With the support of the Erasmus+ Program of the European Union Strategic Partnerships N° 2021-1-SE01-KA220-VET-000028000

Course: BIM introduction. Block 1: BIM definition. Lecture 1.1

Fundamentals of BIM

Lecture Notes

Author(s)/Organisation(s):

Carlos Clemente (AIN)

Esther Bautista Gil (AIN)

Version

Version 2.0

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Learning outcomes

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

- Define the main concepts of Building Information Modeling.
- Identify the benefits of BIM for different stakeholders.
- Recognize the different stages of the BIM lifecycle.
- Describe the importance of BIM standards and best practices.

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Summary

The lecture introduces Building Information Modeling (BIM) as a digital process revolutionizing construction, emphasizing its role in enhancing efficiency, sustainability, and project success. It covers fundamental concepts, historical development, AECOO industry applications, data management, dimensionality, LOD standards, and ISO 19650. Emphasizing collaboration and practical applications, the training equips students with essential skills for real-world BIM projects, ensuring they understand its transformative impact on the construction industry.

Expected competences when entering the lecture

- Familiarity with relational databases
- Basic knowledge about project management

Expected workload

14 slides with course learning content, 3 hours

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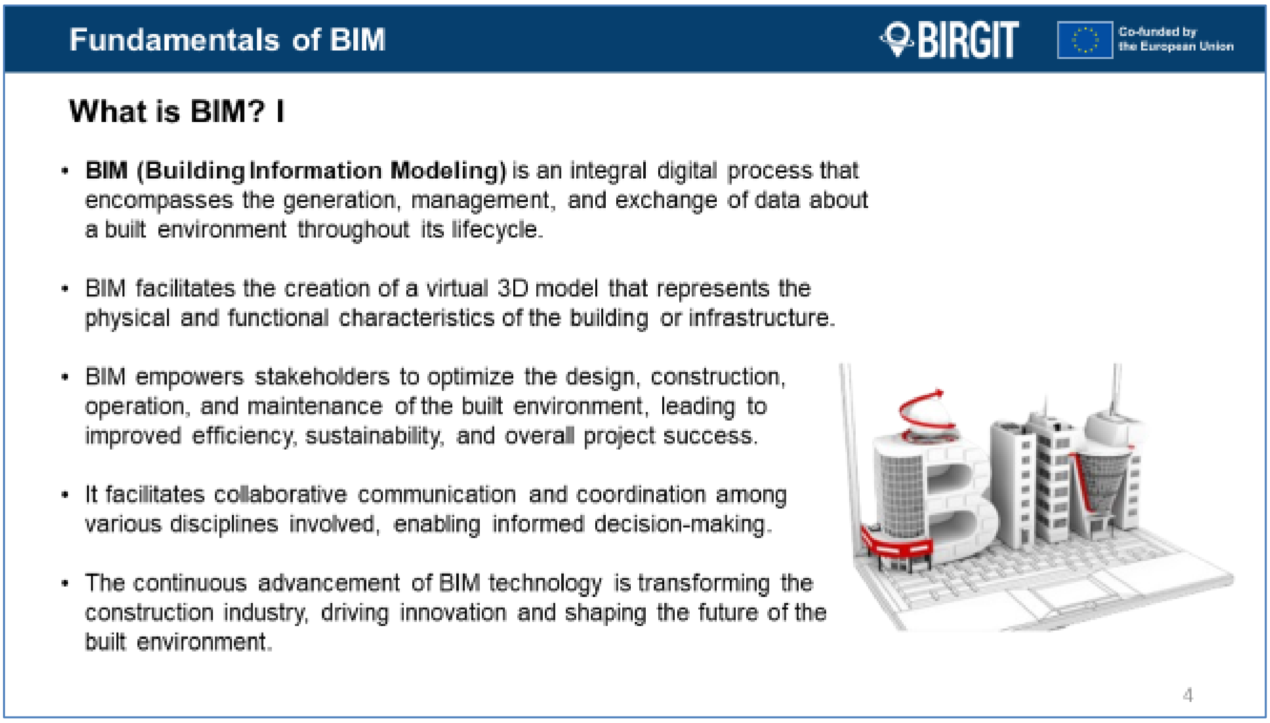
Revision History:

Revision	Date	Author(s)	Status	Description
0.1	2023-09-11	C. Clemente	Draft	First Draft
0.2	2023-11-11	C. Clemente	Draft	Second draft after review R. Molina
0.3	2023-12-11	C. Clemente, E. Bautista	Draft	Third draft after review R. Molina
0.4	2024-03-06	C. Clemente, E. Bautista	Draft	Fourth draft after review R. Molina
1.0	2024-03-14	C. Clemente, E. Bautista	Published	Edited by M. Morbidini
2.0	2025-04-29	C. Clemente, E. Bautista	Published	Updated EU logo and disclaimer. Edited by T. Näslund

Content of the lecture:

What is BIM? I



BIM (Building Information Modeling) is an integral digital process that encompasses the generation, management, and exchange of data about a built environment throughout its lifecycle.
BIM facilitates the creation of a virtual 3D model that represents the physical and functional characteristics of the building or infrastructure.
BIM empowers stakeholders to optimize the design, construction, operation, and maintenance of the built environment, leading to improved efficiency, sustainability, and overall project success. It facilitates collaborative communication and coordination among various disciplines involved, enabling informed decision-making. The continuous advancement of BIM technology is transforming the construction industry, driving innovation and shaping the future of the built environment.

BIM´s basics

COORDINATE

Good coordination is a crucial element when key stakeholders partake in projects, as these drives overall project performance and is essential for an effective deliverable.

COMMUNICATE

By combining good coordination and collaboration, project and BIM leads must
be able to engage in a language that everyone can understand. Cloud-based platforms, such as BIM 360 Design, encourage the design team to make more informed decisions and deliver efficient projects.

COLLABORATE

While collaborating isn't always easy, it provides valued information to project and BIM leads. Today, the construction industry has a number of workflows and processes that connect the various stakeholders within the core design team, encouraging a combined input. Live changes are fed back to the team in real-time and provide a connected BIM approach.

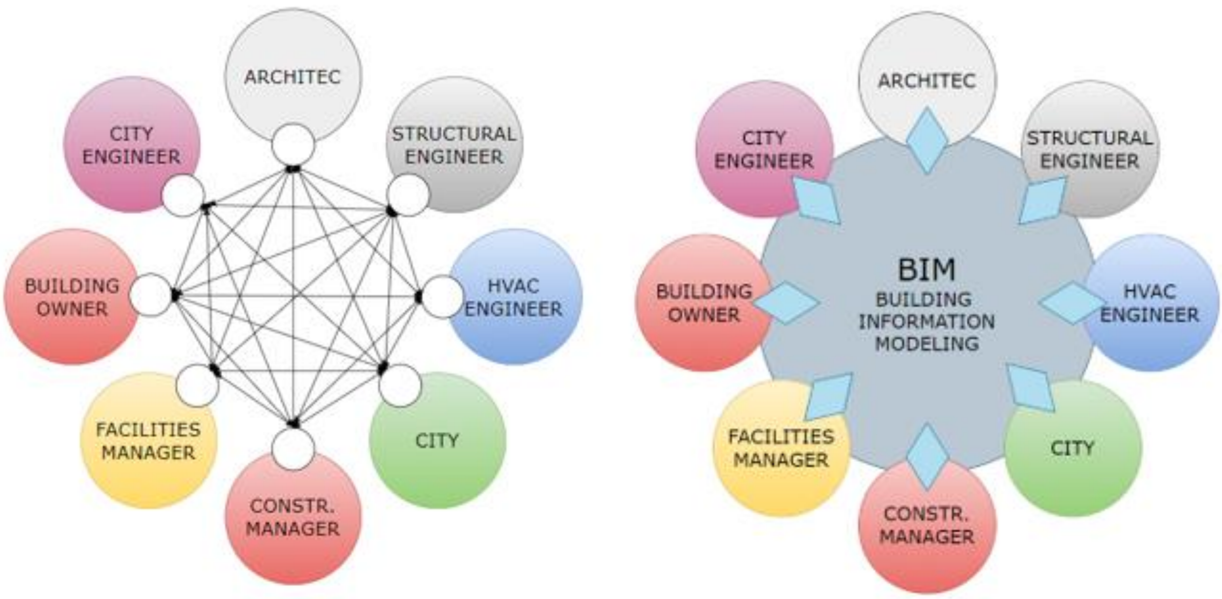


Figure 2. Improving the coordination process with BIM, source: owner

What is BIM? II

As can be seen in the next figure, when working with BIM the models are merged and referenced in the same system. This improves the design and production coordination tasks.

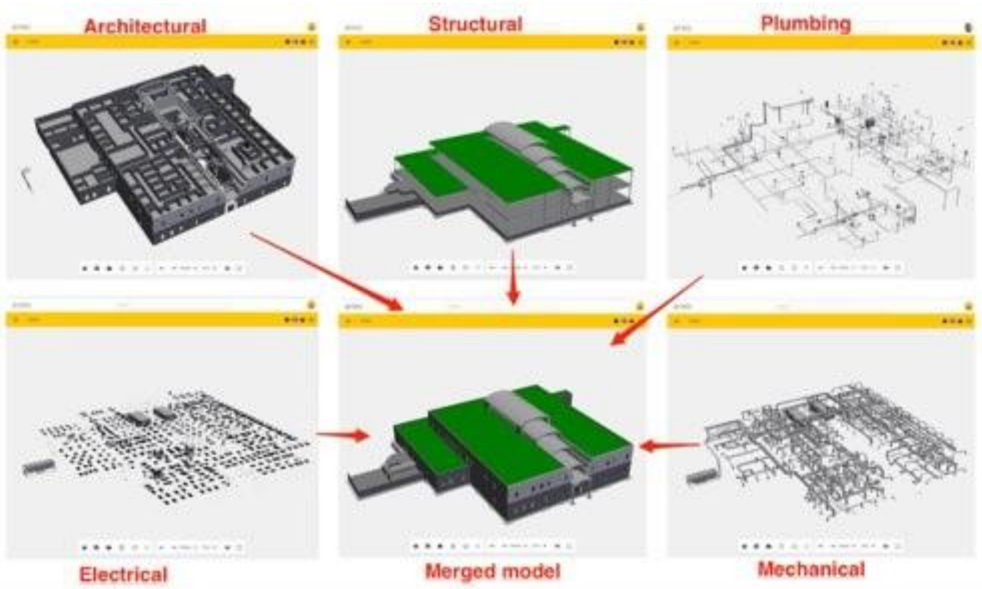


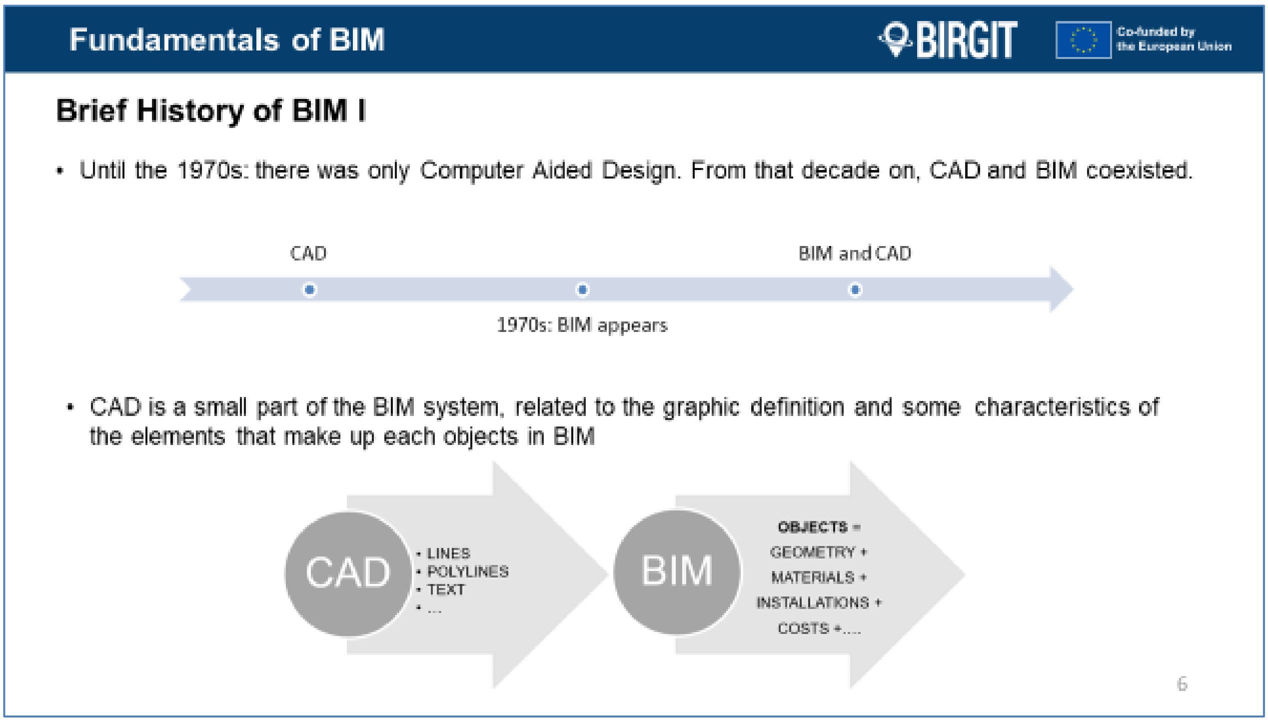
Figure 3. Convergence processes with BIM

Working with BIM therefore implies permanent coordination, communication, and collaboration, which results in the following advantages:

- Integration of information in a single model with information from all phases: planning, design, and management.
- Collaboration: All actors share the same model at all stages.
- Easier and faster communication: insertion of common objects known by all parties involved.

According to **EN ISO 19650,** BIM is defined as the use of a shared digital representation of a built asset to facilitate the processes of design, construction, and operation of the asset and to provide a reliable basis for decision making.

Brief History of BIM I



Until the 1970s: there was only Computer Aided Design. From that decade on, CAD and BIM coexisted.

Figure 4. Transition from CAD to BIM

CAD is a small part of the BIM system, related to the graphic definition and some characteristics of the elements that make up each object in BIM.

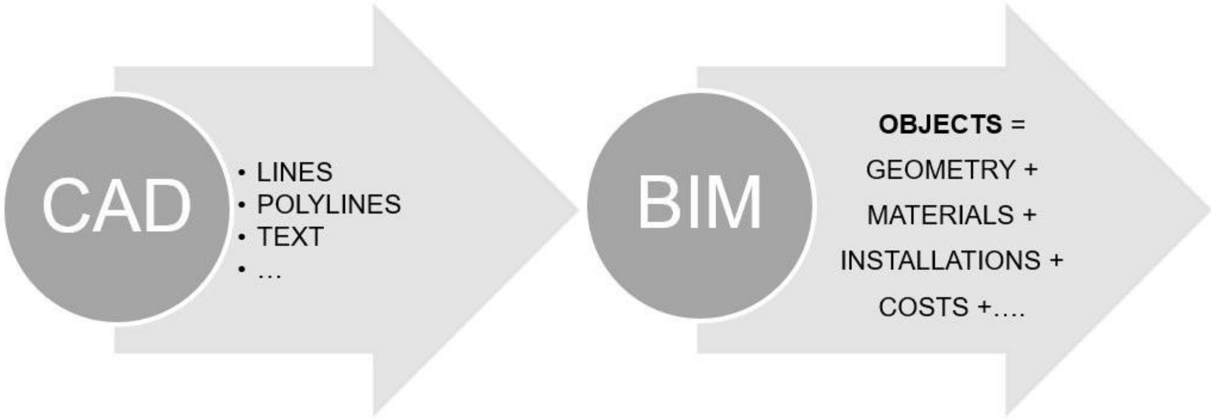
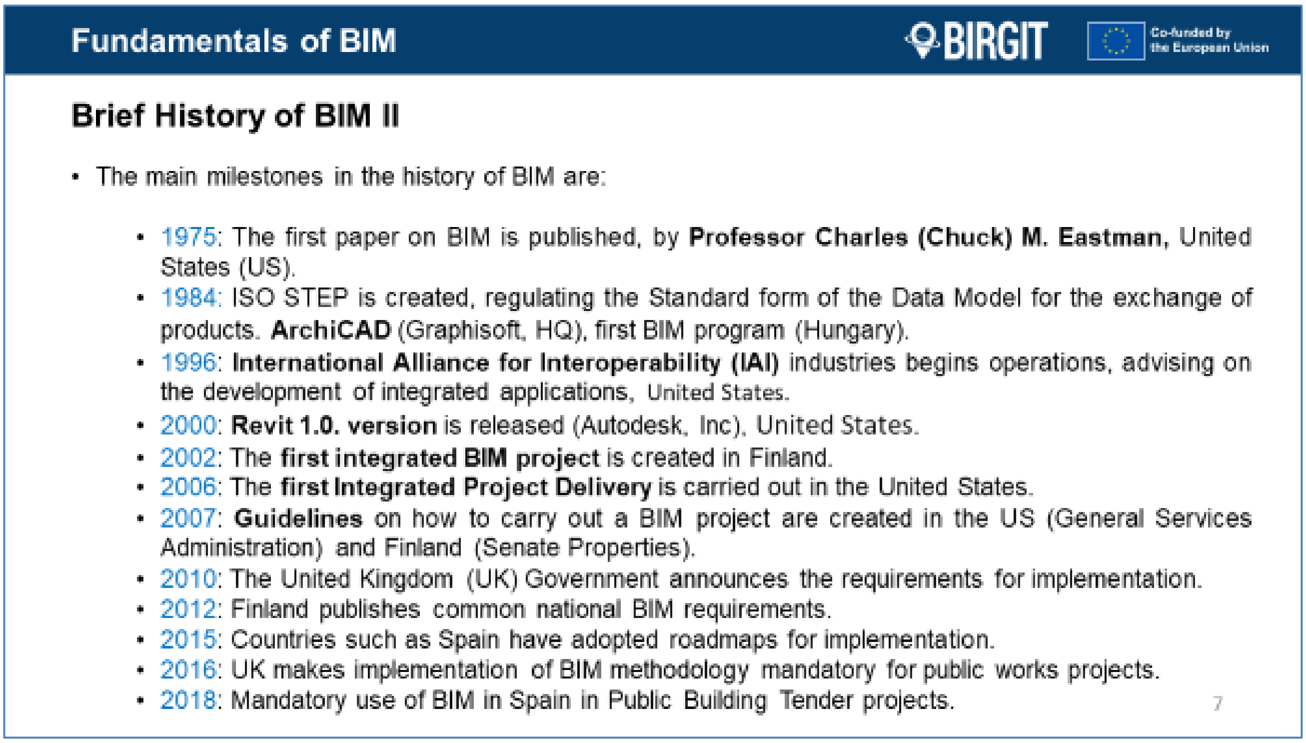


Figure 5. Transition from CAD to BIM

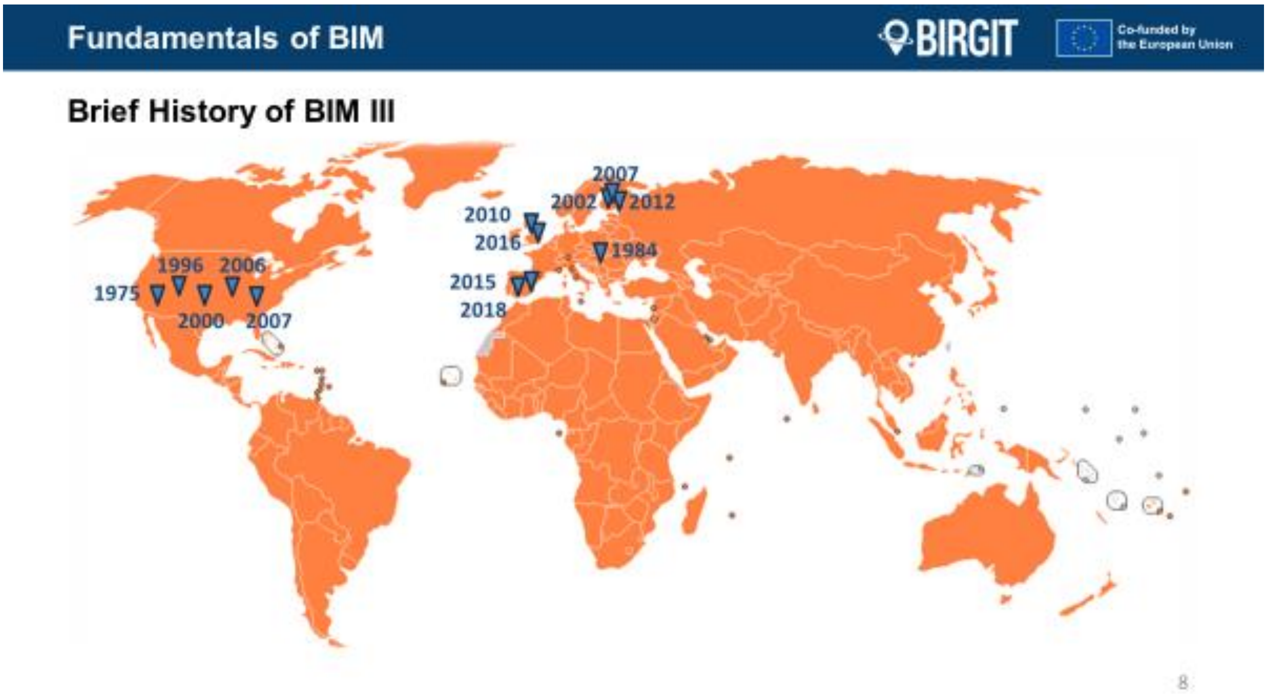
Brief History of BIM II



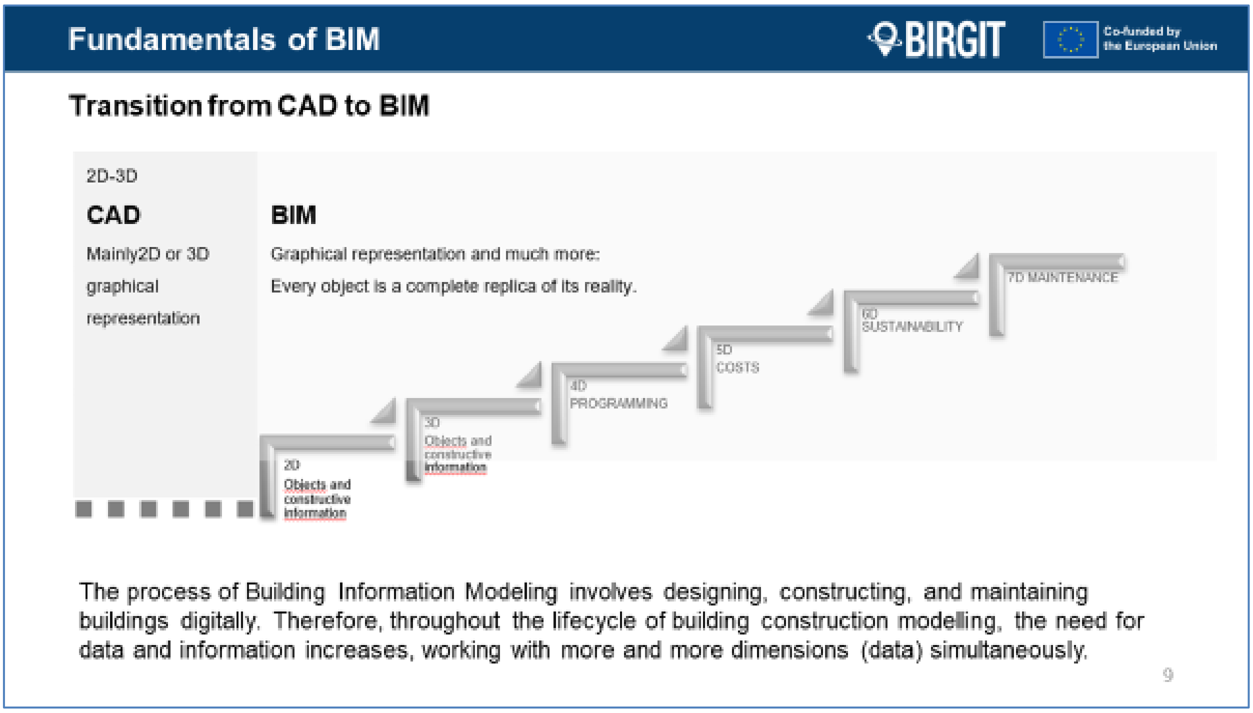
The chronological order of the history of BIM is as follows:

1975: The first paper on BIM is published, by Professor Chuc Eastman.
1984: ISO STEP is created, regulating the Standard form of the Data Model for the exchange of products. ArchiCAD, first BIM program.
1996: IAI Industry Consortium begins operations, advising on the development of integrated applications.
2000: Revit appears.
2002: The first integrated BIM project is created in Finland.
2006: The first IPD project is carried out in the United States.
2007: Guidelines on how to carry out a BIM project are created in the US (GSA) and Finland (Senate Properties).
2010: The UK Government announces the requirements for implementation.
2012: Finland publishes common national BIM requirements.
2015: Countries such as Spain have adopted roadmaps for implementation.
2016: UK makes implementation of BIM methodology mandatory for public works projects.
2018: Mandatory use of BIM in Spain in Public Building Tender projects.

Brief History of BIM III



Transition from CAD to BIM



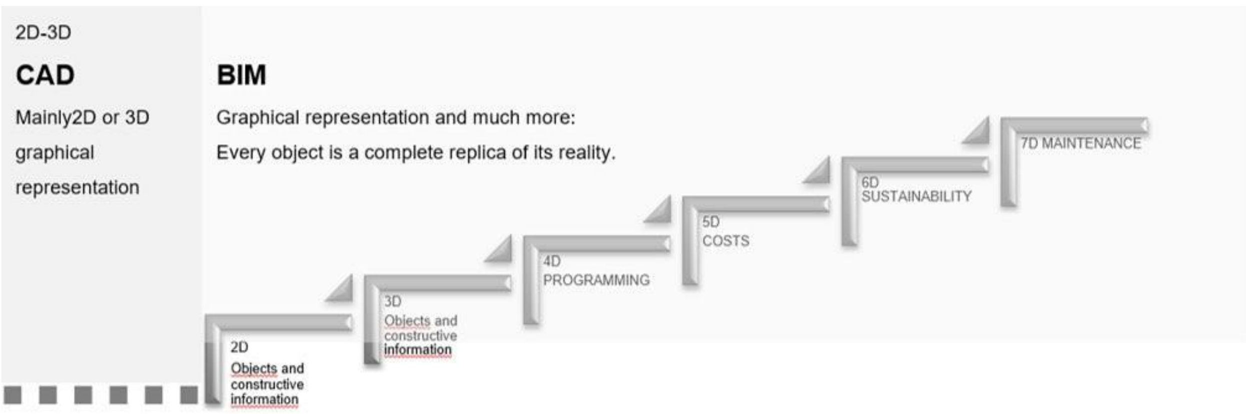
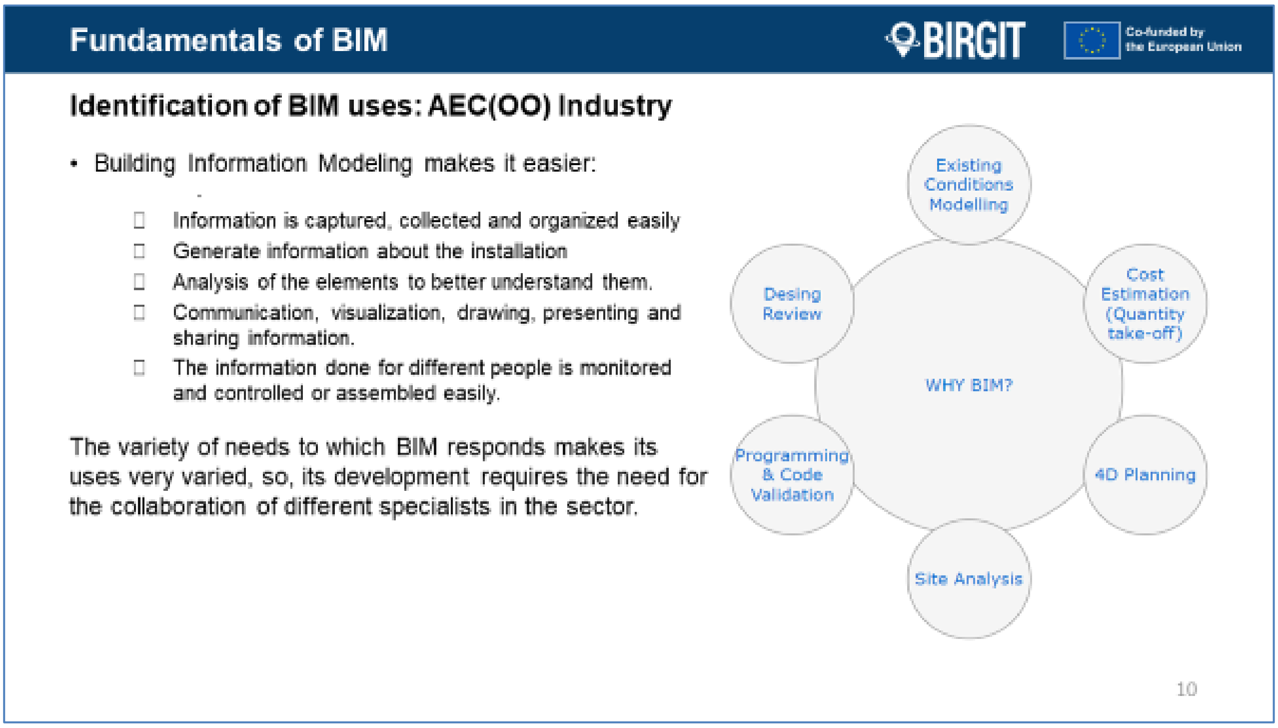


Figure 6. Transition from CAD to BIM. Own source

The process of Building Information Modeling involves designing, constructing, and maintaining buildings digitally. Therefore, throughout the lifecycle of building construction modelling, the need for data and information increases, working with more and more dimensions (data) simultaneously.

Identification of BIM uses: AEC(OO) Industry



Building Information Modeling makes it easier:

- Information is captured, collected, and organized easily.
- Generate information about the installation.
- Analysis of the elements to better understand them.
- Communication, visualization, drawing, presenting, and sharing information.
- The information done for different people is monitored and controlled or assembled easily.

The variety of needs to which BIM responds makes its uses very varied, so, its development requires the need for the collaboration of different specialists in the sector.

The following list gives an understanding of practical uses of BIM that can make the student understand the importance of BIM.

1. **EXISTING CONDITIONS MODELLING**: Use a model to identify the existing and future conditions of a given site. Study the impact that a building can have on the environment from a given side. It is design, through to construction and service life.

2. **COST ESTIMATION (QUANTITY TAKE-OFF):** Use the model for cost control in each of the phases of the project, construction and operation and maintenance.

3. **4D PLANNING:** Using the model to be able to plan the site by adjusting the processes with the variable TIME with 4D modelling, this represents a powerful visualization and communication tool that can give an organization a better understanding of the process to the project team and even to the owner, reaching a better understanding of the project milestones and construction plans.

4. **SITE ANALYSIS**: Use the model to study the appropriate location of the building or infrastructure at a particular site.

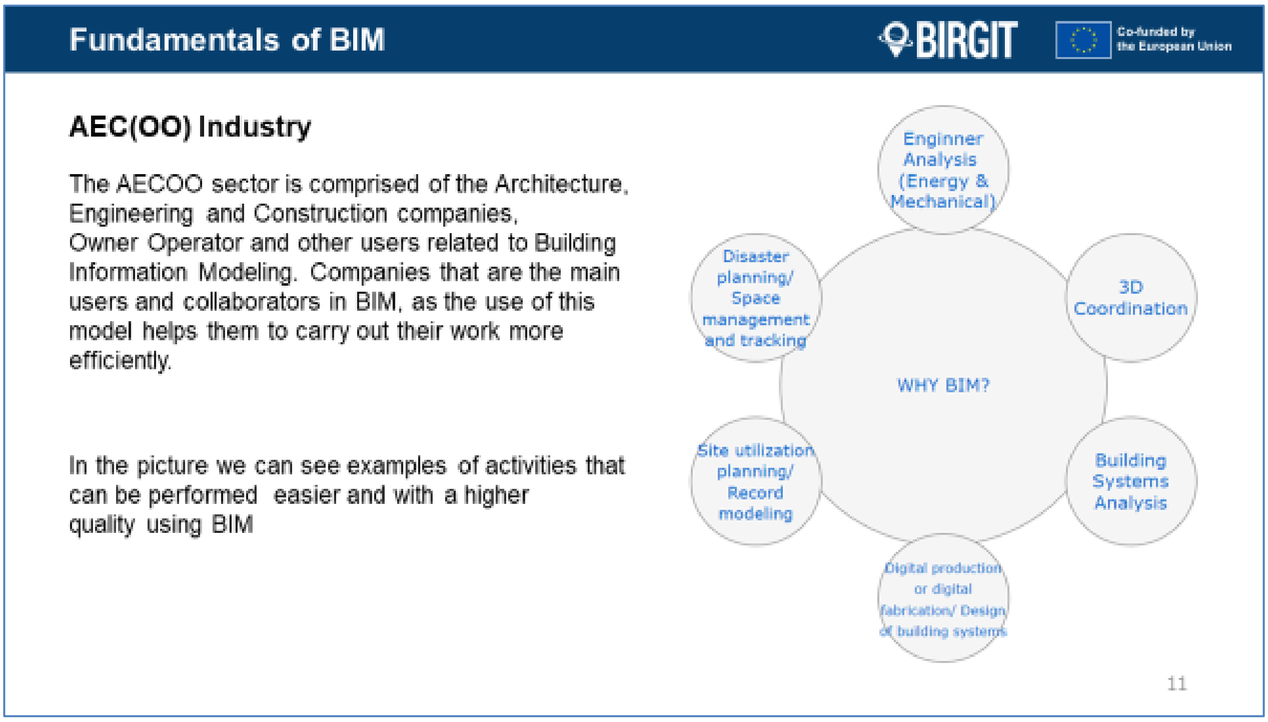
5. **CODE PROGRAMMING AND VALIDATION:** This point encompasses the following functionalities:

5.1 Efficient and accurate assessment of the design performance in terms of spatial requirements.
5.2 Study the regulations through the design of the project.
5.3 Decision-making in the early design phases.
5.4 Use the parameters of the model elements to include universal codes that can be recognized by the industrial construction processes currently under development.

6. **DESIGN REVIEW**: Use the model for decision making allowing a spatial vision as well as architectural review of the building.

7. **BUILDING SYSTEMS ANALYSIS**: Allows the performance of a building to be measured against what has been previously specified in the design to allow for energy use control, lighting analysis, ventilation control, etc. It also allows the establishment of a maintenance programme for the building or infrastructure.

AEC(OO) Industry



The AECOO sector is comprised of the Architecture, Engineering and Construction companies, Owner Operator and other users related to Building Information Modeling. Companies that are the main users and collaborators in BIM, as the use of this model helps them to carry out their work more efficiently.

In the picture we can see examples of activities that can be performed easier and with a higher quality using BIM

The points to be developed are as follows:

8. **ENGINEERING ANALYSIS (ENERGY & MECHANICAL):** Use the model to carry out calculations, analyses and studies relating to structures, installations, energy consumption, etc. Use the model to provide the necessary graphic documentation to cover the scope of the contracted project.

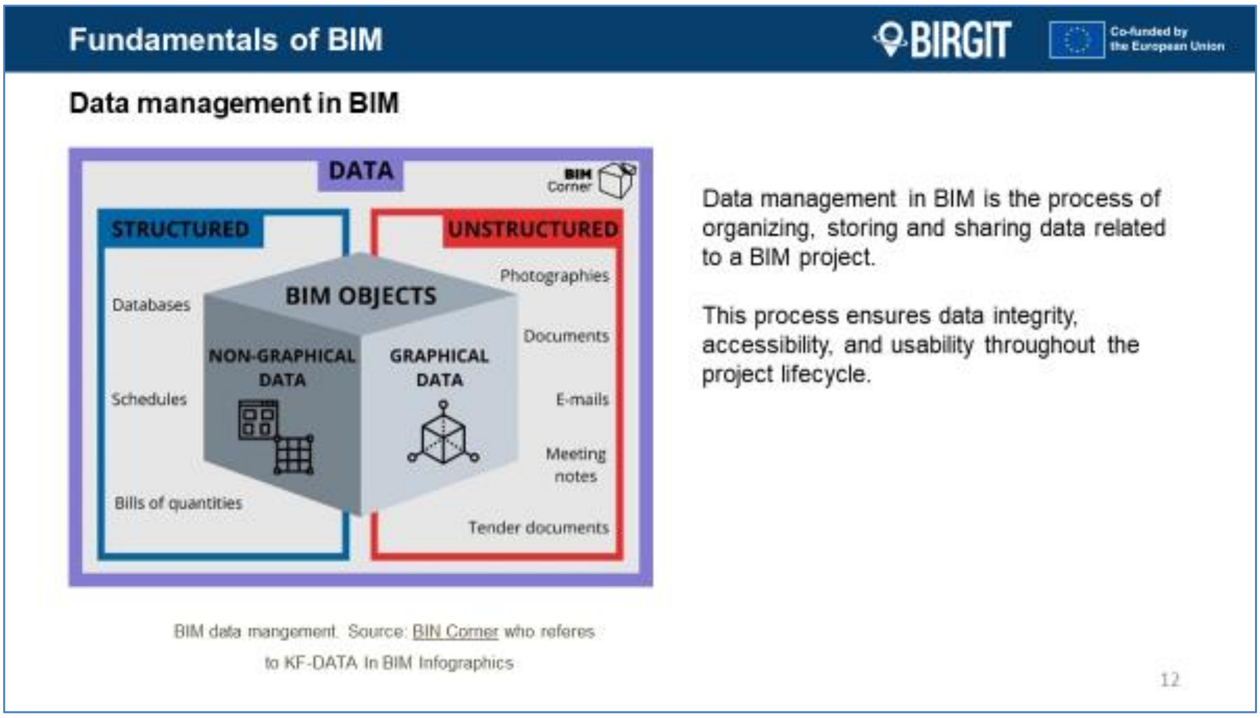
9. **3D COORDINATION:** Detection of interferences between the models of the different specialties, making it possible to eliminate conflicts on the construction site. The model helps to organize the installation and location of a specific piece of equipment on site. Time and work planning for the location of such equipment.

10. **DIGITAL PRODUCTION OR DIGITAL FABRICATION/ CONSTRUCTION SYSTEM DESIG:** Use the digital information of the model to facilitate the fabrication of singular constructive elements. Use the model to solve designs of complex elements and structures during the construction phase.

11. **SITE UTILIZATION PLANNING/ RECORD MODELING:** Locate and manage the implementation on site of cabins, changing rooms, machinery. It also allows you to establish the flow of personnel, etc. Represent the physical conditions of structural, architectural and MEP (Mechanical Electrical Pumpling) elements. Delivery of the As-built model with specific instructions for operation and maintenance.

12. **DISASTER PLANNING/ SPACE MANAGEMENT AND TRACKING:** Use the model by emergency services to prevent incidents, including being able to act more quickly and effectively in the event of a disaster. Use the model to distribute and manage the spaces in the building according to real needs, modify the use of spaces, etc.

Data management in BIM



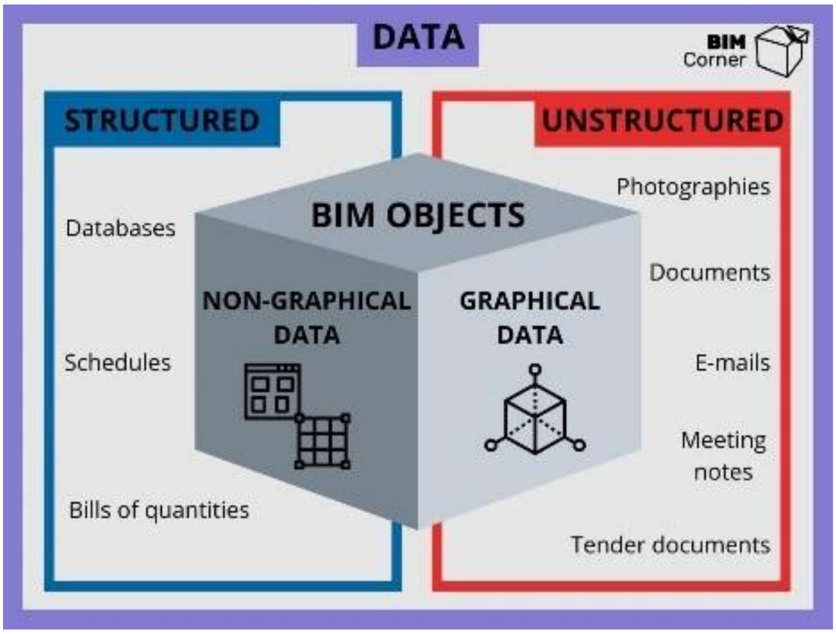
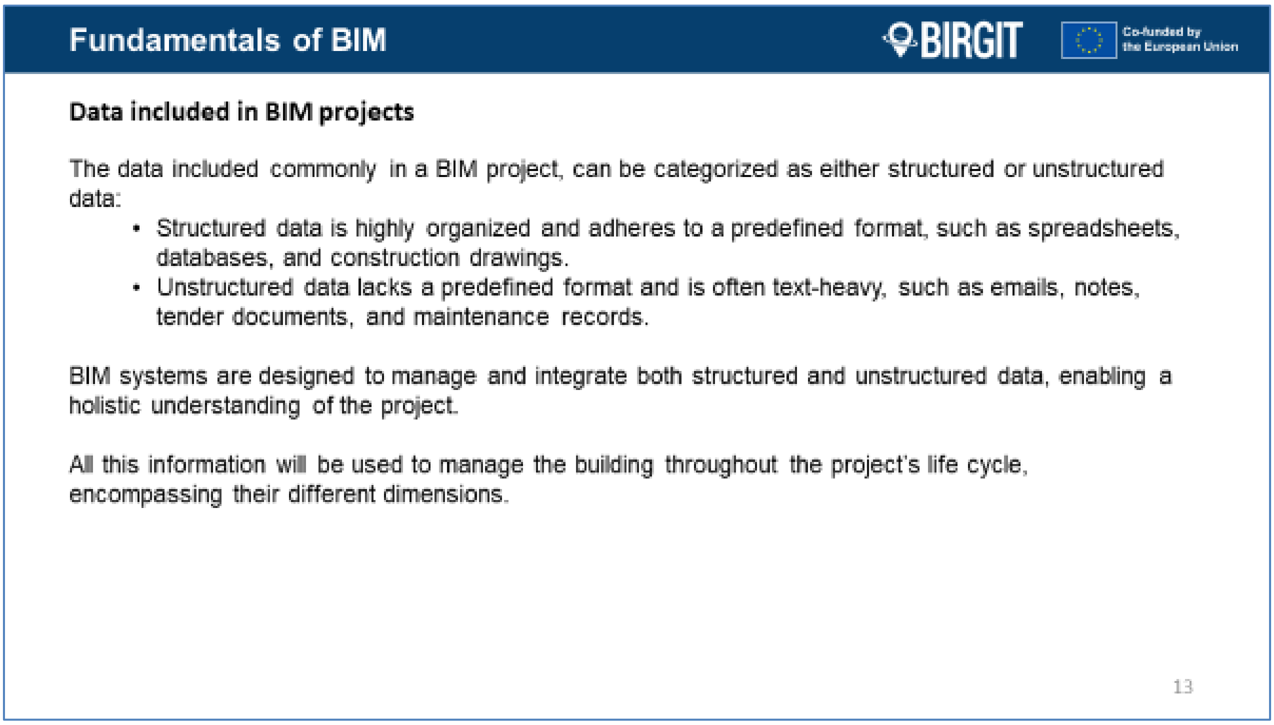


Figure 9. BIM data mangement. Source: BIN Corner who referes to KF-DATA In BIM Infographics

Data included in BIM projects

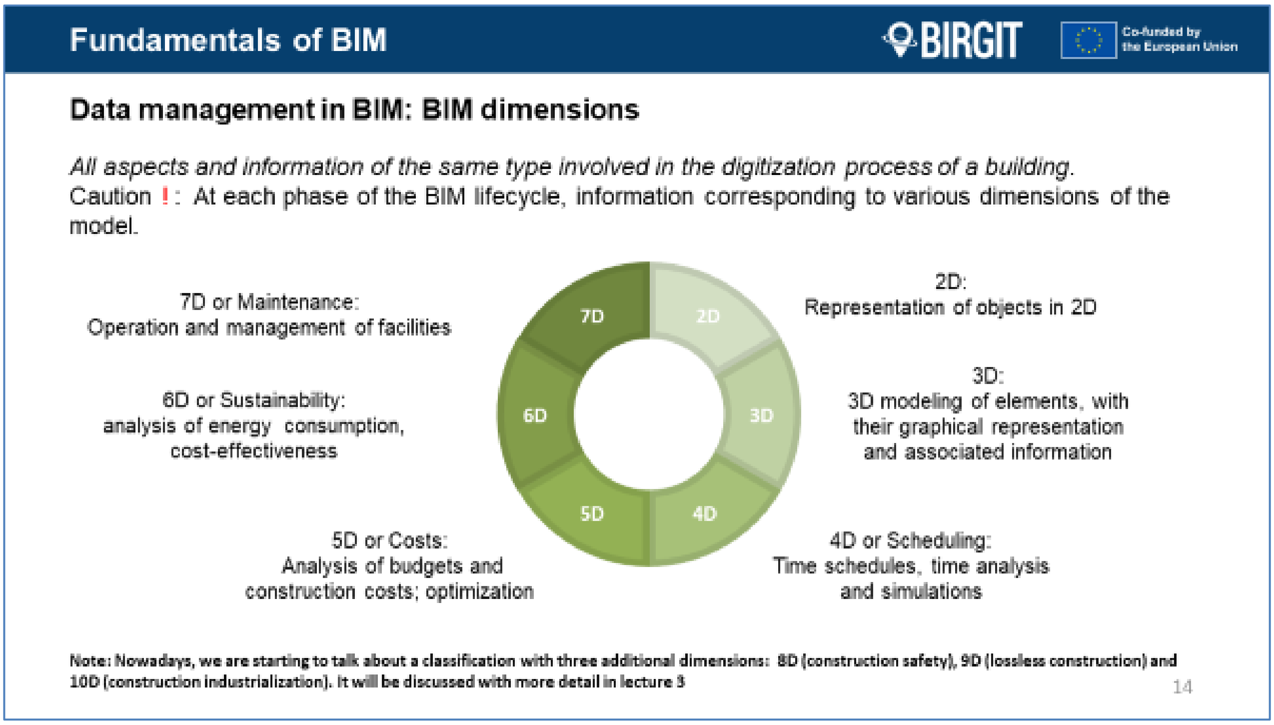


Data management in BIM: Is the process of organizing, storing and sharing data related to a BIM project. BIM data management is the process of organizing, storing, and using data associated with BIM models Ensures data integrity, accessibility, and usability throughout the project lifecycle.
Data commonly encountered in BIM projects, and they can be categorized as either structured or unstructured data:

- Structured data is highly organized and adheres to a predefined format, such as spreadsheets, databases, and construction drawings.
- Unstructured data lacks a predefined format and is often text-heavy, such as emails, notes, tender documents, and maintenance records.

BIM systems are designed to manage and integrate both structured and unstructured data, enabling a holistic understanding of the project.
This implies the need to ensure the traceability and quality of the information exchange between the different agents collaborating in a BIM project. To ensure that communication between agents is efficient and effective, the use of a common language and a Common Data Environment (CDE) is required.
This data format that allows the exchange of an information model without loss or distortion of data or information is named The Industry Foundation Classes (IFC).

Data Management in BIM: BIM dimensions



The BIM methodology entails the possibility of introducing in the digital model a series of dimensions complementary to the traditional dimensions of a project that remain in the 3D dimension (three-dimensional).

- **2D. Linear model in two dimensions**: This consists of the creation of 2D drawings and plans; to do so, the modelling software is defined, the materials are proposed and a series of key parameters such as: systems, objectives, structures, energy consumption. In this way we lay the foundations for the sustainability of the project.

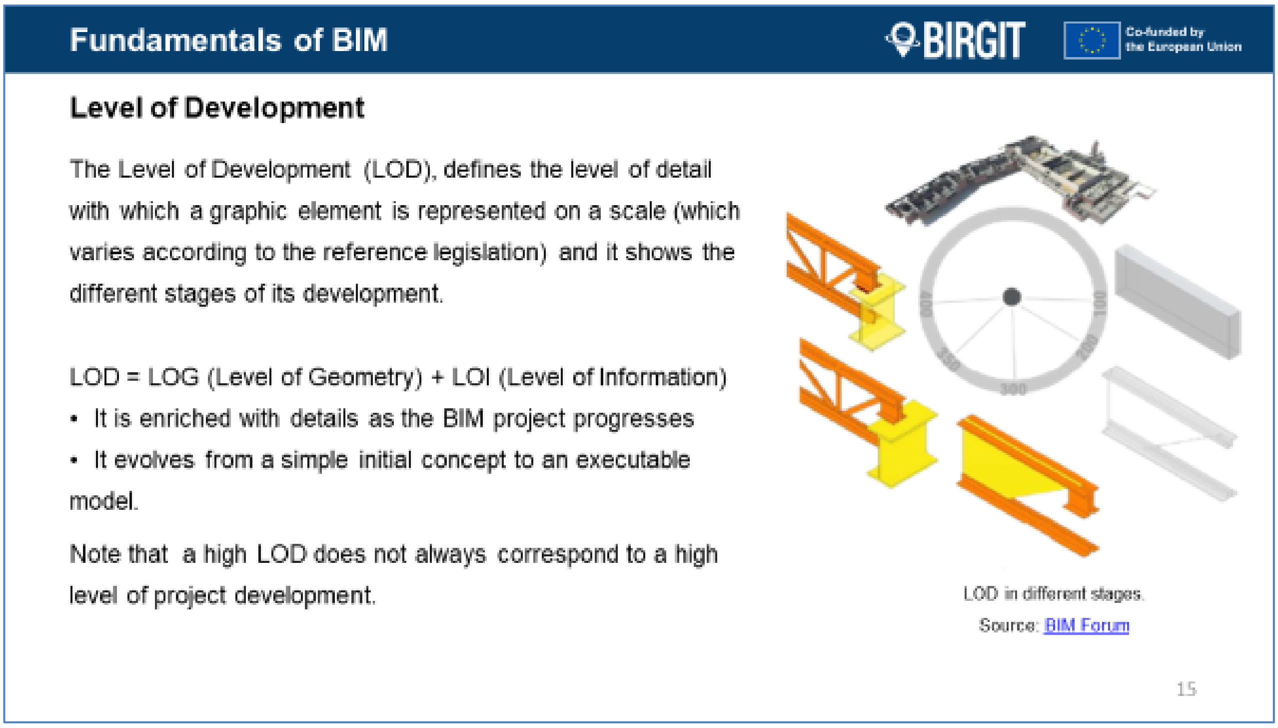
- **3D three-dimensional model:** 3D renders, virtual tours are generated to create the 3D model that will serve as the basis for the rest of the project's life cycle. It is more than a graphic representation of the idea. The 3D model is not only visual, it incorporates all the information that will be necessary for the following phases -dimensions.

- **Time: 4D.** Within the planning of the phases of the project, it is the temporal planning, as well as the realisation of simulations of temporal parameters of life cycle, sun, wind, energy, etc.
- **Cost**. **5D**. In this section budgets, cost control, tenders and contracting are taken into account, so that project costs can be managed or estimated at each stage and the profitability of the project can be improved.

- **5 Sustainability:6D.** By adding economic, environmental and social parameters, simulations can be carried out to find optimal alternatives, taking into account energy analysis, eco-efficiency, GHG emissions, etc.

- **Facility Management 7D.** In this section the user manual of the building or infrastructure is built, allowing to control logistics and operations, inspections and maintenance.

Level of Development



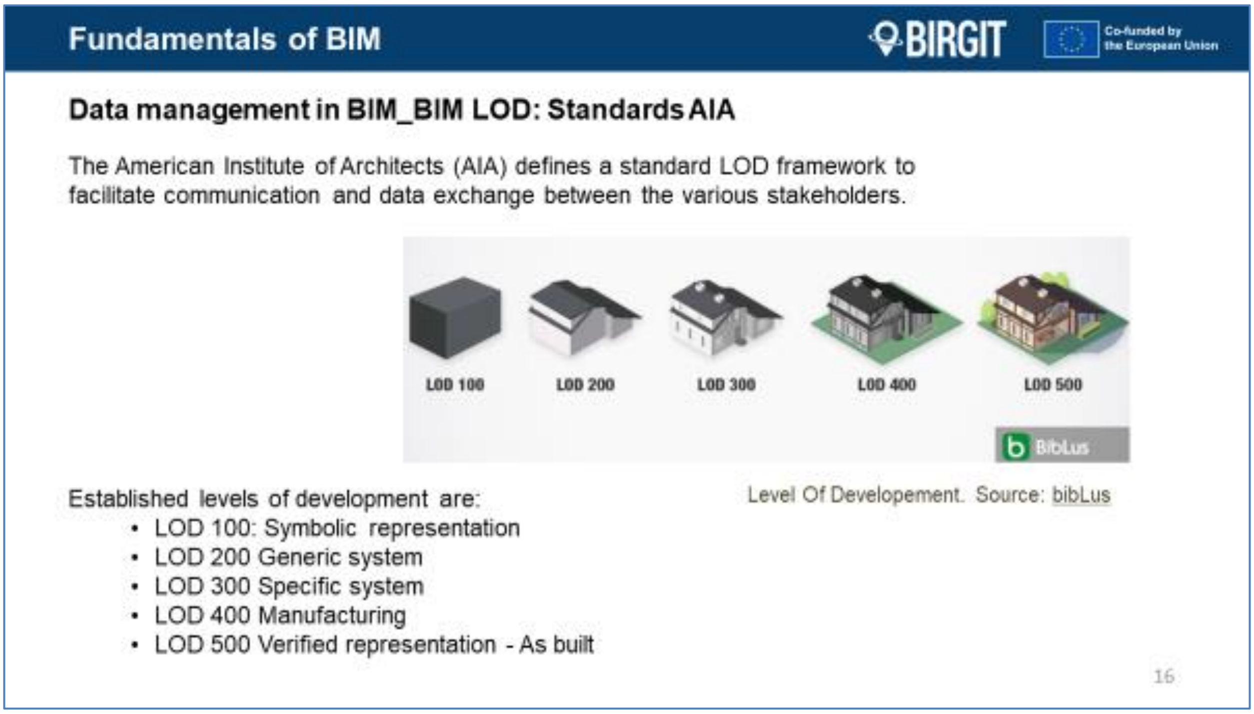
The Level of Development (LOD) defines the level of detail with which a graphic **element** is represented on a scale (which varies according to the reference legislation) and it shows the different stages of its development.

LOD = LOG (Level of Geometry) **+ LOI** (Level of Information)

- It is enriched with details as the BIM project progresses.
- It evolves from a simple initial concept to an executable model.
-

Note: a high LOD does not always correspond to a high level of project development.

BIM LOD: Standards AIA



The American Institute of Architects (AIA) defines a standard LOD framework to facilitate communication and data exchange between the various stakeholders.
Established levels of development are:

- **LOD 100:** Symbolic representation: The Model Element may be graphically represented in the Model with a symbol or other generic representation but does not satisfy the requirements for LOD 200. Information related to the Model Element (i.e. cost per square foot, tonnage of HVAC, etc.) can be derived from other Model Elements.

- **LOD 200**: Generic system: The Model Element is graphically represented within the Model as a generic system, object, or assembly with approximate quantities, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.

- **LOD 300:** Specific system: The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.

- **LOD 400**: Manufacturing: The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of size, shape, location, quantity, and orientation with detailing, fabrication, assembly, and installation information. Non-graphic information may also be attached to the Model Element.

- **LOD 500:** Verified representation - As built The Model Element is a field verified representation in terms of size, shape, location, quantity, and orientation. Non-graphic information may also be attached to the Model Elements.

Figure 10. Level Of Development. Source: bibLus

BIM Standard ISO 19650

To tackle these challenges and improve project outcomes, the International Organization for Standardization (ISO) developed ISO 19650. This globally recognized standard provides comprehensive guidance on managing information throughout the entire lifecycle of a construction project, from inception to operation. This chapter will explore the five crucial reasons why ISO 19650 is paramount for the construction industry.

1.Collaboration: Collaboration lies at the heart of successful construction projects. ISO 19650 emphasizes establishing practical cooperation between all project participants, including architects, engineers, contractors, and owners. The standard facilitates improved communication, coordination, and teamwork by creating a standard information environment and defining clear roles and responsibilities. With consistent data structures, classification systems, and naming conventions, ISO 19650 enables seamless information exchange, reducing errors, conflicts, and delays. Enhanced collaboration leads to better decision-making, increased productivity, and the successful delivery of projects within budget and on time.

EXAMP: Successful Case of ISO 19650 to Drive Collaboration - The Hudson Yards Redevelopment Project, from New York City, NY, is one of the most significant private real estate developments in the United States; it utilized ISO 19650 to drive collaboration. The project fostered effective communication and coordination among architects, engineers, contractors, and developers by implementing a standard information environment and establishing clear roles and responsibilities. ISO 19650 enabled seamless information exchange, streamlined workflows, and facilitated effective decision-making, contributing to the successful delivery of this ambitious project.

2. Efficiency: ISO 19650 promotes efficiency by standardizing information management processes and technologies. It establishes data organization, storage, and retrieval principles, ensuring that information is readily available to stakeholders at the right time. By adopting a standard data environment and implementing robust document control procedures, construction projects can avoid duplication of efforts, streamline workflows, and eliminate unnecessary rework. This streamlined approach saves time and cost, enhancing overall project efficiency and profitability.

EXAMP: Successful Case of ISO 19650 to Enhance Efficiency - The Delhi Metro Rail Corporation (DMRC), India, has implemented ISO 19650 across various projects to maximize efficiency. DMRC, responsible for the construction and operation of the Delhi Metro, adopted ISO 19650's data organization, storage, and retrieval principles. By implementing a standard data environment and robust document control procedures, DMRC streamlined information management processes minimized duplication of efforts, and improved project efficiency. ISO 19650 played a crucial role in ensuring the timely completion of metro lines and enhancing transportation infrastructure in the city.

3. Quality: Maintaining high-quality standards is crucial for the construction industry. ISO 19650 focuses on quality by emphasizing the importance of accurate and reliable information throughout the project lifecycle. The standard provides guidelines for information validation, verification, and approval processes, ensuring that data is complete, consistent, and up to date. By implementing quality control measures such as regular audits and reviews, construction projects can identify and rectify information-related issues early on, mitigating the risk of errors, conflicts, and costly rework. ISO 19650 empowers construction professionals to deliver projects of superior quality, meeting or exceeding client expectations.

EXAMP: The success story of Elevating Quality using ISO 19650 - The construction of The Shard, an iconic skyscraper in London, implemented ISO 19650 to elevate construction quality. The standard guidelines for information validation, verification, and approval processes ensured that accurate and reliable information was used throughout the project. By conducting regular audits and reviews, the project team promptly identified and rectified information-related issues, reducing errors and conflicts. Implementing ISO 19650 contributed to successfully delivering a high-quality building that met or exceeded client expectations.

4. Risk Management: Due to numerous uncertainties and potential challenges, effective risk management is critical in construction projects. ISO 19650 supports robust risk management by providing a structured framework for information management. The standard encourages identifying, assessing, and mitigating risks associated with information exchange, data security, and intellectual property rights. By implementing stringent information security measures such as access controls and encryption, construction projects can safeguard sensitive data and protect against cyber threats. ISO 19650 enables project teams to proactively manage risks, ensuring project success and minimizing potential liabilities.

EXAMP: Successful Case of Strengthening Risk Management with ISO 19650 - The Dubai Expo 2020, a world-class event in the United Arab Emirates, utilized ISO 19650 to enhance risk management practices. The standard structured framework for information management helped identify, assess, and mitigate risks associated with data security and intellectual property rights. The project safeguarded sensitive information from potential cyber threats by implementing stringent information security measures, such as access controls and encryption. The successful implementation of ISO 19650 ensured a secure and risk-aware environment throughout the project, mitigating potential liabilities.

5.Sustainability: ISO 19650 contributes to sustainable construction practices by promoting the efficient use of resources and reducing waste. By adopting digital information management systems, construction projects can significantly reduce paper consumption, leading to less deforestation and a smaller carbon footprint. The standard also encourages the use of Building Information Modeling (BIM), enabling more accurate design, simulation, and analysis, leading to optimized energy consumption and improved building performance. ISO 19650 helps construction professionals incorporate sustainability principles into their projects, contributing to a greener and more sustainable future.

EXAMP: The success story of Fostering Sustainability using ISO 19650 - The Edge Building in Amsterdam, Netherlands, widely regarded as one of the most sustainable office buildings globally, incorporated ISO 19650 to advance sustainable construction practices. By adopting digital information management systems and using BIM technology, the project minimized paper consumption and reduced the environmental impact associated with deforestation. The accurate design, simulation, and analysis facilitated by ISO 19650 and BIM resulted in optimized energy consumption and improved building performance, contributing to the building's exceptional sustainability credentials.

ISO 19650 is a game-changer for the construction industry, providing a comprehensive framework for managing information throughout the project lifecycle. By embracing this international standard, the construction industry can deliver successful projects within budget, on time, and with exceptional quality. The framework helps mitigate risks, minimizes errors, and improves overall project outcomes. Moreover, ISO 19650 aligns the industry with sustainable practices, ensuring a more environmentally friendly approach to construction.
As the construction industry evolves, staying up to date with international standards like ISO 19650 becomes increasingly vital. ISO 19650 serves as a compass, guiding the industry toward successful project delivery, improved productivity, and positively impacting the environment and society. We urge the construction industry to embrace ISO 19650 and unlock the true potential of our complex yet captivating sector.

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