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How BIM Changed Architectural Engineering

1. ABSTRACT

Building information modeling (BIM) has gained traction and sparked a revolution in the construction industry. Companies in the engineering and construction business welcomed BIM's utility with open arms. What once seemed like an impossible challenge is now within reach, all thanks to BIM's transformative power.

However, BIM has been steadily transforming the construction industry for many years. In fact, building information modeling has been evolving for the past half-century. It has revolutionized design and construction as the industry knows it today.

This white paper addresses the challenges the AEC industry faced before the advent of BIM Technology, discusses solutions the technology brought, and highlights the extensive benefits it offers to businesses in the AEC industry.

2. INTRODUCTION

Building Information Modeling is not the brainchild of a single individual; it is a testament to the power of global collaboration and innovation. Its development spans a rich history, originating from the USA to Northern & Central Europe and extending to Japan, which is actual evidence of the global nature of the AEC industry.

The most exciting fact is that BIM's development is intertwined with the Cold War era. These narratives culminate in the pursuit of establishing an optimal solution, fostering collaboration, and improving efficiency to disrupt 2D computer-aided design (CAD) workflows.

What is Building Information Modeling?

Building Information Modeling (BIM) is more than just a digital representation of a building. It's a comprehensive tool that provides functional and physical information from the initial concept to the final demolition. BIM goes beyond geometric data, incorporating spatial relationships, geographic information, properties of building materials, and even light analysis. This wealth of information is invaluable for architects, engineers, and construction managers, enhancing their understanding and decision-making throughout the project lifecycle.

One of BIM's key benefits is its ability to enhance the design process. Engineers can leverage BIM design tools to extract various views of a building, enabling them to generate more precise drawings. The objects extracted by BIM tools are defined by parameters, which automatically adjust with any change in the adjacent object. This dynamic feature allows engineers to visualize the building's appearance from start to finish, significantly enhancing accuracy and efficiency in the design process.

Modern BIM tools allow engineers to create a 3D plan with sections like elevations and voids (like a room). As a building design project develops, BIM software continually alters project drawings to accommodate the changes.

3. PROBLEM DEFINITION

The AEC industry encountered several challenges before the advent of Building Information Modeling (BIM) tools. Historically, architects and engineers relied on hand-drawn sketches.

Architectural drawings have a rich history that dates back centuries. Ancient Egyptians created architectural drawings using reed pens and ink on papyrus to document dimensions, materials, and orientations. The Ancient Greeks also contributed, using wax tablets for sketches, which were later transferred to parchment paper.

Before technological advancements, architects and engineers primarily relied on pen and paper for their designs. They meticulously created detailed sketches, blueprints, and plans by hand, using tools like T-squares, set squares, and different-grade pencils. They measured and hand-drew each line, ensuring precision in their designs.

Although hand-drawn sketches and blueprints were considered works of art, the process came with some challenges.

Lack of Collaboration

Project workflows in the past typically functioned independently, lacking sufficient communication and cooperation among stakeholders such as architects, engineers, and contractors. The absence of a unified platform hindered effective coordination. The process was time-consuming and sometimes inaccurate, leading to delays and increased costs.

Communication relied heavily on paper-based documents, phone calls, and physical meetings. Inefficient communication channels often result in misunderstandings, misinterpretations, and delays.

Even after the invention of early tools, incompatibility between them created communication gaps and data silos among design, engineering, and construction teams. On the one hand, the early tools were insufficient for such magnificent requirements. On the other hand, miscommunication between design intent and construction execution was a common event affair. All these resulted in errors, delays, and rework.

Limited Visualization

Architects and engineers had to rely on 2D drawings and physical models. This limited their ability to visualize complex spatial relationships and simulate different scenarios.

Limited visualization without a comprehensive digital model did not allow engineers and architects to identify design errors or detect clashes at an early stage. Hence, they needed to correct their designs during construction, resulting in costly rework and project delays.

They also dealt with fragmented data management systems. Data related to materials, quantities, schedules, and specifications were stored in separate documents without tools. Retrieving and managing this fragmented data was time-consuming and error-prone.

Inaccurate Cost Estimation

Due to manual calculations and a lack of detailed information, estimating project costs was challenging for engineers, architects, and contractors. Hence, cost overruns were common, as they could not predict unforeseen expenses that arose during construction.

Detecting clashes between different building systems (e.g., structural, mechanical, and electrical) required manual inspections, which were time-consuming and prone to oversight.

Difficulty in Facility Management

Modern BIM tools allow engineers to create an as-built model of an existing building. It helps with facility management. However, maintaining and operating the facility was challenging before the innovation of BIM software.

Contractors did not have a digital model of the building. They solely relied on hand-drawn sketches and blueprints. The hand-drawn blueprints often did not have accurate information, as contractors usually needed to make adjustments during the construction phase. The lack of precise information about building components hindered effective facility management.

4. EVOLUTION OF BIM: IMPACT ON ARCHITECTURAL DESIGNS

BIM software has undergone a significant evolution. It has been an exciting journey, from 2D design software with basic features to extensively detail-oriented software for architects

Building Products Modeling (BPM)

CATIA was a 3D software package for CAD, CAM, and CAE. It was initially used in the shipbuilding, aerospace, and automotive industries. Although it was ideal for architects to create 3D modeling, it made its way to the AEC industry much later.

AutoCAD and MiniCAD entered the market in 1982 and 1984, respectively. While Autodesk launched AutoCAD for PC platforms, Radar CH was for Mac.

Only a few years later, in the 1900s, the term Building Information Modeling was officially introduced. However, the high cost of early BIM software restricted its adoption by smaller AEC firms, limiting their ability to compete in the BIM-driven market.

Generic Building Model (GBM)

At the beginning of the 1900s, Pro/ENGINEER, the first parametric modeling software, was released. Unfortunately, architects and engineers could not cross-pollinate as the software was too basic.

In 1993, Autodesk developed an updated AutoCAD version with solid modeling abilities. Since 2D AutoCAD was already popular among architects, the update was a milestone for Autodesk. Architects and designers started realizing that software could not take away their creativity but could enhance their productivity.

With the introduction of Generic Building Modeling in 1995, BIM software reached a new height. Project stakeholders could collaborate at multiple points in the design process. Besides, enhanced 3D modeling capacity allowed better design outcomes with fewer mistakes.

Building Information Modeling (BIM)

The new millennium brought technological advancements. The AEC industry started changing rapidly with the latest updates. A few AEC companies adopting BIM software for architectural designs started profiting.

Navisworks launched Jetstream in 2001 with a problem-detection feature and 3D CAD navigation, forever changing the face of architecture software. Autodesk acquired Revit in 2022, making it the first 3D modeling software. The evolution of these applications made clash detection possible in real time.

While the United States pioneered the development, adoption, and implementation of BIM software, countries like the UK, Finland, Sweden, etc., have made using BIM software in public projects mandatory.

By integrating modern technologies like Machine Learning (ML) and Artificial Intelligence (AI), BIM software developers can produce better and more accurate simulations, enhancing the productivity of architects and engineers

5. CHALLENGES OF BIM IMPLEMENTATION

While the modern architectural engineering industry cannot imagine working without BIM software, the situation was not always the same. The AEC industry faced many challenges during the early days of BIM development. While the software allowed some support for the manual process, it was not enough for the extensive drawings and details associated with architectural projects.

Here are some significant challenges the AEC firms came across while implementing and using BIM during the early stages:

Wasted Time

Initial BIM software was not fast enough to handle the complexities of architectural designs. While the invention of BIM addressed the problems related to manual designs, time management was a severe issue for the AEC industry.

The AEC firms spent more time on workarounds than on designs. Besides, the 2D software posed limitations regarding designs.

Lack of Infrastructure

Even with the inventions and upgrades in BIM software, the lack of infrastructure made implementation outlandish. The more advanced BIM software became, the more complicated IT infrastructure it needed, which was not readily available to most AEC companies.

The same problem continues today. Many AEC companies still lack access to collaborative tools and cloud storage, which are crucial for BIM implementation. According to an article by Hewlett-Packard, handling vast amounts of multidisciplinary data in BIM applications poses multiple technical and legal challenges for AEC companies.

High Investment

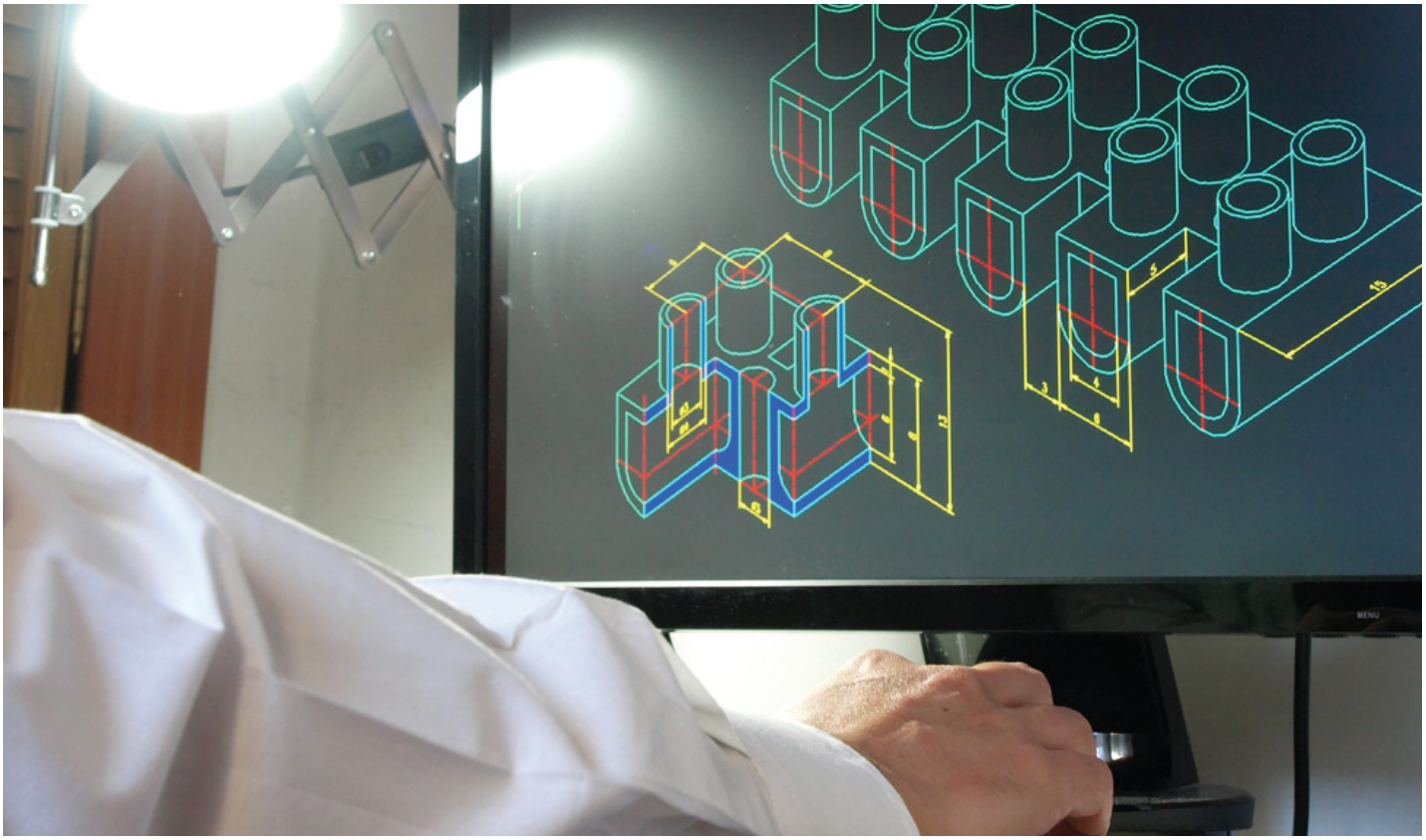
Early BIM software was so costly that most AEC firms did not have the means to invest in it. Even with BIM software's extraordinary journey and improvement within a few decades, investing in it was a high risk for companies in the AEC industry.

Due to a lack of sufficient budget, most AEC studios do not have access to updated BIM software even today, which limits their ability to succeed in this highly competitive market.

Communication Breakdowns

Incompatibility between BIM tools created communication gaps and data silos among design, engineering, and construction teams. This resulted in errors, delays, and rework.

Also, incorporating BIM software into a non-BIM system posed a challenge for organizations. During the early stages of implementation, they did not have access to BIM-trained staff.



6. HIGH-LEVEL SOLUTION

Despite the implementation challenges, BIM provided a comprehensive digital representation of buildings, incorporating functional and physical information from initial concept to demolition. Here's a deeper look at how BIM offers solutions:

Enhanced Design Process

BIM tools empower engineers to extract a wide range of detailed views and produce exact drawings, which empower sustainable designs. By leveraging parametric algorithms, BIM guarantees that any adjustments made to design parameters will seamlessly update interconnected components, ultimately elevating the accuracy and efficiency of the entire design process.

Improved Collaboration

Cloud-based BIM platforms play a crucial role in the construction industry by allowing seamless sharing and collaboration of project data across various disciplines. This reduces errors and rework and enhances efficiency throughout the project lifecycle.

With modern BIM tools, associated parties can ensure interoperability, enabling improved communication and coordination among all project stakeholders, including architects, engineers, contractors, and owners. This interoperability helps streamline workflows, enhance decision-making, and ultimately contribute to successfully delivering construction projects.

Efficient Project Management

Advanced BIM software incorporates sophisticated algorithms that facilitate real-time clash detection. This feature plays a crucial role in the early identification and resolution of conflicts during the design process.

By pinpointing clashes between various building elements, such as structural components, mechanical systems, and architectural features, the software helps prevent issues that could lead to costly rework and project delays.

Using advanced BIM software enhances the efficiency of the design process, leading to substantial cost savings and improved project timelines.

Technology Integration

Integrating cutting-edge technologies such as Machine Learning (ML) and Artificial Intelligence (AI) with BIM can significantly improve the accuracy of simulations and boost productivity. This integration has the potential to streamline the entire design and construction process, leading to more efficient and effective project outcomes.

7. BUSINESS BENEFITS

With the innovative approach toward building projects, the complexity and stakeholders have multiplied to grow. An AEC firm must streamline its workflow, use updated software, and train its employees systematically. Evolving with technology can keep a company thriving.

The new-age BIM software works as the catalyst for reshaping the AEC industry. Companies that do not use BIM software can lose potential clients as it is mandatory in some countries to use BIM for building projects.

Better Efficiency

3D BIM allows for the creation of detailed and realistic visual representations of construction projects. This improves workflow, streamlines processes, and helps complete projects faster with increased efficiency.

Enhanced Collaboration

Cloud-based BIM and improved interoperability enable seamless collaboration and data sharing, reducing errors and rework. Multiple disciplines, such as architecture, civil, and structural engineering, can collaborate more effectively.

Competitive Edge

Adopting advanced BIM solutions provides a competitive advantage. Skilled professionals and updated applications like AutoCAD, Revit, Lumion, Navisworks, Civil 3D, and InfraWorks ensure precision and minimal errors, enhancing project delivery.

Reduced Costs

Early clash detection and data filtering prevent project delays and failures, significantly reducing costs. Customizing BIM data for specific project needs supports better decision-making and maintains project accuracy.

8. CONCLUSION

The AEC industry has been slow to adapt to the digital revolution, but with the advancements in BIM, there is no turning back. Despite its complexity and high costs, BIM's benefits in enhancing productivity, efficiency, and sustainability make it indispensable.

Companies like Uppteam leverage BIM to deliver superior project outcomes, demonstrating the industry's commitment to technological advancement and improved project delivery. BIM's journey from 2D to 7D modeling illustrates its evolving impact on the AEC industry, supporting data-driven decision-making and promoting a more collaborative and efficient approach to construction.

At Uppteam, we believe in fruitful collaboration to enhance the productivity of the AEC industry. Modern BIM software increases project completion rates while staying within the budget. It also allows better interdisciplinary communication and collaboration to reduce reworks. Since clients and contractors are stakeholders, they constantly receive updates, which improves project outcomes and client satisfaction.

BIM software started with 2D model creations and has transitioned to 7D BIM services. This demonstrates the industry's commitment to improving productivity, efficiency, and sustainability while supporting data-driven decision-making.

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