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## Exploring the Adoption of BIM in the UAE construction industry for AEC firms

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### Abstract

Rate of development of the United Arab Emirates (UAE) economy has increased remarkably during the last 25 years with a marked boom in the construction industry. However, the UAE construction industry is encountering several problems as delays and cost overruns. Adoption of the Building Information Modeling (BIM) solution is expected to enhance performance and profitability for the construction industry. This paper looks at the BIM adoption in UAE due to its mandate by the Dubai Municipality in 2015 which was followed by a BIM mandate in UK in 2016. A questionnaire survey was used to assess awareness of, and use and adoption of BIM in the UAE. The survey was distributed to academics and construction professionals working on BIM projects in UAE. The research result reveals three critical barriers in BIM implementation: Lack of BIM Standards, Lack of BIM Awareness and Resistance to change. A synthesis is presented of the state of past and current studies on BIM implementation and future research directions are recommended.

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## 1. Introduction

The United Arab Emirates (UAE) is characterised by cultural diversity, an understanding government, flexibility in regulation, high standard of living and a notably well rated quality of life [1]. The construction sector in UAE has been rapidly expanding specially following the recent development which is the Dubai won to hosting of Expo 2020. This gave Dubai and the UAE a significant boost, especially to the construction industry. Large scale and capital intensive projects will need to be developed, constructed and delivered responsibly [2]. The focus of the construction industry now is to eliminate waste and inefficiency to improve quality and profitability. Recently, Dubai Municipality (DM) became the first authority to command Building Information Modeling (BIM) Implementation in UAE. DM mandate in May 2014 that BIM be used in buildings over 40 stories or more than 300,000ft<sup>2</sup> as well as government projects, followed by the BIM mandate in the UK in public sector projects by 2016 [3]. The BIM concept is not new, and its roots can be tracked back to 1970s in the aerospace aviation and manufacturing industries [4]. However, BIM started appearing in the construction projects in the UAE around the mid-2000s. The definition of BIM has moved from simply being a ‘buzzword’ to become a main attraction to construction industry [5]. Followed by the growing adoption of BIM in UK, USA and Europe, many stakeholders are reporting specific benefits and hurdles in its implementation. The use of BIM, however, is growing slowly in developing countries as well. Although the benefits of BIM is known to the Architecture-Engineering-Construction (AEC) industry, BIM is still considered optional in the UAE [6]. According to Koseogle (2013), the main problem in implementing BIM in UAE is that there are no published and accepted BIM standards and protocols. While most clients want to have BIM used in their projects while they do not have a clear understanding of its meaning and practical implication. No more than 6 10% of the UAE construction industry know or is aware of the full scope of BIM [3]. According to the gradually increasing needs of the UAE construction industry, and the world movement towards adoption and implementation BIM, it is necessary for construction professionals in UAE to catch up soon and start adopting BIM in their construction projects, and to acknowledge that BIM adoption actually benefits all project stakeholders [7], with benefits occurring throughout the project lifecycle. This paper intends to look especially at the adoption level of BIM usage in UAE based on the BIM current practices internationally. The study findings will contribute in revealing the level of BIM awareness, the challenges that lie ahead, and in outlining a way forward to future BIM implementation in the UAE construction industry. The aim of this paper is to recommend an effective deployment plan for BIM workflow, adoption and implementation in the UAE construction industry to achieve the following objectives:

- To assess the BIM concept
- To identify current status of BIM adoption globally
- To investigate challenges and propose solutions to enhance BIM acceptance and application by the UAE construction professionals.

## 2. Research Methodology and Strategy

This paper intends to deliver comprehensive description for BIM status and workflow adoption in the UAE construction projects. The objective of the study concentrates on the generation of BIM in the AEC industry. It highlights different definitions of BIM along with their advantages over the project lifecycle. The barriers and challenges to BIM adoption as well as the current BIM status internationally and in the UAE will be identified. The essential requirements to enhance BIM adoption in the UAE construction industry are highlighted.

The UAE construction industry is in its beginning steps towards BIM adoption, mainly due to recent government mandates. However, the availability and accessibility to professionals who are BIM-aware is still limited in the UAE. Data collection in this research includes both secondary data and primary data. Secondary data is in the form of academic journals, textbooks, magazines, news, industrial papers, governmental papers and reports which provide strong foundation to build a primary data collection effort. Thus, since the research pursue specific key question, a primary data collection is undertaken. The primary data collection used in this research is based on an online survey questionnaire which was deemed as the most appropriate mean among other method (i.e., interviews, direct surveys, and case studies) [8]. The survey is designed with a series of sixteen (16) questions based on the objectives of the research. The questions are purposely formulated so that they are fairly easy to understand

by respondents. The target population is a group of AEC professionals working on UAE construction projects. The survey was sent to eighty (80) professionals; sixty (60) of them completed and returned the survey (a response rate of 75%) within 6 working days.

### 3. Building Information Modeling

The Architecture-Engineering-Construction (AEC), or simply the Construction, industry in the UAE is still seen as a fragmented industry and there are growing calls for that to change. The BIM movement was brought about in response to calls for required change in the AEC industry [9]. BIM has modified the way construction projects are designed, constructed and operated [10]. Using BIM in the construction, led to increase in the profitability, better time and cost management as well as improving in client-customer relationship. BIM is beneficial for all stages of construction as noted by many [5, 10]. The BIM maturity levels were established in the UK to clearly define BIM capability for constructional professionals. BIM maturity levels refer to the quality, repeatability and degree of excellence within a BIM capability [11]. Maturity denotes the extent of the BIM capability in executing a task or in delivering a BIM service or product. BIM, also called Virtual Prototyping Technology or n-D Modelling, is an innovative development which is reshaping the construction industry [10]. This means that BIM is not just defined as 3D model; it similarly includes the capability of transmitting plus reusing of the information imbedded in it. Depending on the information in the model, time model (4D) [13] and cost model (5D) model [12] can be developed [7]. By adding other factors, more dimensions of BIM model can also be developed. A vital goal for all BIM projects is the exclusion of construction plus installation coordination issues prior to the procurement and fabrication of the construction components. The goal can be achieved through integrated collaboration, communication, and controlled project delivery team [14]. There are five factors for collaboration and integration within BIM identified as POWER (Product information sharing, Organizational roles synergy, Work process coordination-Environment for teamwork, Reference data consolidation) [16].

### 4. BIM Adoption & Implementation

The first movement of BIM adoption struck the construction industry from the mid-2000s as a mean to overcome low construction efficiency and other obstacles that were encumbering innovation [16]. Numerous reports indicate that the BIM market would be huge, but its adoption is slow in many countries. In recent years, practitioners started to explore the impact of using BIM in the construction industry and seek to identify key challenges for BIM implementation. Still, there is a slow and limited spread of the BIM adoption in some countries especially the late adopters.

#### 4.1 BIM Status Globally

BIM is mandated in some countries such as US [16], UK and a number of other countries as per the Smart Market Report [19]. In USA, the BIM adoption has increased by 54 % between the 2007 and 2012% [19]. In 2010, BIM adoption in European countries reached 36% [20]. In the UK, BIM adoption between 2010 and 2012 increased from 13% to 39%, respectively [21]. In the Middle East, only 10% of construction projects are using BIM [22]. Some countries in the Europe such as Finland, Denmark [23], Norway and Sweden are known as the BIM leaders in the world [24]. Accordingly, there are numerous publications, research results, and policies developed for BIM implementation in Europe. In the UK there's a high level of BIM awareness among construction professionals. The BIM awareness might be relied on the UK government and its fund and support for the AEC industry [25]. The BIM adoption is mandated by the UK government to be used in 2016 to level 2 for all public governmental construction projects by 2016 for the purpose of reducing construction waste by 20% [24, 26]. In the USA, BIM is used for visualisation purposes in almost 70% of construction projects. In addition, most of the projects use BIM for the

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design stage of projects [27]. In Singapore, the BIM e-submission was mandated by the government in 2008 through the two organizations of Building and Construction Authority (BCA) and the Construction and Real Estate Network (CORENET). Singapore is the earliest BIM adaptor in Asia, and the first in the world to require the BIM e-submission [17]. A BIM Draft handbook was produced in 2014 to be used as a guide and a supporting document to help in the BIM implementation to be used in the New Zealand and Australian AEC industry. That document was introduced as “BIM as a changer” [18].

#### *4.2 BIM Status in UAE*

The United Arab Emirates (UAE) is a union of seven states in the southeastern part of the Arabian Peninsula formed in 1971. The seven states are: Abu Dhabi, Dubai, Ajman, Sharjah, Fujairah, Ras al Khaimah, and Umm al Qawain, located in the Middle East region. The UAE, as a country, has been characterized by extremely rapid economic growth and urbanization. The construction industry in the UAE is one of the key enablers of the country's rapid rise and prosperity [28]. The construction boom in the UAE started in the middle of 1990s with the gradual move from a primarily oil-dependency to more industrial, financial services and tourism hub. Currently, the UAE is firmly the center of dynamic construction move in the Gulf Cooperation Council (GCC) area [29]. In the UAE, ‘the construction industry is also known as project-based industry, which refers to its characteristics as related to the distinctiveness nature of the projects, including design ideas, construction site characteristics, production set up, material supply, management and organization, and the construction process as displayed throughout the history from the construction of the great pyramid in Egypt 5,000 years ago to the recently built Burj Khalifa (formally known as Burj Dubai)’ [30]. Most construction projects in the UAE are fast track, and companies typically execute them on a precipitously accelerated pace, in many cases motivated by incentives from developers, including government agencies.

Most UAE construction projects are unique in their nature, with high level of risk and a large number of challenges [35]. Projects in the UAE are generally with high level of risk, highly fragmented, competitive, and with some unique technical and engineering hurdles [29]. Some of the world's unique, and first-of-a-kind projects were completed in the UAE including Burj Khalifa, the world's tallest building that was completed in 2010, and Burj Al Arab, world only 7-star hotel and 3<sup>rd</sup> tallest hotel [38]. Though the UAE construction industry plays a major role in the national economy, there are multiple serious issues that continue to plague it. These include serious delays that, because of their size connections to nearby development and major infrastructure projects, affect not only the AEC industry but also the whole economy. The global financial crisis which crippled the world economics in 2007 may have slowed the AEC industry but it did not stop the construction and fast project streak in this country. In a report released in 2011, Al-Masrah Capital Limited released a report stating that UAE contributed about 60 percent of the property boom in the GCC countries, with Dubai alone contributing about 47 percent of the total among the GCC countries.

Governments around the world have recognized the inefficiencies affecting the construction industry in general, and have recommended and mandated the practice of Building Information Modelling (BIM) as a strategy to addressing a declining productivity. BIM as a framework used by AEC industry professionals has taken another step forwards in the Middle East. As Austyn (2014) in Middle East Economic digest stated: ‘In November, Dubai municipality announced it would be mandating the usage of BIM in certain projects from the start of this year. Mechanical, electrical and plumbing (MEP) and architectural work must use BIM processes on all buildings that are 40-storeys and highest, or 300,000 square feet and larger. Schemes delivered through international firms must use BIM, and it is also mandatory on complex, specialized buildings such as hospitals and universities’. BIM mandating in UAE, is the result of BIM survey in Middle East as well as BIM adoption in the UK [36]. According to the study on BIM in the Middle East by BuildingSmartME, BIM adoption is slow in the UAE, However, some of the landmark projects are already using BIM. These include the Louvre Museum, Guggenheim, and Midfield Terminal in Abu Dhabi.

## 5. BIM Resistance and Requirements to Enhance BIM Adoption in UAE

There exist three main factors affecting BIM adoption in all construction industries. The first factor is a technology dimension which includes the interoperability between applications, software compatibility, authorising and monitoring of the quality and progress of construction, design clash detection and visualization and BIM standard and protocols. The second factor is an organisational dimension which includes BIM professionals, BIM vendors, professional trainings of BIM technologies, and support of senior management and clients [39]. The third factor is an attitude factor which includes interest in learning BIM, BIM awareness, willingness to use BIM, and perceived cost of BIM technology and platform [40]. The absence of unified BIM definition leads to confusion as to the true BIM understanding by non BIM and non-construction individuals [37]. Even though construction professionals are aware of BIM advantages in the AEC (i.e., construction) industry, there is still a lack of knowledge of the economic effects and outcomes of BIM, and there is no comprehensive list of BIM advantages and associated cost savings [41]. Lack of contractual and legal agreements is another issue. Although the BIM adoption and use benefit the industry, there are related and potentially serious contractual issues that must be addressed [42]. Lack of user security is also an important barrier to BIM implementation which contains Level of details and/or Level of Development of model, model data ownership, liabilities and fees. According to Aibinu and Venkatesh [7], there is absence of industry widespread standard for coding and classifying construction work. In addition, there is lack of skilled personnel, which leads to lack of BIM expertise and suitable conceptions to use BIM features in the market. Xu *et al.* [4] noted in their study of the Chinese construction industry and its slow BIM implementation, that the lack of skills and training is an important barrier to BIM adoption. High cost of investment and implementation are required to implement as “BIM does not come cheap” [14]. The authors also noted that there is resistance to change upon receiving the BIM model as well as more time spent on the accuracy and checking the model prior to information extraction or updating.

There is a need for further studies on BIM awareness, BIM definitions, changes, and how these challenges should be addressed. A common and agreed upon definition of BIM needs to be developed, as well as a methodology to evaluate BIM benefits from a business perspective. An accepted and validated baselines and/or benchmarks are needed. Although BIM is spreading in the AEC industry worldwide, the need for qualified expertise remains a bottleneck for a widespread BIM implementation in new projects. Clients must start to agree in the contract documentation to apply the data-rich BIM model and to use as a contractual condition. In addition, owners must adopt a new mind-set with a shift from justification using Rate of Investment (ROI) to a method of evaluation that encompasses the assessment of value and benefits of BIM in a whole project lifecycle [43]. And there is a need for BIM performance metrics that would enable the project team to measure their own success and/or failures as related to technology, process and policy [11].

## 6. Results and Analysis

This section demonstrates a detailed exploration accomplished through statistical contrasts of responses obtained from an online survey of BIM professionals in the UAE. A questionnaire was presented to potential respondent with questions on factors related to BIM implementation in UAE among different construction stakeholders. The questions posed are shown in Table 1 below. These questions were designed to be simple enough and straightforward yet specific to capture the current state of practice in the UAE as to the use and implementation of BIM. The question, in spirit at least, are not too different from what has been used in other studies and surveys.

Table 1 Survey Questions and Answers Analysis on BIM Adoption in UAE

Questions	Answers Analysis
1. How many employees are there in your organization?	The distribution of workforce of the resonances shows that 52% of the participants are working in large organization with 500 or more employees. Based on the results found, the size of the organizations in this study is not uniform, which shows a health level of interest of UAE construction professional to participate in BIM-related surveys/studies.
2. What is your level of	The second question was pointed at checking the participants experience in the UAE AEC industry. Fifty

- experience in the construction industry? percent (50%) of the respondents have 0 to 5 years of construction industry experience, which shows that they are willing to participate in the survey questioners. The lowest percentage of 3% came from professionals with more than 20 years of construction experience. The opinions noted reflect the UAE's AEC industry for valuation of the technology in terms of collaboration. As a result, the percentage of young and new construction practitioners is almost half among the ones with more than 5 years of experience. Opinions made reflect the UAE's AEC industry for valuation of the technology in terms of collaboration. As a result, the percentage of young practitioners is almost half among the ones with more than 5 years' experience.
3. Which category classifies your organization? Classification of the firms participated in the survey helps to understand different types of participants. Main contractors, consultants, and governmental sectors have 77%, 8%, and 5%, respectively. So the distribution of the participants in the survey is not a normal distribution and it shows that the main contractors have the most interest among others to participate in surveys and knowledge about BIM.
4. Since when you have heard about Building Information Modelling (BIM)? The BIM Awareness is shows that the highest percentage of participants is 43%, which illustrates the BIM existence within the past 3 to 5 years, while 20% of the participants are using BIM for more than 5 years. This indicates that due to the unique projects going on in the UAE construction industry, construction stakeholders are aware of latest technology and processes to adopt.
5. How would you rate your level of proficiency implementing BIM? The BIM skills is relatively high since most of the participants are aware if BIM which supports the results found in question 4. However, 7% are expert in BIM while and 33% and 35% are advance and moderator, relatively. This shows that participants have implemented BIM in their work. There are 10% of non-users. Those have not used BIM at all. Fifteen percent (15%) are beginners. This shows that UAE construction industry stakeholders are aware of BIM and that majority of them have moderator exposure and awareness to BIM. The results show that UAE construction professionals are motivated and interested in BIM.
6. If you are a BIM non-user, what is your thinking about BIM? Most of the participants are BIM users. In the UAE construction industry, even though that most of the participants are aware of BIM, they are still some participants who are not using BIM. Sixty percent (60%) of participants chose "Not Applicable" which indicates that they are aware of BIM. Twenty percent (20%) are open to exploring BIM's value, and only 5% are avoiding BIM since they consider it as an extra cost.
7. If you are a BIM non-user, when do you think you will use BIM? The future plans for BIM implementation were captured by this question. It is noted that 63% of the respondents said it's not applicable since they are already using BIM in their organizations. Almost 23% of the respondents noted that they will use BIM within 2 next years in their organization which supports the BIM awareness among stakeholders, and also illustrates that BIM non-users are all planning to adopt BIM within less than 5 years in their organizations. Also 12% respondents noted that they have been using BIM for 2-5 years.
8. Are you aware of BIM Maturity levels? More than half (63%) of the participants are aware of BIM maturity levels. The high percentage who are aware of the BIM maturity levels could be the result of the diverse and multi culture nature of the UAE construction industry. Around 23% of the participants did not know, and 13% are not aware of BIM maturity levels nor do they know what BIM clearly is. This is expected. Even though BIM awareness is high among construction stakeholders in UAE, there is confusion of BIM maturity levels and the true understanding of BIM deliverables and advantages at each stage of the BIM process. The results emphasis that even though BIM is mandatory by the UAE government, the lack of BIM awareness (true understanding) is because it is not mandated in all emirates (and projects) yet as discussed in the literature review.
9. Have you ever used BIM in your organization? The extent of BIM awareness and familiarity in the UAE is measured through question 4 and question 5 that indicates that BIM awareness is relatively high in the UAE. Eighty seven (87%) of the survey participants indicated that they have used BIM in their organization, which is reasonable given the high demand from clients in the UAE, and the mandatory BIM by the government. Also since most of the survey practitioners are main contractors, according to question 3, BIM is used mostly during construction and operational phase in the UAE.
10. If your answer is 'yes' to Question No. 9, please indicate the number of BIM-engaged projects that you are aware of. The depth of BIM experience is measured in this question. BIM adoption is heading towards positive growth since 62% of participants indicated they have used BIM for more than one project. Hence, the results imply a positive progress towards BIM implementation and the level of BIM skills enhancements.
11. If your answer is 'yes' to question No. 9, please indicate which types of deployment or BIM used 3D coordination, 2D drawing extraction and visualization have the highest applications among others. This was expected. BIM usage is slow, and construction stakeholders are still using BIM for 3D and visualization mostly. It's interesting that 2D extraction also have high percentage which means that BIM models are used for 3D coordination among different disciplines and 2D extractions are extracted from models. Although the BIM experts make up only 7% of BIM users in UAE, BIM skills are being used by

various BIM uses which might be due to the increased users' BIM skills over time.

12. How much do you agree or disagree with the following statements toward statements on BIM adoption in your company?

Identifying the challenges to adopt BIM is important to understand the AEC industry willingness to adopt it. When analyzing the results, 'No availability of standard and protocols' was found to be the main reason of not adopting BIM (45%). Furthermore, 'Resistance to change from the current construction methodology' is the second main reason of not adopting BIM in UAE. The third reasons are 'Lack of BIM awareness' and 'Lack of BIM awareness from cost perspective' found out to have highest resistance factors respectively. It is a sign that the AEC industry is moving towards the BIM contractual agreement for UAE AEC industry to adopt BIM.

13. In your opinion, please rank below drivers and solutions to overcome BIM barriers adoption in the UAE construction industry

Mandating BIM for construction projects has the highest rank among the best solutions, which shows that the UAE industry is willing to adopt BIM. It's shown that the highest average rate is towards the 'Increase in support from the software vendors' which shows that BIM implementation is still in the early stages in the UAE construction industry. Referring to question 5 about the variations of BIM users in UAE and lack of BIM awareness and challenges to adopt BIM, BIM software vendors need to enhance and support the market more than before in order to support BIM implementation in the UAE. Above all, the survey results reflect the high caliber of the present AEC industry's undertaking on the current situation and drivers to overcome these challenges to BIM adoption. To conclude, the above results show that the UAE industry is self-motivation towards BIM implementation in bigger ways than what was identified throughout the literature review.

14. How much do you agree or disagree with the following statements on the advantages of BIM implementation in your company?

Improve collaboration and communication with 53%, was shown to be the highest rating among other BIM benefits. It is known that BIM is known as collaborating among UAE construction stakeholders. 'Reduce rework' and enabling 3D visualization' are both noted as having the highest benefits.

15. According to the BIM mandating in UAE, when do you think that BIM will be commonly used within UAE construction industry?

In UAE, BIM is already mandatory in one emirate of Dubai. BIM non-users are going to adopt BIM within 5 years. Since BIM awareness is increasing among construction professionals, 52% and 47% of participants believe that BIM is going to be used commonly less than 5 years and within 5 to 10 years, respectively. As a result, 99% of participant's envision that BIM will be commonly used across UAE. Their high concentration towards BIM implementation will make sound successful BIM implementation establish fast and healthy growth of BIM adoption in the future.

16. Which stakeholders do you think should take leadership in BIM adoption in the UAE construction industry?

The top high disciplines according to the participants are government (45), main contractors (37), and designers (36). However, 75% of the respondents believe that government should take the leadership in BIM adoption in the future. The results clearly show that BIM is not going to be implemented in future projects unless it is part of the scope of work and mandated by the government. Government also as client for most iconic and governmental projects are required to support BIM for future construction projects.

## 7. Conclusions

BIM application spans over the project lifecycle including pre-construction, construction and post construction. Even though construction organizations are showing interest in knowing BIM, these interests are expressed as beliefs of the future and not as a fact today. Non-existence of standards and not having comprehensive BIM stated advantages and related costs and profitability are of the main challenges in BIM implementation in UAE construction industry. Professionals, educational institutions and organizations have started to adopt BIM software tools and adapt their own project delivery systems to satisfy market requirements. The literature review shows that BIM is already mandated in Dubai but for specific type of projects. BIM is not yet mandatory in all the UAE construction projects, nor is it mandated in all of the emirates. Furthermore, there is a need to develop BIM standard and BIM protocols for the UAE construction industry. A standardization of the BIM process as a whole based on the nature of UAE construction industry is a must to deliver projects with BIM Scope. Even though the BIM implementation is beginning in UAE, there is absence of BIM contractual documents. There are several software companies that are addressing some part of the BIM process. Nevertheless they do not treat the process as one whole. Hence, there is a need to standardize the BIM process to define the BIM procedures for adoption within UAE construction industry. To optimise BIM performance, the vendors and companies need to lessen the learning curve of BIM trainees. The industry will have to develop processes and policies that promote BIM use which governs BIM contractual, legal, ownership and risk management. The research shows that there are few papers published on the

UAE construction industry, and no papers were found on the BIM implementation in the UAE. Moreover, due to the recent BIM mandatory in the UAE, there is no journal paper published about it. Due to time limitations, face-to-face interviews was not possible as part of this study.

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