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# Building Information Modelling (BIM) and Engineering Evolution in a Digital World

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Delivery processes



**Abstract:** *Building Information Modelling (BIM) is the foundation of digital transformation in the architecture, engineering, and construction (AEC) industry. This is an instrument helping professionals and students to gain an understanding of technologies that will be crucial to the future industry. In addition, BIM is a tool that improves the efficiency and integration of building designs by integrating architectural knowledge with technical processes. Contractors, architects, and engineers are increasingly utilising virtual technology for long-distance communication. According to Reuters, the worldwide BIM industry is anticipated to grow at a CAGR of 14.9 percent from 2018 to 2023. Government mandates for the development and implementation of BIM to improve project efficiency and reduce operations costs are the driving force behind it. BIM was portrayed in specialised literature as a component of the solution for an industry beset by cost and schedule overruns, enabling owners and stakeholders to make knowledgeable decisions based on the real-time information the digital models provide.*

## 1. INTRODUCTION

Building Information Modelling (BIM) as Gaikwad, Rake and Kumar (2020, p. 103) mention is an intelligent 3D model-based process, which provides construction professionals, architecture, and engineers to efficiently design, manage, construct and plan the infrastructure of the buildings. BIM can be thought of as a virtual process that integrates all aspects, disciplines, and systems of a facility into a single, virtual model, allowing all members of the design team (owners, architects, engineers, contractors, subcontractors, and suppliers) to work together more precisely and quickly than they could with conventional methods. To make sure the model is as precise as possible before the project actually starts; team members are constantly modifying and revising their portions in accordance with project specifications and design modifications.

BIM is not just software; it is a process and software. By using BIM, you may significantly alter how projects are delivered and the workflow. BIM is a new paradigm in AEC that promotes the integration of the roles of all project stakeholders. It could encourage more cooperation and efficiency between players who previously considered each other as rivals. Integrated project delivery is a revolutionary project delivery approach that integrates people, systems, and business structures and practices into a collaborative process to minimize waste and maximize efficiency, and it is supported by BIM as well.

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The following applications for a building information model are possible: 3D renderings for visualisation; fabrication/shop drawings: It is simple to create shop drawings for different building systems. For instance, once the model is finished, sheet metal ductwork shop drawings can be easily created; code reviews: These models may be used by fire departments and other authorities to examine construction projects; cost estimation: BIM software has capabilities for cost estimation; Coordinate the ordering, fabrication, and delivery schedules for all building components during construction. All significant systems may instantaneously and automatically be checked for conflicts, interferences, and collisions. Forensic analysis: Using a building information model, facilities management can graphically display probable breakdowns, leaks, and evacuation strategies.

## 2. METHODS

Construction, engineering, and architecture (AEC) are sectors of the economy that are entering a new industrial era. Digitization of the AEC sector is one of Industry 4.0's primary goals. Building information modelling, which develops a digital database of data on a building object, is a step in this direction. As Nechyporchuk et al. (2020) stated the level of BIM awareness is crucial at the higher education stage because it is one of the primary trends in the growth of construction today. To significantly increase building efficiency, this new approach calls for new mentalities and technical proficiency. Universities must concentrate as Sampaio (2015, p. 302-315) emphasises on the strategy of utilising BIM as an innovative technology to enable students to pick up new abilities and get ready for their future work in a cutthroat environment.

According to each organisation' size and position in the value chain, BIM adoption and sophistication varies greatly from nation to country and from company to company, changing existing processes and fostering increased collaboration, including data sharing (Figure 1). BIM is currently standard practice for some large engineering firms, but the majority of small businesses in the value chain lack BIM expertise. In truth, BIM has never been employed on any of the big contractors' projects. The adoption rates in Europe vary significantly according to the World Economic Forum (2016); for instance, only 16% of E&C companies in the UK have ever used BIM, compared to 49% in Austria. "Big and open" BIM, which combines the entire value chain and is defined by full software compatibility and open access to it, is what the industry needs. The technical obstacles are probably going to be resolved in the near future as Poljanšek (2018, p. 5) estimates, but it might be harder to alter current procedures and foster greater collaboration, including data sharing.

Heesom et al. (2020) developed a systematic collaborative heritage building information modelling (HBIM) to integrate tangible and intangible cultural heritage. Based on two innovations, Dore and Murphy (2014) developed a novel semi-automatic method for producing accurate BIM facade models for as-is buildings from laser and picture data. Building Energy Performance Simulation (BEPS) models were created by O'Donnell et al. (2019) by converting point clouds from a laser scanner into a building's outside façade geometry as input data. Semantic enrichment was then manually completed. In order to produce geometric shapes in a BIM-compatible format, Laefer and Truong-Hong (2017, p. 66-77) suggested a method to automatically identify steel structure components from terrestrial laser scan point clouds. To choose the appropriate cross-sectional forms and sizes, they used kernel density estimation. An approach related to measured metrics was introduced, determining the best match of diverse cross-sections from a pre-filled library.

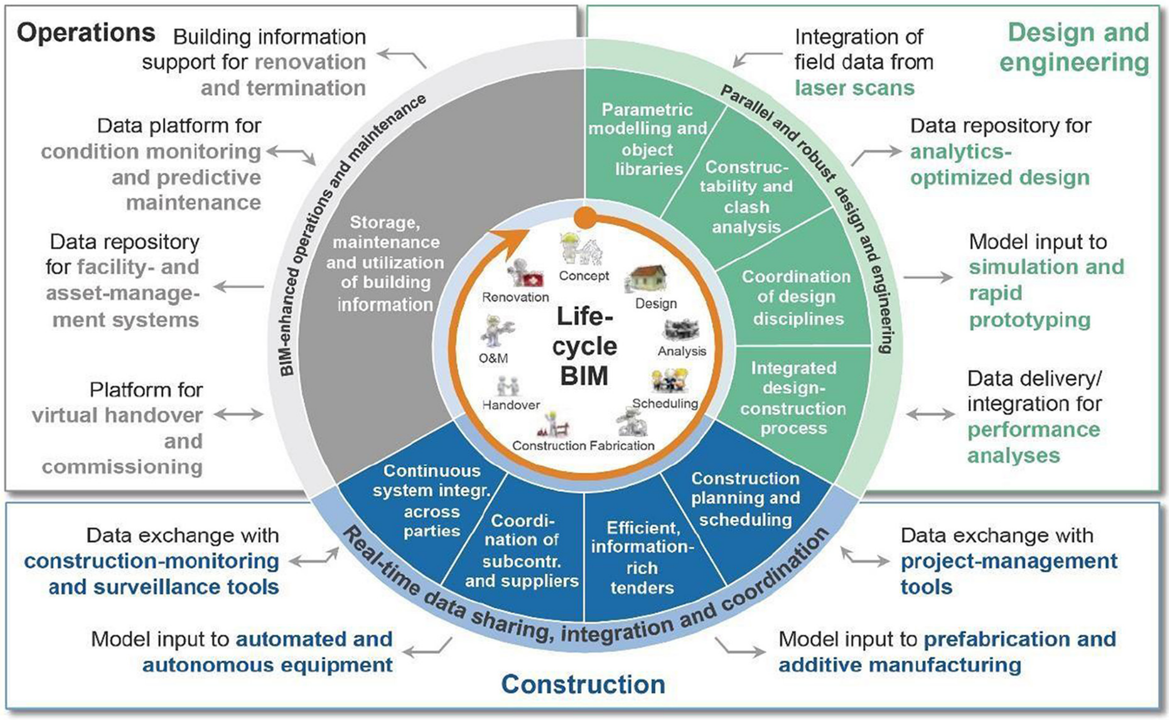


**Figure 1.** Applications of BIM along the engineering and construction value chain

**Source:** Shaping the Future of Construction

Wei and Akinci (2019) proposed a vision and learning-based framework using a shared convolutional neural network to perform localization and semantic segmentation simultaneously. Using point cloud data gathered by laser scanners, Xiong et al. (2013) suggested a method for creating 3D information models of structural components in an indoor environment. In order to create a systematic, accurate, and practical digital twinning system based on photos and CAD drawings, Lu et al. (2020) created a semiautomatic framework. Infrastructure experts Lu and Brilakis (2019) proposed a slicing-based object fitting method that can generate the geometric DT of an existing reinforced concrete bridge efficiently and accurately from four types of labelled point clusters. By using the highly regulated and standardised character of railroads, Ariyachandra and Brilakis (2020) demonstrated a method to identify railway masts using airborne LiDAR data. The coordinates of the mast placements, point clusters that were found, and 3D models of the IFC format masts are the method's final outputs.

Jiang et al. (2021) with the help of Terrestrial Laser Scanning (TLS) data (p.4), and Cheng et al. (2019) suggested a method to automatically classify component types (rails, cross-sections, pipelines, catenary equipment, and refuges) and construct parametric as-is BIMs for single-track railway tunnels. Therefore, as we plan, design, and build the railway, it is essential to have an integrated "virtual" or "digital model" of the project information and all the railway assets visualised as three-dimensional (3D) designs in the environment in which they will be built. We must also interrogate data, test hypotheses, and validate decisions with our stakeholders. Using practical methods, architects and engineers can evaluate a design's performance before it is created and maximize an asset's performance over the course of its whole life. Drone imaging augmented and virtual reality, internet of things sensors, improved building materials, artificial intelligence, and machine learning are all included in the field of digital engineering. Together with BIM, these technologies help a digital twin reflect the real-time characteristics of its physical counterpart.

## 3. RESULTS

Complex architectural works, modern construction techniques, and the management of the entire construction site are inconceivable without modern technical solutions stated Vasić et al. (2021, p. 1). One of the technologies that emerged in project management and construction is BIM. BIM is similar to the idea of PLM (Product Lifecycle Management) because it deals with cost management, project management, and concurrent work on various elements of an item used in addition to an object's physical qualities according to Sabadoš et al. (2016, p. 149-161). The majority of contemporary businesses use BIM to plan and organise three-dimensional projects. Many construction-related problems and conundrums are effectively resolved with the use of 3D models and their inspection. The use of BIM has several advantages, from project management to mistake detection to the visual identity of the building itself. As Vasić et al. mention (2020) this might also avoid issues while the building is being done.

BIM is a collaborative work approach that aims to link individuals, systems, and digital models in construction and infrastructure projects as stated by Freire et al. (2002, p. 248) to facilitate information and communication flow. As a result, it is hoped to manage the design, construction, and administration phases of the project using a digital graphic representation of its physical attributes and functionality throughout its lifecycle, taking into account relevant data that goes along with the graphic representation and enabling its use for a variety of purposes as Vitiello et al. (2019, p. 90) state. Early on in the project, there is a critical demand for BIM according to Zuppa et al. (2009, p. 503). In particular, it has been shown that BIM makes it easier for professionals from other disciplines to communicate and share information during the structural design process, as Eastman et al. (2010, p. 25) underline enabling increased accessibility and regular updating of information, even in real-time. BIM improves knowledge management, which decreases according to Ho et al. (2013) the time and expense of resolving issues with constructability and project coordination. In addition, it allows architects and structural engineers (bidirectional flow) to visualise modifications and conflicts and assists immediate decision-making, significantly reducing rework and optimising project times and costs. Also, by detecting errors in advance and automating variables that were traditionally used in "manual" processes, Harrington et al. (2010, p. 1645) appreciate that BIM enhances the automation of detail engineering and documentation processes, reducing work times and increasing project quality (according to Pezeshki et al., 2016, p. 273). The possibility of integrating structural and non-structural elements into the model controls the performance of the whole is underlined by Muñoz-La Rivera et al. (2019, p.3).

The quality, repeatability, and level of excellence within a BIM capacity also need to be acknowledged as part of the definition of BIM maturity as Liu et al. (2016, p.273) underlined. In other words, it serves as a gauge for BIM adoption within a company. The Bew-Richards model according to Bew et al. (2008) and the Succar model as Succar (2009) presented it are two scales that are widely used to assess BIM Maturity. Succar model uses more specific descriptors than the Bew-Richards model does, both models employ them to indicate where one Level ends and another begins. Traditional building delivery systems, which use paper-based mediums for all papers and technical drawings, are what define Level 0 (also known as Pre-BIM). Level 1 denotes object-based modelling, where 2D or 3D digital objects represent structural components. Model-based collaboration between various stakeholders participating in a construction project happens at Level 2. As the intermediate step before integrated project delivery, Level 3 denotes, as Sinoh (2020, p.5) emphasizes network-based integration and is the long-term goal of BIM deployment. Figure 2 shows the Bew-Richards BIM Maturity model.

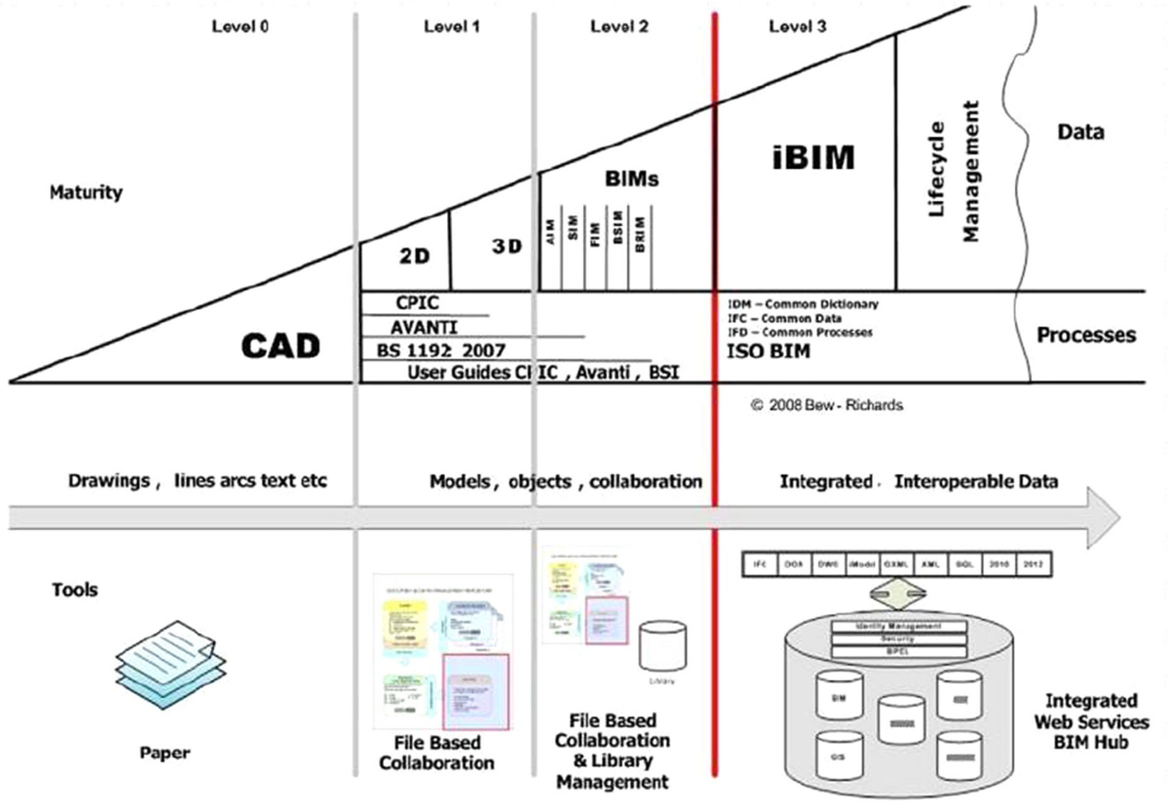


**Figure 2.** Bew-Richards model for BIM Maturity
**Source:** Bew et al. (2008)

BIM maturity is associated with the fact that it is not possible to move from a traditional modelling approach toward an open BIM approach. The change, according to Poljanšek (2017, p. 4) has to be managed progressively as climbing up a stair step by step.

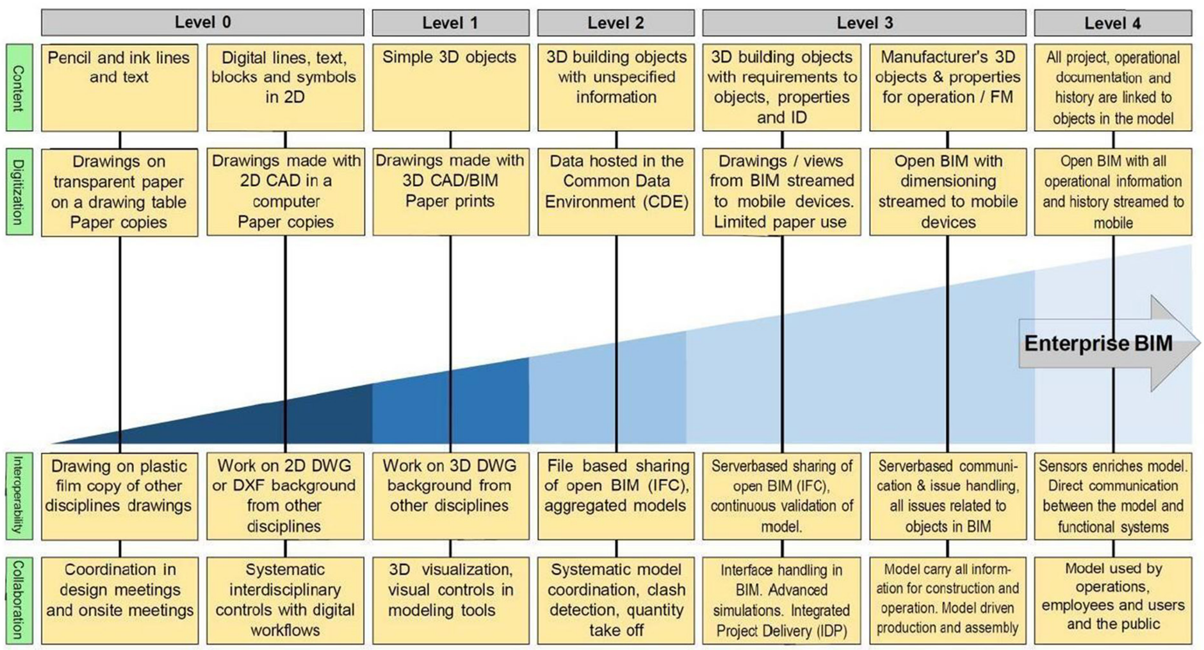


**Figure 3.** BIM Maturity Levels
**Source:** Adapted from Martin Poljanšek, JRC Science Hub, https://ec.europa.eu/jrc, JRC Technical Reports, Building Information Modelling, (BIM) standardisation

## 4. DISCUSSION

The correct exchange, quality information extraction and storage, are relevant to the success of BIM. There, according to Xu et al. (2018, p. 5) the importance of universal archives, such as IFC format, is relevant to the achievement of these objectives. Despite the aforementioned lack of consensus, approaches or recommendations for the adoption of BIM exist, primarily from industrialized nations like the United States, Holland, and the United Kingdom, among others.

These lists, as mentioned by the BIM Committee (2015, p. 5) of IM guidelines are organized around project development, roles played, and the duties, goals, and responsibilities assigned to each participant, according to Penn State University (2011, p. 4). The procedures for putting BIM into practice in businesses-plans, training, studies, gradual modifications, etc. remain to be established. It is critical to make it clear that the introduction of BIM does not change design standards or criteria; rather, it restructures how experts and processes grow and collaborate. As a result, each team member understands the significance and goals of the process, has clearly defined roles and responsibilities, and learns the necessary skills, competencies, processes, and interactions for a project to be successful as Muñoz-La Rivera et al. (2019. p.4) stated. The implementation plan also acts as a manual for new experts joining the project at hand and a source for assessments of the project's success in the future as Smith stated (2014, p. 484).

Succar and Sher (2014, p.4) have analysed the way in which organisational and educational institutions have started to adapt their delivery systems to meet changing demands on the market. One of the first articles to use taxonomies and conceptual models to explain how to categorise, filter, and aggregate individual responsibilities into a database of competencies. It also covered the advantages the competency-based approach has for both business and academics. Individual BIM skills, as defined by the authors, are the character qualities, technical talents, and professional skills needed by an individual to successfully complete a BIM activity or to produce a BIM-related output. These abilities, outcomes, or processes could be evaluated against performance standards and acquired through development, training, and education.

Wu and Issa (2014, p. 849) recommend preparation as a means of enhancing BIM curves while noting that young graduates' credentials fall short of what is required for industry positions. Instead, they suggest that BIM education should prepare graduates to the point where their BIM skills can be shaped by organizations in accordance with their particular requirements. The expertise of BIM for managing buildings is emphasised by Meziane and Rezgui and Antons et al (2020). They also highlight how a team leader with excellent BIM abilities may significantly influence project success and teamwork. The construction sector appreciates finding prospective employees that not only have BIM technology experience but also have a wide range of analytical skills. The main goals of other social media mining algorithms that have been studied by various researchers, including Lopez-Castroman et al. and Song et al. (2019) are crime predicting and alarm systems as well as suicide prevention. We can see that there is room for improvement in the BIM business, notably in relation to BIM jobs and skills, and that there is a gap in the current literature, reflected by a lack of usage of social media mining. Nevertheless, we could find numerous attempts to use the BIM industry field as an application for social media mining, such as the one of Zhang and Ashuri which attempted to mine the BIM design logs to discover connections between social network features and the production success of designers. Additionally, Kassem et al. attempted to identify the key competencies of the BIM expert positions which are selected on the basis of their quotes and the review of their skills overlap, as also Hodorog et al. (2020, p. 1216) mentioned.

## 5. CONCLUSION

Building Information Modelling (BIM) is an intelligent 3D model-based process, which provides construction professionals, architects, and engineers to efficiently design, manage, construct and plan the infrastructure of the buildings. BIM can be thought of as a virtual process that integrates all aspects, disciplines, and systems of a facility into a single, virtual model, allowing all members of the design team (owners, architects, engineers, contractors, subcontractors, and suppliers) to work together more precisely and quickly than they could with conventional methods. Without a current technological solution, it would be impossible to handle modern building methods, complex architectural works, and the complete construction site. BIM is comparable to the idea of PLM (Product Lifecycle Management) because it deals with cost management, project management, and concurrent work on various elements of the item used in addition to an object's physical qualities.

The majority of contemporary businesses use BIM to plan and organize three-dimensional projects. Many construction-related problems and conundrums are effectively resolved with the use of 3D models and their inspection. The use of BIM has several advantages, from project management to mistake detection to the visual identity of the building itself. This might also avoid issues while the building is being done. BIM improves knowledge management and sharing, which cuts down on the time and money needed to address issues with constructability and project coordination. Additionally, it facilitates quick decision-making, reduces rework significantly, and optimizes project times and costs by enabling architects and structural engineers (bidirectional flow) to view alterations and conflicts. Additionally, BIM improves the automation of detail engineering and documentation procedures, cutting down on work hours and improving project quality by spotting problems beforehand and automating variables that were previously employed in "manual" operations. The ability to incorporate both structural and non-structural components into the model governs how well it performs as a whole.

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