Towards BIM Guidelines in Saudi Arabia: Literature Review and Stakeholders Identification

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Abstract. BIM is a graphical representation for a given engineering design, let be the structure of a building, which carries information related to 3D view, cost estimation, scheduling, and others. BIM is created and used mainly by the owner. By default, the designer, contractor, and supplier are shared and treated by all parties as an advanced medium of technical and visual communication. In the last few years, and many developed countries, BIM documents, and related legal provisions have become mandatory in construction projects contract documents by public and private owners and project stakeholders as best practice. The authors observed that although some projects in Saudi Arabia have used BIM, it is still not as widely used as it is supposed to be. It is apparent to the authors that the leap of using BIM in the Saudi Construction Industry without proper provisions in the contract documents among the construction project stakeholders will create confusion. The paper explores the current status and trend of using BIM in the construction industry and related difficulties and challenges to using BIM in Saudi Arabia. Ultimately, based on those investigated results, the paper proposes the basic guidelines for applying BIM following the situation of the national construction industry in Saudi Arabia.

1. Introduction
In the last decade, BIM technology and practice in the construction industry have progressed steadily in developed countries, including the U.S. and U.K., due to its many advantages such as cost-saving, integration design, construction, and operating phase’s information. Numerous conferences, workshops, and training were held to develop BIM-related software, practice, and training personnel to meet BIM applications, technology, and service demand. BIM applications can be found in different construction projects depending on the size and complexity of project elements vis-a-vis sophistication of stakeholders, and parties involved. Challenges are facing developing countries such as Saudi Arabia in adopting and regulating BIM use. There is an ongoing debate on whether there is a need for regulations or not to mandate BIM technology in the construction industry in Saudi Arabia, as either one has its own merits.
This paper assumes that the best practice BIM regulations in the developed countries can be adapted with modification in Saudi Arabia, given the fast pace of public and private sectors digitalization in recent years. More, many legal issues related to BIM implementation will arise sooner or later, as the case already in developed countries.
Second, there is a need to address contract provisions in line with Saudi public laws in BIM-enabled projects for deployment and governance.
Saudi Arabia had handled the COVID 19 pandemic successfully at medical and administrative levels. More, it employed the latest available applications on Mobiles to monitor the vaccinations of millions of people, which had enthralled the world. Thus, the authors find it fit to put forward guidelines for BIM Mandate in Saudi Arabia.
The literature survey is divided into two parts; the first covers the international best practice of BIM mandates. The second part will cover a literature survey on the status of BIM use in Saudi Arabia.

2. International Literature

Construction Project Information Committee (CPIC 2021) defines BIM as the digital representation of a facility's physical and functional behavior that provides broad knowledge materials for information to form a reliable basis for decisions throughout its life cycle, from initial construction to demolition [1]. Private firms and government BIM mandates, according to Sacks R. et al. (2018), closely followed government policies, laws, and administration systems, including e-Submission platforms. The government's BIM mandates are generally announced through a strategic roadmap for changing or improving regulations, standards, and procedures that encourage changes made by BIM mandates. The BIM guides are often updated based on the new BIM requirements. For instance, Public organizations in Europe countries, the United States, and Asia countries began BIM mandates before 2010. In 2007, Norway, Denmark, and Finland, for example, announced their first BIM requirements for public projects. Similarly, the United States General Services Administration (GSA) announced in 2008 that BIM will be required for all government project work. South Korea's government, on the other hand, enforced BIM on public projects in 2010. Subsequently, more than 15 countries have started or set up a plan to recommend a BIM. The list of countries that mandate BIM is shown in Table 1.

**Table 1. BIM Mandates Sample list (Sacks, R. et al (2018))**

| Country  | Organization       | Year    | Total project registered                                                                 |
|---------|--------------------|---------|----------------------------------------------------------------------------------------|
| Norway  | Statsbygg          | 2007–2010 | “1 – 5 – 15 - all” is one project, five projects, and fifteen projects in 2007, 2008, and 2009, respectively, with a total cost of EUR 3 million required by IFC as a requirement for BIM mandate. |
| Denmark | bips/MOLIO         | 2007–2013 | In 2013, Danish government widen the scope of the BIM mandate to cover public building projects costing more than EUR 0.7 million or projects costing more than EUR 2.7 million with government loans or grants to employ ICT/BIM. |
| Finland | Senate Properties  | 2007    | After the emergence of Common BIM Requirements (COBIM) in 2012, all projects should use IFC/BIM. Hence, Senate properties and major construction industries used COBIM as a guiding principle to implement the BIM requirement on their projects. Finland launched KIRAdigi, a program that combines BIM into the construction approval procedure. |
| U.S     | GSA                | 2008    | Following GSA Guide Series, GSA imposed BIM on all major projects (over USD 35 million) including appropriations from the US government. |
| U.S     | Wisconsin          | 2010    | Starting in 2010, the state of Wisconsin mandated that all projects amounting to USD 5 million or more, as well as all new construction work with a |
budget of USD 2.5 million or higher must use BIM.

| Country          | Organization                                | Year       | Requirement                                                                 |
|------------------|---------------------------------------------|------------|-----------------------------------------------------------------------------|
| South Korea      | Ministry of Land, Infrastructure, and Transport (MoLIT)/Public Procurement Service (PPS) | 2010–2016  | In 2010 and 2011, at least two and three projects, respectively, were required to employ BIM, as were all "total service" projects exceeding KRW 50 billion in 2012, and all "total service" projects from 2016. A "whole service" project is one in which PPS plans and manages the full procurement and construction process. |
| Singapore        | Building and Construction Authority (BCA)   | 2013–2015  | Architecture BIM, Engineering BIM, Architecture and Engineering BIM e-submission were recommended for all new construction projects larger than 20,000 m², 20,000 m², and 5,000 m², respectively, between 2014 and 2015. |

For example, the South Korean government's Ministry of Land, Infrastructure, and Transport (MoLIT) and Public Procurement Service (PPS) have played a significant role in making BIM applications mandatory. Each organization had different leading roles and goals. The MoLIT establishes requirements and procedures to use the BIM mandate in construction industries for clients, architects, e.t.c. The BIM is flexible such that it accommodates changes or is updated by clients according to their demands for a given project. The guide primarily involves the planning, technical, and managerial guides [2]. The PPS provide detailed instructions on how to complete BIM-assisted projects. It has mandated BIM design in construction projects with a total contract sum of over KRW50 billion ($42.2 million) each and plans to use BIM in all construction project orders by 2016 [3].

The Singapore government planned to improve the productivity of construction industries to 25% over the next decade. To overcome the construction industry's challenges in adopting BIM, the government and industry have undertaken a number of steps to help enterprises and professionals shift from traditional two-dimensional building designs to BIM models. Hwang et al. (2019) provide an overview of the policies, activities, and development of BIM adoption in Singapore's construction industry from 2008 to 2017. Several regulations and recommendations have been developed to assist professionals in adopting the new BIM-based regulatory submission process. When using BIM at various project stages, the BCA published a BIM guide to define project stakeholders' roles and responsibilities (BCA 2013b). The Centre for Construction Information Technology formed a BIM Guide Series and gave references on BIM best practices in Singapore (BCA 2013a). Therefore, the public sector became the most implementing BIM.

The above reporting covered the benefits of using BIM internationally, the spread of BIM mandates and regulations in different countries at different paces, and following local laws and construction industry practice and maturity.
3. BIM in Saudi Arabia
The authors explored the literature survey about BIM-related applications and research in Saudi Arabia. Table 3 presents what is recounted in the literature, while the authors believe there might be more use without reporting, given the ongoing large-scale projects.
Fifteen mega-projects shaping the future of Saudi Arabia (2021) were reported to include Riyadh Metro Project, Neom, Red Sea Project, Qiddiya, Ad Diriyah, Makkah Public Transport Program to name a few. Obaid Aljobaly and Abdulaziz Banaw (2019) reported that BIM in the Saudi Arabia construction industry lacks government support and official guidelines or protocols. Saud Alhumayn et al. (2017) suggested strategies for adopting BIM in Saudi Arabia that involve legislation and supportive regulatory agencies and financial support from the government. More educationists should be involved in benchmarking against other countries. Ibrahim Al-Hammad and Zaidan Zanklo (2021), Brian Lahiff et al. (2019), and Adel Alshibani & Othman Subhi Alshamrani (2017) carried out BIM applications in Saudi Arabia construction projects. Among the many challenges facing BIM implementation in Saudi Arabia, BIM Mandate will be addressed by this paper.

Table 2. BIM literature related to Saudi Arabia

| Reference | Description |
|-----------|-------------|
| Ibrahim Al-Hammad and Zaidan Zanklo (2021) | Evaluation and selection of qualitative internal doors for buildings using BIM |
| Brian Lahiff et al. (2019) | BIM for Infrastructure on the Bonded and Re-Export Zone at King Abdullah Port, Kingdom of Saudi Arabia |
| Obaid Aljobaly and Abdulaziz Banaw (2019) | Evaluation of Saudi Construction Industries for Adoption of Building Information Modelling |
| Saud Alhumayn et al. (2017) | The Barriers and Strategies Of Implementing BIM In Saudi Arabia |
| Adel Alshibani & Othman Subhi Alshamrani (2017) | ANN/BIM-based model for predicting the energy cost of residential buildings in Saudi Arabia |
4. Stakeholders Roles in BIM Macro Diffusion in Saudi Arabia

This is an early effort by the authors to sketch an approach to promogulated a BIM mandate in Saudi Arabia, hoping that it will be a driving force for transformational change in the Saudi digital built environment. As policymakers are competing to imitate other policymakers or to establish new BIM guides for themselves. The guiding principles and mandates might be beneficial to start from where others stopped. Bilal Succar and Mohamad Kassem (2015) advocated the Diffusion Responsibilities model (which identifies nine unique Player Groups (P.G.). BIM experts operate under three overlapping BIM areas starting at the highest conceptual level. Figure.2 maps the BIM Saudi Stakeholders to the aforesaid model with the following description:

- The Policy Field involves experts in guiding practitioners, providing protocols, and establishing regulatory frameworks to establish stakeholder relationships. An example of a BIM Policy Player, Player Group 1 (PG1) is the Minster of Municipality and Rural Affairs (MOMRA), Minister of Finance (MOF), Shura Council (semi-legislative body), Saudi Arabian Standardization Organization (SASO). Play Group 2 includes Education Institutions like Prince Sultan University and King Saud University.

- The Process Field involves all expert/players in the procurement, design, construction, and so on of the infrastructures. For example, “BIM Process Player” groups of 3 and 4 are the Saudi Commission of Engineers, Commission of Contractors, and Saudi real-estate Fund.

- The Technology Field consists of all players involved in developing, selling, and maintaining software, hardware, and networking systems. Examples of BIM Technology Players Group (P.G.) 5 and 6 are AutoCAD, Navisworks, Autodesk Revit, and Trimble Connect.

- P.G. 7. Industry Associations: the union that protects the individual/ organizational members’ interest for a particular company, field, discipline, or specialty – Saudi Chamber of Commerce and Industry

- P.G. 8. Communities of Practice: these are informal groups of individual professionals share similar interest in a particular software, hardware, e.t.c. For example a ArchiCAD user group or SmartGeometry, not known in Saudi Arabia

Figure 2. Adapted Macro-Diffusion Responsibilities Model, Bilal Succar and Mohamad Kassem (2015)
• PG 9. Technology Advocates: these are formal groups of professional works to develop and promote technology-centric standards and policies. For example building SMART or ACS such as Saudi commission of A.I.

5. Conclusion and Further Research
This paper is the first step in developing specific Saudi BIM Mandates and Protocols following its institutional capabilities. The literature review has shown that many countries adopt BIM regulations and bylaws, which has positively impacted the project life cycle. It further exposed that Saudi Arabia is lagging in BIM mandates and applications.

The researchers used a model of responsibility diffusion to identify the stakeholders for regulating BIM Technology use and implementation in Saudi Arabia. A further step in this direction and further research is to develop a plan to formulate BIM Mandates and a timeline for executing them to fit Saudi Arabia's institutional capacities and readiness to keep pace with the international best practice.

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