UNIVERSITY ASSET DIGITALIZATION GUIDELINES: THE PILOT CASE OF POLITECNICO DI MILANO REAL ESTATE

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ABSTRACT: *This study describes a multi-year project aimed at digitizing the real estate assets of an Italian university, specifically the Politecnico di Milano. The objective is to enhance and streamline university asset management through the implementation of Building Information Modelling (BIM) methodology. BIM fosters a collaborative environment among stakeholders, facilitating the digitalization of asset management processes. The project focuses on modeling the university's assets in a BIM environment, for the creation of a repository of structured information that will streamline and optimize the processes related to the buildings' life cycle. This initiative aims to enhance real estate management services, optimize space utilization, and ultimately elevate user satisfaction within the university community. The project commenced with an in-depth analysis of the technical areas within the university responsible for design, construction, redevelopment, and overall real estate asset management. Each of these areas was evaluated for strengths, constraints, and critical points. Various approaches to BIM integration were explored to enhance digitalization processes. Based on these initial assessments, a comprehensive set of methodological and operational guidelines was formulated, encompassing modelling, management, and data-sharing aspects of digitalization. This paper provides an overview of the initial phases of the project, highlights its strengths, and identifies areas for improvement and testing in future project development. Emphasis is placed on standardizing information to ensure consistency throughout the asset's entire life cycle.*

KEYWORDS: *Building Information Modelling, Real estate management, University asset digitalization guidelines*

1. INTRODUCTION

The digital transition in the Architectural, Engineering, Construction, and Operation (AECO) industry has emerged as a priority in national policies, thereby garnering attention from administrative bodies. The AECO industry, however, remains relatively under-digitized, leading to diminished productivity. This is exacerbated by the fragmented processes within the industry, resulting in information loss throughout project lifecycles (Succar, 2010).

Frequently, the absence of accessible and up-to-date information underlies inadequate resource control in real estate asset management (Lauria et al., 2015; Meschini et al., 2022; Vivi et al., 2019). Incorporating operational strategies and digital tools like BIM into administrative procedures holds the potential to enhance data quality in decision-making processes, thereby fostering better-informed choices (Cacciaguerra et al., 2022; Derakhshan et al., 2019; Munir et al., 2019).

BIM's capability to construct digital building models incorporating information from various project stages provides valuable data for operations and maintenance across the building's lifecycle. Moreover, it transforms the relational dynamics among stakeholders involved in the construction process (Eastman, C., Teicholz, P., Sacks, R., Liston, 2008).

This research marks the initial phase of an extensive project undertaken by the Politecnico di Milano for asset digitalization, which started in 2021. The objective is to establish a BIM management system that enhances and streamlines real estate asset management through a digital transition process.

The project standardizes procedures and processes through the introduction of BIM methodology, aligning with the Polytechnic's endeavour to digitize building documents stipulated in the University Strategic Plan. This is achieved through proprietary guidelines and operational protocols. The development of these documents emanates from an analysis of the current organizational model's state, task and workflow assessments, and interdepartmental interactions. Consequently, the project identifies needs and revamps the organizational model to cultivate a collaborative environment among contributors to real estate development and management, integrating procedures.

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This project holds replicable potential: Politecnico di Milano's digital transition process could serve as a pilot case for other university campuses, given the shared requirements and challenges of similar Italian institutions.

2. REFERENCE CONTEXT

2.1 Government BIM implementation and Guidelines

The role of governments in the successful implementation of BIM is crucial. Numerous studies have sought to evaluate implementation initiatives across various scales, investigating both limitations and drivers for adoption (Jiang et al., 2022). Challenges such as institutions unprepared for the market, high associated costs, and lengthy training periods have been identified as significant obstacles. Additionally, difficulties arise from a lack of clear standards and a structured approach to change management (Elmualim & Gilder, 2014). The adoption of BIM within construction processes remained sluggish until government institutions mandated its usage in public works projects. To achieve effective implementation, the legislative bodies must strategically plan and structure interventions to facilitate adoption. Many governments have championed initiatives aimed at advancing construction industry digitalization through BIM (Abdirad, 2017; Liu et al., 2015; Marocco et al., 2023).

Recognizing the increasingly acknowledged benefits of the BIM methodology, a growing number of nations have adopted comprehensive implementation strategies. In the United States, a leading figure in this domain, the General Services Administration (GSA) has mandated the utilization of BIM in all projects since 2007, with guidelines and standards developed by the National Institute of Building Science (NIBS) (National Insitute of Building Sciences US, 2023). The formulation of tailored guidelines, aligning with client needs, facilitates the generation of coherent information-rich models, essential for effective BIM implementation within organizations (Di Giuda et al., 2017). This underscores the importance of both public and private institutions establishing customized guidelines during the initial stages of transitioning to BIM, ensuring clear objectives and actions throughout all project phases.

Organizations equipped with well-defined guidelines can translate their requirements into precise information, thus ensuring the desired outcomes. Simultaneously, professionals and manufacturers can follow a structured work plan, fostering seamless collaboration and cooperation, and supported by standardized practices.

2.2 Regulatory background

The global and Italian legal and technical regulations governing BIM methodology draw upon references from both mandatory and voluntary standards. In the European context, Directive 2004/18/EC marked the initial directive, subsequently replaced by European Directive 2014/24/EU in 2014. Article 22 comma 4 of this directive emphasizes Member States' authority to "require the use of specific electronic tools, such as electronic simulation tools for building information or similar tools." This directive compels member states to incentivize, specify, or mandate digital tool adoption through dedicated legislative measures. In Italian law, this directive was adopted by Delegated Law n. 11 of January 28th, 2016, and subsequently confirmed by D.Lgs 50/2016, followed by its implementing decree (DM 560/2017), and the recent D.lgs 36/2023, which reinforces the significance of digitalization across the entire procurement lifecycle. This decree outlines the incremental, mandatory introduction of BIM in public procurement. Organizations are obligated to establish a comprehensive plan for staff training, hardware and software acquisition and maintenance for digital decision-making and information management processes. The decree underscores the importance of an organizational framework that articulates the control and management of information and related aspects. DM 312/2021 incorporates elements from the preceding decree, explicitly stipulating that models should be accompanied by decision-support workflows. Furthermore, this decree references the use of technical specifications in accordance with voluntary European technical standards (EN or EN ISO), international technical standards (ISO), and national technical standards (UNI). Notably, in the construction industry, relevant standards encompass the ISO 19650 Series on BIM-based information management, the UNI 11337 Series on digital construction information process management, the ISO 21500 Series on project, program, and portfolio management, the 55000 Series on asset management, and the ISO 9000 Series on quality management.

3. DIGITALIZATION ROADMAP METHODOLOGY

One of the principal challenges of a digital transition process is related to the need to implement a new working logic within practices that are not always regulated but are well-rooted and difficult to change (Ahmed et al., 2017; Barbosa et al., 2017) Moreover, the necessity to maintain information at the core of the construction process throughout its different phases is a key aspect of BIM methodology and necessitates the practical application of concepts such as information sharing and standardization. This often becomes critical as the individuals responsible for managing information during the various stages of the building's life cycle are diverse and handle an array of disparate or non-uniform information.

This research introduces the initial stages of the digital transition process within a public university, which began in 2021 and anticipated to be completed over approximately six years. It is segmented into three strategic work phases. The project's long-term objective is to execute the digital transition process for the digitalization of the university's real estate and its management procedures through BIM (Fig.1). The proposed methodology can be readily replicated for other university real estate assets.

The project addresses the need to integrate the new digital work methodology into an organization with established processes while striving to strike a balance between coexisting established practices and implementation of new ones. To achieve this, a framework was established across three consecutive and interconnected phases, progressively integrating novel methods. Emphasis was placed on optimizing work processes and resolving critical issues primarily stemming from information loss during the transition from building design to management phases. Maintaining the structuring and management of information vital for the building management phase remained the focal point of the project.

The first phase represents a strategic stage, during which strategic macro-objectives of the digitalization project were defined. The research context was examined, organizational processes were analyzed, and project-specific objectives were formulated, aligned with regulations for optimization purposes. This phase culminates in the creation of the Methodological Guideline, a strategic document that elucidates project objectives and the application context, outlines the document structure comprising the Guideline, and delineates the roles of involved stakeholders.

The following phase, the application phase, focuses on delineating the information content of digital models through the development of operational documents. These documents outline modeling specifications, element hierarchies, information granularity, and asset attributes. The phase concludes with the initial implementation of case studies to validate guideline content.

The ongoing third phase involves the practical integration of BIM into facility management, enabling comprehensive utilization. This phase necessitates comprehensive staff training to ensure the adoption of guidelines and their gradual integration into strategic projects, ultimately leading to their universal application.

The described workflow, reflected in the hierarchical structure of the Guideline's documents, is characterized by three levels:

- Methodological Guideline: The primary document defining the foundational principles underpinning the application of BIM methodology within the university's processes.
- Operational Documents: These executive documents address specific concerns.
- Project Operational Documents: templates for specialized documents mandated by regulations in contracts.

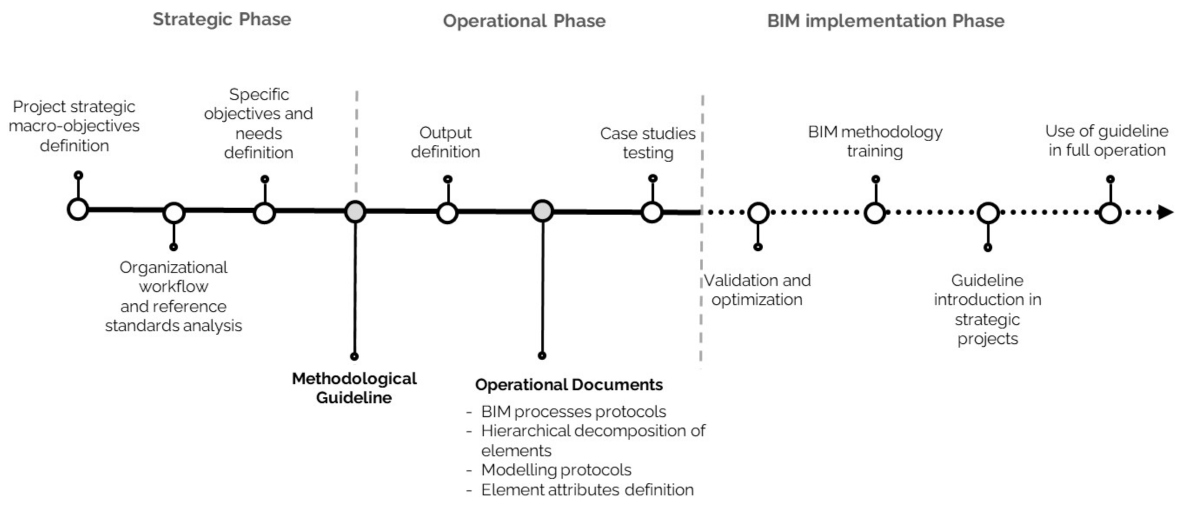

Fig. 1: Digitalization roadmap

4. POLYTHECNIC OF MILAN CASE STUDY

The Polytechnic's real estate holdings are spread across six campuses situated in different cities, comprising a total of 117 buildings and covering an extensive area of 467,000 square meters. The university community comprises approximately 53,264 individuals who engage with and utilize these facilities in various capacities. These include students, researchers (including research fellows and PhD students), professors and technical and administrative staff (Fig. 2).

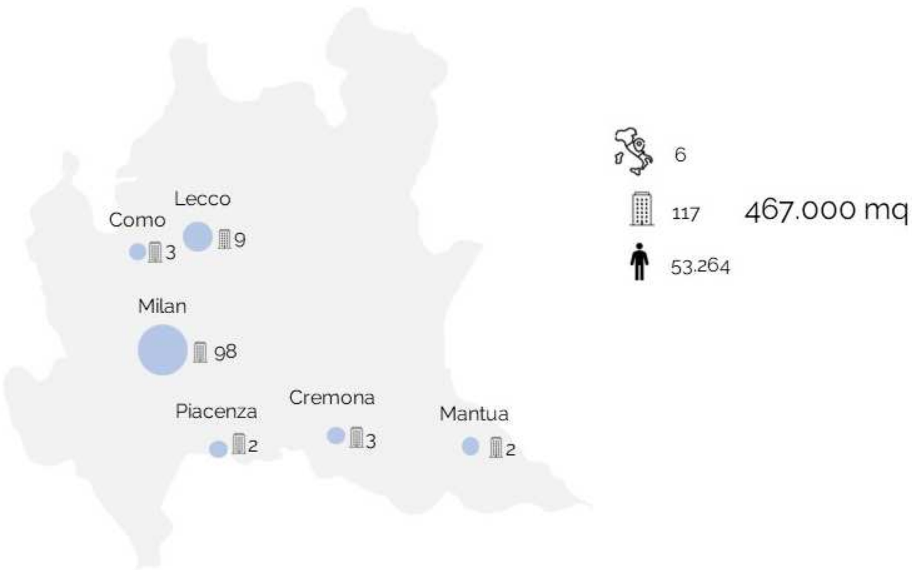

Fig. 2: Consistency of the real estate assets of the Politecnico di Milano

The Politecnico di Milano is a large, complex organization and its management is quite challenging. To address this complexity, the institution has undertaken the development of the BIM Management System Standards. These standards have been devised while considering the regulations pertaining to quality, asset, and project management, as well as information management. While the adoption of these regulations remains partial within the technical domains and their associated activities, the overarching goal is to achieve comprehensive integration into all operational processes. Such integration is anticipated to yield intricate synergies, fostering streamlined operations while concurrently minimizing both effort and expenses.

The following sections provide an overview of the stages completed to date in this ongoing process.

4.1 Strategic and organizational Phase

4.1.1 Organization chart and existing processes analysis

Achieving a successful digital transition process requires integrating change with existing processes. Therefore, the initial phase of the process was dedicated to comprehending the organization and its operational logic, achieved through an in-depth examination of the departments involved in the university's building processes.

At the organizational level, a dedicated BIM Task Force was established at the central university level to oversee the project. This Task Force, comprised of technical and research personnel, was specifically constituted for this purpose.

By examining the organizational structure, the primary departments engaged across all stages of the building process were identified (Fig.3):

- Technical Building Area: This office assumes responsibility for the strategic planning and coordination of real estate development, encompassing activities such as extraordinary maintenance, restoration, rehabilitation, building renovations, and new construction.

- Infrastructure and Services Management Area: This office tasked with maintaining university spaces, ensuring their livability, security, cleanliness, and the provision of services and resources essential for administrative operations.
- ICT Services Area: This office manages the provisioning and administration of ICT services, facilitating the cohesive management of information in support of governance, administration, and all stakeholders. Its primary role within the process is to facilitate information management.

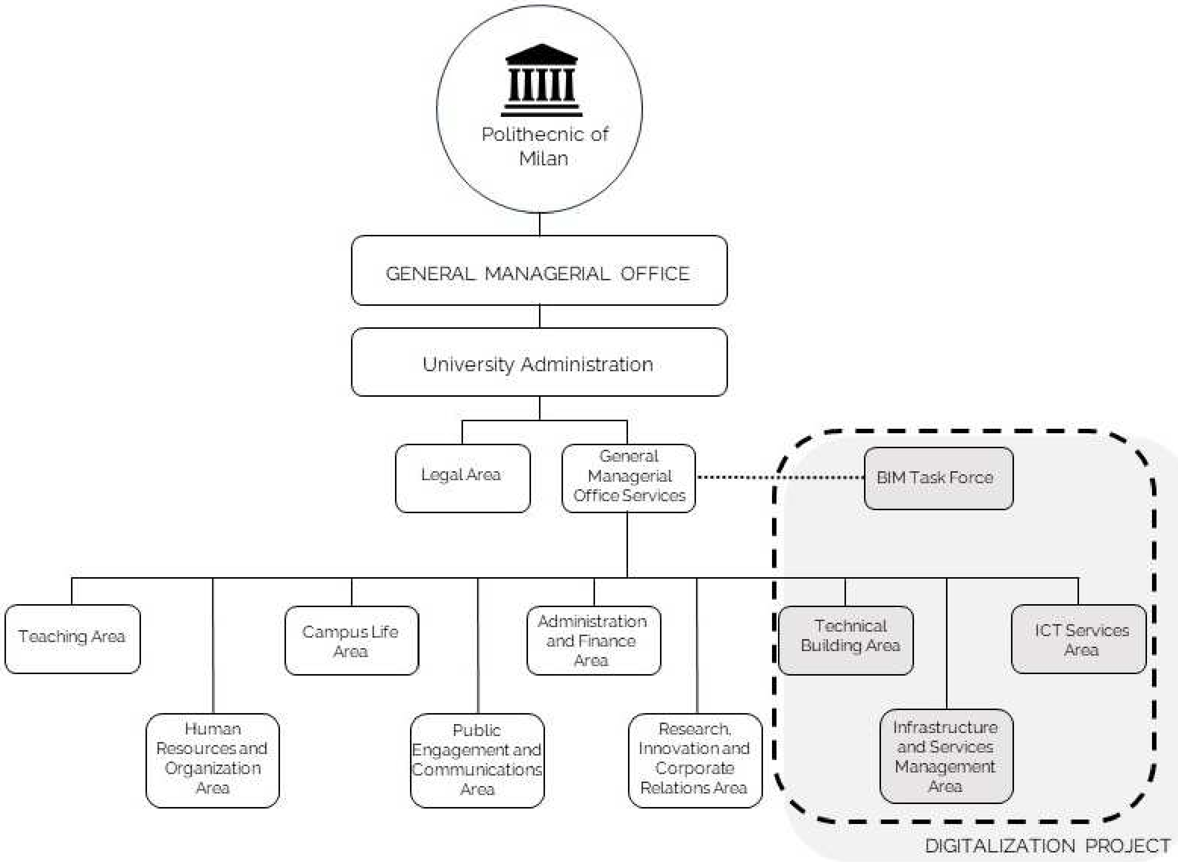

Fig. 3: Examination of the University Organizational Structure and Identification of Involved Departments

The workflows of these offices were studied through the analysis of the documentation provided and a survey campaign, with the aim of learning about the procedures and interactions between internal and external parties and assessing possible problems.

This phase of the offices analysis occurred in two cycles:

- The first cycle involved conducting standardized interviews across all offices to identify characteristics, responsibilities, tasks, and structural facets. It further sought to analyse the means of communication, document exchange, and interactions among individuals, both within offices and across different departments and external entities.
- The second cycle encompassed tailored interviews for each office, delving into specific inquiries pertaining to the adoption of information modeling, particularly during the design and management phases.

The main critical issues highlighted by this analysis were:

- Difficulties in collaboration between offices.
- Inadequate management of the document exchange from construction to building management phases.
- Unclear delineation of roles and responsibilities throughout distinct stages of the construction process.
- Absence of standardized storage systems.

- Inaccurate or incomplete building information.
- Lack of uniform and shared coding across offices of spatial and technological-functional elements.
- Absence of protocols and technical specifications for the transition from the design phase to the management phase.
- Lack of a definitive list detailing elements to be maintained and their associated attributes.

All existing processes were then mapped and diagrammed through Business Process Model and Notation (BPMN), an internationally recognized open standard that provides a graphical notation for specifying an organization's processes. This graphical notation system has gained prominence within the AECO industry due to its capacity to simplify comprehension between individuals with diverse backgrounds enhance interoperability. The schematic representation of processes promotes clearer apprehension of tasks, roles, and information exchanges, and consequently, information requirements (ISO 19560) are defined. In that way, processes are translated into a computing language, making possible future automation (Fleischmann et al., 2012; Meschini et al., 2023)

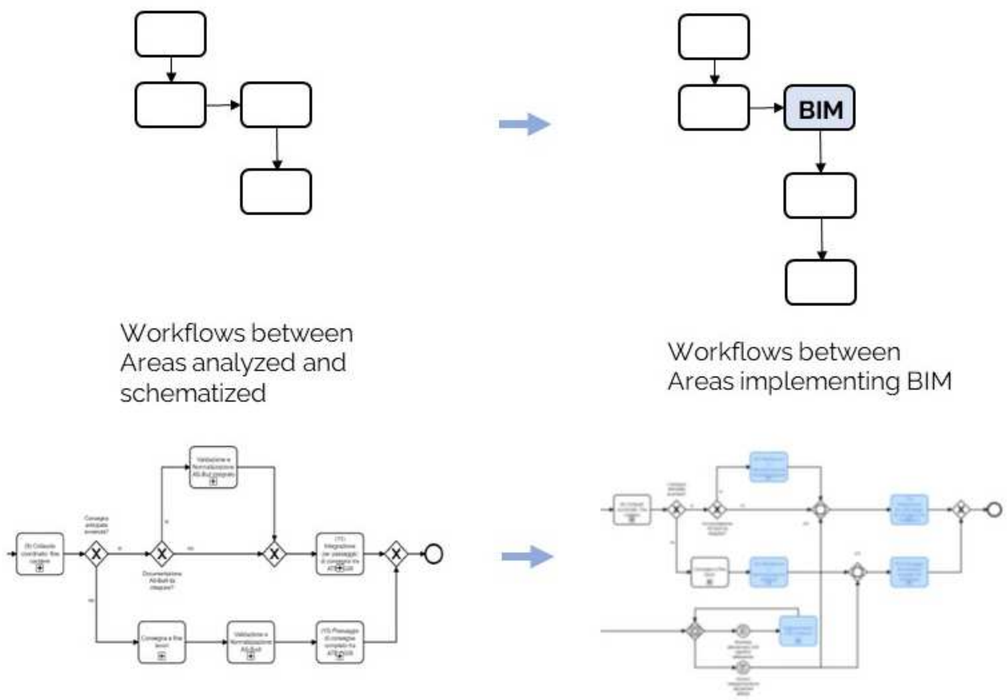

Fig. 4: Exemplification of a BPMN extrapolation illustrating an analyzed process and its redesign proposal through BIM.

Processes have been classified into three categories:

- Main processes: These encompass workflows that involve activities spanning multiple departments. They relate to tasks such as designing and constructing new buildings, revitalizing existing structures, and initiating property management.

  These can be represented in:

  - Process models: sequence or flow of activities with the goal of accomplish a task;
  - Collaboration models: a set of processes that work together for a purpose and are individually referred to as actors involved in exchanging information.

  Main processes may contain sub-processes and recursive sub-processes, which may be process or collaboration models:
- Sub-processes: These represent processes identified within main processes.
- Recursive sub-processes: These further delineate processes within main processes, outlining a series of activities conducted between departments. These sub-processes can be invoked within various higher-order processes.

After sistematically analyzing existing processes, a proposal to reimagine these processes using a BIM-based approach was formalized. This proposal underwent subsequent rounds of review, revisions, and validation by the offices that had been previously investigated (Fig.4).

Furthermore, an updated organizational chart was devised, introducing new roles within each department. These additions catered to the responsibilities of individuals resulting from the integration of BIM into processes, as mandated by technical regulations.

4.1.2 Defining the specific goals and Organizational needs

The specific objectives of the project were established by deriving insights from the strategic objectives defined within the transition process framework. This process was further informed by an analysis of the structure and evidence of critical issues uncovered during the process study.

This was supported by the BPMN flows study, which examined the path and importance of each piece of information throughout the building process, from the design phase (Technical Building Area) to the management phase (Infrastructure and Services Management Area).

The needs of the new building asset management system were identified with respect to the needs of each of the previously identified offices, with the aim to solve the highlighted critical issues. In particular, the new building asset management system must ensure collaboration among the subjects by optimizing building management through coordination among various project disciplines. The need to collect information consistently despite different data collection occasions must be considered to ensure reliable and up-to-date information in a single BIM repository of as-built BIM models (Fig.5).

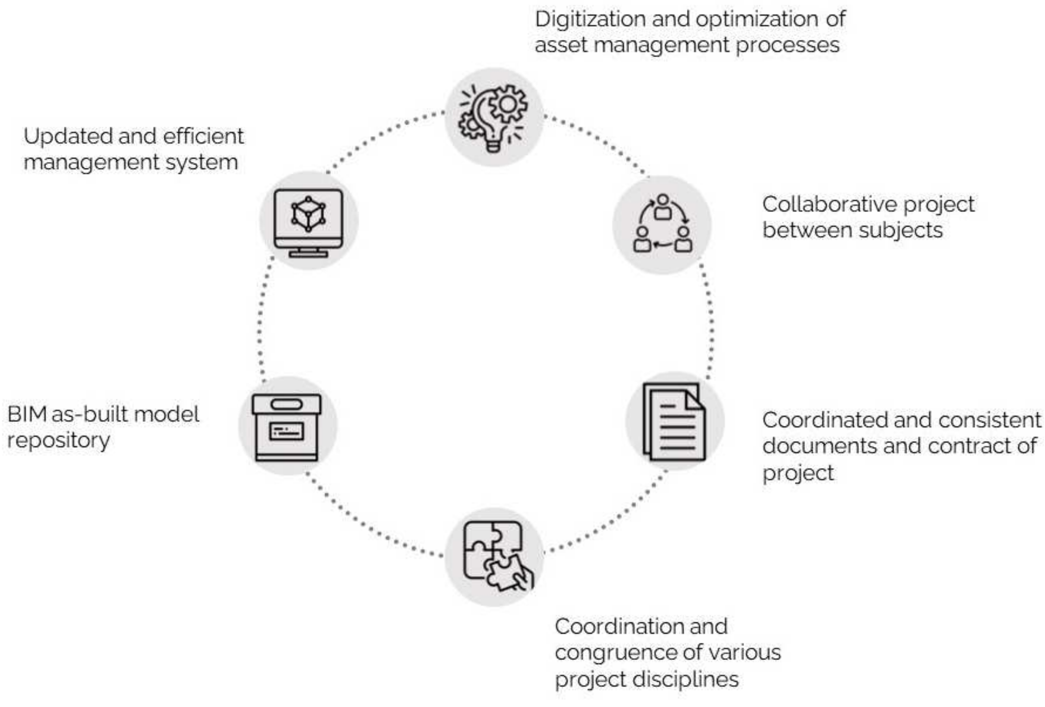

Fig.5 Goals of the New Building Management System

This new system is characterized by its focus on shaping a dataset of information tailored to enhance real estate management. Through this strategic emphasis, the project aims to forge a comprehensive and coherent solution to the challenges identified within the organization's building processes.

4.2 Operational Phase

4.2.1 Define the information requirement

Defining information content is essential for proper asset management through BIM methodology. Within the Politecnico di Milano Guideline was based on the guidance provided by the UNI EN ISO 19650 and UNI 11337 series of standards.

Central to this initiative is the concept that information should be produced and retained with a distinct purpose. The process of defining information requirement revolves around outlining the specifics of the information to be generated and preserved, all with the overarching goal of ensuring that whatever the stakeholder's role, the subsequent objective is achieved seamlessly. Organizations able to govern the management of information during the processes allow the progress of both internally and externally coordinated operations to be made fast and uninterrupted, obtaining only the products they need, avoiding unhelpful material, and guaranteeing the quality of the information obtained.

Therefore, it is essential to establish a structure capable of managing requirements to ensure the effectiveness of data production, collection, and exchange throughout the process. Client awareness regarding the value of information content also clarifies client requirements for various aspects, such as production and sharing methods, delivery times, and formats. Furthermore, this awareness supports the development of verification and control methods.

The approach to defining information content for the Polytechnic is based on three concepts:

- Information needs level: detail with respect to quality, quantity, and granularity of data to be adopted to define information related to a purpose.
  Information that makes explicit the level of information need is divided into:
  - Geometric information
  - Alphanumeric information
  - Documentary information
- Granularity: degree of subdivision and specification of information management levels;
- Data aggregation strategies: ways in which data should be aggregated or disaggregated.

The process of defining information requirements for the real estate assets of the Politecnico di Milano was motivated by the need to address critical issues identified during the study of information flow throughout the processes. Specifically, the investigation focused on the issue of data collection's relevance to the maintenance phase under different circumstances.

One of the issues found was the mismatch of elements from the design phase to the maintenance phase. This problem was leading to a mismatch between the data entered into the archives during the design phase and those entered during the maintenance phase, resulting in the need to re-search the information with a consequent loss of time. This lack of correspondence, combined with the absence of an unambiguous listing of assets to be maintained and the sharing of related management information requirements, led to the inability to record the related operations performed on the items, resulting in the impossibility of timely control their maintenance status and standardization of contracts.

The subsequent focus of the endeavor was on establishing a unified and shared asset list for the As-Built and maintenance phases. To achieve this objective, the technological-functional elements that were previously employed by the Technical Building Area (a Project Breakdown Structure that segments the project into its technological elements used in the design phase) were examinated. Subsequently, we formulated an inventory of homogeneous objects that amalgamate various technical elements related to maintenance contracts. This endeavor culminated in the creation of a new asset list that seamlessly binds these components together (Fig. 6).

Through the establishment of this unified asset listing, bridging the technical aspects of the design phase with maintenance-oriented elements, the attributes requisite for each identified element during both design and maintenance phases were effectively defined. This meticulous approach ensures the determination of the minimum essential information required for each phase.

The level of information detail required will vary during different phases of the building's life and will be managed to streamline the recording of essential data, optimizing the time dedicated to information census and modeling. At the same time, the quality of the information entered into the system must be excellent, with the goal that it will always be completely reliable.

To ensure cohensiveness across all information derived from models, at whatever stage of the asset life cycle these were produced, the operational document "Modeling Protocols" was formalized. This is a document that makes explicit the rules and guidance necessary for the development of information models within the University's BIM Management System. The document aims to ensure a defined and shared BIM model structure.

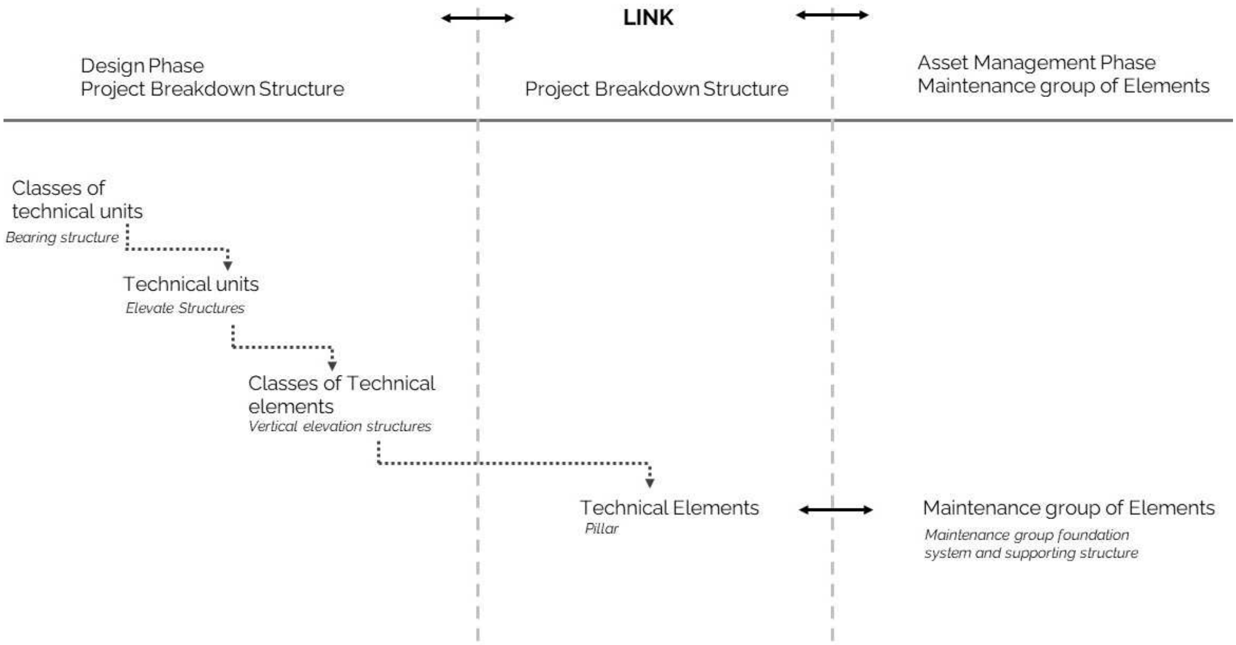

Fig. 6 Relationship between hierarchies of elements in the design and in the maintenance phases

The requirements underpinning the regulation of BIM Modeling in the document, which is based on the relevant legislation, are (i) the definition of a clear and shared structure, (ii) the need for continuity between pre-existing processes in terms of models and software, and (iii) streamlined models that can be used and reworked efficiently while ensuring the exchange of information.

The protocols are structured with consideration of three information modeling scenarios that the Organization may face:

- new construction interventions.
- representation of the existing.
- existing redevelopment interventions.

The paper explicitly outlines the technical characteristics models must possess to ensure consistency within the management system. A particularly important aspect of ensuring consistency between model elements is the mapping process, which relates elements to: (i) the Product Breakdown Structure of the assets previously illustrated, (ii) the categories of the modeling software chosen by the university, (iii) and the related entities for exporting the models in open format IFC (Industries Foundation Classes) ensuring interoperability (Laakso & Kiviniemi, 2012) (Fig. 7).

Throughout the transition project, we identified software to be used for information management based on various purposes. Rearding modeling, information collection, and management in the later phase, a comparative evaluation of FM and CDE software was conduced to determine the most suitable ones at the technical level according to the University’s requirements.

To validate the correctness of protocols and decisions in the operational documents, two pilot buildings were modeled following the guidelines. Pilot cases were selected to test an already existing building and a new construction project, ensuring that each.

Product Breakdown Structure Asset	Proprietary BIM authoring software Category	Non-proprietary software entity
Pillar	Structural Columns	IfcColumn
Stair	Stair	IfcStair
Window	Window	IfcWindow
Boiler	Mechanical Equipment	IfcBoiler

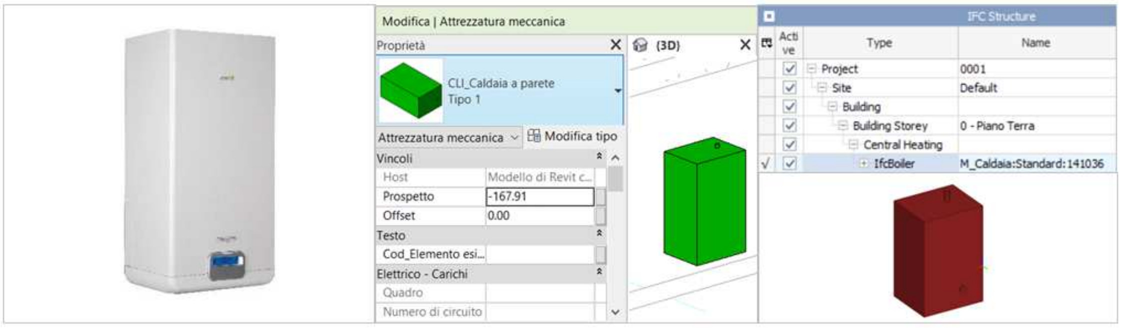

Fig. 7 Example of boiler element mapping

5. FIRST RESULTS DISCUSSION AND FURTHER DEVELOPMENT

To date, the digitalization project of the Politecnico di Milano organization is an ongoing process expected to be completed by 2026. The first two phases of the project have concluded successfully with the approval of the Methodological Guideline and Operational Documents, detailing specific features of information modeling. These documents were validated through the modeling of two case studies to verify the accuracy of the decisions made.

The University Governance intends to base new procurements addressing the university's space needs on these approved Guideline documents. This approach ensures that new construction adheres to defined rules, gradually populating the university's BIM repository with consistent information. The ability of external parties to use the Guideline will enable the research team to validate comprehension and correctness in data reception, addressing and resolving any issues through updated document versions. Therefore, establishing protocols for internal data verification is essential.

The subsequent phase of the digital transition project involves the actual implementation of the BIM methodology within the organization. This phase commences with comprehensive training for the offices on the use of the Proprietary BIM Guidelines and compliance with the new standardized procedures. This training ensures their assimilation and prevents the distortion of client requirements in terms of information content over time, which could render the entire data processing process ineffective.

6. CONCLUSIONS

This work explored the implementation of a digital transition process for the property management of a large university. The application research was structured in three progressive phases, aiming to optimize the management of the information flow through process implementation, resulting in improved management of the entire building process while structuring information essential for the real estate management phase.

The specific focus was on defining a consistent information set derived in part from existing processes. The implementation addressed critical issues related to the loss of useful information during the transition from the design phase to the management phase. The definition and subsequent verification of information requirements by the organization are essential for properly aggregating and disaggregating information as needed.

For this type of process to succeed, the organization must possess proprietary Guidelines aligned with its processes and requirements while internally training its staff to recognize the importance of maintaining consistent information content.

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