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Course: BIM introduction. Block 3: BIM applications. Lecture 3.2

BIM for Historical Existing Buildings

Lecture Notes

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Version

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Learning outcomes

At the end of this lecture, the learner is expected to be able to

- Understand the specialized application of BIM and its key benefits in the context of the historical building and structures
- List the steps of the HBIM process
- Describe concrete possible applications of HBIM

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Summary

This lecture introduces the use of BIM to manage the historical buildings and structures. It presents the key benefits of using HBIM for historic buildings and the steps to perform the entire process - from the preliminary data acquisition to the modelling and its maintenance. Finally, it presents some examples of possible applications and 3 real cases.

Expected competences when entering the lecture

Basic knowledge about BIM

Expected Workload

14 slides with course learning content, 1 hour

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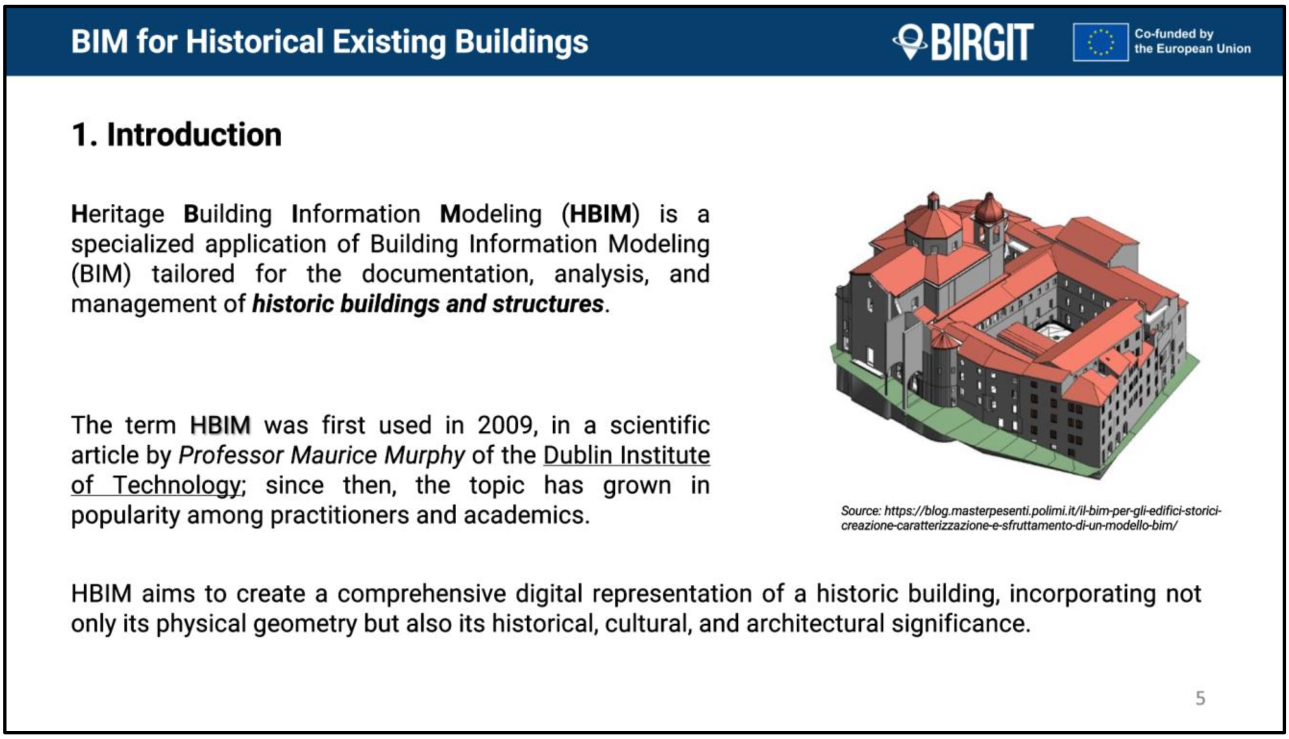
0.3	March 2024	Silvia Gorni	Draft	Third version after internal assessment
1.0	2024/03/14	Silvia Gorni	Published	Edited by M. Morbidini

Content of the lecture:

1. Introduction



An historic building is generally considered to be a building or structure that has some kind of 'historic value', i.e. people in the present are connected to it via past events in some way. This value warrants it being afforded consideration in planning decisions that have to be made concerning it.

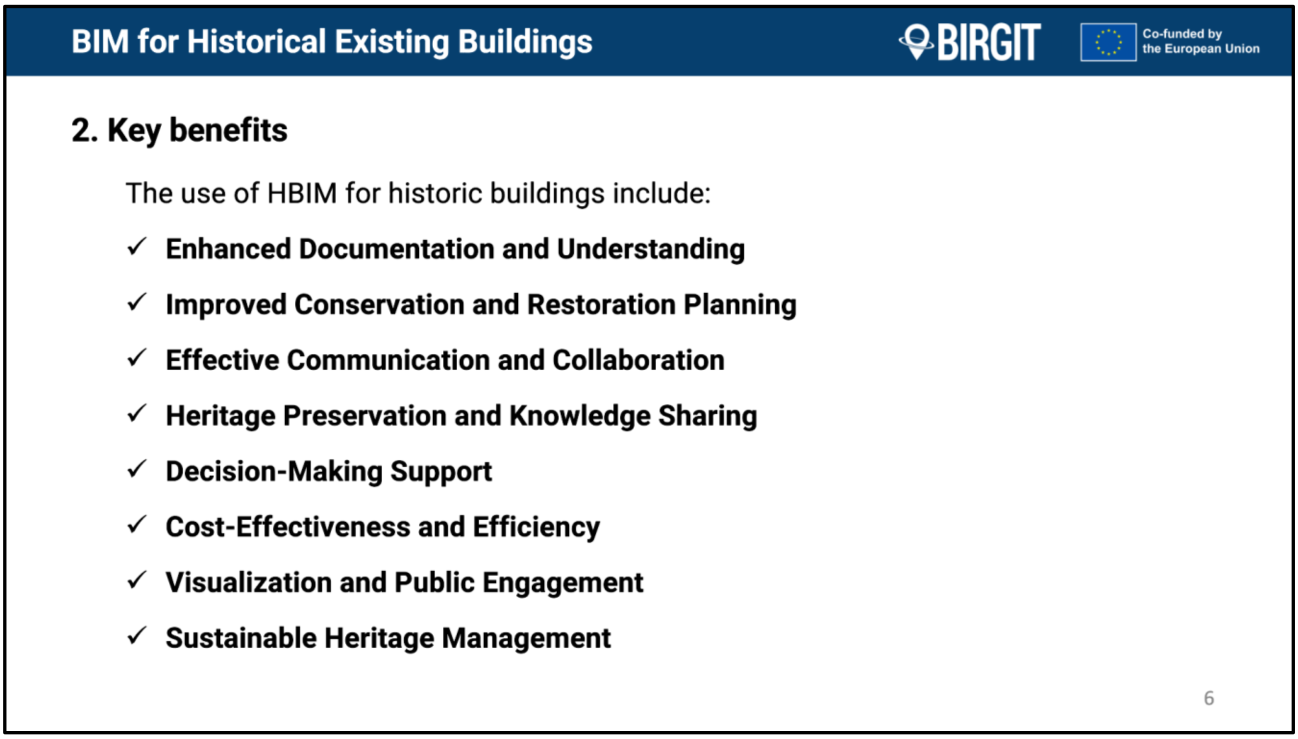
Conservation of built heritage is progressively linked to the regular maintenance of buildings, defining the preventing conservation as a real necessity in everyday practice. In this view, it is necessary to have an instrument that allows to collect, compare, share and manage all the data available concerning the geometry and state of conservation of buildings. Such data include, not only the products of surveys, drawings, thematic and historical contents, but also the information about maintenance or restoration activities and many other information.

Heritage Building Information Modeling (**HBIM**) is a specialized application of Building Information Modeling (BIM) tailored for the documentation, analysis, and management of historic buildings and structures. While traditional BIM focuses on new construction projects, HBIM specifically addresses the unique challenges and complexities of historic buildings, which often have irregular geometries, non-standard construction methods, and a rich historical context.

The term HBIM was first used in 2009, in a scientific article by Professor Maurice Murphy of the Dublin Institute of Technology (Historic Building Information Modelling – Adding intelligence to laser and image based surveys of European classical architecture *Maurice Murphy, Eugene McGovern, Sara Pavia*); since then, the topic has grown in popularity among practitioners and academics.

HBIM aims to create a comprehensive digital representation of a historic building, incorporating not only its physical geometry but also its historical, cultural, and architectural significance. This detailed model serves as a central repository of information for various stakeholders involved in the preservation, restoration, and management of historic building.

2. Key benefits



Key benefits of using HBIM for historic buildings include:

➢ **Enhanced Documentation and Understanding:** HBIM enables the systematic collection, organization, and visualization of vast amounts of data related to historic buildings, including historical records, construction details, material specifications, and past interventions. This comprehensive documentation provides a deeper understanding of the building's history, construction techniques, and current condition.

➢ **Improved Conservation and Restoration Planning:** HBIM facilitates informed decision-making for conservation and restoration projects. By creating a virtual model, professionals can simulate various interventions and assess their impact on the building's integrity before actual implementation. This reduces the risk of unintended damage and ensures that interventions are compatible with the building's historical value.

➢ **Effective Communication and Collaboration:** HBIM serves as a common platform for collaboration among various stakeholders, including architects, conservators, historians, engineers, and building managers. The detailed and accessible information within the HBIM model fosters effective communication, ensuring that all parties involved are working with consistent and accurate data.

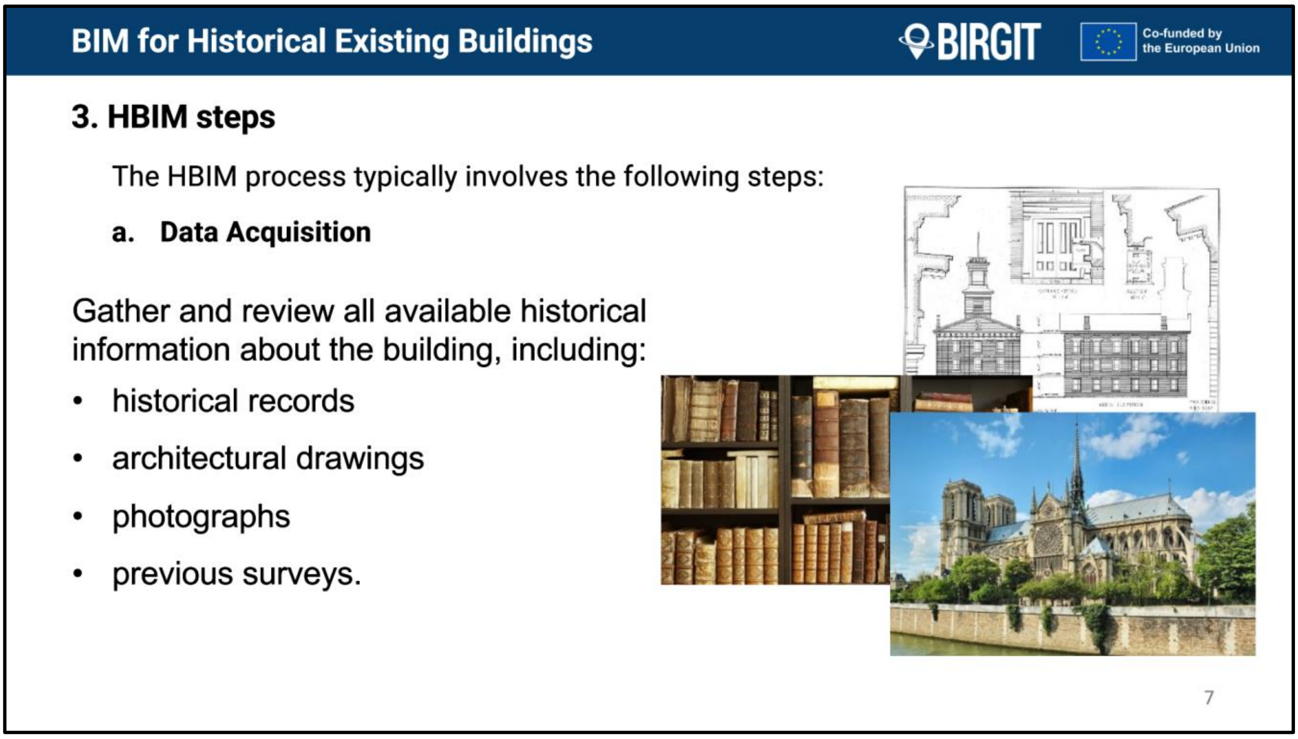
➢ **Heritage Preservation and Knowledge Sharing:** HBIM contributes to the preservation of cultural heritage by creating a lasting digital record of historic buildings. This digital archive can be used for research, education, and public engagement, promoting a deeper understanding and appreciation of historical architecture.

- **Decision-Making Support**: HBIM models can be used to simulate different scenarios and assess the impact of various interventions on the building's structural integrity, energy efficiency, and overall performance. This allows for informed decision-making about the building's preservation and management.
- **Cost-Effectiveness and Efficiency**: HBIM can help to reduce costs and improve efficiency in the conservation and restoration of historic buildings. By providing a comprehensive understanding of the building and allowing for virtual simulations, HBIM can minimize errors, rework, and delays during the project lifecycle.
- **Visualization and Public Engagement**: HBIM models can be used to create immersive visualizations and virtual tours of historic buildings, providing a unique and engaging way for the public to learn about and appreciate historical architecture. This can enhance public awareness of heritage conservation efforts and promote cultural tourism.
- **Sustainable Heritage Management**: HBIM can contribute to sustainable heritage management by providing a framework for monitoring the condition of historic buildings, tracking changes over time, and identifying potential risks or vulnerabilities. This proactive approach can help to prevent damage and extend the lifespan of historic structures.

The HBIM approach to the management of historic buildings ensures their preservation and deepens our appreciation for cultural heritage. The advancement of HBIM technology is expected to propel its scope, making it an indispensable tool for heritage preservation specialists.

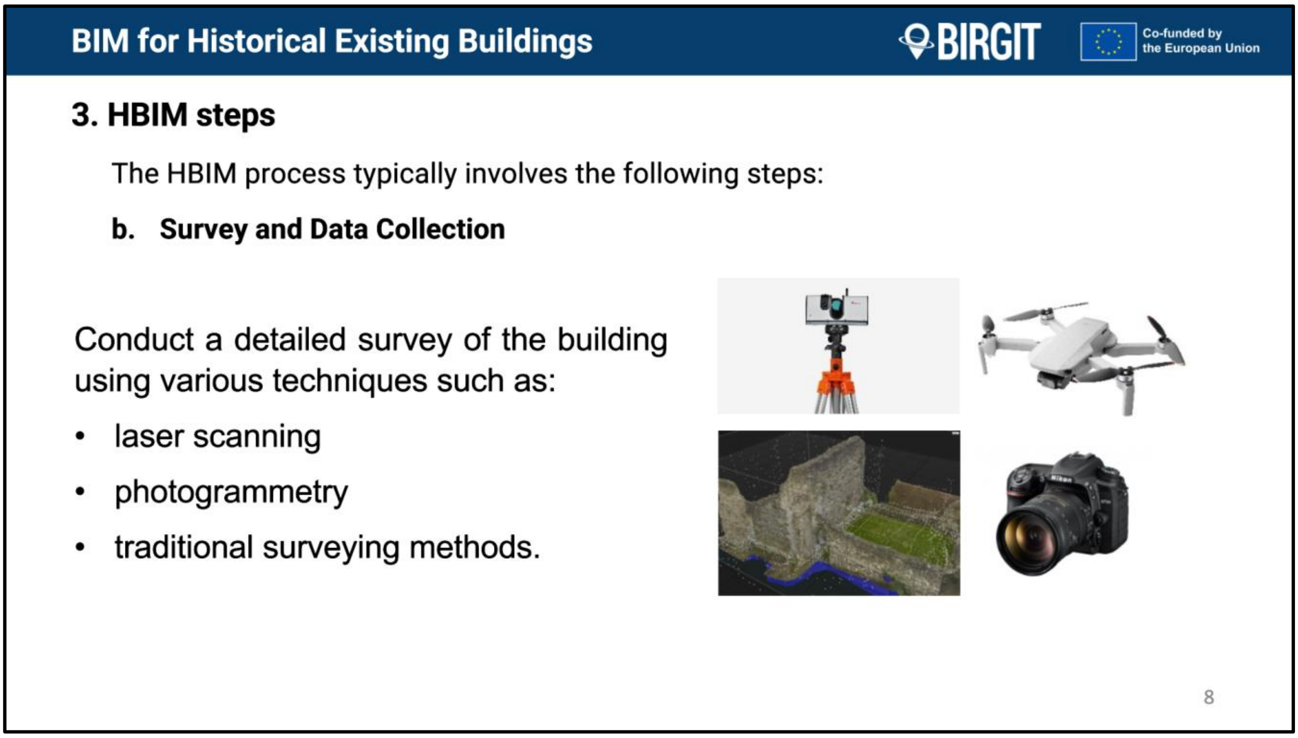
3. HBIM steps

a. Data Acquisition



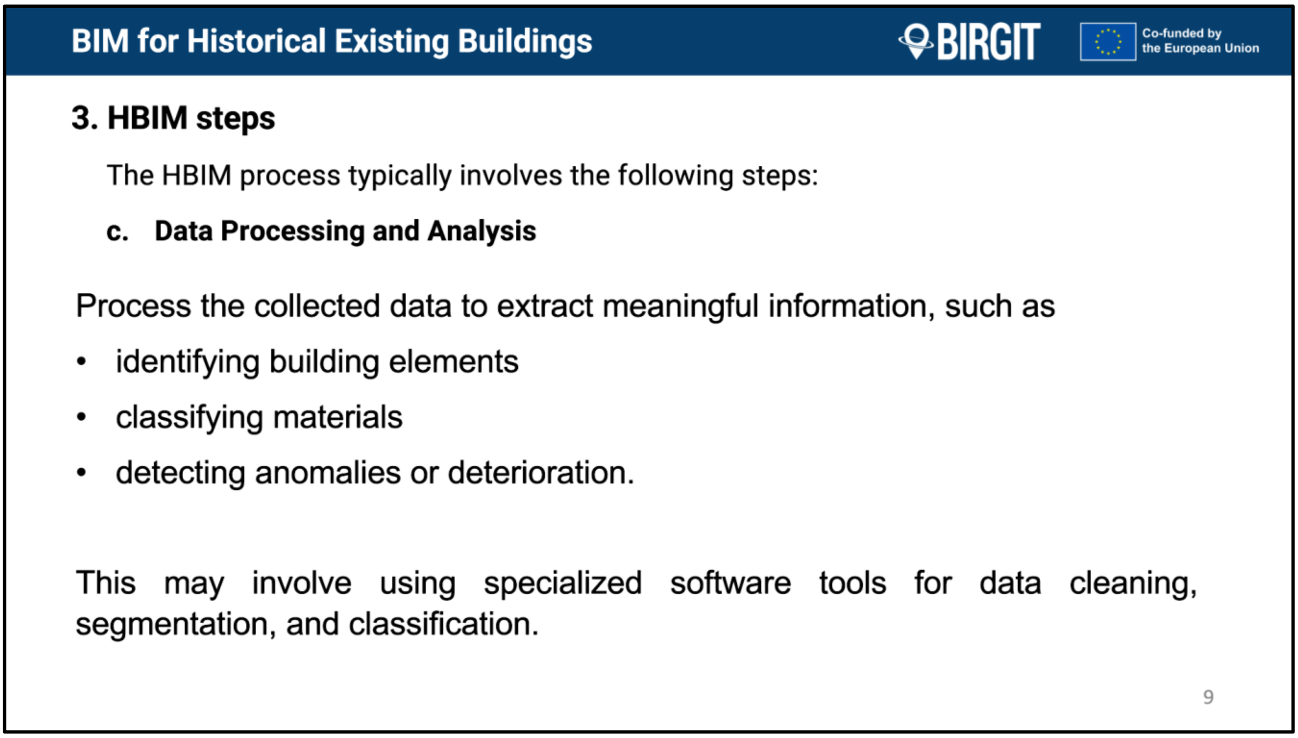
This phase involves extensive research and analysis to understand the building's history, construction techniques, and alterations over time.

b. Survey and Data Collection



This generates a comprehensive point cloud or 3D model of the building, capturing its geometry, dimensions, and spatial relationships.

c. Data Processing and Analysis



d. HBIM Modeling

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3. HBIM steps

The HBIM process typically involves the following steps:

d. HBIM Modeling:

Create a detailed HBIM model using BIM software, incorporating both geometric and non-geometric information.

This involves:

- creation of specific libraries of parametric objects
- assigning material properties
- linking historical data to specific elements within the model.

Considering then that existing buildings almost never present characteristics of regularity and repetitiveness, the parameterisation of the components becomes a rather complex operation with a considerable expenditure of time and resources.

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e. Model Validation and Review

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3. HBIM steps

The HBIM process typically involves the following steps:

e. Model Validation and Review

Validate the HBIM model against the collected data and historical records to ensure accuracy and consistency.

This may include performing clash detection, comparing dimensions, and reviewing models with historical architecture experts

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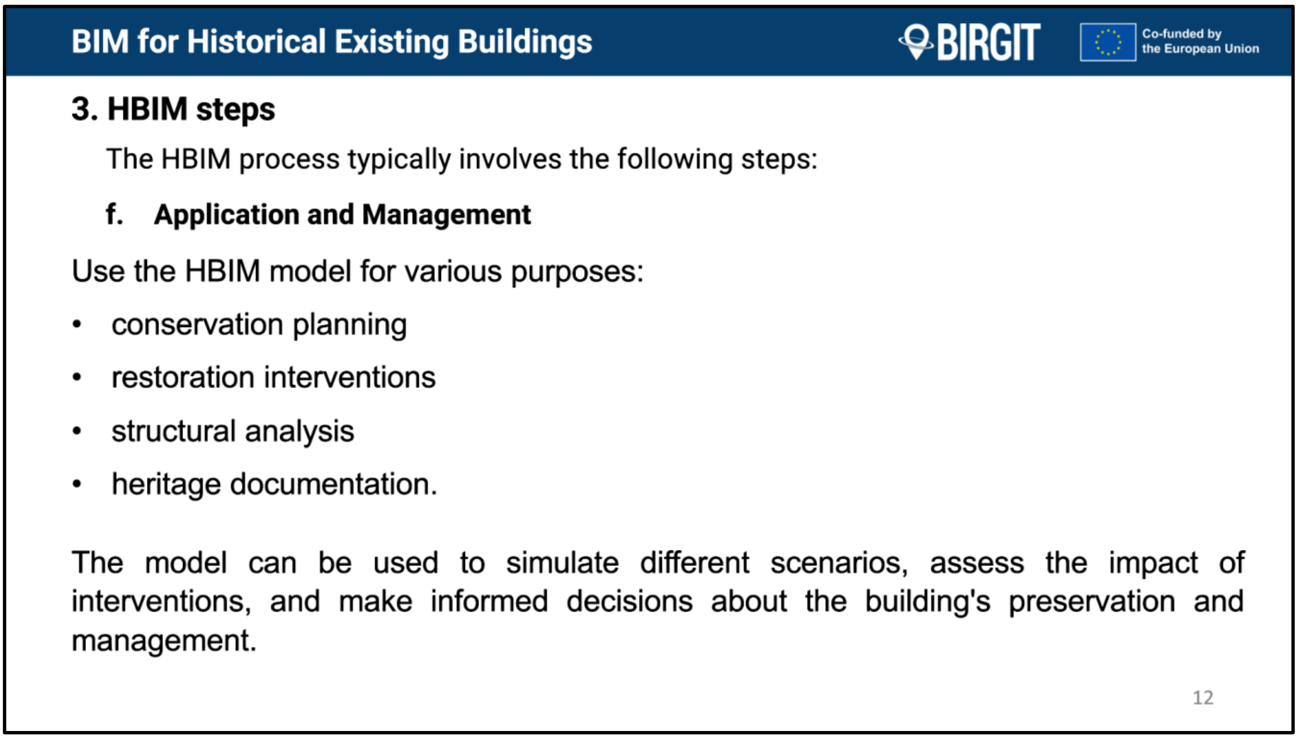
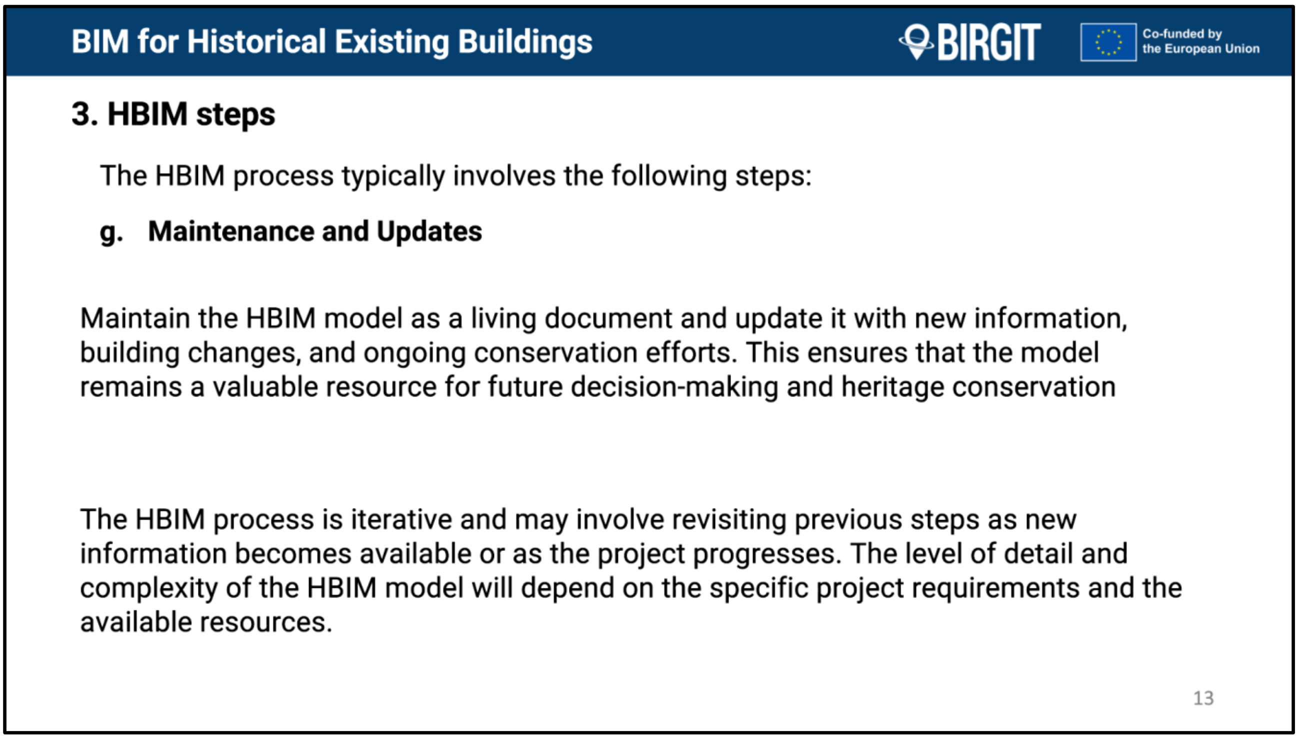
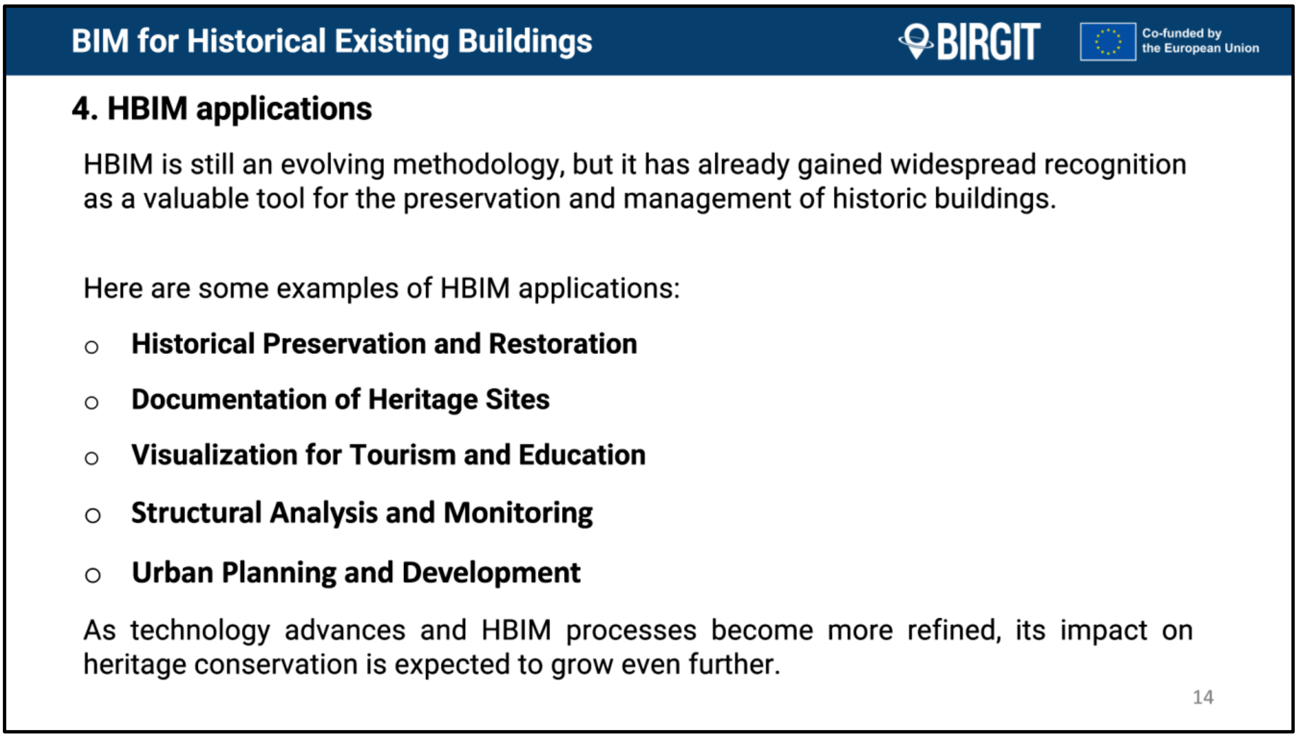
f. Application and Management



g. Maintenance and Updates



4. HBIM applications

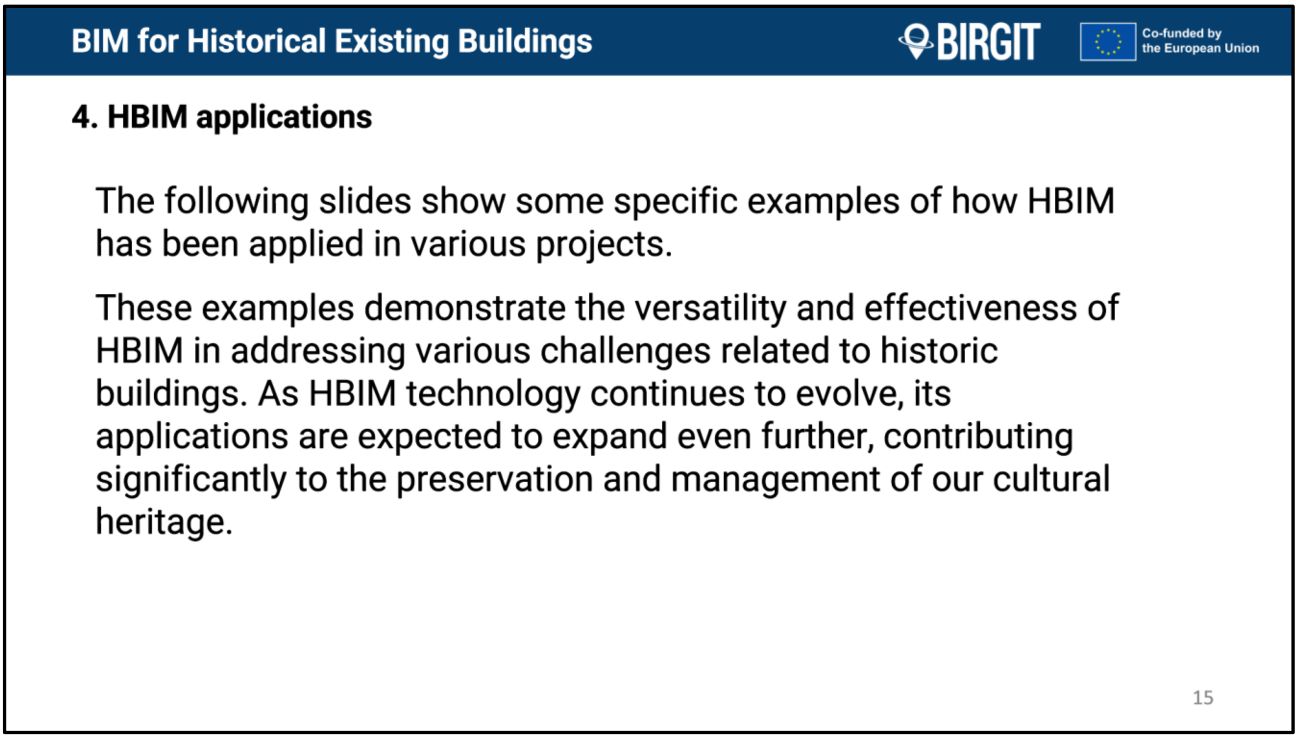


The application of HBIM enables the evaluation of structural stability in historical structures and facilitates long-term monitoring to assist in maintenance and conservation initiatives; detailed 3D models can be constructed, providing a digital repository for future generations and researchers.

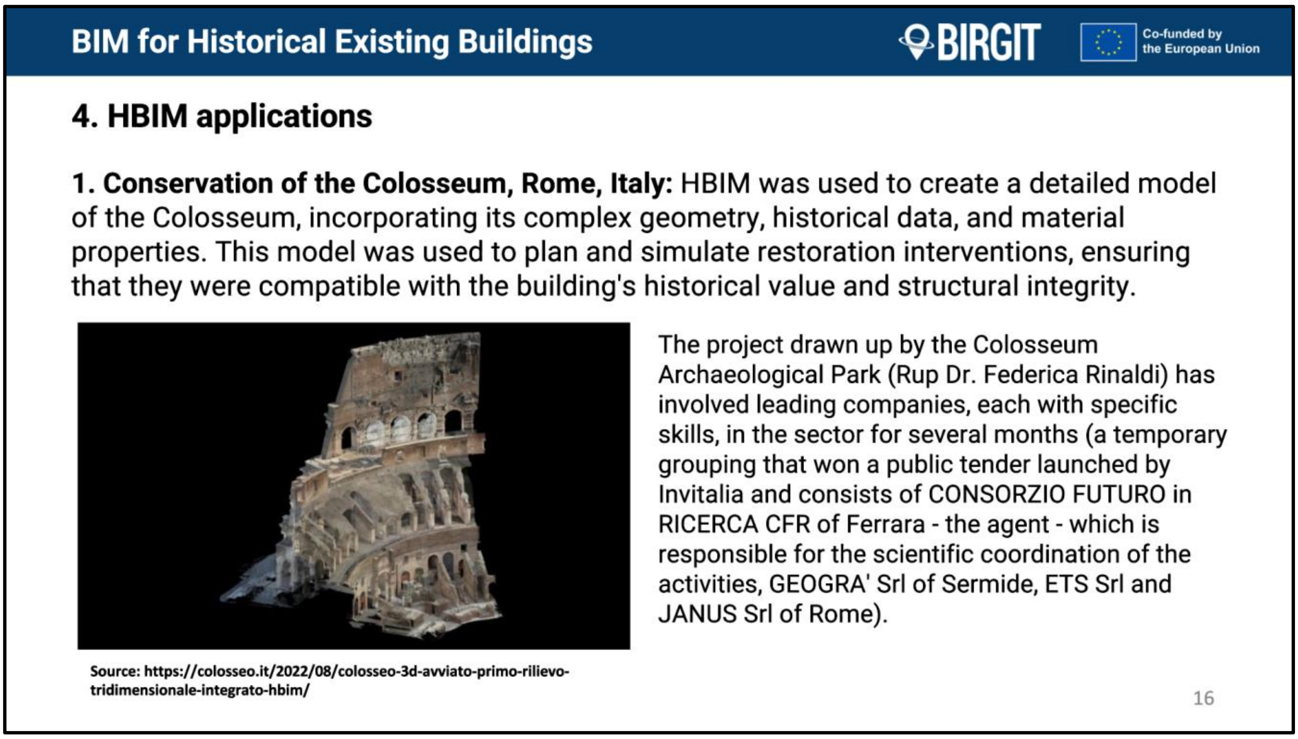
Moreover, by seamlessly blending historical buildings into modern cityscapes, it can play a crucial role in the planning and development of urban areas while preserving their cultural value.

By leveraging HBIM, historical buildings can be transformed into interactive virtual tours, providing visitors with a digital platform to discover its rich history.

3. HBIM applications



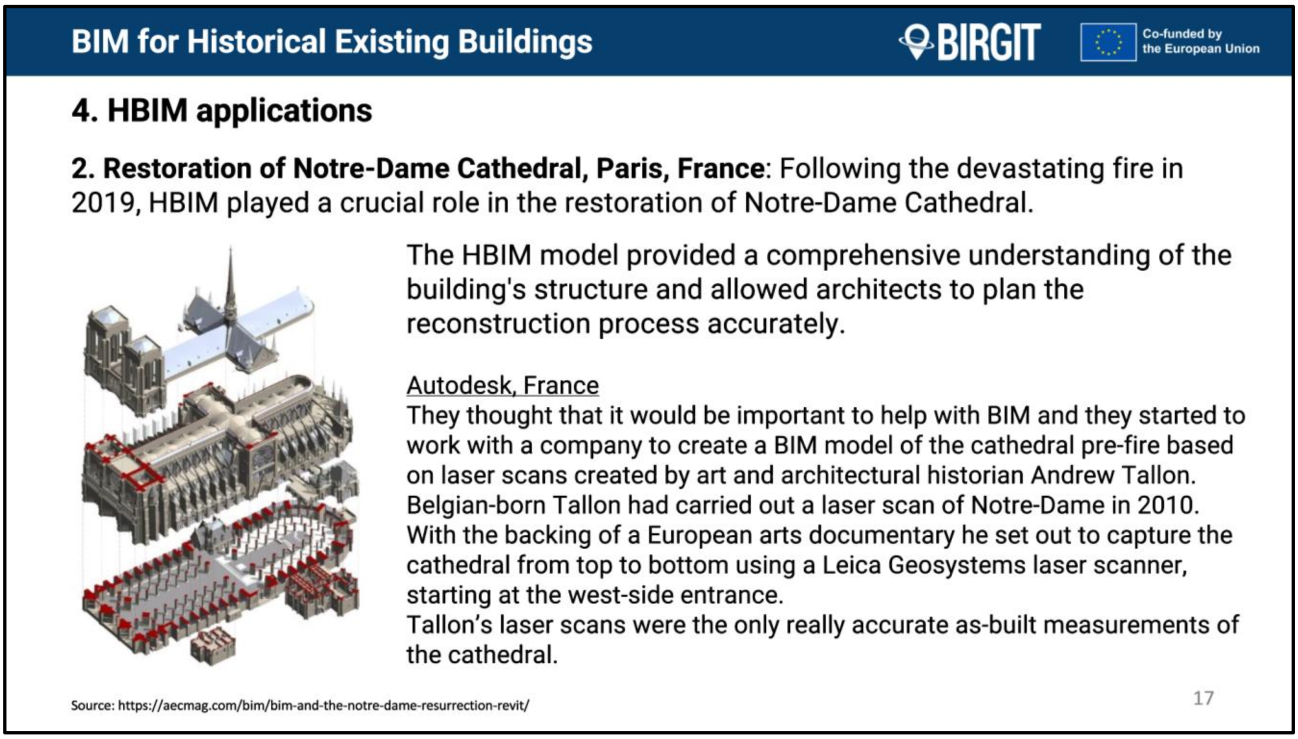
1. Conservation of the Colosseum, Rome, Italy



For the integrated three-dimensional digital survey of the Colosseum, topographic, laser scanner, terrestrial and drone technologies, photogrammetric acquisitions and direct surveys are used simultaneously, which will make it possible to describe in detail the state of the monument, with the georeferencing of every single point.

The 3D point cloud survey will also form the geometric-morphological basis in the HBIM environment, the information development of which will enrich the geometric model with information on materials, construction techniques, states of decay and precisely the structural condition of the monument.

2. Restoration of Notre-Dame Cathedral, Paris, France



Following are the 5 BIM steps used for heritage preservation of Notre-Dame Cathedral:

1. ***Data Collection*** – Billions of measurements were collected onsite using drones and laser scanners. Laser scanning takes distance measurements in every direction to capture the surface shape of building components and objects. A large and thorough set of point cloud data was collected at Notre-Dame by twelve laser scanners producing 46,000 images. The information collection was targeted so it could be used to form a 3D representation of the onsite conditions and structural stability after the fire, down to the individual stones. Notre-Dame has unique features that determined the preferred conditions for the scanning process and the techniques that were used.

2. ***Analyzing Scans*** – Supported by cloud computing, the scans were processed, cleaned up, stitched together, and merged to form the best possible 3D representation of the actual site. Information from the new laser surveys was combined with previous scans completed during other projects in 1993 and 2010. Using the "before" and "after" scans, it could be determined what had changed. The Redshift article explained that both 2D and 3D rendering data are considered essential for keeping endangered heritage buildings like 850-year-old Notre-Dame – a product of engineering advances during Medieval times – relevant and dynamic.

3. ***3D Modeling*** – Creating the BIM model was a fundamental part of the overall project, and it continues to enable simulations, space planning and future management options. Using Autodesk software, it was developed the model using the processed data. Autodesk ReCap Pro was used to prepare the data for import into Autodesk Revit. The BIM model that was then created in Revit contained objects rich with

data: floors, columns, walls, windows, roofs. Autodesk explained that, because of the complexity, structural details and size of Notre-Dame, it took over a year to create the full digital BIM model. That model included:

- 12,450 objects
- 323,219 square feet of stone walls
- 42,248 square feet of lead roof
- 186 vaults

4. ***Documentation*** – Material types and quantities and technical documents were extracted from the BIM model. These included plans, elevations, sections, shop drawings, perspectives, and orthographic projections. After some debate, it was decided the rebuild would utilize the same types of materials as the original structure: stone, oak wood and lead.

5. ***Digital Representation*** – The data-rich BIM model enabled the architects, engineers, graphic designers, stonemasons, restorers, and other construction professionals to get exact measurements for each team's portion of reconstruction work. The team used and continues to use the BIM model to get accurate estimates of construction costs as well.

(Source: https://asti.com/blog/5-bim-steps-used-for-heritage-reconstruction-of-notre-dame-cathedral/)

More info and images: https://aecmag.com/bim/bim-and-the-notre-dame-resurrection-revit/

3. Virtual Tours of Pompei, Italy

The project is implemented by the ***Archaeological Park of Pompeii*** together with the ***Federico II University*** of Naples, which since 2010 has followed the accessibility improvement projects "Pompei accessibile", "Accordo Deloitte" and "Enhancing Pompeii" for the site of Pompeii, the ***Politecnico di Milano***, which has been conducting research for years on overcoming traditional data storage models and building interoperable platforms for cultural heritage, and the ***Institute of Cultural Heritage Sciences of the CNR***, with consolidated research experience on the use of ICT technologies for the knowledge, conservation and use of cultural heritage.

The project aimed to create a digital web-based platform for the monitoring and conservation of archaeological evidence and for the definition of new ways of use because of the possibilities and limits of cultural participation imposed by the Covid pandemic.

The web-based platform allows quick access and easy interpretation of information, increasing the level of fruition for the visitor in terms of flexibility, simplicity and perception.

Characterized by an "urban" dimension, in fact, the archaeological park requires innovative tools for new management strategies and an operational speed that can be supported only by the modern information technology.

For the first phase of the web-based platform, the case study of Arianna's Domus was chosen. Critical issues were identified both from the point of view of degradation and the use of the domus. The knowledge phase was based on the cross between the archived documents also unpublished and bibliography available, with the relief using drones and 3D laser scanners. This study helped us understand how the domus changed over time and the work that was done to fix it.

The next phase saw the realization of an HBIM model by the company Acca Software. Each element can be checked and refers to dimensional data, material, and storage status.

The last phase of the research involved the creation of a maintenance sheet to show the interventions to be carried out in situ and the schedule of the maintenance activities. The analysis of internal flows for operators and the immediate availability of information for visitors improve the fruition of the domus, increasing its cultural interest and ensuring its transmission to the future.

Source: Universal Design and Interoperable Digital Platforms Between Conservation and New Fruition Opportunities. The Case Study of Arianna's Domus in Pompeii - Renata PICONE Department of Architecture | University of Naples "Federico II". doi:10.3233/SHTI220874)

Further reading and references

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- **Historic England 2017 BIM for Heritage: Developing a Historic Building Information Model**. Swindon. Historic England. https://historicengland.org.uk/images-books/publications/bim-for-heritage/
- **Historic Building Information Modelling (HBIM) For Recording and Documenting Classical Architecture in Dublin 1700 to 1830** PhD thesis https://www.researchgate.net/publication/265396963_Historic_Building_Information_Modelling_HBIM_For_Recording_and_Documenting_Classical_Architecture_in_Dublin_1700_to_1830_PhD_thesis
- **HBIM DATA MANAGEMENT IN HISTORICAL AND ARCHAEOLOGICAL BUILDINGS** December 2020 DOI**:**10.19282/ac.31.1.2020.11 https://www.researchgate.net/publication/346673256_HBIM_DATA_MANAGEMENT_IN_HISTORICAL_AND_ARCHAEOLOGICAL_BUILDINGS