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BIM PROCESS MANAGEMENT

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"Construction and Architectural Information Modelling,
BIM Process Management"*

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This textbook examines the basic principles and BIM processes in project management, as well as standards for a process-oriented approach. It aims to introduce students to the theoretical foundations and practical aspects of applying BIM technologies in conjunction with effective process management tools. Examples of problem-solving and self-assessment questions are provided.

Intended for students of the second (Master's) level of higher education in specialty G19 Civil Engineering and Construction.

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Foreword

The modern construction industry is on the verge of revolutionary changes driven by the rapid development of digital technologies. Traditional methods of design, construction, and operation, which relied on two-dimensional drawings and disparate data, are gradually becoming a thing of the past, giving way to integrated and highly efficient approaches. In this context, Building Information Modelling (BIM) acts not just as a set of software tools, but as a comprehensive methodology that transforms the entire lifecycle of a real estate object.

BIM is more than a 3D model. It is an intelligent digital object that contains all the necessary data about the physical and functional characteristics of a building. It allows not only to visualise the project but also to effectively manage information, ensuring an unprecedented level of coordination, risk reduction, and optimisation of costs and time at all stages of the object's lifecycle — from idea to demolition.

However, to fully unleash the potential of BIM technologies, a deep understanding and implementation of process management are necessary. After all, even the most advanced technologies prove ineffective without well-established workflows, standardised interaction between project participants, and proper allocation of responsibilities. It is precisely the symbiosis of BIM and process management principles that creates a synergy that transforms complex construction projects into manageable, predictable, and successful initiatives.

This textbook (6 ECTS credits) is an advanced course designed to introduce the theoretical foundations and practical aspects of applying BIM technologies in conjunction with effective process management tools. It aims to provide students with comprehensive knowledge and practical skills necessary for successful adaptation to the demands of the modern digital construction ecosystem. You will learn not only to use BIM tools but also to think systematically, optimise processes, and manage projects in a way that maximises their efficiency and success.

We believe that the acquired knowledge will become a strong foundation for your future professional activities and will allow you to make a significant contribution to the development of the construction industry.

Introduction

Modern society is rapidly moving along the path of digital transformation, encompassing all spheres of life — from economics and public administration to education and everyday communications. The construction industry, traditionally one of the most conservative, is currently undergoing its own digital revolution, with Building Information Modelling (BIM) as its central element.

BIM is not just a set of software tools for creating three-dimensional models. It is a comprehensive methodology and project management philosophy based on the creation and use of a single, coordinated, and intelligent digital model of an object. This model contains all the necessary data about the physical and functional characteristics of a building or infrastructure object throughout its entire lifecycle — from initial concept and design, through construction and operation, all the way to demolition. The implementation of BIM allows for a radical increase in transparency, efficiency, accuracy, and quality of construction projects, minimising errors, risks, and resource overruns.

However, the true potential of BIM technologies is revealed only in synergy with other advanced digital tools, among which Artificial Intelligence (AI) occupies a key place. The application of AI takes BIM beyond simple modelling and information management, opening up possibilities for:

- **Automated Optimisation:** AI can analyse vast amounts of data from BIM models and generate optimal solutions for design, resource allocation, energy efficiency, or structural strength, often surpassing human capabilities.
- **Predictive Analytics:** AI can predict potential risks, delays, or problems before they arise, using historical data and machine learning, which allows for proactive management decisions.
- **Intelligent Management:** AI enables the automation of routine processes, increases the accuracy of estimates, optimises logistics, and even manages the operation of facilities in real-time, particularly in the concept of "smart cities" through "digital twins."

Thus, the integration of BIM and AI is becoming a driving force in the digital transformation of the construction industry, turning it into a more innovative, sustainable, and efficient sector. This will not only change the way we design and build but also profoundly impact urban infrastructure management, the quality of life of residents, and the economic development of society as a whole. Ukraine, with its ambitious reconstruction plans, has a unique opportunity to leverage this innovative tandem to create a modern, transparent, and efficient construction ecosystem.

GENERAL PROVISIONS

This textbook is based on the application of modern approaches to BIM design with the use of process management, in particular, international standards that guide those elements, concepts, and practical results of BIM design for which implementation is important and which affect management in general and are recognized in world practice of general process management. This textbook considers BIM processes in the management of a building object's lifecycle, at all its phases, organisational and management aspects of BIM implementation as a basis for discussing their impact.

Creating and maintaining procedures for ensuring process management to achieve the set goal and product requires a systematic approach. This approach should focus on ensuring that the needs of the consumer and other stakeholders are understood and taken into account in the process of implementing BIM technologies.

The approach of applying Artificial Intelligence elements for projects of various complexity, size, duration, in different industries, and regardless of the type of project being considered, including hardware, software, services, or their combination, is also considered. This implies the possibility of applying the materials contained in the textbook to a specific project in which BIM will be used.

Chapter 1.

Fundamentals of BIM Technologies.

Fundamentals of Process Management.

1.1. Definition and Concepts of BIM

This sub-section lays the fundamental understanding of what BIM is, how it has evolved, and why it has become a key paradigm in the modern construction industry.

Definition of BIM, History of Development, Key Concepts

- **Definition of BIM (Building Information Modelling).** BIM is not just software or a 3D model. It is an integrated process of creating, managing, and using an information model of a construction object throughout its entire life-cycle. It covers all stages: from initial concept, design, construction, operation and maintenance to demolition. The main idea is that each element of the model is not just a graphical object, but carries a large amount of non-graphical information (parameters, characteristics, cost, time data, etc.) that can be used by various project participants.

- **History of Development.** Although the term "BIM" became widely used in the 2000s, its roots go back to the 1970s, when the first concepts of integrated databases for design began to emerge. Professor Charles Eastman from the Georgia Institute of Technology is considered one of the pioneers who developed some of the first systems that integrated graphical and non-graphical data. The development of technologies such as CAD (Computer-Aided Design) and hardware improvements gradually paved the way for modern BIM systems. A significant impetus for the spread of BIM was the realization of the need to increase efficiency and reduce waste in the construction industry.

- **Key Concepts.**

- **Digital Model.** This is a three-dimensional geometric representation of a building object. It is the visual basis, but in the context of BIM, it is only part of a larger information model. Each element of the model (wall, door, window, engineering system) has its form, dimensions, and spatial location.

- **Information Model.** This is an extended digital model that contains not only graphical but also a large volume of semantic data. For example, a wall in an information model will know not only its length and height but also the type of material, thermal conductivity, manufacturer, cost, service life, fire resistance characteristics, etc. This data allows for various analyses (energy, cost, structural), and automatic generation of specifications and estimates.
- **Lifecycle of an Asset.** BIM technology covers all stages of a building object's existence, traditionally divided into:
 1. **Planning and Concept.** Formation of an idea, site analysis, feasibility study.
 2. **Design.** Architectural, structural, engineering design, documentation development.
 3. **Construction.** Project management, procurement, installation, quality control.
 4. **Operation and Maintenance.** Facility Management, repair, modernization, energy management.
 5. **Demolition/Disposal.** Dismantling, material recycling. BIM ensures a continuous flow of information between these stages, which is its greatest advantage.

Comparison of BIM with Traditional Design and Construction Methods

• Traditional Methods (2D CAD).

- **Fragmented information.** Drawings are created independently (plans, sections, elevations), and information is often duplicated or not synchronized.
- **Manual checks and coordination.** Clash detection (intersections of engineering systems, structures) occurs manually, leading to errors, rework, and delays.
- **Frequent errors.** Human factor plays a significant role, as many operations are performed manually.
- **Difficulty in making changes.** Changing one element requires manual updating of all related drawings and specifications, which is time-consuming and error-prone.

- **Limited analysis capabilities.** Most analyses (e.g., energy) require exporting data to specialized programs and re-entering data.
- **Lack of a single source of truth.** Each department has its own set of data, complicating collaboration.

• BIM Methodology

- **Single integrated model.** All project information is stored in a single, centralized information model. Changes in one place are automatically reflected in all related views (plans, sections, schedules, specifications).
- **Automatic coordination and clash detection.** Software can automatically detect spatial clashes and other conflicts, significantly reducing the number of errors during the construction phase.
- **Improved visualization and communication.** A 3D model with rich information allows all stakeholders to better understand the project, facilitating communication and decision-making.
- **Rapid change implementation.** Changes in the model are updated automatically, saving time and reducing the risk of errors.
- **Extended analysis capabilities.** The BIM model can be directly used to perform various analyses (energy, solar, structural, cost), optimizing design solutions.
- **Lifecycle data.** Information from the BIM model is a valuable asset for building operation and management.

Advantages and Disadvantages of BIM Implementation

• Advantages of BIM Implementation.

- **Cost and schedule optimization.** Early error detection, better construction planning (4D modelling — time), material optimization (5D — cost) lead to significant cost reductions and shorter project implementation times.
- **Improved project quality.** More accurate and consistent design solutions, reduced rework on the construction site.
- **Increased collaboration efficiency.** All project participants (architects, engineers, contractors, clients) work with a single source of information, ensuring transparency, better communication, and mutual understanding.

- **Better risk management.** Ability to visualize and analyse potential problems before construction begins.
- **Sustainability and energy efficiency.** BIM allows integrating data about materials and systems to optimize energy consumption and building environmental friendliness.
- **Value for operation.** Information from the model can be used for effective facility management after construction completion, including maintenance planning, asset tracking, and energy management.
- **Competitive advantage.** Companies implementing BIM gain an advantage in the market as they can offer higher quality and more efficient services.
- **Disadvantages (Challenges) of BIM Implementation.**
 - **High initial investment.** Acquisition of software (e.g., Autodesk Revit, ArchiCAD, Tekla Structures), powerful hardware, and significant costs for personnel training.
 - **Complexity of transition.** Changing established workflows and habits, which requires time and effort. This is not just mastering a new program, but changing the entire paradigm of design and management.
 - **Need for qualified personnel.** Lack of specialists with deep knowledge of BIM processes and tools. Companies must invest in training or attract new specialists.
 - **Compatibility and interoperability issues.** Although standards exist (e.g., IFC — Industry Foundation Classes), full compatibility between different software products can still be a challenge.
 - **Resistance to change.** Some employees may resist the implementation of new technologies due to inertia or unwillingness to learn something new.
 - **Need for standardization.** For effective BIM implementation within a company, clear internal standards and work protocols are required.

Overall, the advantages of BIM significantly outweigh the disadvantages in the long run, making it an indispensable tool for the future of the construction industry. Understanding these aspects is key to the successful implementation and use of BIM technologies.

1.2. Fundamentals of Process Management

This section is dedicated to a deep understanding of the process approach in management, which is critically important for the effective implementation and use of BIM technologies in the construction industry. After all, BIM is not only about software but also about optimizing workflows.

Concepts and Methodologies of Process Management

Definition of process, classification of processes, process participants

- **Definition of process.** In the context of management, a process is a sequence of interconnected actions that transform input resources (materials, information, people) into output results (products, services, solutions) that have value for internal or external customers. Each process has clearly defined boundaries, inputs, outputs, and an owner.

- **Classification of processes.** Processes can be classified by various criteria.

- **By purpose.**

- **Core (operational) processes.** Directly create value for the end customer. For example, designing a house, building a foundation.

- **Support (auxiliary) processes.** Ensure the functioning of core processes but do not directly create value for the customer. For example, human resource management, IT support, accounting.

- **Management processes.** Regulate and coordinate other processes, ensure strategic planning and control. For example, company strategic planning, quality management.

- **By level of detail.** Macro processes, subprocesses, operations.

- **By degree of automation.** Manual, automated, hybrid.

- **Process participants.** Key process participants include:

- **Process owner.** The person or department responsible for the process's effectiveness and its results, with authority to improve it.

- **Process executors.** Employees who directly perform actions within the process.

- **Suppliers.** Provide input resources for the process.

- **Customers.** Receive the output results of the process (both internal and external).
- **Stakeholders.** Anyone who has an interest in or influence on the process.

Methodologies for process description (IDEF, BPMN, EPC)

Specialized notations are used for visualizing and documenting processes

- **IDEF (Integration DEfinition for Function Modelling).** This is a family of modelling standards developed by the U.S. Air Force. IDEF0 is used for functional modelling, focusing on actions and information flows. It is effective for describing high-level processes, showing what is done and how it is related. It uses blocks for functions and arrows for inputs, outputs, controls, and mechanisms.

- **BPMN (Business Process Model and Notation).** A standard graphical notation for modelling business processes. It is the most common and flexible, allowing modelling of both simple and complex processes. BPMN uses elements such as events (circles), activities (rectangles), gateways (diamonds), and arrows for sequence, as well as "pools and lanes" to represent roles and participants. This allows creating models understandable to both technical specialists and business users.

- **EPC (Event-driven Process Chain).** A graphical notation developed in Germany, used in the ARIS methodology. EPC focuses on events and the functions that initiate and complete them. It is well suited for modelling complex logical sequences and is often used to document business processes before their automation in ERP systems (e.g., SAP).

Principles of process management, process lifecycle

● Principles of process management.

- **Customer orientation.** The main goal of the process is to satisfy the needs of an internal or external customer.
- **Focus on results.** Not the process itself is important, but its final result.
- **Continuous improvement (Kaizen).** Constant search for ways to optimize and increase the efficiency of processes.

- **Systematic approach.** Considering processes as an interconnected system, not isolated actions.
- **Measurement and analysis.** Regular collection of data on process effectiveness and its analysis.
- **Responsibility and authority.** Clear definition of process owners and their responsibilities.
- **Process lifecycle.** A process, like a project, has its own lifecycle, which includes:
 - **Identification and definition.** Identifying existing processes, their boundaries, inputs, and outputs.
 - **Documentation and modelling.** Creating graphical and textual descriptions of the process (“as-is”).
 - **Analysis.** Identifying weaknesses, “bottlenecks,” redundant steps, duplication.
 - **Improvement/Reengineering.** Developing new, optimized processes (“to-be”).
 - **Implementation.** Implementing changes in the process, training personnel.
 - **Monitoring and control.** Continuous collection of data on process effectiveness, comparison with planned indicators.
 - **Re-analysis and continuous improvement.** The cycle repeats for further optimization.

1.3. Process Analysis and Improvement

Methods of process analysis

● **As-Is Analysis.** Detailed study and documentation of the current state of a process. The goal is to understand how the process currently functions, identify its strengths and weaknesses, “bottlenecks,” duplication, redundant steps, and sources of inefficiency. Interviews with participants, observation, and analysis of existing documentation are used.

● **What-If Analysis.** Modelling different scenarios to evaluate potential changes in a process. Allows predicting the consequences of implementing new technologies, changing resources, or sequence of steps without real experiments. Often used with process simulation software.

- **Root Cause Analysis.** A method aimed at identifying the deep-seated causes of problems or defects in a process, not just their symptoms. Popular tools:

- **Ishikawa Diagram (Fishbone Diagram).** Visualises possible causes of a problem, grouping them by categories (people, processes, equipment, materials, environment, measurements).
- **“5 Whys” Method.** Repeatedly asking “why?” up to five times to get to the root cause of a problem.

Methods of process improvement (reengineering, Kaizen, Six Sigma)

- **Business Process Reengineering (BPR).** Radical rethinking and fundamental redesign of business processes to achieve significant improvements in key performance indicators (cost, quality, service, speed). This is not just improvement, but a complete restructuring, often using new technologies. Example: transition from paper-based document flow to a fully digital BIM workflow.

- **Kaizen.** A Japanese philosophy and practice of continuous, gradual improvement. Focuses on small, constant changes made by all employees at all levels of the organization. The goal of Kaizen is to constantly identify and eliminate small problems, which over time leads to significant improvements.

- **Six Sigma.** A methodology focused on reducing variability (deviations) in processes and products, leading to fewer defects and higher quality. Uses statistical methods and the DMAIC (Define, Measure, Analyse, Improve, Control) approach to identify and eliminate the causes of defects. The goal is to achieve no more than 3.4 defects per million opportunities. In construction, it can be applied to improve installation quality, reduce the number of errors in design documentation, etc.

Definition and monitoring of Key Performance Indicators (KPIs)

Key Performance Indicators (KPIs) are measurable values that demonstrate how effectively an organization, project, or individual process is achieving its key business objectives. Properly defined KPIs help track progress, identify problems, and make informed decisions.

- **Examples of KPIs for the construction industry (in the context of BIM).**
 - **Time.** Time from design start to permit approval, speed of making changes to the model, time to detect and resolve clashes.

- **Cost.** Percentage of budget savings due to BIM, accuracy of cost estimates, cost of rework.
- **Quality.** Number of clashes detected before construction begins, number of errors in outgoing documentation, quality of data exchange.
- **Productivity.** Number of projects executed with BIM, efficiency of resource utilization.
- **Safety.** Number of incidents on the construction site (BIM can assist in safety planning).
- **KPI Monitoring.** Includes regular data collection, analysis, and visualization (e.g., using dashboards). This allows management and process owners to promptly react to deviations and take corrective actions.

1.4. Process Approach in Project Management

Integration of project management processes with organizational business processes

Project management (especially in construction) is part of the company's overall business processes. Integration means that project management processes (e.g., planning, execution, control processes) do not exist in isolation but are organically embedded in the organization's broader business process system.

- For example, the project initiation process in a construction company should be linked to sales, financial analysis, and legal assessment processes.
- The process of procuring materials for a project is integrated with the company's general procurement process.
- BIM significantly facilitates this integration, as a single information model can be used by various departments and systems (e.g., ERP, document management systems), ensuring transparent data exchange.

Application of the process approach at different project stages (initiation, planning, execution, monitoring, completion)

The process approach forms the basis of modern project management, where each project stage is viewed as a set of interconnected processes.

- **Initiation.** Processes of project definition, project charter development, and stakeholder identification.

- **Planning.** A central stage that includes numerous processes: developing a project management plan, planning scope, schedule, budget, resources, risks, communications, procurement, and quality. In BIM projects, this includes developing a BIM Execution Plan (BEP).

- **Execution.** Processes related to the actual execution of work, team management, procurement, and communication management. In BIM, this can be modelling, coordination with other disciplines.

- **Monitoring and Control.** Processes for tracking progress, measuring performance, identifying deviations from the plan, and taking corrective actions. Includes quality control, change management, and risk monitoring. Thanks to BIM, monitoring capabilities are significantly expanded (e.g., 4D modelling for tracking construction progress).

- **Completion.** Processes for closing the project or project phase, including transferring the final product (including the As-Built BIM model), lessons learned collection, and contract closure.

The role of processes in ensuring the quality of design solutions

The process approach is fundamental to quality management systems (e.g., ISO 9001).

- **Standardisation.** Clearly defined and documented processes ensure stability and predictability of results, which is fundamental for quality.

- **Error reduction.** Adherence to defined processes, especially with the use of tools such as BIM for automatic clash detection, significantly reduces the number of errors and defects in design solutions.

- **Transparency and accountability.** Each participant understands their role and responsibility in the process, which increases accountability.

- **Continuous improvement.** Regular analysis and optimisation of processes allows for continuous improvement of design solution quality.

- **Control and verification.** The presence of control points in processes allows for the timely detection and correction of deviations. In the context of BIM, this includes checking the model for compliance with standards, client requirements, and the absence of clashes.

Understanding and effectively applying these principles of process management allows companies not only to implement BIM technologies but also to maximise their potential for increasing efficiency, quality, and competitiveness.

Chapter 2.

BIM in the Lifecycle Management of a Building Object

2.1. BIM Technologies at the Design Stage

This section reveals the practical application of BIM technologies directly at the design stage, which is one of the most important for unleashing the full potential of BIM. We will consider how a BIM model is created and coordinated, how information support is organized, and how BIM is used for analysis and optimization of design solutions.

Creation and Coordination of the BIM Model

Principles of BIM model creation, parametric modelling

Creating a BIM model radically differs from traditional CAD design. Instead of drawing lines and circles, the designer works with intelligent objects that carry information.

- **Principles of BIM Model Creation.**

- **Object-oriented approach.** Instead of separate graphical primitives, the model consists of “smart” building components (walls, windows, doors, columns, beams, engineering equipment). Each such object is a digital twin of a real element and contains rich information about its properties.
- **Information richness.** Each element of the model carries not only geometric but also parametric, functional, and other data (material, manufacturer, cost, thermal conductivity, fire resistance characteristics, etc.).
- **Centralised database.** All information is stored in a single integrated model. Changing any parameter of one object automatically updates all related views (plans, sections, elevations, schedules, specifications). This minimises errors and ensures data consistency.

- **Use of element libraries.** Designers use standard or customised libraries of BIM objects (families), which speeds up modelling and ensures consistency.
- **Parametric modelling.** This is a key feature of BIM. Instead of fixed dimensions, model elements are defined by parameters and interrelationships between them.
 - **Dynamism.** Changing one parameter can automatically affect other related parameters or geometry. For example, changing the height of a wall automatically adjusts the height of windows located in it, or elements of engineering systems passing through it.
 - **Flexibility.** Allows for quickly generating alternative design options and evaluating them.
 - **Automation.** Many elements automatically adjust to changes in the model, reducing manual work.
 - **Relationships.** Parametric relationships can be established between different elements and even between different models, ensuring a high level of coordination.

Coordination of architectural, structural, and engineering sections of the project

One of the most important advantages of BIM is the ability to integrate and coordinate all sections of the project in a single information environment. Traditionally, architects, structural engineers, and mechanical, electrical, and plumbing (MEP) engineers work on separate drawings, which often leads to inconsistencies and clashes on the construction site.

- **Model consolidation.** Different project sections create their separate BIM models (e.g., architectural model, structural model, MEP model). These models are then combined into a **federated BIM model** in specialised software (e.g., Autodesk Navisworks, Solibri).

- **Shared access and synchronisation.** Thanks to a Common Data Environment (CDE), specialists from different disciplines have access to up-to-date versions of their colleagues' models, ensuring rapid information exchange and synchronisation.

- **Clash Detection.** This is an automatic process of detecting intersections or "clashes" between elements of different sections. For example, a duct passing through a beam, or a pipe conflicting with an electrical cable. This allows

identifying and eliminating problems at the design stage, rather than during construction, when their correction is significantly more expensive and labour-intensive.

- **Visualization and problem resolution.** Detected clashes are visualized, facilitating their analysis and joint resolution. Teams can conduct "coordination meetings" using the federated model to discuss and find optimal solutions.

Detection and elimination of clashes, ensuring compatibility of design solutions

- **Clash detection process.**

- **Import and combine models.** Uploading BIM models of different disciplines into coordination software.
- **Run clash check.** Automatic search for intersections between selected groups of elements (e.g., "pipes vs beams", "ducts vs ceilings").
- **Analyse results.** Review the list of detected clashes, filter by type, priority. Some "clashes" may be acceptable (e.g., a pipe passes through an opening in the wall provided by the design), others require immediate correction.
- **Create reports and tasks.** Generating clash reports and assigning responsibilities for their elimination.

- **Clash elimination.** Detected clashes are transferred to the relevant specialists (architect, structural engineer, MEP engineer), who make changes to their models. This iterative process continues until the number of clashes is minimised or eliminated.

- **Ensuring compatibility.**

- **Common standards.** Use of unified modelling and element naming standards.
- **Templates and libraries.** Application of common project templates and object libraries for all disciplines.
- **Open formats.** Use of open formats such as IFC (Industry Foundation Classes), which allows information exchange between different BIM programs regardless of the manufacturer. This is key to interoperability.
- **Regular coordination meetings.** Conducting systematic meetings with all stakeholders to discuss and resolve emerging problems.

2.2. Information Support for Design

- **Development of a BIM Execution Plan (BEP)**

A BEP is a key document that defines how BIM will be used on a specific project. It is, in essence, a "roadmap" for BIM implementation. It is developed in the early stages of the project and agreed upon by all key participants.

- **Content of the BEP:**

- **BIM Goals and Objectives:** What the project aims to achieve with BIM (e.g., reduce clashes by 20%, optimise energy consumption).
- **Roles and Responsibilities:** A clear definition of who is responsible for what within the BIM processes.
- **BIM Processes:** A detailed description of workflows related to modelling, information exchange, and coordination.
- **Standards and Protocols:** Requirements for file naming, model structure, and Level of Development (LOD).
- **Technologies and Software:** A list of the software products to be used.
- **Data Exchange Strategy:** How models and information will be exchanged (e.g., via a CDE, in IFC format).
- **BIM Work Schedule:** Stages and deadlines for completing BIM tasks.
- **BIM Model Quality Requirements:** Criteria for assessing the quality of the model.

- **Importance of the BEP:** It ensures clarity, consistency, and efficiency in the use of BIM throughout the project. It is a living document that can be updated as the project evolves.

- **Organization of a Common Data Environment (CDE)**

A CDE is a centralized digital repository for all project information. It is not just a file server but an integrated platform that provides shared access, version control, access rights management, and workflow automation.

- **Purpose of the CDE:**

- **Single Source of Truth:** All project participants have access to the same current version of information.
- **Version Control:** Ensures tracking of all changes, who made them, and when, allowing for the restoration of previous versions.

- **Access Management:** Delineation of access rights to different parts of the project for different users.
- **Workflow Management:** Automation of approval, validation, and information exchange processes (e.g., uploading models, publishing documents).
- **Risk Reduction:** Reduces the likelihood of using outdated data, which leads to errors.
- **Examples of CDEs:** Autodesk BIM 360/Construction Cloud, Trimble Connect, Bentley ProjectWise, as well as cloud platforms and SharePoint-based solutions.

- **Project Information Management and Version Control**

Effective information management is the foundation of a successful BIM project.

- **Information Management:** This includes the processes of collecting, storing, processing, distributing, and archiving all project-related data. This includes not only BIM models but also drawings, specifications, contracts, correspondence, site photos, reports, etc. The key is the classification and structuring of information for easy search and use.

- **Version Control:** A critically important aspect in a collaborative environment. Each time a change is made to a file or model, a new version is created, and previous ones are saved. This allows for:

- **Tracking Changes:** Seeing who changed what and when.
- **Reverting to Previous Versions:** In case of errors or the need for comparison.
- **Avoiding the Use of Outdated Data:** Always work with the most current version.
- **“Audit Trail”:** Ensures transparency and the ability to audit all actions taken with the information.

2.3. Overview of BIM Software Products for Construction

Building Information Modelling (BIM) has revolutionised the construction industry, transforming it from two-dimensional drafting to intelligent three-dimensional modelling with integrated information. This transition has been made possible by a wide range of software products that enable the

creation, management, analysis, and exchange of construction information at all stages of an asset's lifecycle.

Choosing the right software is key to the successful implementation of BIM technologies. Below is an overview of the main categories of BIM products and their most popular representatives.

2.3.1. BIM Authoring Tools

These are the primary programs for creating intelligent 3D models and populating them with information.

- **Autodesk Revit:** One of the most popular and comprehensive tools for BIM modelling. It allows for the creation of architectural, structural, and MEP (Mechanical, Electrical, and Plumbing) models, data integration, automation of documentation creation, and clash detection. It is widely used due to its multi-functionality and collaboration capabilities.

- **GRAPHISOFT ArchiCAD:** Another leading tool, known for its intuitive interface and focus on architectural design. It supports the "Virtual Building" technology, allowing work with a 3D model and automatic generation of 2D documentation.

- **Bentley OpenBuildings Designer (formerly AECOsim Building Designer):** A comprehensive solution for building design that supports multi-disciplinary modelling and collaboration. It is particularly strong in large and complex infrastructure projects.

- **Allplan Engineering/Architecture:** A software suite offering solutions for architectural and engineering design, with an emphasis on structural elements and reinforcement detailing.

- **Vectorworks Architect:** Popular among architects and designers for its flexible modelling tools, including 2D drafting, 3D modelling, and BIM functionality.

2.3.2. Analysis and Simulation Software

These tools allow for various analyses based on the BIM model to optimise design solutions.

- **Autodesk Insight (for energy analysis):** A tool integrated with Revit for conducting building energy analysis, insulation modelling, and optimising energy efficiency.

- **IES Virtual Environment (IESVE):** A powerful package for detailed energy modelling, analysis of HVAC systems, lighting, and indoor comfort.

- **Rhino with Grasshopper (for parametric and generative design):** Although Rhino is not a full-fledged BIM modeller, in combination with the Grasshopper plugin, it is widely used for complex parametric and generative design, allowing the creation of optimised forms and structures that can then be integrated into BIM models.

- **Robot Structural Analysis Professional (Autodesk):** Used for the calculation and analysis of structures. It can be integrated with Revit for model exchange.

- **SCIA Engineer:** Comprehensive software for structural analysis and design.

2.3.3. Coordination and Clash Detection Software

These tools help to combine models from different disciplines, detect conflicts, and manage them.

- **Autodesk Navisworks Manage:** A flagship product for model aggregation, clash detection, 4D simulation (construction schedule), and 5D modelling (cost estimation). It allows importing models from various formats and creating a single federated model.

- **Trimble Connect:** A cloud-based platform for collaboration, model viewing, clash detection, and project information management. It supports IFC.

- **Solibri Model Checker:** A specialised tool for verifying BIM models for compliance with standards, detecting clashes, and ensuring information quality.

2.3.4. 4D/5D BIM Software (Scheduling and Cost)

Tools for integrating time and cost with the 3D model.

- **Synchro 4D Pro:** Specialized software for 4D planning that allows visualizing the construction sequence, optimizing schedules and resources, and identifying potential problems.

- **CostX (RIB Software):** Software for quantity take-off and cost estimating directly from 2D drawings and 3D models. It can be integrated with BIM models for automated quantity calculation.

- **BIM Q (Autodesk):** Allows for the automation of creating quantity and cost reports based on data from Revit.

2.3.5. Data Management and Common Data Environment (CDE) Platforms

These platforms provide centralised storage and management of all project information.

- **Autodesk Construction Cloud (formerly BIM 360):** A comprehensive cloud platform that includes modules for project management, documentation, quality, safety, as well as capabilities for BIM model coordination.
- **Trimble Connect:** (Mentioned above, but also a powerful CDE platform)
- **Asite:** A global platform for project management and CDE that supports collaboration and information exchange for large and complex projects.
- **Other Common Data Environment (CDE) platforms:** There are other solutions from various vendors that provide CDE functionality, such as ProjectWise (Bentley) or proprietary developments by large companies.

2.3.6. Software for BIM in Operations (FM – Facility Management)

Tools that use BIM models to manage a facility after construction is complete.

- **Archibus:** A leading platform for real estate management that can integrate with BIM models for asset management, maintenance planning, energy management, and space management.
- **FMSystems:** A similar platform for facility management that uses information from BIM to optimise operational processes.
- **IBM Maximo:** A comprehensive enterprise asset management (EAM) system that can use BIM data for equipment lifecycle management and maintenance planning.

The BIM software landscape is constantly evolving, offering increasingly integrated and intelligent solutions. The choice of a specific product or suite of products depends on the project's specifics, organisation size, budget, and user needs. It is important to remember that BIM is not just software but a methodology that requires changes in processes, culture, and approaches to project management. The effective use of these tools, combined with the principles of process management, allows for a significant increase in the efficiency, quality, and sustainability of construction projects.

2.4. Using BIM for Analysis and Optimisation of Design Solutions

One of the most valuable capabilities of BIM is the ability to use the information model to conduct various analyses, which allows for the optimisation of design solutions before construction begins.

Energy analysis, insolation modelling, and visibility analysis

• **Energy Analysis:** BIM models contain all the necessary data (geometry, materials, windows, HVAC systems) to perform detailed energy analysis. This allows for:

- Predicting the building's energy consumption at different stages.
- Evaluating the effectiveness of different options for insulation, glazing, heating, and cooling systems.
- Optimising the design to achieve energy efficiency goals and reduce operating costs.
- Using software integrated with BIM (e.g., Autodesk Insight, Green Building Studio).

• **Insolation Modelling (Solar Analysis):** Analysis of solar radiation on the building and its rooms. This allows for:

- Assessing natural lighting and thermal loads.
- Optimising the placement of windows and shading elements (overhangs, blinds).
- Determining the best locations for solar panels.
- Visualising shadows at different times of the day and year.

• **Visibility Analysis (Line of Sight Analysis / Viewshed Analysis):** Especially relevant for urban planning and architecture. This allows for:

- Assessing views from specific points (e.g., from an apartment window or the street).
- Checking if a new building blocks the view of important landmarks or other buildings.
- Optimising the placement of buildings to ensure desired visual characteristics.

Optimisation of structural solutions, calculation of material quantities

• **Optimisation of Structural Solutions:** BIM allows for the integration of the structural model with analysis software (e.g., Robot Structural Analysis, LIRA-SAPR). This enables:

- Performing structural analyses and calculations for strength and stability.
- Optimising element cross-sections, selecting optimal materials, and reducing the weight of structures.
- Quickly assessing the impact of changes in the structure on its behaviour.

• **Quantity Take-Off:** Thanks to the information richness of the BIM model, software can automatically generate accurate bills of quantities and material specifications.

- **Accuracy:** Reduces the likelihood of errors in calculations that are common with manual take-offs from 2D drawings.
- **Speed:** Significantly speeds up the process of creating cost estimates and ordering materials.
- **Cost Control:** Allows for accurate tracking and control of material costs at all stages.
- **Example:** Automatic calculation of the quantity of concrete for foundations, bricks for walls, area of windows, length of cables, etc.

Visualisation and presentation of design solutions to the client

The BIM model is a powerful tool for visualising and effectively presenting the project to the client and other stakeholders.

• **Realistic Visualizations (Renders):** Creation of high-quality photorealistic images and animated videos based on the 3D model. This allows the client to "see" the future building before it is built.

• **Virtual and Augmented Reality (VR/AR):** The ability to "immerse" oneself in the model using VR headsets or "overlay" the model onto the real environment using AR technologies. This provides a unique experience of interacting with the project.

- **Walkthroughs:** Interactive "walks" inside the virtual building, allowing for the evaluation of spatial solutions, lighting, and functionality.

- **Detailing and Understanding:** Unlike flat drawings, the BIM model provides a complete understanding of the volume, form, materials, and functionality of the project. This significantly simplifies the decision-making process and coordination of design solutions with the client.

- **Comparison of Options:** Easy presentation of different design options and their comparison to choose the best solution.

The use of BIM technologies at the design stage not only increases efficiency and accuracy but also opens up new opportunities for analysis, optimisation, and visualisation, which is key to creating high-quality and competitive construction projects.

2.5. BIM Technologies at the Construction Stage

The application of Building Information Modelling (BIM) during the construction stage radically changes project management approaches, allowing for increased efficiency, quality control, and cost optimisation. The key aspects of using BIM during the erection of a facility are detailed below.

2.5.1. Planning and Management of Construction Production Using BIM

This stage focuses on integrating the three-dimensional model with time and resources, which transforms a static drawing into a dynamic action plan.

Development of a 4D model (schedule planning), simulation of construction work sequence.

- **4D modelling** is the process of linking 3D model elements to a construction schedule. Each element (column, wall, window, pipe section) receives time parameters: start and end dates of installation.

- **Process visualisation.** This allows for a visual playback of the entire construction process before it begins. The team can see how the building will "grow" day by day, which helps to identify logistical and technological errors at an early stage.

- **Sequence optimisation.** Modelling allows testing different work sequence scenarios to find the fastest and most efficient path, avoiding equipment and worker downtime.

Optimisation of logistics on the construction site, resource management

- **Space planning.** The BIM model helps to optimally locate temporary structures, material storage areas, equipment movement paths, and crane operation zones on the construction site, minimising collision risks.
- **"Just-in-Time" delivery.** Based on the 4D model, it is possible to accurately determine when and what materials are needed on site. This allows organising deliveries on a "just-in-time" basis, reducing the need for large storage areas and the risk of material spoilage.

Using BIM for construction safety management

- **Risk identification.** By analysing the 4D model, potentially hazardous operations (e.g., installing structures at height, operating multiple pieces of equipment in one zone) can be identified in advance.
- **Planning of safety measures.** BIM allows for the visual modelling of the placement of safety barriers, nets, temporary walkways, and planning safety briefings for workers for specific types of work.

2.5.2. Quality Control and Execution of Construction Work

BIM becomes the single source of reliable information, ensuring that the constructed object corresponds to its digital twin.

Application of BIM for controlling compliance with design documentation

- **Mobile access to the model.** Foremen and technical supervision engineers use tablets to access the BIM model directly on site. This allows for an instant comparison of the actual work performed with the design solutions.
- **Laser scanning.** Periodic 3D scanning of constructed structures and comparison of the point cloud with the BIM model allows for the detection of deviations with high accuracy, which is critical for complex engineering systems and facades.

Using BIM for automated measurement of work volumes.

- **Accurate calculation.** The BIM model allows for the automatic and accurate calculation of the volumes of work performed (e.g., area of constructed walls, volume of poured concrete), which simplifies the preparation of work completion certificates and settlements with contractors.

Providing information support for the construction process.

- **Digital document flow.** All comments, changes, and approvals are recorded directly in the model. This creates a transparent history of decision-making and helps to avoid misunderstandings among project participants. A so-called **As-Built Model** is created.

2.5.3. Construction Cost Management Using BIM

Integrating financial data into the model turns it into a powerful tool for budgeting and financial control.

Development of a 5D model (cost planning), cost monitoring.

- **5D modelling** is the addition of another dimension—cost—to the 4D model (3D + time). Each model element is linked to a corresponding item in the cost estimate.

- **Dynamic budget.** The 5D model allows you to see how the project cost changes over time according to the construction schedule. This enables accurate cash flow forecasting.

- **"Plan-vs-Fact" monitoring.** During construction, actual costs can be compared with planned costs, promptly identifying overruns.

Managing changes and their impact on project cost.

- If changes to the project are necessary, BIM allows for a quick update of the model, automatic recalculation of work volumes and materials, and an instant assessment of how this will affect the overall cost and construction timeline.

Optimization of procurement and material supply.

- Thanks to accurate specifications automatically generated from the model, the procurement department can conduct tenders and order materials with minimal risk of error. Integration with the 4D model ensures the timeliness of these procurements.

2.5.4. Ukrainian Resources and Companies Working with BIM.

- **DedalSoft — BIM technologies in construction.** <https://dedalsoft.com.ua/blog/bim-tekhnologii-v-budivnitstvi>
 - This site offers articles and information about the benefits and possibilities of BIM in the Ukrainian context, particularly regarding the automation of the construction business.
- **BUILDIT.LAB — Advantages of using BIM for the construction industry of Ukraine.** <https://www.builditlab.org/news/perevagi-vikoristannya-bim-dlya-budivelnoyi-industriyi-ukrayini>
 - An article that discusses the specific advantages of applying BIM for construction projects in Ukraine.
- **Walraven Ukraine — BIM (Building Information Modelling).** <https://www.walraven.com/ua/проектна-підтримка/bim/>
 - The Ukrainian branch of an international company that offers BIM models of its products and support for projects.
- **ResearchGate / MDPI — BIM Implementation in Post-War Reconstruction of Ukraine.** https://www.researchgate.net/publication/385440138_BIM_Implementation_in_Post-War_Reconstruction_of_Ukraine and <https://www.mdpi.com/2075-5309/14/11/3495>
 - Research and publications discussing barriers and recommendations for implementing BIM in the reconstruction of Ukraine.
- **BIM Leaders LTD.** <https://bim-ae.com/news-room/>
 - A company working in the BIM field that publishes thematic case studies, which may likely include projects in the region.

International Sites with Examples of BIM Projects and Their Application.

- **RIB Software — 5 Award-Winning BIM Project Designs In Construction.** <https://www.rib-software.com/en/blogs/bim-design-innovation-projects>
 - This blog presents examples of award-winning BIM projects, showcasing innovative approaches.

- **Neuroject — World's 10 Best BIM Projects.** <https://neuroject.com/bim-projects-2/>
 - An overview of some of the world's best BIM projects, illustrating the application of 4D, 5D, 6D, 7D, and 8D BIM.
- **Novatr — 15 Most Impressive BIM Projects Globally.** <https://www.novatr.com/blog/example-of-bim-projects-globally>
 - A collection of impressive BIM projects from around the world, showing the diversity of the technology's application.
- **Autodesk — 6 examples of buildings around the world using BIM to meet LEED.** <https://www.autodesk.com/design-make/articles/bim-examples>
 - Examples of projects where BIM was used to achieve sustainable development goals and LEED certification.
- **FARO — What Is BIM and How Does It Impact the Construction Industry?.** <https://www.faro.com/en/Resource-Library/Article/BIM-and-how-does-it-impact-the-construction-industry>
 - While not exclusively a project gallery, the article explains how BIM impacts the construction industry and includes application examples.
- **PlanRadar — 6 key steps to successfully integrate BIM technology in construction projects.** <https://www.planradar.com/au/6-steps-integrate-bim-technology/>
 - This resource offers practical steps for implementing BIM and demonstrates its benefits by describing its functionality.

2.6. BIM Technologies at the Operation and Real Estate Management Stage

The completion of construction is only the beginning of a building's life-cycle, which can last 50-100 years or more. Operating costs over this period significantly exceed the initial investment. Using BIM at this stage allows for effective asset management, reduction of operational costs, and improvement of occupant comfort and safety.

2.6.1. Transfer of Information from Construction to Operation

The key task at this stage is to ensure a smooth and lossless transfer of data accumulated during the design and construction process to the operations team.

Creation of an “as-built” model

- The **as-built model** is the final version of the BIM model that fully corresponds to the actually constructed object. It is created by adjusting the design model based on as-built survey data, concealed work certificates, and 3D scanning.
- **Value.** This model becomes the **digital twin** of the building and contains accurate information about the location of all structures and engineering communications, including those that are concealed (e.g., pipes in walls, cables behind suspended ceilings).

Preparation of information for building management systems (BMS, FM).

- The BIM model contains not only geometry but also a huge amount of attribute information: equipment brand and model, manufacturer data, installation date, warranty period, links to technical documentation.
- This data is structured and exported into formats compatible with facility management (FM) software. The most common standard for this is **COBie** (Construction Operations Building Information Exchange).

Ensuring data interoperability.

- **Interoperability** is the ability of different software systems to exchange data and interpret it correctly. Open formats like **IFC** (Industry Foundation Classes) are used for this, allowing the integration of the BIM model with Building Management Systems (BMS), resource accounting systems, and other software.

2.6.2. Using BIM for Operation and Maintenance Management

The digital twin becomes an interactive tool for the team servicing the building.

Planning and management of maintenance based on BIM.

- **Prevention instead of repair.** In an FM system integrated with BIM, automatic reminders for planned maintenance can be set up for any element—from a pump to an elevator. A technician, upon receiving a task, can see the exact location of the equipment on the model and access its maintenance instructions.

- **Example.** A manager sees on the model that a ventilation unit's filter replacement is due. They create a task to which the filter type and its location are automatically attached.

Monitoring the condition of engineering systems, energy consumption management.

- **Integration of BIM with the Internet of Things (IoT)** allows receiving data from sensors (temperature, humidity, pressure) in real-time and visualizing it on the 3D model.

- This enables an immediate response to emergency situations (e.g., a pipe leak) and analysis of energy consumption data to find ways to optimize it and reduce utility bills.

Providing access to information about the object for different users.

- Access to the model is granted by roles: the owner can see financial indicators, the engineer can see technical data, and the tenant can see instructions for the equipment in their apartment.

2.6.3. BIM for Reconstruction, Renovation, and Demolition

A building's lifecycle does not end with operation. Sooner or later, there is a need for changes.

Using the existing BIM model for work planning.

- The availability of an accurate as-built model significantly simplifies and cheapens the planning of any reconstruction or redevelopment work. There is no need to conduct complex measurements and surveys—all information is already in the model.

Managing information about changes made during operation.

- The BIM model must be "living." Any changes—equipment replacement, repairs, redevelopment—must be entered into the model. This ensures that the digital twin always remains up-to-date.

Ensuring the possibility of reusing materials and structures.

- When a building reaches the end of its lifecycle, the BIM model, containing detailed information about all materials, becomes the basis for planning deconstruction, not just demolition. This allows for the most efficient sorting of materials for their reuse or recycling, which aligns with the principles of sustainable development and the circular economy.

Chapter 3.

Organizational and Managerial Aspects of BIM Implementation

3.1. Change Management in BIM Implementation

This chapter is key to the successful integration of BIM into any organization. It covers not only the technical aspects but also, just as importantly, the human factor and organizational processes, which are crucial for any large-scale change.

3.1.1. Assessing the Organization's Readiness for BIM Implementation

Goal: To understand the current state of the organization, its current capabilities and limitations, and to determine its current position regarding BIM implementation. This stage is the foundation for all subsequent steps.

Analysis of existing processes and infrastructure.

• **Details:** Start with a thorough study of how your organization works now. This includes:

- **Design Processes:** What standards are used? How is information exchanged between departments? What tools (CAD, 2D drawings, other) are applied? How are changes coordinated?
- **Construction Processes:** How is information transferred to the construction site? How is quality control and project compliance monitored? What tools are used for planning and monitoring?
- **Operation Processes:** How is information about the building accumulated and used after construction is completed? What building management systems (BMS, CMMS) exist?

- **Existing IT Infrastructure:** Assess the power of servers, network capabilities, availability of cloud solutions, and data security. Does the current infrastructure meet the requirements for working with large BIM models and shared access?
- **Software:** Make a list of all software used, its versions, and licenses. Determine the level of integration between different programs.
- **Why this is important:** Understanding the "as-is" state will help identify bottlenecks, duplication of functions, and inefficient processes that BIM can optimise. It will also help to understand exactly what changes need to be made to current workflows.

Identifying strengths, weaknesses, opportunities, and threats (SWOT analysis).

- **Details:** This strategic tool allows for a systematic assessment of internal and external factors.
 - **Strengths:** Internal positive factors that will facilitate BIM implementation. For example: highly skilled personnel who learn quickly; presence of an IT department; management's openness to innovation; some experience with 3D modelling.
 - **Weaknesses:** Internal negative factors that may hinder BIM implementation. For example, outdated equipment, lack of experience with BIM software, limited financial resources, conservatism of some staff, and absence of internal standards.
 - **Opportunities:** External positive factors that can be used for successful BIM implementation. For example: government support for BIM initiatives; availability of quality training courses; growing market demand for BIM services; availability of new, more efficient software.
 - **Threats:** External negative factors that may complicate or prevent BIM implementation. For example: high cost of licenses and training; shortage of qualified BIM specialists in the labour market; economic instability; possible resistance from partners or clients.
- **Why this is important:** A SWOT analysis provides a holistic picture, helps identify risks and develop strategies to minimise them, and allows for the maximum use of existing advantages.

Assessing the knowledge and skills of personnel.

- **Details:** Conduct surveys, interviews, or even small tests among key employees (architects, engineers, structural designers, project managers, IT specialists).
 - **Proficiency in CAD/2D tools:** How fluently do they work with current software?
 - **Knowledge of 3D modelling basics:** Does anyone have experience with 3D models, even without BIM specifics?
 - **Understanding of BIM principles:** Do employees know what BIM is, what its benefits are, and what it is used for? Is there a general understanding of collaborative work on a model?
 - **Readiness to learn:** How open are the staff to mastering new tools and changing work processes?
 - **Identifying “change agents”:** Identify employees who are already interested in BIM or have some knowledge. They can become the driving force and “champions” of BIM within the team.
- **Why this is important:** The results of this assessment will form the basis of the training program and will help to understand who needs basic training, who needs advanced training, and who can become an internal mentor.

3.1.2. Developing a Strategy and Plan for BIM Implementation

Goal: To define clear objectives, develop a specific, phased action plan, and allocate the necessary resources to achieve these objectives. This is the "roadmap" for your BIM implementation.

Defining the goals and objectives of BIM implementation.

- **Details:** Goals should be **SMART**: Specific, Measurable, Achievable, Relevant, and Time-bound. **Examples of goals:**
 - Reduce the number of clashes by 30% within the first year of using BIM.
 - Shorten the development time of project documentation by 15% in 18 months.
 - Improve the quality of interaction between departments (architects, structural engineers, MEP engineers) by 50% through the use of a common model.

- Enable the calculation of material quantities directly from the BIM model for 80% of projects by the end of next year.
- Obtain BIM certification for 70% of key personnel within 2 years.
- **Objectives:** These are smaller steps that lead to achieving the goals. For example, for the goal “reduce clashes,” an objective might be “implement weekly clash detection checks in the model.”
- **Why this is important:** Clear goals provide direction, motivate the team, and allow for the measurement of implementation success.

Development of an implementation roadmap, defining stages and timelines.

- **Details:** This is a visual plan that breaks down the entire process into manageable stages. **Implementation Phases:**
 - **Pilot Project:** Start with a small but representative project to test BIM processes and tools in real-world conditions without significant risks. This will allow for identifying problems and adjusting the plan.
 - **Gradual Expansion:** After a successful pilot project, gradually expand the application of BIM to more projects or departments.
 - **Full Implementation:** Ultimately, BIM becomes the standard way of working for all relevant projects. **Key Stages and Milestones:**
 - Software and hardware selection.
 - Training of the first group of “champions.”
 - Development of internal standards.
 - Launch of the pilot project.
 - Evaluation of pilot project results.
 - Expansion of implementation to other teams/departments.
 - Full integration of BIM into all relevant processes.
 - **Timelines:** Set realistic deadlines for each stage and key milestone.
 - **Responsible Persons:** Assign responsibilities for each stage and task. Create a BIM implementation team.
- **Why this is important:** The roadmap ensures consistency, helps monitor progress, and allows for timely responses to challenges.

Defining necessary resources (financial, human, technical).

- **Details:** Create a detailed list of everything that will be needed. **Financial:**

- Cost of software licenses (one-time and annual subscriptions).
- Costs for equipment upgrades (powerful computers, monitors).
- Cost of personnel training and certification (internal and external trainers).
- Potential consulting services from external BIM experts.
- Costs for developing or adapting internal standards. **Human:**
- Allocation of an internal BIM team or BIM manager.
- Time required for employees to train and adapt to new processes.
- Potential hiring of new specialists with BIM experience. **Technical:**
- Purchase of new or modernisation of existing computer equipment.
- Network infrastructure upgrades (higher bandwidth).
- Selection and configuration of servers for storing and collaborating on BIM models (local, cloud).
- Data backup and recovery solutions.

- **Why this is important:** Thorough resource planning will help avoid unforeseen expenses, downtime, and missed deadlines.

3.1.3. Implementing the BIM Implementation Plan

Goal: To bring the developed plan to life, integrating BIM technologies and processes into the organisation's daily operations.

Software selection and configuration.

- **Details:**

- **Selection:** Based on the assessment of needs and goals (from 6.1 and 6.2), choose a BIM platform (e.g., Autodesk Revit, Graphisoft ArchiCAD, Bentley MicroStation) and associated tools (for clash detection, calculations, scheduling, visualisation, etc.). Consider compatibility, functionality, cost, support, and market popularity.
- **Configuration:** Software installation, workstation setup. This includes setting up templates, element libraries, and default parameters according to the company's internal standards. Integration with other systems used (ERP, document management).

- **Why this is important:** Properly selected and configured software is the primary tool for working with BIM. An incorrect choice can lead to significant time and resource expenditure.

Personnel training and upskilling.

- **Details:** This is one of the most important aspects.
 - **Development of a training program:** Based on the knowledge assessment (6.1), create individual or group programs. Consider different levels of preparation (basic, advanced). **Training Formats:**
 - **Internal training:** Involving “change agents” or newly trained specialists.
 - **External courses and seminars:** Collaboration with accredited training centres.
 - **Online resources:** Using webinars, video tutorials, specialised platforms.
 - **Practice on pilot projects:** “Learning by doing” is the most effective.
 - **Regular knowledge updates:** BIM technologies are constantly evolving, so it is important to organise a continuous learning process.
- **Why this is important:** Qualified personnel are the driving force behind BIM implementation. Without proper training, even the best software will be underutilised.

Development of internal BIM standards and methodologies.

- **Details:** To ensure consistency, quality, and efficiency in working with BIM, clear internal rules must be established.
 - **BIM Execution Plan (BEP) Template:** Create a template for the BEP that will be adapted for each project. This plan defines the BIM goals for a specific project, participant roles and responsibilities, model Level of Detail (LOD), data exchange formats (IFC), model quality check procedures, and work schedules.
 - **Naming Standards:** Clear rules for naming files, layers, and model elements.
 - **Model Structure:** How models should be organised (e.g., breakdown into separate files by discipline, work sets).

- **Modeling Rules:** Requirements for modeling accuracy, use of parametric objects, and attribute assignment.
- **Quality Control Procedures:** How to check models for compliance with standards, clash detection, and information completeness.
- **Data Exchange Procedures:** Definition of formats (IFC, RVT, DWG, etc.) and methods for exchanging information between project participants.
- **Why this is important:** Internal standards ensure consistency, reduce errors, increase collaboration efficiency, and guarantee that all participants work according to unified rules.

3.1.4. Managing Resistance to Change

Goal: To minimise the negative impact of resistance, turning it into an opportunity for improvement and staff engagement.

Identifying the causes of resistance to change.

- **Details:** Be open to feedback. Reasons can vary.
 - **Fear of the unknown:** People fear what they don't understand.
 - **Loss of control:** Changes in familiar processes can cause a feeling of losing control over one's work.
 - **Lack of self-confidence:** Fear of not coping with new tools or tasks.
 - **Protection of the "status quo":** Comfort in familiar routines.
 - **Misunderstanding of benefits:** If employees do not see personal benefits from the changes, they will resist.
 - **Previous negative experience:** If previous implementations were unsuccessful.
 - **Lack of information:** Insufficient or unclear communication.
 - **Overload:** Feeling that new tasks are added to existing ones without reducing the latter.
- **Methods of identification:** Conducting anonymous surveys, individual interviews, focus group meetings, and observing behaviour.
- **Why this is important:** Understanding the root causes allows for the application of adequate and effective strategies to overcome resistance, rather than fighting symptoms.

Developing strategies to overcome resistance.

- **Details:** Depending on the identified causes, apply appropriate approaches.
 - **Training and Education:** The most effective way to combat fear of the unknown and uncertainty. Explain how BIM works, show examples, provide access to training materials and support.
 - **Participation and Involvement:** Engage employees in the process of planning and implementing changes. Allow them to make suggestions, participate in standard development. This creates a sense of ownership and responsibility.
 - **Support and Facilitation:** Provide practical assistance, mentorship, access to experts. Reduce workload during the training period, if possible.
 - **Negotiation and Agreement:** In some cases, especially with key figures, it may be appropriate to discuss individual terms or additional bonuses for adaptation.
 - **Manipulation and Co-optation:** (To be used cautiously and as a last resort) This may involve including leaders of resistance in implementation committees to give them a sense of involvement and control, but without real power.
 - **Coercion:** (As a last resort, when all other methods are exhausted) May involve direct application of power, threats, or dismissal. This method can cause strong dissatisfaction and negatively affect team morale. It should be avoided if possible.
 - **Demonstrating Success:** Show concrete examples of successful BIM use, results of pilot projects, and financial benefits.
- **Why this is important:** Active resistance management not only overcomes obstacles but also transforms sceptics into advocates for change, contributing to faster and more complete BIM implementation.

Ensuring effective communication and employee engagement.

- **Details:** Communication is the cornerstone of change management.
 - **Openness and Transparency:** Be honest about the reasons for BIM implementation, its benefits, and potential challenges.
 - **Regular Information:** Create channels for regular communication (meetings, newsletters, internal portal).

- **Two-Way Communication:** Provide opportunities for employees to ask questions, express their concerns, and offer suggestions. Listen to them.
- **“Why are we doing this?”:** Constantly remind them of the purpose of BIM implementation and its benefits for the company and each employee.
- **Recognition and Encouragement:** Celebrate successes, even small ones. Encourage those who actively participate in the implementation process.
- **BIM Champions:** Identify and support internal BIM “champions” — enthusiasts who can serve as examples and mentors for others.
- **Why this is important:** Effective communication builds trust, reduces uncertainty, increases motivation and engagement, transforming “resistance” into “cooperation.”

3.2. Organization of Collaboration and Information Management in a BIM Project

This section focuses on how to effectively organize interaction among all project participants and manage the flow of information in a BIM environment. This is critically important, as BIM is not just about models, but about collaborative work and access to a single source of truth.

3.2.1. Roles and Responsibilities of BIM Project Participants

Goal: To clearly define who is responsible for what in a BIM project to avoid confusion, duplication of functions, and ensure a smooth workflow.

Defining roles (BIM Manager, BIM Coordinator, BIM Specialist) and their functions.

● **BIM Manager:**

- **Functions:** This is the strategic leader of BIM implementation within the organisation and on the project. They are responsible for developing and implementing the company’s overall BIM strategy, standardising BIM processes, selecting software, and training staff. At the project level, the BIM Manager monitors compliance with standards, ensures resources, and resolves complex issues. They are the main point of contact for the client regarding BIM requirements.

- **Responsibilities:** Developing corporate BIM standards, managing the BIM budget, evaluating the effectiveness of BIM processes, communicating with senior management, and developing BIM competencies within the company.

- **BIM Coordinator:**

- **Functions:** This role is operational and technical. The BIM Coordinator ensures the coordinated work of all disciplines on a single model. They are responsible for integrating models from different sections, performing clash detection, controlling the quality of the information model, and adhering to project BIM standards. They may provide technical support to BIM specialists.
- **Responsibilities:** Combining models (architecture, structures, engineering networks), performing clash detection, generating clash reports, ensuring model accuracy, supporting the collaborative work platform, and consulting BIM specialists.

- **BIM Specialist (BIM Modeller, BIM Author):**

- **Functions:** This is the main performer of the work. The BIM Specialist directly creates and updates information models by project requirements and company standards. They work within their discipline (architecture, structures, HVAC, plumbing, etc.).
- **Responsibilities:** Modelling building elements, adding attribute information to model elements, creating working documentation from the model, updating the model by project changes, and collaborating with the BIM Coordinator.

- **Other roles (depending on the project):** May include BIM Lead (head of a team of BIM specialists in a department), BIM Developer (for software customisation), BIM Analyst, etc.

Distribution of responsibilities among project participants.

- **Details:** After defining the roles, it is necessary to clearly outline their responsibilities in the context of a specific project. This can be done in the BIM Execution Plan (BEP).

- **Example:**

- **BIM Manager:** BEP approval, resource provision, final quality control of the model before handover to the client.
- **BIM Coordinator:** Daily clash detection, maintaining an issue log, organizing coordination meetings.
- **BIM Specialist:** Creating their part of the model by a certain deadline, correctly adding parameters, responding to inquiries regarding their model.

- **Why this is important:** A clear distribution of responsibilities prevents conflicts, increases work transparency, and ensures that all necessary tasks are completed.

Forming an effective BIM project team.

- **Details:** This is not only about role distribution but also about creating a favorable environment for collaboration.

- **Skills:** Balance technical skills (BIM software) with “soft” skills (communication, problem-solving, teamwork).
- **Training and Development:** Provide opportunities for continuous learning and professional development.
- **Motivation:** Encourage and recognize the contribution of each participant.
- **Cross-functionality:** Encourage knowledge sharing and understanding of other disciplines’ processes.
- **Leadership:** Ensure strong leadership from the BIM Manager and Coordinator.

- **Why this is important:** The success of a BIM project depends on the coordinated work of the team. An effective team is able to quickly adapt to changes, solve problems, and achieve set goals.

3.2.2. Information Exchange and Management Processes

Goal: To create mechanisms for seamless, accurate, and timely information exchange among all project participants, ensuring that everyone works with up-to-date data.

Developing data exchange protocols.

- **Details:** These protocols define how, when, and in what format information is exchanged.
 - **File Formats:** Define the main exchange formats (e.g., **IFC** for interdisciplinary interaction, RVT/DWG for internal use, PDF for final documentation). Emphasise the importance of **OpenBIM** and the use of IFC for interoperability.
 - **Exchange Frequency:** Establish the regularity of exchanging updated models (daily, weekly, after significant changes).
 - **Transfer Methods:** Determine through which platforms or systems the exchange will occur (e.g., CDE, FTP, cloud storage).
 - **File Naming Standards:** Establish unified rules for naming models, drawings, and other documents so they can be easily found and identified.
 - **Levels of Detail (LOD/LOIN):** Define the required level of graphical and informational detail (Level of Detail / Level of Information) for different elements at various project stages.
- **Why this is important:** Clear data exchange protocols minimise the risks of errors, information loss, and ensure that all participants work with current and correct information.

Ensuring effective communication among project participants.

- **Details:** Communication is the foundation of a successful project.
 - **Regular Coordination Meetings:** Organise regular meetings (online or offline) to discuss progress, resolve issues, check for clashes, and approve changes.
 - **Clear Communication Channels:** Define who contacts whom for specific issues (e.g., BIM specialist to BIM coordinator for technical questions, BIM coordinator to BIM manager for strategic issues).
 - **Issue Tracking Systems:** Use specialized software or CDE functionality to log, track, and resolve detected clashes and other issues (e.g., **BCF — BIM Collaboration Format**).
 - **Decision Logging:** Be sure to record all decisions made and those responsible for their execution.

- **Why this is important:** Effective communication prevents misunderstandings, accelerates decision-making, and facilitates problem resolution at early stages.

Using shared online collaboration platforms (Common Data Environment – CDE).

- **Details:** A CDE is a central repository for all project information and a tool for collaborative work. **CDE Functionality:**

- **Centralised Data Storage:** All models, drawings, documents, and specifications are stored in one place.
- **Version Control:** Ability to track changes and revert to previous file versions.
- **Access Control:** Differentiation of access rights for different users and roles.
- **Approval Processes:** Mechanisms for reviewing and approving documents and models.
- **Model Viewing Capabilities:** Viewing 3D models without the need to install specialised software.
- **Commenting and Markup Functions:** Ability to add comments and markups to models and documents.
- **Task and Issue Tracking:** Tools for managing model-related tasks.
- **Platform Examples:** Autodesk Construction Cloud (BIM 360/Docs), Trimble Connect, Dalux, Allplan Bimplus, and others.

- **Why this is important:** A CDE is a single source of truth for all project participants. It significantly improves collaboration efficiency, reduces errors related to outdated data, and accelerates information exchange.

3.2.3. Legal and Contractual Aspects of BIM

Goal: To regulate legal issues related to BIM use to protect the interests of all parties, minimise risks, and ensure legal certainty.

Allocation of ownership rights to the information model.

- **Details:** It is important to clearly define who owns the BIM model at different stages of the project.

- **Initial Ownership:** Typically, the organisation that creates the model (designer, architect) is the initial owner.

- **Usage Rights:** Define what rights the client receives to use the model after its handover (for construction, operation, and subsequent changes).
- **Modification and Updates:** Who has the right to make changes to the model and under what conditions?
- **Archiving:** How long will the model be stored, and who is responsible for it?
- **Why this is important:** Uncertainty in this matter can lead to complex legal disputes, especially in the case of commercial use or modification of the model.

Execution of BIM Addendums to Contracts.

- **Details:** Standard construction contracts often do not account for the specifics of BIM. Therefore, special addendums or sections need to be developed.
 - **Employer's Information Requirements (EIR):** The client must clearly formulate their requirements for the BIM model (what information is needed, for what purposes, level of detail, exchange format, etc.). This should be part of the contract.
 - **BIM Execution Plan (BEP) as part of the contract:** The BEP, developed by the contractor and approved by the client, should also become a mandatory part of the contractual documents.
 - **Definition of Data Responsibility:** Clearly state who is responsible for the accuracy, completeness, and timeliness of data in the model at each stage.
 - **Change and Control Procedures:** How changes in the model and related documentation will be formalised and approved.
 - **Definition of Data "Reliability":** What data from the model is considered "official" (e.g., whether the model is legally significant, or only the drawings).
 - **Penalties and Incentives:** Mechanisms may be provided for non-compliance with BIM requirements or, conversely, for exceeding them.
- **Why this is important:** BIM addendums provide a legal basis for collaboration, set expectations, and minimise risks for all parties, making the process more transparent.

Dispute resolution related to BIM use.

- **Details:** Even with careful planning, disputes can arise. It is important to have a clear mechanism for their resolution.
 - **Mediation and Arbitration:** Instead of lengthy and costly court proceedings, alternative dispute resolution methods can be provided.
 - **Expert Assessment:** In case of technical discrepancies related to the model, independent BIM experts can be engaged.
 - **Clear Reporting Procedures:** High-quality reports on clashes, changes, and errors in the model are important evidence in case of disputes.
 - **Fixing the “Moment of Truth”:** The ability to capture the state of the model at a certain date to determine responsibility for changes.
- **Why this is important:** Having pre-defined dispute resolution procedures allows for quick and efficient resolution of conflicts, minimising their impact on the project and business relationships.

3.4. BIM Model Concept for a 24-Story Building in Kyiv

This document describes the structure and key aspects of the Building Information Model (BIM) for the design and construction of a modern 24-story residential complex in Kyiv.

3.4.1. General Information about the Object

- **Project Name:** Modern Residential Complex.
- **Location:** Kyiv, Ukraine (conditional site selection considering urban planning restrictions).
- **Number of Floors:** 24 residential floors + technical floor + two-level underground parking.
- **Purpose:** Business-class multi-apartment residential building with commercial premises on the ground floor (shops, cafes, service centres).
- **Architectural Style:** Modern minimalism using panoramic glazing, ventilated facades, and ecological materials.
- **Key Features:** Energy efficiency class A, "smart home" system, enclosed landscaped adjacent territory.

3.4.2. Structure of the Comprehensive BIM Model

A BIM model is not just a 3D visualisation, but an integrated database consisting of several interconnected models.

Architectural Model (AR – Architectural Solutions)

This is the visual and functional basis of the project.

- **Layout:** Detailed floor plans, including apartment layouts (1-bedroom, 2-bedroom, 3-bedroom apartments, duplex penthouses).
- **Facades:** Detailed design of facade systems, finishing materials (porcelain stoneware, composite panels), placement of windows and balconies.
- **Elements:** Walls, partitions, windows, doors, stairs, elevator shafts. Each element contains information about material, manufacturer, cost, and thermal performance.
- **Interiors:** Modelling of common areas (lobbies, corridors).

Structural Model (KZ/KM – Reinforced Concrete / Metal Structures)

This model ensures the strength and stability of the building.

- **Frame:** Monolithic reinforced concrete frame (columns, pilasters, beams, floor slabs).
- **Foundation:** Slab-pile foundation, calculated based on geological surveys.
- **Reinforcement:** Detailed 3D modelling of reinforcement cages to avoid clashes and optimise steel usage.
- **Loads:** The model contains data for calculating static and dynamic loads (snow, wind, seismic).

MEP Model (Mechanical, Electrical, Plumbing)

A complex of building life support systems.

- **Heating, Ventilation, and Air Conditioning (HVAC):** Piping layout, placement of radiators, fan coils, ventilation ducts, and equipment on the technical floor.
- **Water Supply and Sewerage (WS&S):** Hot/cold water supply and wastewater disposal systems.

- **Electrical Supply (ES):** Power cables, lighting systems, distribution boards, transformer substation.
- **Low-current Systems:** Internet, television, fire alarm, access control system, video surveillance.

3.4.3. Stages of Development Based on BIM

1. **Pre-project Analysis (LOD 100):** Creation of a conceptual model for analysing volumes, insulation, and compliance with urban planning regulations.
2. **Project (LOD 200-300):** Detailed development of all model sections. At this stage, clash detection between architectural, structural, and engineering networks is performed.
3. **Working Documentation (LOD 400):** Automated creation of drawings (plans, facades, sections), specifications, and quantities directly from the model.
4. **Construction and Operation (LOD 500):** The model is used for planning construction works, controlling material supply, and, in the future, for managing building operations.

3.4.4. Compliance with Ukrainian State Building Codes (DBN)

The project must strictly comply with current regulations, in particular:

- **DBN V.2.2-15.2019 "Residential buildings. Basic provisions":** Regulates planning solutions, room areas, and accessibility requirements.
- **DBN V.1.1-7.2016 "Fire safety of construction objects":** Defines requirements for evacuation routes, fire resistance of structures, and fire protection systems.
- **DBN V.2.6-98.2009 "Concrete and reinforced concrete structures":** Basic requirements for the design of load-bearing structures.
- **DBN V.1.2-2.2006 "Loads and impacts":** Norms for calculating loads on the building.
- **DBN V.2.5-67.2013 "Heating, ventilation, and air conditioning":** Requirements for microclimate and energy efficiency of engineering systems.

Section 4.

Examples of BIM Use and Advantages of Integrated Application of BIM and AI

4.1. Example of BIM Use in Fayna Town

4.1.1. Design and Coordination

BIM was used to create a detailed 3D model of the development, including architectural, structural, and engineering solutions. This allowed for:

- Minimising clashes between networks (electricity, water supply, ventilation, etc.).
- Simplifying interaction between architects, structural engineers, and engineers.
- Reducing the number of errors during implementation.

4.1.2. Construction Management

The BIM model was used for planning the sequence of construction works (4D modelling), which allowed for:

- Efficient organisation of logistics on the construction site.
- Synchronising contractor schedules.
- Monitoring adherence to deadlines.

4.1.3. Cost Planning (5D)

Thanks to BIM, the developers of Fayna Town could quickly estimate changes in project costs when adjusting solutions. This allowed for:

- Optimizing the budget.
- Avoiding cost overruns.

4.1.4. Operation and Facility Management (6D)

For subsequent operation, a digital model of the buildings was created with integrated data on all systems, which:

- Facilitates the management of engineering networks.
- Enables prompt maintenance.
- Simplifies property management.

4.2. Other BIM Examples in Kyiv.

- **UNIT.City** — an innovation park also implemented using BIM for effective infrastructure planning and data management.
- **Residential Complex Respublika** — BIM application at the design stage and during construction.
- **Kovalska Central Office** — used BIM for reconstruction and modernization.

Table 1

Structure of the Comparative Table of BIM Projects in Kyiv

Project	Type/Scale	BIM Implementation Stage	BIM Application (3D/4D/5D/6D)	Key Results	Source
Fayna Town	Residential Complex	Design, Construction	3D Modelling, 4D Planning, 5D Cost Estimation, 6D Operation	Fewer clashes, more accurate planning, efficient maintenance	(Expected official reports)
UNIT.City	Business Innovation Park	Involved from the design	3D + 4D Coordination, Infrastructure Data Management	Participant coordination, network optimisation	Project management statements
Residential Complex Respublika	Residential Quarter	Design	3D Models, Basic 4D Synchronisation	Reduced revisions and redesigns	Ukrbud press releases
Kovalska Office	Office Complex, Reconstruction	Design, Construction	3D Model, Clash Detection	Reduced delays, clear change control	Kovalska announcements

1. Official technical cases of developers — often published on websites, especially in the “project passport” or “news” sections.

2. Professional presentations — BIM specialists share their experience at conferences (Building Kyiv, BIM Forum UA).

3. Interviews and articles — architects and engineers are sometimes quoted in BIM publications.

4. Press releases — sometimes mention the use of 4D/5D analytics.

Examples of BIM technology drawings for residential building plans in Kyiv are shown in Figures 1-4.

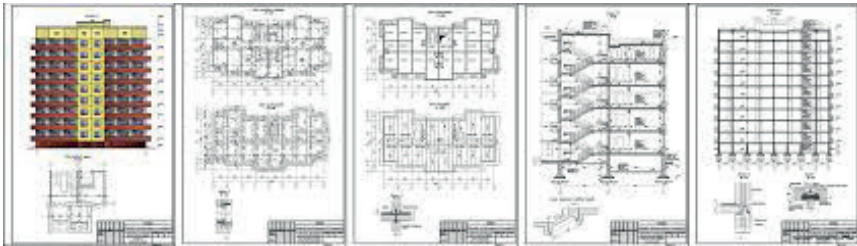


Fig. 1. Examples of BIM technology drawings.

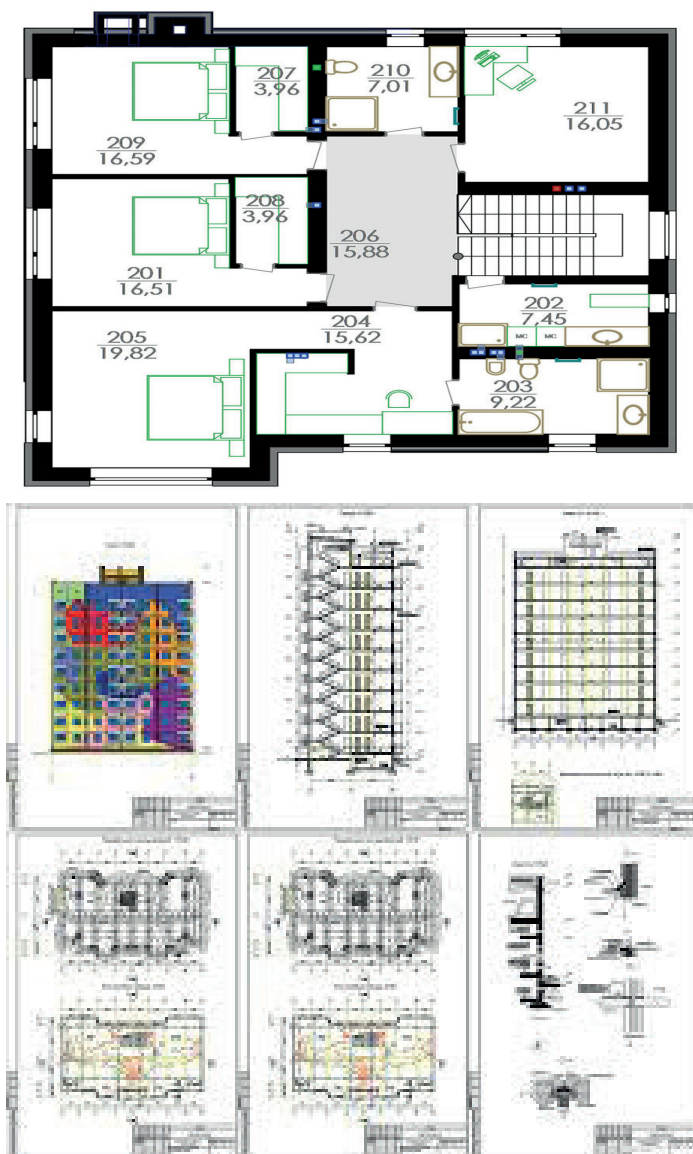


Fig. 2-3. Examples of BIM technology drawings.

вул. Милославська, 18 Деснянський район
3-кімнатна квартира № 32 на 4 поверсі
Заг.пл. 81,76 кв.м. / Жит.пл. 42,65 кв.м

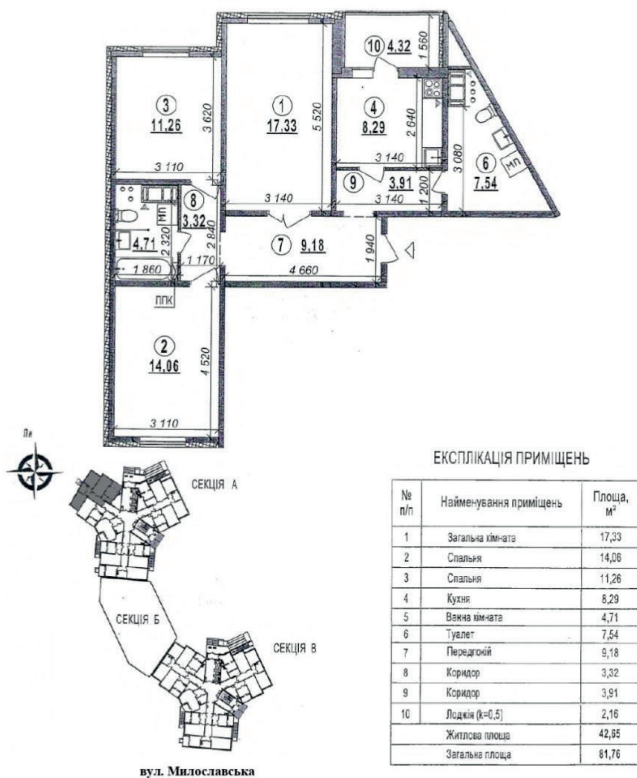


Fig. 4. Examples of drawings of residential building plans in Kyiv and typical architecture.

9-story building drawings

This is a typical option for a student or coursework project — facade, horizontal plan, and longitudinal section of a floor. Usually, such drawings are presented without details on engineering systems but with clear labelling of apartment areas, stairs, and balconies (realexpert.ua+3chertezhi.ru+3zhitlo-invest.kiev.ua+3).

Detailed floor plan of a residential complex

The drawing shows several 2-3 room apartments, with indicated areas, door/window placement, and sometimes furnishing. Usually used for presenting the middle floors of the project.

Comprehensive drawing: facades, sections, plans

This format is often used in multi-story panel or frame buildings — a combination of sections, facades, and floor plans on one sheet. Ideal for technical documentation and structural node verification.

Apartment layouts in Residential Complex “Myloslavska, 18”

An example of a commercial plan: visualisation of three-room apartments with indicated room square footage, navigational labels, and developer’s logo. Such drawings are popular in apartment sales departments.

What are these drawings used for?

- **Design and approval:** Architects and engineers coordinate technical solutions with each other.
- **Communication:** Developers present layouts to potential buyers.
- **Permitting documentation:** Drawings are part of the package for obtaining construction permits.

Example

I plan to build a 3-story cottage with an area of 300 sq. m on a 20-acre plot in the Kyiv suburbs. I need to develop plans and facades. For seasonal living for 2 adults and 3 children. Integrated garage, kitchen-living room, 4 bedrooms, study, utility room, and sauna, modern style, in a pine forest.



Fig. 5. Plan for building the cottage's electrical supply system.

To build an electrical supply system for a cottage, several key aspects need to be considered — from power source selection to safety and comfortable electricity use. Here is a basic scheme and the stages of designing an electrical supply system for a cottage.

1. Determining electricity needs

- Calculation of total consumption (power of all appliances, lighting, heating, and household appliances).

- Assessment of simultaneous load (to correctly select cables and circuit breakers).
- Possibility of future expansion.

2. Power source

- **Main:** connection to the city power grid (via a transformer substation).
- **Backup:** generator, solar panels + batteries (optional).

3. Incoming cable and input device

- Cable from the transformer substation to the input panel.
- Input circuit breaker (depending on power, 25-63 A).
- Switches, RCDs for protection against short circuits and current leakage.

4. Distribution board (panel)

- Installation of automatic circuit breakers to protect individual lines (lighting, sockets, kitchen, heating).
- Distribution by zones (first floor, second floor, garage, outdoor lighting).
- Control devices (meter, indicators).

5. Internal wiring

- Cable selection (copper or aluminium, cable cross-section according to load).
- Laying cables in pipes or corrugated pipes, hidden in walls.
- Installation of sockets and switches according to the placement plan.

6. Protection and safety

- Installation of RCDs (Residual Current Devices).
- Grounding of the cottage (grounding electrodes, connection to metal structures).
- Use of circuit breakers with the correct rating.

7. Lighting and additional systems

- Development of a lighting plan (rooms, corridors, outdoor lighting).
- Possible installation of automatic control systems (smart home).
- Ventilation, heating, and boiler — separate lines.

Example of a simple cottage electrical supply system diagram:

220/380 V Network → Input Circuit Breaker → Distribution Board

- └─ Lighting Line (circuit breaker)
- └─ Socket Line (circuit breaker)
- └─ Kitchen Appliance Line (circuit breaker)
- └─ Heating Line (circuit breaker)
- └─ Outdoor Lighting Line (circuit breaker)

4.3. Integrated Application of BIM Technologies and Artificial Intelligence in Construction Project Management

The integrated application of BIM technologies and Artificial Intelligence (AI) is one of the most promising directions for the development of construction project management. This synergy allows transcending traditional modelling, using AI capabilities to analyse vast amounts of data, make more informed decisions, automate routine tasks, and predict outcomes.

Advantages of Integrated Application of BIM and AI:

1. Improved Design and Design Optimisation.

- **Generative Design:** AI can generate thousands of design variations based on specified parameters (budget, materials, functionality, energy efficiency), then analyse them and propose optimal solutions.
- **Automatic Optimisation:** AI can optimise room layouts, equipment placement, engineering systems, and structural calculations for maximum efficiency and cost minimisation.
- **Clash Detection and Automatic Resolution:** While BIM already provides tools for clash detection, AI can automatically suggest or even resolve them by analysing dependencies and priorities.

2. Accurate Planning and Schedule Optimisation.

- **Timeline Prediction:** AI can analyse data from previous projects (resources, weather, productivity) and predict task completion times with high accuracy, identifying potential delays before they occur.
- **Resource Optimisation:** AI can optimise the allocation of workforce, equipment, and materials, minimising downtime and maximising productivity.

- **Dynamic Planning:** AI can automatically adjust work schedules in real-time based on changing site conditions (weather, supply delays, unforeseen circumstances).

3. Risk Management and Safety.

- **Risk Prediction:** AI can analyse BIM models, sensor data, and historical data to identify potential hazards, vulnerable structural points, or areas with a high risk of accidents.
- **Real-time Safety Monitoring:** Cameras and sensors integrated with AI can monitor compliance with safety rules on the construction site, detect unsafe behaviour or the presence of people in dangerous areas, and issue warnings.
- **“What-if” Analysis:** AI can simulate various scenarios (e.g., equipment failure, material delivery delays) and assess their impact on the project, helping to develop risk mitigation strategies.

4. Cost Estimation and Cost Control.

- **Accurate Cost Forecasting:** AI can analyse vast amounts of data on materials, labour, equipment, and subcontractors, account for market fluctuations, and provide more accurate project cost estimates.
- **Real-time Cost Monitoring:** Integration with BIM allows AI to track actual costs against the budget, identify deviations, and forecast the final project cost.
- **Procurement Optimisation:** AI can analyse the market, supplier offers, and optimal timing for procurements to minimise costs.

5. Operations and Facility Management (Digital Twins).

- **Creation of “Digital Twins”:** BIM models can serve as the basis for creating digital twins that collect real-time data from building sensors (energy consumption, temperature, humidity, equipment status).
- **Predictive Maintenance:** AI analyses data from the digital twin to predict potential equipment failures, optimise maintenance schedules, and extend asset lifespan.
- **Energy Consumption Optimisation:** AI can analyse occupant behaviour, weather conditions, and the status of engineering systems to automatically optimise energy consumption, increasing building sustainability.
- **Space Management:** AI can analyse space utilisation and suggest optimal configurations to improve efficiency or comfort.

Examples of Application:

- **Automated Generation of BIM Models:** AI can be used to automatically create 3D models from 2D drawings or point clouds (Scan-to-BIM), accelerating the modelling process.
- **Voice Control of BIM:** Development of systems that allow interaction with a BIM model using voice commands, speeding up navigation and information retrieval.
- **Chatbots for Project Management:** AI assistants can answer project-related questions, provide up-to-date information on schedules, materials, or participant contact details.
- **Construction Site Analysis using Drones and AI:** Drones collect visual data, and AI analyses it to compare with the BIM model, detect deviations from the plan, and monitor progress and safety.
- **Predictive Performance Models:** AI can analyse data on the productivity of crews and equipment under various conditions, helping managers make informed decisions regarding resource allocation.

Challenges of Integration:

- **Data Compatibility (Interoperability):** Ensuring seamless data exchange between different BIM platforms and AI tools is a critical challenge.
- **Data Quality:** The accuracy and completeness of data in the BIM model are crucial for effective AI operation. "Garbage In, Garbage Out."
- **Trust and Acceptance:** Professionals must trust the solutions proposed by AI and be ready to adapt their workflows.
- **Implementation Cost:** Investments in AI technologies and their integration can be significant.
- **Ethical Aspects and Data Security:** Collecting and analysing large volumes of data requires adherence to ethical norms and ensuring cybersecurity.

Despite the challenges, the integrated application of BIM technologies and Artificial Intelligence is the future of construction project management. It promises to increase efficiency, accuracy, safety, and sustainability throughout the entire construction lifecycle, which is extremely important for countries like Ukraine, facing the challenges of large-scale reconstruction.

4.4. What is Generative Design?

Generative design is an iterative design process where, instead of a human designer creating one or more options and then optimising them, artificial intelligence algorithms (or, more precisely, specialised computer programs) generate hundreds or even thousands of possible solutions based on a set of defined parameters, goals, and constraints. These solutions are then evaluated, filtered, and presented to the designer, who can choose the best ones or use them as a starting point for further refinement.

Key Difference from Traditional Design:

- **Traditional:** Human creates design → Computer analyses and optimizes.
- **Generative:** Human sets rules and goals → Computer generates options → Human selects the best.

How Does Generative Design Work?

The generative design process typically includes the following steps:

1. Defining Goals: The designer defines what they aim to achieve. This can include:

- Minimising material costs.
- Maximising structural strength.
- Optimising energy efficiency.
- Reducing construction time.
- Ensuring natural lighting.
- Maximizing seating/workspaces.
- Adherence to building codes and regulations.
- Aesthetic criteria.

2. Setting Constraints: Constraints are defined within which solutions can exist. These can include:

- Available materials.
- Budgetary limits.
- Site or building size.
- Requirements for room functionality.
- Geometric constraints (e.g., not intersecting existing utilities).
- Building codes (height, distances).

3. Defining Inputs/Parameters: These are variables that the algorithm can change to generate variations. For example, room dimensions, wall thickness, window shape, column placement, and building orientation.

4. Generating Solutions: At this stage, AI algorithms (often using evolutionary algorithms, optimisation algorithms, or machine learning) generate many possible designs. Each option is a unique combination of input parameters that satisfies the defined constraints.

5. Evaluation and Ranking: Each generated option is evaluated against the criteria defined in step 1. The software can visualise these options and present them in a Pareto chart or other convenient form, allowing the designer to see which options are optimal from the perspective of different goals (e.g., strength vs. weight).

6. Selection and Iteration: The designer reviews the generated solutions, selects the most promising ones, can introduce additional constraints or modify goals to start a new generation cycle, or manually refine the selected options.

Connection to BIM Technologies:

BIM is an ideal platform for generative design for several reasons:

- **Unified Information Model:** A BIM model already contains all data about the object (geometry, materials, properties, engineering systems). This allows generative design algorithms to work with a rich, structured dataset.

- **Parametric Modelling:** Many BIM programs are built on parametric modelling principles, which makes them flexible for changing parameters, a core principle of generative design.

- **Data Analysis:** BIM models can be used for rapid analysis of the effectiveness of generated options (energy analysis, daylight analysis, structural calculations, building material optimisation).

- **Creation of Ready-to-Use Models:** Generative design can directly generate BIM-compatible models, allowing for quick transitions from concept to detailed design and construction.

Applications of Generative Design in Construction Projects:

1. Optimisation of Room Layouts:

- Generating optimal layouts for offices, apartments, hotels, considering area, natural lighting, views, proximity to utilities, evacuation routes, etc.

- For example, Autodesk Project Refinery (part of Dynamo and Revit) allows exploring thousands of arrangement options.

2. Design of Facades and Building Envelopes:

- Creating facades that optimise solar lighting, thermal performance, visual comfort, while having a unique aesthetic appearance.
- Developing sun-shading elements or perforations based on insolation.

3. Structural Optimisation:

- **Topology Optimisation:** Generating forms of structural elements (e.g., trusses, beams) that are maximally strong with minimal material consumption. This leads to unique, organic forms that were previously impossible for manual design.
- Optimising the size and placement of columns, beams to reduce building weight or increase its stability.

4. Construction Site Planning:

- Optimising the placement of construction cranes, storage areas, and access roads to minimise construction time and increase safety.

5. Energy Efficiency:

- Generating design options that maximise passive heating/cooling, daylight utilisation, and natural ventilation.

Advantages of Generative Design:

• **Exploration of More Options:** A human cannot physically go through thousands of options; AI can.

• **Discovery of Unexpected Solutions:** Algorithms can propose solutions that a human would not consider due to their biases or limited vision.

• **Optimisation and Efficiency:** Significant improvement in performance indicators (strength, weight, energy consumption, cost).

• **Acceleration of the Design Process:** While setup can take time, the generation process itself is very fast.

• **Minimisation of Errors:** The automated process reduces the human factor.

• **Sustainability:** Ability to design more environmentally friendly and resource-efficient buildings.

Challenges:

- **Algorithm Setup and Understanding:** Requires new skills from designers in defining parameters and goals.
- **Computational Resources:** Generating thousands of options can require significant computational power.
- **Interpretation of Results:** It is not always easy to choose the best option from a large number of generated ones.
- **Aesthetic Aspects:** Although generative design can create amazing forms, the question of aesthetics and artistic value remains with the human.

Generative design, combined with BIM technologies, is a powerful tool that changes the approach to design, making it more intelligent, efficient, and data-driven. This allows architects and engineers to focus on creative aspects and strategic thinking, delegating routine optimisation and option iteration to the computer.

Automatic Optimisation in Construction Projects

Automatic optimisation is the application of computational algorithms, often based on artificial intelligence (AI) and machine learning (ML), to find the best possible solution or a set of optimal solutions for a given problem. This process occurs based on predefined goals and constraints, with parameter adjustments, resource allocation, or process flows carried out iteratively, without explicit manual human intervention for each adjustment.

Unlike generative design, which creates many diverse solutions for human selection, automatic optimisation often seeks to refine or improve an existing design or plan to a single, optimal (or nearly optimal) state, or to continuously adapt to changing conditions.

4.5. Core Principles of Automatic Optimisation.

1. Definition of the Objective Function: This is a mathematical representation of what you want to optimise (e.g., minimise cost, maximise energy efficiency, minimise construction time, maximise structural integrity).

2. Definition of Variables/Parameters: These are the elements that can be changed or adjusted by the optimisation algorithm (e.g., beam dimensions, material type, wall location, task schedule, number of workers).

3. Setting Constraints: These are the rules or limits that must be adhered to (e.g., building codes, site boundaries, budget limits, material availability, load-bearing requirements).

4. Optimisation Algorithm: This is the “brain” that performs the optimisation. Common algorithms include:

- **Heuristic algorithms:** (e.g., genetic algorithms, particle swarm optimisation) which explore the search space to find good solutions, especially for complex problems where finding the absolute best solution is computationally impossible or too slow.
- **Gradient-based algorithms** (e.g., gradient descent) for problems where the objective function is differentiable.
- **Linear/Non-linear programming:** For problems that can be formulated as mathematical programs.
- **Machine Learning Models:** Trained on historical data to predict optimal configurations or responses to changes.

5. Iteration and Evaluation: The algorithm repeatedly changes variables, evaluates how well the new configuration meets the objective function while adhering to constraints, and then refines the solution. This process continues until an optimal solution is found, a predefined number of iterations is completed, or a certain performance threshold is reached.

Areas of Application for Automatic Optimisation in BIM and Construction:

1. Design Optimisation:

- **Structural Optimisation:** Automatically adjusting the size, shape, and material of structural elements (beams, columns, slabs) to minimise material usage while maintaining required strength and rigidity. This goes beyond simple structural analysis; the algorithm actively finds the *most efficient* structure.
- **MEP Systems Optimisation (HVAC, Electrical, Plumbing):** Automatic optimisation of ductwork, pipe, and electrical cable routing to minimise length, reduce interference, and improve flow efficiency, often considering access for maintenance.
- **Facade Optimisation:** Automatically adjusting window sizes, shading devices, and material properties to maximise natural light,

minimise solar heat gain, and optimise views, while adhering to aesthetic and cost constraints.

- **Space Planning:** Optimising internal layouts of offices, apartments, or hospitals to maximise usable area, improve workflows, ensure accessibility standards, and enhance occupant comfort.

2. Construction Planning and Scheduling:

- **Resource Levelling and Allocation:** Automatic optimisation of workforce, equipment, and material distribution over time to minimise idle time, reduce peak demand, and balance workloads throughout the project.
- **Schedule Optimisation:** Adjusting task sequences and durations to minimise overall project completion time (critical path optimisation) or to level resource utilisation, considering dependencies and constraints.
- **Logistics Optimisation:** Planning the optimal flow of materials to and from the construction site, including delivery schedules, storage locations, and crane paths, to reduce congestion and improve efficiency.

3. Cost Estimation and Control:

- **Material Selection Optimisation:** Automatically selecting the most cost-effective materials that meet performance requirements, considering factors like availability, lead time, and sustainability.
- **Cost-Benefit Analysis:** Evaluating different design or construction methodologies to identify the most economically efficient solutions that deliver the desired value.

4. Operations and Facility Management (Digital Twins):

- **Energy Consumption Optimisation:** Using AI to dynamically adjust HVAC systems, lighting, and other building management systems in real-time based on occupancy, external weather conditions, and energy prices to minimise operational energy consumption.
- **Predictive Maintenance:** Analysing data from building sensors (integrated with BIM models) to predict potential equipment failures and automatically schedule maintenance *before* malfunctions occur, minimising downtime and repair costs.

Integration with BIM:

BIM provides a crucial data foundation for automatic optimisation:

- **Semantic Information:** BIM models contain not only geometry but also rich semantic data about building components (material properties, cost, performance characteristics, manufacturer information). This data is an essential input for optimisation algorithms.
- **Geometric Representation:** 3D geometry from BIM allows for spatial analysis, clash detection, and visualisation of optimised solutions.
- **Parametric Capabilities:** BIM software often has parametric modelling capabilities, meaning design elements can be easily modified by adjusting parameters. This makes it ideal for iterative optimisation processes.
- **Digital Twin Integration:** For operational optimisation, real-time data from building sensors can be fed into a BIM-based digital twin, allowing AI to perform real-time adjustments and predictive analysis.

Advantages of Automatic Optimisation:

- **Higher Performance:** Can find solutions that human designers might miss, leading to more efficient, cost-effective, or sustainable solutions.
- **Increased Efficiency:** Automates time-consuming and laborious tasks of iterating through design options or adjusting schedules.
- **Reduced Errors:** Minimises human errors in complex calculations and decision-making.
- **Accelerated Design Cycles:** Speeds up the exploration and refinement of design alternatives.
- **Improved Decision-Making:** Provides data for informed decisions in project management.
- **Enhanced Sustainability:** Helps optimise for energy efficiency, material reduction, and waste minimisation.

Examples in Practice:

- **Autodesk's Project Refinery (now part of Forma):** Allows users to set up optimisation studies in Revit/Dynamo for various design goals, such as maximising views, minimising solar heat gain, or optimising floor plans.

- **Building Performance Simulation Tools:** Many tools use optimisation algorithms to find the optimal building orientation, window-to-wall ratios, and insulation levels for energy efficiency.

- **Computational Fluid Dynamics (CFD) with Optimisation:** Used to optimise airflow within spaces for comfort and energy efficiency.

- **AI-powered Construction Planning Software:** Modern planning platforms are beginning to incorporate AI to automatically optimise resource allocation and task sequencing based on actual project progress and constraints.

In essence, AI-powered automatic optimisation transforms BIM from a descriptive tool (what the building *is*) into a prescriptive tool (what the building *should be* for optimal performance). It enables project teams to push the boundaries of design and construction efficiency, leading to smarter, more sustainable, and cost-effective assets.

4.6. Clash Detection and Its Automatic Resolution in the Context of BIM and AI.

What is Clash Detection?

Clash detection is the process of identifying collisions or interferences between elements in a digital BIM model of a building. The goal is to detect problematic areas where different building systems (e.g., architectural, structural, mechanical, electrical, plumbing, fire protection) occupy the same space or interfere with each other. This is done in advance, during the design phase, to avoid costly reworks, delays, and safety issues during construction.

Types of Clashes:

1. **Hard Clashes:** When two or more elements physically intersect or occupy the same space (e.g., a pipe running through a beam, a duct cutting into a wall). These are the most obvious and critical clashes.

2. **Soft Clashes/Clearance Clashes:** When elements do not physically intersect, but requirements for minimum clearance or access for maintenance, installation, or disassembly are violated (e.g., insufficient space between pipes for insulation or valve access).

3. **Workflow Clashes/Schedule Clashes:** When there are conflicts in the sequence or schedule of works that could lead to downtime or inefficiency on the construction site (e.g., installing a wall before laying utilities that need to be inside it).

Traditional Approach to Clash Detection:

Typically, clash detection is performed using specialized BIM software (e.g., Autodesk Navisworks, Solibri, Tekla BIMSight). The process involves:

1. Model Aggregation: Individual BIM models from different disciplines (architecture, structures, MEP) are imported and combined into a single coordination model.

2. Defining Check Sets: It is defined which categories of elements will be checked for clashes (e.g., “ducts vs. structures,” “pipes vs. electrical cables”).

3. Running the Check: The software automatically scans the model for intersections or clearance violations.

4. Generating Reports: A report is generated containing a list of detected clashes, their location, type, involved elements, and screenshots.

5. Manual Resolution: This is the most labour-intensive stage. Project teams (architects, engineers, structural engineers) need to manually review each clash, analyse its cause, discuss possible solutions, and make changes to the respective BIM models. This often happens during coordination meetings.

Limitations of the Traditional Approach:

- **Time-consuming:** Manually reviewing hundreds, and sometimes thousands, of clashes is very labour-intensive.

- **False Positives:** Software often detects “clashes” that are not problems (e.g., allowed intersections or minor ones that do not affect construction). This requires additional time to filter them out.

- **Lack of Priorities:** Reports usually just list all clashes without intelligent ranking by importance or risk.

- **Complexity of Multi-level Clashes:** It is difficult to resolve clashes involving multiple systems simultaneously.

- **Manual Changes:** Even after detection, the process of changing the models remains manual.

The Role of AI in Automatic Clash Resolution:

This is where artificial intelligence comes to the rescue, which can significantly accelerate, automate, and improve the clash detection and resolution process. AI not only detects clashes but also proposes, and in some cases, even automatically makes changes to eliminate them.

How AI Improves Clash Detection and Resolution:

1. Intelligent Clash Detection and Prioritisation:

- **Reduction of False Positives:** AI can learn to distinguish “true” clashes from allowed or insignificant intersections by analysing context, element types, and established tolerances.
- **Clash Prioritisation:** Instead of a simple list, AI can assess the criticality of each clash based on factors such as:
 - Cost of potential rework.
 - Impact on project schedule.
 - Impact on safety.
 - Complexity of resolution.
 - Number of disciplines involved.
- **Predictive Detection:** AI can analyse incomplete designs or early sketches and predict potential clashes even before they are fully modelled, based on data from previous projects.

2. Automatic Solution Proposal (Suggestive Resolution):

- **Option Analysis:** Based on existing BIM model data, building codes, design standards, and historical data (how similar clashes were resolved previously), AI can generate and evaluate several options for resolving a clash.
- **Examples of Proposals:**
 - For a "duct-beam" clash: suggest changing the duct size, offsetting it, changing the beam shape (if possible), or even proposing an alternative route.
 - For a "pipe-cable" clash: suggest changing the height of the pipe/cable, or offsetting them.
 - For soft clashes: suggest a minimum clearance increase.
- **Impact Assessment:** AI can assess the impact of each proposed solution on other aspects of the project (cost, schedule, energy efficiency, structural integrity).

3. Automatic Clash Resolution:

- **Model Modification:** The most advanced AI systems can directly make changes to the BIM model to eliminate clashes, using generative design and optimisation algorithms.

- **Rule-Based Guidance:** AI can follow pre-established priorities (e.g., “structural elements have the highest priority, then plumbing, then electrical”) to decide which element should be modified.
- **Continuous Monitoring:** Through integration with cloud-based BIM platforms, AI can continuously check the model for new clashes as changes are made by any discipline, automatically detecting and resolving them.

Advantages of Automatic Clash Resolution:

- **Significant Time Reduction:** Dramatically reduces the time spent on manual review, analysis, and resolution of clashes.
- **Reduced Rework Costs:** Detecting and resolving problems early in the design phase prevents expensive errors on the construction site.
- **Improved Project Quality:** Ensures a more coordinated and clash-free design, leading to better construction documentation and a smoother construction process.
- **Optimised Workflows:** Allows engineers and designers to focus on complex, creative tasks, delegating routine work to AI.
- **Better Collaboration:** Reduces the number of disputes and approvals, as many clashes are resolved automatically or with clear proposals.

Examples and Developments:

While full automatic resolution of all types of clashes is still an active area of research, significant advancements already exist.

- **BAMROC by Vavetek.AI:** This is one example of software positioned as a tool for automatic resolution of MEP (mechanical, electrical, plumbing) system clashes in BIM. They claim that their AI-based system can automatically resolve a significant portion of detected clashes.
- **Research Projects:** Universities and research institutions worldwide are actively working on AI algorithms for automatic clash detection, classification, and resolution in BIM.
- **Extensions for Existing BIM Platforms:** Some developers create add-ins for popular BIM programs (e.g., Revit) that use algorithms to automate part of the clash resolution process.

Challenges:

- **Complexity of Decision-Making:** For some complex clashes, the solution may depend on many factors that are difficult to formalise for AI (e.g., aesthetics, unique client requirements).
- **Trust in AI:** Engineers and architects must trust the solutions proposed or implemented by AI. A mechanism for verification and human oversight is needed.
- **Quality of Input Data:** The effectiveness of AI directly depends on the quality and completeness of BIM models. Inaccurate or incomplete data will lead to incorrect solutions.
- **Regulatory Constraints:** The need to integrate building codes and regulations into AI algorithms, which can be a complex task.

The integration of AI into the clash detection and resolution process is a key step towards creating a fully digital and intelligent construction ecosystem. This will allow construction projects to become even more efficient, transparent, and cost-effective.

4.7. Smart City and BIM Technologies

The concepts of "Smart City" and BIM technologies are two powerful drivers of modern urbanism and construction, with immense potential when integrated.

What is a Smart City?

A Smart City is an urban area that uses digital technologies (Information and Communication Technologies — ICT) and the Internet of Things (IoT) to improve the quality of life for residents, enhance infrastructure, modernise public services, increase environmental sustainability, and accelerate economic development.

Key Characteristics of a Smart City:

- **Connectivity:** Widespread use of sensors, cameras, and other IoT devices that collect data on various aspects of urban life (transport, utilities, safety, air quality, etc.).
- **Intelligent Data Analysis:** Collected data is analysed using Big Data and artificial intelligence to identify patterns, predict events, and make informed decisions.

- **Efficiency and Optimisation:** The goal is to optimise resource use (energy, water, transport), reduce waste, and improve the efficiency of city services.
 - **Sustainability:** Focus on environmental aspects, reducing carbon footprint, waste management, and sustainable development.
 - **Resident-Oriented:** Providing convenient and accessible digital services for citizens, involving them in city governance (e-petitions, mobile apps for reporting issues).
 - **Innovation and Economic Development:** Creating conditions for the development of innovative technologies and businesses.
- Examples of Application Areas in Smart Cities:**
- **Smart Transportation:** Traffic-based traffic light management, intelligent parking, real-time tracking of public transport.
 - **Smart Utilities:** Monitoring water/electricity consumption, leak detection, waste collection optimisation.
 - **Safety and Security:** Video surveillance with recognition functions, emergency notification systems.
 - **Energy Efficiency:** Smart street lighting, building energy consumption management.
 - **Environmental Management:** Monitoring air quality, water quality, and noise levels.

The Role of BIM Technologies in the Smart City Concept

BIM is a critically important foundation for the development of Smart Cities because it provides a digital representation of buildings and infrastructure, key components of the urban ecosystem.

1. Creation of a “Digital Twin” of the City (Urban Digital Twin):

- BIM models of individual buildings and infrastructure objects (roads, bridges, tunnels, utilities) can be combined and integrated with geospatial data (GIS) to create a comprehensive “digital twin” of the entire city or its district.
- This digital twin becomes a dynamic platform that reflects the physical environment and collects real-time data from IoT sensors.

2. Accurate and Comprehensive Infrastructure Modelling:

- BIM allows detailed modelling not only of buildings but also of underground utilities (water supply, sewerage, gas pipelines, electrical

and telecommunication networks), transport interchanges, bridges, and tunnels. This information is vital for efficient city management.

- It helps avoid clashes during the laying of new networks and enhances operational safety.

3. Optimisation of Urban Planning and Development:

- BIM models allow visualising and analysing the impact of new buildings on the urban environment (shadows, airflow, solar lighting, traffic) already at the planning stage.
- Allows modelling various development scenarios (e.g., building density, public transport placement) and evaluating their effectiveness before making decisions.
- Contributes to integrated planning, where all urban systems are considered as interconnected elements.

4. Effective Asset Management and Maintenance:

- BIM models contain information about all components of buildings and infrastructure, including manufacturer data, installation dates, and maintenance schedules.
- Integration with IoT data enables predictive maintenance: AI systems analyse data from sensors (e.g., elevator status, HVAC systems) and predict potential breakdowns, automatically planning repairs *before* failures occur, minimising downtime and costs.
- This applies not only to individual buildings but also to bridges, roads, water supply systems, etc.

5. Increased Sustainability and Energy Efficiency:

- BIM allows analysis of the energy consumption of buildings and districts, optimising the use of natural resources.
- AI, leveraging data from BIM and IoT, can dynamically manage energy consumption of entire areas, optimising lighting, heating, and cooling to minimise costs and environmental footprint.

6. Emergency Management and Safety:

- BIM models with detailed building information (floor plans, evacuation routes, fire suppression system locations) can be integrated with security systems and AI to improve emergency response.
- For example, evacuation routes can dynamically adapt to the situation (blocked exits), and emergency services can receive accurate information about the location and status of people in the building.

Integration of BIM and Smart City is:

- **A Unified Information Ecosystem:** Transition from disparate databases to a single, integrated source of information about the urban environment.
- **From Big Data to Smart Data:** BIM structures data about physical objects, making them understandable and suitable for AI analysis.
- **From Reactive to Proactive Management:** The ability not just to react to problems, but to predict and prevent them.
- **From Projects to City Lifecycle:** The focus shifts to managing the city throughout its entire lifecycle, not just during the construction phase.

Examples and Prospects in Ukraine:

Ukraine is actively developing the Smart City concept, especially in the context of post-war reconstruction. Kyiv, Lviv, and other cities have their own "Kyiv Smart City" initiatives, etc., related to the implementation of digital services.

- **Reconstruction Plans:** Legislative initiatives regarding the mandatory use of BIM for objects being restored with state funds directly correlate with the Smart City concept. Digital models of destroyed and newly built structures will form the basis for the integrated management of the restored infrastructure.

- **Transparency and Efficiency:** The use of BIM in conjunction with Smart City principles will ensure transparency in reconstruction processes, financial tracking, and efficient resource utilisation.

- **Infrastructure Modelling:** Projects for the reconstruction and construction of new roads, bridges, energy, and utility networks will be modelled in BIM and then integrated into city-wide systems for management and monitoring.

The integration of BIM technologies and the Smart City concept is a key factor in creating efficient, sustainable, safe, and comfortable urban environments. BIM provides structural data about physical objects, while the Smart City uses this data (often with the help of AI and IoT) for dynamic management, optimisation, and improving the quality of life. This synergy is vitally important for the future of urban development, especially for Ukraine, which faces unique challenges and opportunities for reconstruction on new, intelligent foundations.

4.8. The Future of BIM Technologies in the Digital Transformation of Society

The future of BIM technologies in the digital transformation of society is not just an evolution of design and construction tools, but a profound transformation of the ways we create, manage, and interact with our built environment. BIM will become an integral part of a broader digital ecosystem, influencing the economy, public administration, education, and quality of life.

Here are the key directions of BIM's development and impact in the digital transformation of society:

1. Deepened Integration and Macro-Level “Digital Twin” Creation

- **From Object to City/Country:** The future of BIM lies in scaling from modelling individual buildings to creating comprehensive digital twins of cities, regions, and even entire countries. This will enable the integration of data about buildings, infrastructure, natural resources, demographics, and social indicators.
- **Integration with GIS (Geographic Information Systems):** The combination of detailed BIM models with broad geospatial GIS data will create a powerful platform for urban planning, emergency management, environmental monitoring, and sustainable infrastructure development.
- **Dynamic Digital Twins:** Linking BIM models with real-time IoT data will create dynamic digital twins that will not only reflect the status of objects but also predict their behaviour, optimise operations, and warn of potential malfunctions.

2. Expanded Application of Artificial Intelligence and Machine Learning

- **Automated Design and Optimisation:** AI will not just assist designers but also generate and optimise entire design solutions (generative design), considering thousands of parameters (cost, sustainability, functionality, aesthetics, building codes).
- **Predictive Project Management:** AI will analyse vast amounts of data to predict risks, delays, budget overruns, and propose proactive solutions.
- **“Smart” Construction Sites:** Drones, robots, and sensors, controlled by AI, will monitor construction progress, ensure safety, control quality, and optimise logistics.

- **Construction Robotics:** BIM models will serve as the basis for programming construction robots and 3D printers that will automate work execution on-site.

3. Blockchain and Increased Trust and Transparency

- **Data Security and Immutability:** Blockchain can be used to create immutable records of all changes in the BIM model, contracts, supply chains, and payments, ensuring a high level of transparency and trust among all project participants.
- **Smart Contracts:** Automatic execution of contract terms (e.g., payment upon reaching a certain construction milestone, recorded in the BIM model) using blockchain-based smart contracts.
- **Supply Chain Management:** Tracking the origin and movement of materials, ensuring their authenticity and compliance with sustainability standards.

4. Virtual and Augmented Reality (VR/AR)

- **Immersive Design and Presentation:** VR will allow full immersion into BIM models to assess space, materials, and functionality even before construction begins.
- **AR on the Construction Site:** Augmented reality will allow overlaying the BIM model onto the real environment, helping workers visualise hidden utilities, verify compliance of completed work with the design, and receive step-by-step instructions.
- **Collaborative Work in VR/AR:** Project participants from different parts of the world will be able to meet in virtual BIM environments for joint reviews and decision-making.

5. Focus on Lifecycle and Sustainable Development

- **From 7D to 8D, 9D...:** Further development of BIM will include deeper analysis of sustainability (8D), safety (9D), and other aspects throughout the entire lifecycle of the object.
- **Circular Economy:** BIM will facilitate the design of buildings that are easy to dismantle, and their components reused or recycled, aligning with circular economy principles.
- **Resource Optimisation:** Maximally efficient use of materials, water, and energy at all stages, from manufacturing to operation and disposal.

6. Impact on Society and Economy

- **Transparency and Accountability:** Particularly relevant for Ukraine in the context of reconstruction. BIM and related digital tools will provide an unprecedented level of transparency in fund utilisation, progress tracking, and quality control.
- **Creation of New Jobs:** The need for BIM managers, data specialists, and AI solution developers for construction will create new opportunities in the labour market.
- **Increased Investment Efficiency:** Accelerated projects, reduced errors, and optimised costs will make the construction industry more attractive for investment.
- **Quality of Life:** More efficient urban planning, “smart” buildings, better infrastructure management — all this will directly affect the comfort, safety, and quality of life of residents.
- **Standard Harmonisation:** International cooperation will facilitate the development and implementation of unified global BIM standards, easing cross-border collaboration.

The Future of BIM in Ukraine

For Ukraine, facing the challenge of large-scale reconstruction, the future of BIM is not just desirable, but vital.

- **Transparency of Reconstruction:** Legal consolidation of mandatory BIM use for state projects will be a key element of transparency and efficient use of international funds.

- **Speed and Quality:** BIM will allow designing and building quickly, with high quality and minimal errors.

- **Integration into the European Ecosystem:** The implementation of BIM will contribute to the harmonisation of Ukraine's construction industry with European standards and practices.

- **Attracting Investment:** Foreign investors expect and demand the use of BIM for their projects, which will make Ukraine more attractive for investment.

BIM technologies will become the central element of the digital transformation of the construction industry, which, in turn, will be a key driver of the digital transformation of society as a whole, creating “smarter,” more efficient, and sustainable cities and infrastructure of the future.

Conclusions

The textbook "BIM Technologies and Process Management" has revealed the multifaceted nature of the modern construction industry, emphasising its transitional stage from traditional methods to the digital era. We have explored how Building Information Modelling (BIM) Technologies have become the cornerstone of this transformation, offering not just tools for 3D modelling but a holistic project management methodology that covers the entire lifecycle of an object.

The key conclusions drawn from the materials of this textbook can be grouped as follows:

1. BIM as the Foundation of Digital Transformation: BIM is the central element of the digitalisation of the construction industry. It is a single source of truth about a project, providing unprecedented transparency, accuracy, and efficiency at all stages — from concept to operation and demolition. The implementation of BIM allows for minimising errors, reducing project timelines, and optimising costs.

2. Inseparability of Process Management: The effectiveness of BIM technologies is impossible without a deep understanding and application of process management principles. Established workflows, standardised interaction between project participants, and competent allocation of roles and responsibilities are critically important for realising the full potential of BIM. The synergy of BIM and process management transforms complex projects into manageable and successful ones.

3. AI as a Catalyst for Innovation: The application of Artificial Intelligence (AI) elevates BIM capabilities to a qualitatively new level. AI allows automating design optimisation, performing predictive risk analysis, and intelligently managing resources and objects. AI-based tools such as generative design, automatic optimisation, and automatic clash resolution not only accelerate processes but also pave the way for innovative and previously impossible solutions.

4. BIM and SMART Cities: BIM is a fundamental basis for building “smart cities” (SMART City). The integration of BIM models with IoT data and AI analytics enables the creation of “digital twins” of urban infrastruc-

ture, providing intelligent resource management, increased energy efficiency, improved safety, and enhanced quality of life for residents.

5. Prospects and Challenges for Ukraine: For Ukraine, facing large-scale reconstruction tasks, BIM technologies are not just a tool, but a strategic necessity. They will ensure transparency, efficiency, and investment attractiveness of reconstruction projects. However, successful implementation requires overcoming challenges such as adapting the regulatory framework, training qualified personnel, overcoming industry conservatism, and significant initial investments.

In conclusion, mastering BIM technologies and the principles of process management is critically important for construction industry professionals in the era of digital transformation. This knowledge not only opens doors to new professional opportunities but also allows active participation in creating an efficient, transparent, and sustainable future for our built environment. The future of construction is intelligent construction, and you, as future specialists, will play a key role in shaping it.

Self-Assessment Questions:

Section 1. Fundamentals of BIM Technologies and Fundamentals of Process Management

Part 1: Fundamentals of BIM Technologies

1. What is BIM? Provide a full definition of the BIM acronym and explain its essence, not just as software, but as a process.
2. What are the main differences between 2D CAD and BIM modelling? List at least 3 key differences.
3. Name the main dimensions of BIM (n-D BIM) and briefly explain what each represents. (For example, 3D, 4D, 5D, 6D, 7D).
4. What are the main advantages of implementing BIM for construction project participants (e.g., for the client, designer, contractor)? List at least 3 advantages.
5. What is an information model (BIM model)? What components does it consist of (geometry, attributes)?
6. Explain the concept of a “single source of truth” in BIM. Why is this important?
7. What is IFC (Industry Foundation Classes)? What role does IFC play in the context of OpenBIM?
8. Name examples of software used for BIM modelling.
9. What risks can arise when implementing BIM technologies without proper preparation? Name 3 risks.
10. What is LOD (Level of Development) or LOIN (Level of Information Need)? Explain their significance in a BIM project.

Part 2: Fundamentals of Process Management

1. What is Process Management (Business Process Management — BPM)? Provide a definition.
2. What are the main stages of Process Management? List them in logical sequence.
3. Why is it important to document and analyse existing business processes before optimising them or implementing new technologies (such as BIM)?

4. What tools or methods can be used to visualise and model business processes? Provide 2 examples.
5. What does “business process optimisation” mean? What goals does it usually aim to achieve?
6. Explain the difference between a functional and a process approach to organisational management.
7. Provide an example of a business process in the construction industry that can be optimised using BIM.
8. What is a “process owner” and what role do they play in process management?
9. What indicators (metrics) can be used to assess the effectiveness of a business process? Provide 2 examples.
10. How are Process Management and the implementation of BIM technologies interconnected? Explain this connection.

Self-Assessment Questions:

Section 2. BIM in Construction Object Lifecycle Management

- 1. Lifecycle Definition:** Name and briefly describe the main stages of a construction object’s lifecycle, from idea to operation/demolition.
- 2. Overall BIM Value:** Explain why BIM is an effective tool for managing the entire lifecycle of a construction object, not just the design stage.
- 3. Concept and Planning Stage (Pre-design/Conception):**
 - How can BIM be used in the early stages of a project (concept, feasibility study, architectural concept)?
 - Provide 2-3 examples of the benefits of using BIM at this stage.
- 4. Design Stage (Design):**
 - What are the main disciplines (project sections) that work with the BIM model at the design stage?
 - How does BIM facilitate coordination and clash detection between these disciplines? Name the tools.
 - What types of documentation are generated from the BIM model at the design stage?
- 5. Construction Stage (Construction):**
 - How can BIM help in managing the construction schedule (4D BIM)?

- How is BIM used for calculating material quantities and generating estimates (5D BIM)?
- What benefits does a construction company gain from using BIM on the construction site?

6. Operations & Maintenance (O&M) Stage:

- What information from the BIM model is most valuable for the building's operation stage?
- Provide 2-3 examples of using BIM (or information from the BIM model) for effective facility management after construction completion.
- What is an "As-Built" model, and why is it important for the operation stage?

7. Decommissioning/Renovation Stage:

- How can a BIM model be useful at the stage of demolition or major repair/renovation of a building?

8. Information Flow:

- How can information created in previous lifecycle stages using BIM be utilised in subsequent stages?
- Explain the concept of "continuous data flow" in the context of BIM and the object's lifecycle.

9. Importance of Integration: Why is it important to ensure the integration of data and processes between different stages of a construction object's lifecycle using BIM?

10. Challenges: What are the main challenges or obstacles that may arise when attempting to apply BIM at all stages of a project's lifecycle?

Self-Assessment Questions:

Section 3. Organisational and Management Aspects of BIM Implementation

1. BIM as a Strategic Tool:

- Why is BIM implementation considered not just a software change, but a strategic change for the organisation?
- What long-term benefits can a company gain by integrating BIM into its strategy?

2. Changes in Organisational Structure:

- How can BIM implementation affect a company's existing organisational structure?
- Name new roles or departments that may emerge in an organisation after BIM implementation (e.g., BIM department, BIM manager).
- Which traditional departments or roles may require retraining or functional changes?

3. Project Management with BIM:

- How does BIM change approaches to project management in the construction industry?
- What new project management tools or methodologies become relevant when using BIM (e.g., Common Data Environment)?
- Describe how BIM improves collaboration and coordination among different project participants.

4. BIM Execution Plan (BEP):

- What is a BIM Execution Plan (BEP)? What is its purpose?
- Who is responsible for developing and approving the BEP?
- What key sections does a BEP usually include? (Name at least 3).

5. Information Requirements (EIR/AIR):

- What are Employer's Information Requirements (EIR) and Asset Information Requirements (AIR)? What is the difference between them?
- Why does the client need to formulate their requirements for the information model?

6. Leadership and Management Support:

- Why is senior management support critically important for successful BIM implementation?
- What actions should management take to demonstrate their support?

7. Knowledge Management and Training:

- What is the importance of continuous learning and competence development for staff after BIM implementation?
- What training formats can be used to improve the qualifications of BIM specialists?

8. Process Standardisation:

- Why is the standardisation of internal processes and work procedures important when transitioning to BIM?
- Provide examples of what can be standardised (e.g., file naming, model structure).

9. Measuring Implementation Success:

- What indicators (metrics) can be used to assess the success of BIM implementation in an organisation? (Provide 2-3 examples).
- Why is it important to conduct regular analysis and adjustment of BIM processes?

10. Management Challenges:

- What are the main management challenges that may arise during BIM implementation?
- How can they be minimised or overcome?

Self-Assessment Questions:

Section 4. Examples of BIM Use and Advantages of Integrated Application of BIM and AI

Part 1: Examples of BIM Use

1. 3D Modelling and Visualisation:

- What advantages does 3D modelling in BIM provide at the conceptual design stage and for client presentations?
- Provide examples of how high-quality visualisation created with BIM can influence stakeholder decisions.

2. Clash Detection:

- What is “clash detection” in the context of BIM?
- Why is it important to perform clash detection in the early stages of design? What advantages does it offer?
- What types of clashes can be detected using BIM?

3. Quantity Take-off & Cost Estimation (5D BIM):

- How does a BIM model facilitate the accurate and rapid generation of material and labour quantities?
- What advantages does the use of 5D BIM offer for project budgeting?

4. Planning and Schedule Management (4D BIM):

- What is 4D BIM? How does it help in managing the construction schedule?
- Provide an example of how visualising construction stages using 4D BIM can be useful.

5. Operations and Maintenance Management (FM / 6D BIM):

- What information from the BIM model is critically important for the subsequent operation of the building?
- Provide 2-3 examples of how BIM can optimise facility management processes, such as maintenance, energy management, or asset management.

6. Sustainable Development and Energy Efficiency:

- How can BIM be used to analyse a building's energy efficiency and optimise its environmental performance?

Part 2: Advantages of Integrated Application of BIM and Artificial Intelligence (AI)

7. BIM and AI Synergy:

- Explain why the integration of BIM and AI is considered a promising direction in the construction industry. What is their synergy?

8. AI for Design Optimisation:

- Provide 2-3 examples of how AI can be used at the design stage of BIM models (e.g., generative design, layout optimisation).

9. AI for Analysis and Management:

- How can AI help in analysing large volumes of BIM model data to make better decisions (e.g., risk prediction, resource utilisation optimisation)?
- Provide an example of an AI application for automating clash detection or model checking for standard compliance.

10. AI on the Construction Site:

- Describe how AI can be integrated with BIM at the construction stage (e.g., for progress monitoring, quality control, safety).

11. AI in Building Operations:

- How can AI, using data from BIM, improve infrastructure management and building operations (e.g., predictive maintenance, energy consumption optimisation)?

12. Integration Challenges:

- What are the main challenges or limitations that exist when trying to integrate BIM and AI in real projects?

Self-Assessment Questions:

Change Management in BIM Implementation

Part 1: Assessing Organisational Readiness for BIM Implementation

1. Name the main steps that need to be taken to assess an organisation's current readiness for BIM implementation.
2. What aspects of existing processes and infrastructure should be analysed before BIM implementation? Provide 3 examples.
3. Explain what a SWOT analysis is and how it is applied to assess BIM readiness. Provide one example for each of the four elements (Strengths, Weaknesses, Opportunities, Threats) in the context of BIM implementation.
4. What methods can be used to assess the level of BIM knowledge and skills of personnel? Why is this assessment important?

Part 2: Developing a BIM Implementation Strategy and Plan

5. What should be the goals of BIM implementation (requirements for goal formulation)? Provide 2 examples of SMART goals for BIM implementation.
6. What is a "BIM implementation roadmap", and why is it important? What key stages can be included in such a roadmap?
7. What are the three main categories of resources that need to be identified and planned for BIM implementation? Provide 2 examples for each category.
8. What role does a pilot project play in a BIM implementation strategy?

Part 3: Implementing the BIM Implementation Plan

9. What criteria should be considered when choosing software for BIM?
10. Describe the importance of continuous learning and professional development of personnel in the context of BIM implementation and further development.
11. Why does an organisation need to develop its own internal standards and working methods for BIM? Provide 3 examples of such standards.
12. What might the software setup process include after its selection?

Part 4: Managing Resistance to Change

13. Name at least 4 typical reasons for resistance to change when implementing new technologies, such as BIM.
14. Describe three strategies for overcoming resistance to change. For each strategy, provide an example of its application in the BIM context.
15. Why is effective communication critically important for change management? What communication principles should be followed?
16. Who are “BIM champions”, and what role do they play in the process of overcoming resistance and implementing BIM?
17. What steps can be taken to engage employees in the BIM implementation process?

References

Core Literature:

1. National and International BIM Standards:

- DSTU ISO 19650-1:2020 Organisation and digitisation of information about buildings and civil engineering works, including building information modelling (BIM). Information management using building information modelling. Part 1. Concepts and principles¹ (ISO 19650-1:2018, IDT). [Essential for understanding key terms and principles of information management in BIM]
- Quality management systems, REQUIREMENTS, Official edition: DSTU ISO 9001:2015 (ISO 9001:2015, IDT) — [Valid from 2016]. — Kyiv: State Enterprise “UkrNDNTS” 2016 — 30 p. (National standards of Ukraine).
- Guidelines for quality management in projects: ISO 10006:2018 (ISO 10006:2017, IDT) — [Valid from December 12, 2018. No. 479]. — Kyiv: State Enterprise “UkrNDNC” 2017 — 36 p. (National standards of Ukraine).
- DSTU ISO 19650-2:2020 Organisation and digitisation of information about buildings and civil engineering works, including building information modelling (BIM). Information management using building information modelling. Part 2. Delivery phase (ISO 19650-2:2018, IDT). [Practical recommendations for the construction phase]
- DSTU ISO/TS 12911:2020 Framework for building information modelling (BIM) standards (ISO/TS 12911:2012, IDT). [General principles for developing BIM standards]
- Other parts of the ISO 19650 series (e.g., ISO 19650-3 for operations, ISO 19650-5 for information security, when they are harmonised in Ukraine).
- Concept for the Implementation of Building Information Modelling (BIM) Technologies in Ukraine until 2025. Approved by the Cabinet

of Ministers of Ukraine. [For understanding the state strategy and roadmap for BIM implementation]

2. General Concepts of BIM and Project Management:

- Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2018). *BIM Handbook. A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors*. Wiley. (2018). [Classic, comprehensive BIM guide]
- Aynon, J. (2017). *Construction Manager's BIM Handbook*. Wiley Blackwell. [Focus on BIM application for construction management]
- Pavan, A., Daniotti, B., Mirarchi, C., Pasini, D., Lupica Spagnolo, S., & Caffi, V. (2020). *BIM-Based Collaborative Building Process Management*. Springer. [Good resource for integrating BIM and process management]
- Bushuyev S.D., Yaroshenko F.O. (2018). *Upravlinnya proyektamy. Osnovy. Navchalnyy posibnyk* [Project Management. Fundamentals. Textbook]. Kyiv. IRIDIUM. [General principles of project management, adapted to Ukrainian realities]

Additional Literature and Electronic Resources:

1. BIM and Artificial Intelligence:

- Sarker, M., & Das, S. (2022). *Artificial Intelligence in Construction Management. A BIM-Based Approach*. CRC Press. [One of the latest resources on AI integration in construction]
- Bilal, M., Oyedele, L. O., & Owolabi, H. A. (2018). *Artificial Intelligence and Machine Learning in BIM*. Springer. [Overview of AI and ML applications in BIM]
- Current articles and reviews from scientific journals (e.g., *Automation in Construction*, *Journal of Construction Engineering and Management*) and conferences (e.g., CIB W78, EG-ICE) on generative design, automatic optimization, blockchain, and VR/AR in construction.

2. Process Management:

- *PMBOK Guide (A Guide to the Project Management Body of Knowledge)*. Project Management Institute. [Recognized standard for project management]

- Hammer, M., & Champy, J. (1993). *Reengineering the Corporation. A Manifesto for Business Revolution*. HarperBusiness. [Classic work on business process reengineering]
- Porter, M. E. (1985). *Competitive Advantage. Creating and Sustaining Superior Performance*. Free Press. [Although not about construction, the concepts of value chain and processes are fundamental]

3. Ukrainian Sources and Communities:

- Official websites of state bodies. Ministry for Communities, Territories and Infrastructure Development of Ukraine, SE “UkrNDNC” (National Standardisation Body).
- Bushuyev, Sergiy; Bushuyeva, Natalia; Bushuiev, Denis; Bushuieva, Victoria; ,Integrated Intelligence Model for Assessment Digital Transformation Project,2023 IEEE International Conference on Smart Information Systems and Technologies (SIST),42-46,2023,IEEE (**Scopus**)
- BIM communities and associations in Ukraine. Ukrainian BIM Community (UBC), Intergovernmental Guild of Consulting Engineers (MGIC), Ukrainian Steel Construction Centre (USCC). [These organisations often publish translations of standards, recommendations, and conference materials]
- Scientific articles and dissertations by Ukrainian authors on BIM and project management, published in leading technical universities (KNUBA, LP, KhNUBA, etc.).

4. Software and Platforms:

- Documentation and training materials for leading BIM software products (Autodesk Revit, ArchiCAD, Tekla Structures, Solibri, Autodesk Navisworks).
- Online courses and webinars from software developers and training centres.

Appendices

Appendix A

Process approach according to requirements Quality management systems, REQUIREMENTS, Official edition: DSTU ISO 9001:2015 (ISO 9001:2015, IDT) — [Valid from 2016]. — Kyiv: State Enterprise “UkrNDNTS” 2016 — 30 p. (National standards of Ukraine).

0.3 Process approach

0.3.1 General

This International Standard promotes the adoption of a process approach when developing, implementing and improving the effectiveness of a quality management system, to enhance customer satisfaction by meeting customer requirements. Specific requirements considered essential to the adoption of a process approach are included in 4.4.

Understanding and managing interrelated processes as a system contributes to the organization's effectiveness and efficiency in achieving its intended results. This approach enables the organization to control the interrelationships and interdependencies among the processes of the system, so that the overall performance of the organization can be enhanced.

The process approach involves the systematic definition and management of processes, and their interactions, so as to achieve the intended results in accordance with the quality policy and strategic direction of the organization. Management of the processes and the system as a whole can be achieved using the PDCA cycle (see 0.3.2) with an overall focus on risk-based thinking (see 0.3.3) aimed at taking advantage of opportunities and preventing undesirable results.

The application of the process approach in a quality management system enables:

- a) understanding and consistency in meeting requirements;
- b) the consideration of processes in terms of added value;
- c) the achievement of effective process performance;
- d) improvement of processes based on evaluation of data and information.

Figure 1 gives a schematic representation of any process and shows the interaction of its elements. The monitoring and measuring check points, which are necessary for control, are specific to each process and will vary depending on the related risks.

Educational Publication

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BIM PROCESS MANAGEMENT

Textbook