

The BIM implementation journey in Nuevo Leon, Mexico

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Abstract— Digitalization in the construction industry in Mexico is limited. Despite significant advancements in technological development, computing power, and network connectivity, productivity in the construction sector appears not to change, while the manufacturing industry, for example, has embraced digital transformation. While there are notable differences between both, there certainly are efficiencies that should be harnessed. In Mexico, there is still no law that obligates State governments to work on public construction projects using BIM methodologies. Therefore, to bring about a change, government initiative is required to form a working group where public, private, and academic institutions collaborate to implement BIM in public and private construction projects. In this regard, the government of the state of Nuevo Leon took the initiative to form a working group involving both public and private institutions, playing a crucial role in implementing the BIM Methodology in both public and private construction. The goal is to develop high-quality projects in less time and at lower costs, leveraging the technological resources and human capital from the public and private sectors through the implementation of the BIM Methodology in the state of Nuevo Leon. This work presents a methodology, including the preliminary results of the pilot project, describing the roadmap to implement BIM and highlighting its benefits.

Keywords—BIM, Higher Education, Educational Innovation, Digitalization, Public Construction Projects, Construction Management

I. THEORETICAL BASIS

The term BIM (Building Information Modeling) has been widely employed in the construction industry for over a decade and is currently being adopted in Mexico. The prevailing definitions center around BIM as an integrated, effective, and collaborative methodology for creating, sharing, and managing information on a project or digital asset, all underpinned by digital technology [1].

BIM focuses on information and how collaboration is represented through data exchange among diverse stakeholders [1]. BIM represents a coordinated set of processes supported by technology that enables the efficient creation, management, and shared utilization of information related to an asset throughout its entire lifecycle.

It is crucial to bear in mind that the BIM methodology is not confined solely to the construction phase of the asset but encompasses its entire lifecycle [2], as stipulated by the ISO 19650 standard. The centralization and coordination of information facilitates the establishment of a shared knowledge base, becoming a reliable source for informed decision-making. In Construction Management, precisely defining requirements is crucial, but as per the ISO 19650

standard, even more critical is initially identifying and defining all information to be developed, shared, and approved.

The limited digitalization within the sector directly impacts its productivity. Despite remarkable advances in technological development, computing power, and network connectivity, productivity in the construction industry has remained stagnant, in stark contrast to the manufacturing industry, which has embraced digital transformation and increased productivity by two-thirds. Although there are differences between both industries, there are efficiencies that should be harnessed. For instance, it is estimated that poor information management decreases the employees' productivity due to time wasted searching for necessary information to carry out their duties [3].

Digitalizing engineering and construction processes could yield savings of up to 20 percent in capital expenses [1]. The necessity for digitalization and enhanced productivity is particularly relevant in capital projects worldwide. Furthermore, it is very common that infrastructure megaprojects incur cost overruns and delivery delays, with railway projects exceeding budgets by 45 percent and road projects by 20 percent [4]. As the delivery of assets and infrastructure becomes increasingly complex, achieving on-budget and on-time delivery using traditional approaches becomes ever more challenging and less probable. All these factors underscore the urgency of swiftly implementing the BIM methodology in public construction projects.

II. INTRODUCTION

In the construction industry, numerous large-scale infrastructure projects encounter challenges related to cost overruns and delivery delays [4]. A primary contributing factor to this predicament is the inadequate level of digitalization within these projects. Despite significant advancements in technological development, computing power, and network connectivity, construction efficiency has remained relatively unchanged compared to other sectors, such as the manufacturing industry, which has embraced digital transformation and significantly increased productivity. Although there are many differences between these industries, there are certainly efficiencies that can be leveraged in construction by adopting digital technologies and approaches.

One of the main problems arising from the limited digitalization in the construction sector is the mismanagement of information. Construction companies frequently expend significant amounts of valuable time searching for essential data for project execution. Moreover, decision-making based on incomplete or inaccurate information, along with redundant acquisition and generation of data, results in

considerable costs. Digitalizing engineering and construction processes could potentially reduce capital expenditures around 5% [5].

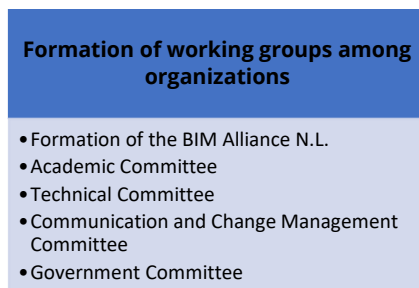
In this context, the need for digitalization and productivity improvement is particularly relevant in the execution of construction projects worldwide. With the increasing complexity of delivering assets and infrastructure, meeting budgets and established timelines using traditional approaches has become increasingly difficult and less likely.

To effectively address these challenges, the adoption of methodologies such as BIM has been widely recognized. Adopting BIM involves a cultural shift in the way work is done, rather than simply incorporating technology. It's about conducting processes more systematically, with a clear definition of needs and information exchange flows among different project stakeholders. The BIM methodology facilitates verifying and approving information based on the asset owner's needs, enabling more efficient work and a higher-quality result. Research has shown that BIM helps in the project flow and implementation by reducing poor payment practices [6]. BIM platforms have also been used for risk management reducing the potential hazards at a construction project [7]. A study shows the benefits of BIM tools to identify and prioritize energy consumption optimization strategies in buildings [8]. In terms of planning, coordination, design validation and cost optimization, it has been demonstrated the benefits of implementing BIM [9].

The manifold advantages of the BIM methodology have been extensively validated at an international level, with noteworthy applicability across various construction and asset operation projects. This reality has led the government of the state of Nuevo Leon to take the initiative of gradually and strategically integrating the BIM methodology into the processes of planning, bidding, execution, and operation of public works in the region.

As part of this initiative, a methodology for the implementation of BIM in public works projects has been developed. The phases of this methodology include defining the BIM Alliance Council, defining commissions, analyzing the current state of the State government, developing the required infrastructure for the BIM methodology, outlining the BIM implementation and pilot project development plan, analyzing results, instituting BIM regulations within Nuevo Leon, and fostering public works development under the aegis of the BIM methodology.

III. METHODOLOGY



The BIM implementation methodology comprises several stages. Firstly, the formation of various working groups takes place with the purpose of establishing a skilled and coordinated team for the process.

Subsequently, a comprehensive analysis of the current situation is conducted, serving as a reference line to comprehend the areas that require improvements and adjustments for the future implementation of BIM. This analysis provides valuable insights for designing an appropriate implementation strategy.

Next, the focus shifts toward developing the necessary infrastructure for the BIM methodology. This may involve creating a unique catalog of concepts, standardizing processes, implementing software tools, and providing training for the involved personnel.

Once these foundations are in place, the implementation plan is set in motion. This entails executing pilot projects where BIM practices and tools are applied in a controlled context to gain practical experience and validate the effectiveness of the methodology.

The final stage revolves around the implementation of BIM regulations, establishing rules and guidelines for project execution under this methodology. This ensures a consistent and efficient application of BIM in all projects, including public works.

A visual diagram summarizing the BIM implementation methodology is presented in Fig.1.

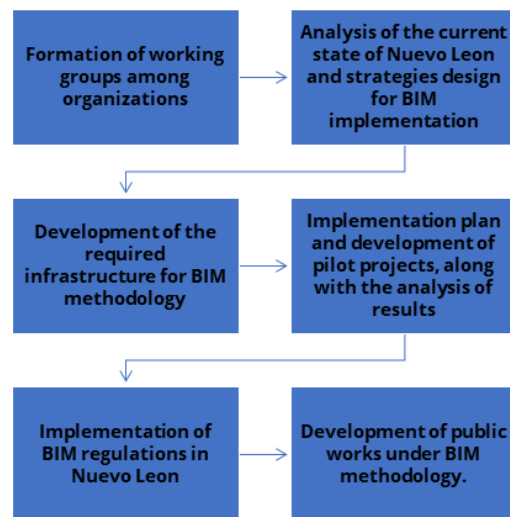


Fig. 1. BIM implementation methodology diagram.

The first phase of the BIM implementation methodology involves the formation of working groups, which encompasses various organizations such as universities, professional guilds, associations, and/or government entities. The purpose of this is to integrate an heterogeneous team that allows for a diverse range of perspectives from the stakeholders involved in the process.

Furthermore, the establishment of working committees is proposed, where academics, representatives from professional guilds, government officials, and association members can collaborate. Creating these committees will facilitate cooperation and knowledge exchange, thereby fostering a comprehensive approach to BIM implementation. Table I illustrates this dynamic.

TABLE I. FORMATION OF WORKING GROUPS AMONG ORGANIZATIONS

The second phase of the BIM implementation methodology involves conducting a comprehensive analysis of the current state to establish a robust reference line. This stage also proposes the definition of tracking indicators, a detailed analysis of existing processes, and the creation of work catalogs. Table II illustrates these aspects.

TABLE II. ANALYSIS OF THE CURRENT STATE OF NUEVO LEON AND STRATEGIES DESIGN FOR BIM IMPLEMENTATION

Analysis of the current state of Nuevo Leon and strategies design for BIM implementation
<ul style="list-style-type: none"> • Strategy • Tracking Indicators • Process Analysis • Catalog of Works Analysis

In the third phase of the BIM implementation methodology, the focus is on the core stage of the process, where the implementation strategy is formulated. This phase involves the development of a unique catalog of concepts and the planning of pilot models to establish the necessary infrastructure for the successful adoption of BIM. Table III provides detailed insights into the aspects addressed in this phase.

TABLE III. DEVELOPMENT OF THE REQUIRED INFRASTRUCTURE FOR BIM METHODOLOGY

Development of the required infrastructure for BIM methodology
<ul style="list-style-type: none"> • Unique Concept Catalog • Analysis of BIM Standards (ISO 19650) • Analysis of BIM Standards • Analysis of Technological Infrastructure • License Analysis • Planning of Pilot Models

The next phase is the implementation of the plan and the development of pilot projects. In this stage, the collaboration among alliance members is formalized, and continuous improvement of the unique concept catalog is pursued. Additionally, work is undertaken to create a common data environment using the BIM methodology. The progress made in this phase is detailed in Table IV.

TABLE IV. IMPLEMENTATION PLAN AND DEVELOPMENT OF PILOT

Implementation plan and development of pilot projects, along with the analysis of results
<ul style="list-style-type: none"> • Signing of Collaboration Agreement - BIM Alliance N.L. • Technological Adaptation • Training Program • Updating of the Unique Concept Catalog (C.U.C.O.P.) • BIM Office "Projects" • Common Data Environment • Monitoring and Analysis of Results

PROJECTS AND RESULTS ANALYSIS

Finally, a phase is proposed to implement BIM regulations in the State to ensure proper deployment of the

methodology. The key aspects of this stage can be observed in Table V.

TABLE V. BIM REGULATIONS IMPLEMENTATION IN THE STATE OF NL

Implementation of BIM regulations in Nuevo Leon
<ul style="list-style-type: none"> • Updating of Public Works Law • Modification of Bidding Rules • Updating of Regulations (Projects, Bidding, Execution)

IV. IMPLEMENTATION

Based on the proposed methodology, invitations were extended to various stakeholders from the higher education institutions, government, guilds, and associations to form a group to implement BIM in the public works bidding process. The Nuevo Leon BIM Alliance was integrated with the distribution shown in Fig. 2.

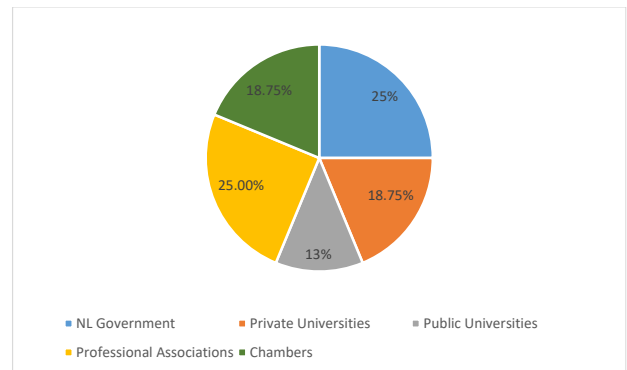


Fig. 2. BIM Alliance members distribution.

Through virtual meetings conducted via Zoom video conferencing tool, the Council of the Nuevo Leon BIM Alliance was formed and its commissions were established. Fig. 2 is an example of these meetings.



Fig. 3. Nuevo Leon BIM Alliance Zoom virtual meeting.

The next subsections describe how the proposed BIM methodology was implemented.

A. Commissions for the Implementation of BIM in Public Works Bidding.

The four commissions were integrated as follows:

1. Academic Commission (integrated by 4 higher education institutions from the private and public sectors)
 - Tecnológico de Monterrey - Private
 - Universidad de Monterrey (UEM) - Private
 - Universidad Autónoma de Nuevo Leon (UANL) - Public
 - Centro de Estudios Superiores de Diseño de Monterrey (CEDIM) - Private
2. Technical Commission
 - Civil Engineers Association of Nuevo Leon (CICNL)
 - Architects Association of Nuevo Leon (CANL)
 - BIM Plan Mexico
 - Mexican Association of the BIM Industry (AMIBIM)
3. Dissemination Commission
 - Mexican Chamber of Construction Industry (CMIC)
 - National Chamber of Housing Development and Promotion (CANADEVI)
 - Construction Industry Foundation (FIC)
 - Training Institute for the Construction Industry (ICIC)
4. Government Commission
 - Secretariat of Mobility and Urban Planning (SMPU)
 - Trust for Strategic Projects (FIDEPROES)
 - Construction Institute of Educational and Sports Physical Infrastructure of Nuevo León (ICIFED)
 - Nuevo Leon Road System
 - Nuevo Leon State Highway Network
 - Water and Drainage of Monterrey
 - Health Secretary

B. Formation of a Working Group Among Organizations

a) Academic Commission

The Academic Commission's main objective is to ensure the continuous implementation of the BIM philosophy in academic programs. To achieve this, it will focus on proper change management to adapt to the construction industry's new needs. Additionally, the commission will provide tools, training, and defined roles to all involved parties, fostering a sense of ownership in the process and promoting continuous improvement.

The commission will operate based on a master plan that will guide its actions and decisions toward the successful implementation of BIM in the academic sphere and the

construction industry. Fig. 3 shows an outline of this master plan.

In June 2022, the first meeting of the Academic Commission was held, and since then, monthly gatherings have taken place to work on the development of the master plan. Each of the universities that integrate the Academic Commission has organized a conference on the BIM Alliance. For September 2023, the first Conference of the BIM Alliance will take place at the CICNL.

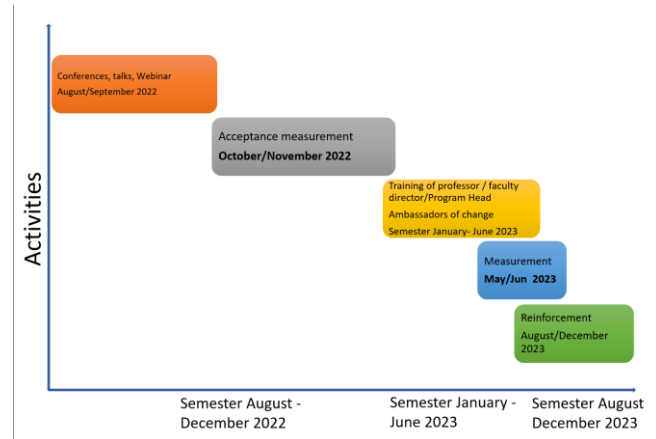


Fig. 4. Master plan outline.

b) Government Commission

The Government Commission has set the following objectives:

1. Provide BIM training to key personnel within the state government.
2. Facilitate the use of BIM guidelines and standards for government projects.
3. Encourage a gradual and progressive adoption of the BIM methodology in various administrative units.

The Government Commission's work project focuses on achieving effective implementation of BIM in the governmental sphere, promoting efficient project management, and enhancing the quality and efficacy of public works carried out by the state government.

During the stage of "Analysis of the current state of Nuevo Leon and design of strategies for BIM implementation," the primary focus has been on developing a robust implementation strategy. This strategy has been structured around short, medium, and long-term objectives, with detailed specifications and scope.

In the "Development of the required infrastructure for the BIM methodology" phase, significant emphasis has been placed on creating a unified catalog of concepts through regular meetings scheduled every 15 days. The primary objective is to design and implement a concept classification system for the government of Nuevo Leon, serving as a fundamental tool for top-level management in decision-making for project planning, bidding, execution, and administrative control.

The proposal for this classification system arises from the pressing need to have a clearer reference for the proper understanding of the concepts involved in projects. By assigning a unique classification code to each concept, precise data is obtained, facilitating analysis and information organization at the state level.

This approach towards the creation of a unified and structured catalog represents a significant advancement for the government of Nuevo Leon, providing a solid foundation for the successful adoption of the BIM methodology. It optimizes infrastructure project management and fosters greater efficiency in the decision-making processes of public administration. This strategic initiative aims to streamline and enhance the overall project lifecycle, leading to better project outcomes and improved resource utilization, ultimately benefiting the citizens of Nuevo Leon.

The working groups (WG) created by the commission are as follows:

1. WG1: Public Works Processes to BIM Methodology
2. WG2: Technological Adaptation
3. WG3: Manual of Standards, Templates, and Parametric Objects Library
4. WG4: Training and Change Management
5. WG5: Unique Catalog of Construction Concepts
6. WG6: Normative Adaptation and Bidding Foundations
7. WG7: BIM “Pilot Project” Project Implementation
8. WG8: Automation and Tool Innovation with Dynamo

In addition, the government of Nuevo Leon, through the government working group, has established a collaborative agreement with the United Nations Office for Project Services (UNOPS).

Through this collaboration, the government of Nuevo Leon reaffirms its commitment to share its expertise and knowledge to enhance the implementation capacity of BIM and provide support to other countries in developing their capabilities and resources in line with the United Nations Sustainable Development Goals (SDGs). As part of this commitment, the government will closely collaborate with Mexico in the development and adoption of new technologies that promote greater sustainability in infrastructure projects, thereby contributing to the SDGs 2030, particularly SDG 7 (affordable and clean energy), SDG 8 (decent work and economic growth), SDG 9 (industry, innovation and infrastructure), SDG 10 (reduced inequalities), SDG 11 (sustainable cities), and SDG 12 (responsible consumption and production), among others [10].

c) Technical Commission

The primary objective of the Technical Commission is to assess the level of maturity among companies affiliated with professional organizations. Additionally, this commission organizes webinars for the members of these organizations with the support of the Outreach Commission (Fig. 5). A significant activity of the Technical Commission is providing BIM training to its affiliated members. Moreover, like the Government and Academic Commissions, the Technical Commission plays a crucial role in the development of the unique catalog of construction concepts.

Finally, one of the key responsibilities of the Technical Commission is to focus on adopting guidelines and standards, as well as reviewing terms of reference for BIM-based tenders. The commitment of this commission lies in promoting the efficient implementation of the BIM methodology within companies associated with professional organizations, ensuring higher quality and advancements in the construction industry of the state.



Fig. 5. Offered webinars by BIM Alliance.

C. Implementation and Development Plan for BIM Pilot Projects and Results Analysis

This stage of the implementation process is crucial for the Alliance, as it involves establishing a collaboration agreement among all members. The agreement was previously signed in 2022. Fig. 6 shows some images from the event where the collaboration agreement was signed.



Fig. 6. Collaboration Agreement of the BIM Alliance.

D. Implementation of BIM Normativity in Nuevo Leon

In this phase, the main objective is to update the law of public works and modify the bidding bases, as well as update the regulations, to integrate and adopt the BIM methodology in construction and public works processes in the state.

To carry out this implementation, there is an intention to request the modification of Article 6 of the Law of Public Works and Related Services, with the support and collaboration of the BIM Alliance members. The BIM Task

Group is providing its backing in this initiative. It is important to note that although the existing laws do not explicitly mention the BIM methodology, they do promote process modernization, as well as the principles of effectiveness, efficiency, and honesty established in the Political Constitution of the United Mexican States (CPEUM), and the laws on anticorruption and transparency.

So far, significant progress has been made in this phase:

1. Allocation of resources for implementation, licensing, and necessary equipment, as well as for conducting pilot projects.
2. Development of a preliminary diagnosis that will be strengthened during the current year, and whose results will be shared with state government agencies to reinforce the diagnosis.
3. Work on BIM processes for their proper implementation in the regulations.
4. The Technical Commission will propose a liaison to work jointly with the government on the Unique Catalog of Public Works Concepts, Templates, and Parametric Objects.
5. A BIM survey will be conducted to understand contractors' level of knowledge about this methodology.
6. Adaptation in the Construction Regulation (REC) to include aspects related to BIM.
7. The Technical Commission has designated a liaison with the BIM Task Group for the development of guides and manuals.
8. Creation of 8 subcommittees to specifically address different aspects of BIM implementation in regulations.
9. The airport standards have already been released and have distribution rights by the Government.

E. Development of Public Works under the BIM Methodology

The development of public works under the BIM methodology represents a pending but crucial aspect once the previous phases have been addressed and advanced significantly. This last stage requires a change in the Law of Public Works to fully implement the BIM methodology in construction and public works projects in Nuevo Leon.

It is expected that during 2023, work will begin to carry out this final phase, which involves making the necessary legislative modifications to establish the legal framework that allows the comprehensive use of the BIM methodology in the field of public works in Nuevo Leon.

V. RESULTS

The work conducted by Nuevo Leon BIM Alliance has been comprehensive and progressive, involving several phases that have led to significant achievements in advancing the implementation of BIM in the state.

One of the most notable accomplishments of this process has been the establishment and consolidation of specialized commissions: Academic, Technical, Dissemination, and Government. These commissions have played a crucial role in bringing together key stakeholders from various fields, including academic representatives, technical experts,

industry professionals, and government officials. Their formation has been essential in fostering a holistic and collaborative approach to implementing the BIM methodology in Nuevo León.

Throughout this journey, a significant milestone was reached with the signing of the Nuevo Leon BIM Alliance agreement, wherein all commission members demonstrated their commitment and dedication to this important project. This agreement represents a strong and collective commitment to drive the adoption of BIM in the construction and public works industry throughout the state.

Undoubtedly, one of the most remarkable outcomes to date has been the approval of the construction pilot project. This project involves the construction of a nursery in the municipality of El Carmen, N.L., made possible through the successful implementation of the BIM methodology (Fig. 7). The approval of this pilot project stands as a clear testament to the success and significance of Nuevo Leon BIM Alliance in promoting innovative and efficient practices within the construction sector.

BIM methodology in developing this nursery has led to improved planning and efficiency in the construction process, as well as fostering greater integration and collaboration among the various stakeholders involved. This pilot experience will serve as a benchmark for future infrastructure and public works projects in the state, promoting the further adoption of BIM and its positive impact on construction quality and sustainable development in the region.

Furthermore, an ambitious plan has been outlined to commence construction of the nursery in November 2023, marking a significant milestone in the BIM implementation process within the realm of public works in Nuevo Leon.

In summary, the results achieved so far exemplify the commitment, collaborative efforts, and leadership demonstrated by Nuevo Leon BIM Alliance in promoting and adopting innovative practices within the construction sector.

One of the great results for the organization of the FORO Universities in September 2023 with the help of the Monterrey Technology Center and the hub of activities to present academic projects for part of students and lecturers.

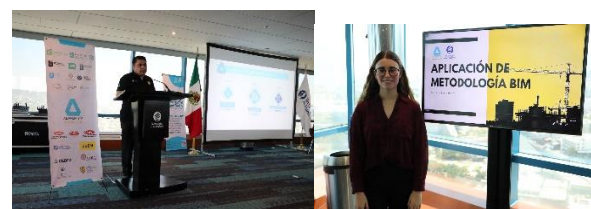


Fig. 7. Foro BIM

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