describing them – attribute data tables, where usually one graphic object corresponds to one record (row) in attribute tables. The tables may contain textual, numerical, and logical data that provide versatile quantitative and qualitative information about

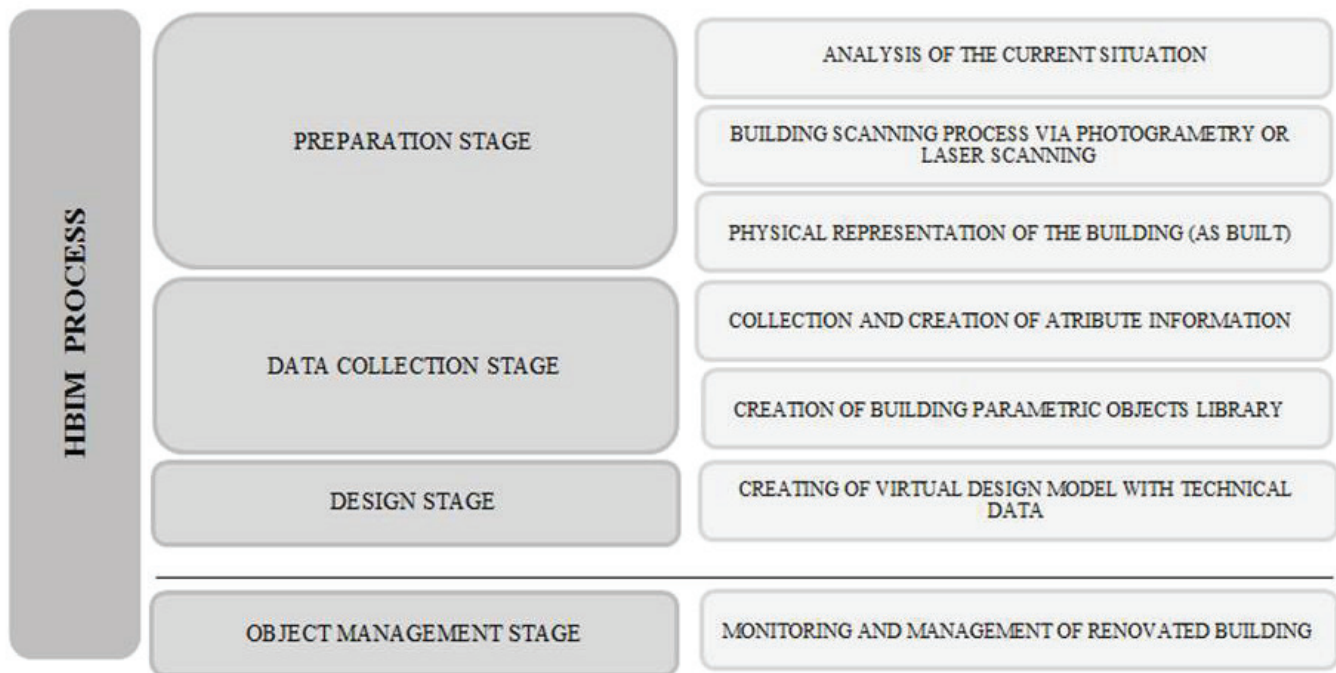


Fig. 1. Main stages of HBIM process [Figure: authors of the article].

the object. For heritage objects these are valuable features with precise position fixation, historical data, materiality, structural elements, etc.

Creating of virtual design model with technical data. Virtual reality helps to restore the historical view of territory, exterior and interior elements of the building, and the object's original image.

These two components are essential for collecting and storing detailed information about individual heritage objects or areas. The use of digital data makes possible to move on to the next heritage renovation and upgrade level where the designer could see changes of valuable properties in the design proposals and technical project parts.

Monitoring and management of the renovated building. The evaluation of built heritage changes is based on the quantitative and qualitative assessment and constant monitoring of changes. The aim of the principal method for the analysis of changes, i.e. monitoring, is to observe systematically, to analyse and forecast the state of the environment, to determine the changes conditioned by the anthropogenic impact. Digital database gives possibility to make prognoses of historical building valuable properties changes while the damage has not occurred heritage object yet. It also ensures the processes of regulating the change of valuable properties of heritage objects. At the moment there is no common system for monitoring heritage objects in Lithuania. A digital heritage monitoring system would ensure processes for regulating heritage changes.

CONCLUSIONS

Historic Building Information Modelling (HBIM) as a new approach for modelling historic buildings has been developed in the Dublin Institute of Technology by Murphy, M. and others in 2009. Today HBIM method in foreign countries mostly is used in the case of renovation of existing historical buildings, in cases when certain existing buildings should have a renovation of the structure or architecture details, as well as in the case of a virtual reconstruction of historical building when a certain building does not exist anymore and the new function has been suggested, a physical reconstruction no longer makes sense but still the existence of such building is important to the public.

In Lithuania, the process of digitization of cultural heritage objects started in 1996 by scanning and archiving historical documents of heritage objects. A legal framework has been created to conduct and manage this process. Nowadays the policy of digitization of Lithuanian cultural heritage is implemented on the basis of the concept of digitization of Lithuanian cultural heritage, the strategy of digitization of Lithuanian cultural heritage, the strategy of digital content preservation and access and the program of digitalization and preservation of cultural heritage. The purpose of this program is to define the main directions for the development of the virtual cultural heritage space in order to develop a unified system of digitization and dissemination of Lithuanian cultural heritage.

Digitization of heritage objects using BIM and HBIM technologies in Lithuania is still practically at a theoretical level. Currently, the focus is on scanning heritage sites and reproducing realistic images. Creating of attribute data for cultural heritage sites and incorporating them into HBIM models is in the initial stage. The parametric database of valuable properties of heritage objects is not being created yet. However, from 1 July 2020, it is planned to apply BIM in the new design and construction of all or part of complex and high value public sector buildings.

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