A proposal to facilitate BIM implementation across the South African construction industry

S Calitz, J A Wium

The value of Building Information Modelling (BIM) has been noted by the global construction industry, and several countries are facilitating BIM through national strategies and initiatives. However, the South African Construction Industry (SACI) lacks widespread and effective BIM implementation. Therefore, this study presents a proposal to facilitate BIM implementation across the industry.

A qualitative, exploratory methodology was followed involving semi-structured interviews with nine BIM experts. The interviews were analysed using thematic analysis. An understanding was gained of the challenges associated with BIM implementation across the construction industry. Possible solutions were found in terms of initiatives and strategies to facilitate and promote BIM implementation locally. Key role-players responsible for facilitating BIM implementation in the SACI were identified.

Finally, a proposal is made to facilitate BIM implementation across the local industry, which comprises three key concepts, namely leadership, strategy, and roles and responsibilities. This research contributes to BIM adoption and implementation in the SACI and can be used for future research on national BIM implementation strategies.

INTRODUCTION

Background

The fourth industrial revolution (4IR) introduced trends in the construction industry such as automation, big data, cloud computing, smart cities, and the Internet of Things (IoT). A pivotal moment in the construction industry was the introduction of Building Information Modelling (BIM). According to the International Organisation of Standardisation (ISO) 19650 standard, BIM is "*… a shared digital representation of a built asset to facilitate design, construction and operation processes to form a reliable basis for decisions.*" (BS 2019). In simpler terms, a BIM model contains all information about a built asset (graphical data, non-graphical data, and all project-related documents), allowing for better decision-making during the asset's design, construction and operational phases. BIM processes increase efficiency and productivity since it allows multidisciplinary project teams to work collaboratively and exchange information in a digital environment (Georgiadou 2019). Therefore, BIM has become the centre of digital information management processes in the Architecture Engineering Construction and Operations (AECO) industry.

The rate of BIM adoption and digitalisation still varies rapidly amongst countries and organisations because of different cultures, government initiatives and a variation in the rate of the development of national BIM standards and guidelines (Akintola *et al* 2017; Edirisinghe & London 2015). Some countries, such as the United Kingdom (UK), have recognised the economic value of BIM and put in place strategies to facilitate BIM implementation (HM Government 2015; Royal Institution of Chartered Surveyors 2020). However, South Africa has yet to reach a high level of BIM maturity across the industry (Akintola *et al* 2020; Govender 2018; Mtya 2019). Although a handful of larger AECO firms have gained some BIM capabilities, BIM implementation in South Africa is neither widespread nor optimal (Akintola *et al* 2017; Kiprotich 2014; Mtya 2019).

Calitz S, Wium JA. A proposal to facilitate BIM implementation across the South African construction industry. J. S. Afr. Inst. Civ. Eng. 2022:64(4), Art. #1450, 9 pages. http://dx.doi.org/10.17159/2309-8775/2022/v64n4a3

TECHNICAL PAPER

JOURNAL OF THE SOUTH AFRICAN INSTITUTION OF CIVIL ENGINEERING
ISSN 1021-2019 (print) | ISSN 2309-8775 (online)
Vol 64 No 4, December 2022, Pages 29–37, Paper 1450

STEPHAN CALITZ, a Candidate Civil Engineer, obtained his BEng and MEng (*cum laude*) in Civil Engineering at the University of Stellenbosch. He is currently employed as a civil engineer in the Civil and Transport Department of Lithon Project Consultants in Namibia.

Contact details:
Lithon Project Consultants
Windhoek
Namibia
T: +264 81 207 1300
E: stephan.calitz@lithon.com

Department of Civil Engineering
Stellenbosch University
Private Bag X1
Matieland 7602
South Africa

PROF JAN WIUM (Pr Eng, FSAICE) is professor in the Department of Civil Engineering at Stellenbosch University. He specialises in Construction Engineering and Management, and in Structural Engineering.

Contact details:
Department of Civil Engineering
Stellenbosch University
Private Bag X1
Matieland 7602
South Africa
T: +27 21 808 4348
E: janw@sun.ac.za

Keywords: Building Information Modelling (BIM), BIM implementation strategies, BIM adoption, digital construction, construction management

In South Africa BIM implementation is driven amongst others by the BIM Institute, the BIM Academy Africa and software developers (Natspec 2019). However, the BIM Institute operates separately from the government and software developers (Natspec 2019) and there is still a lack of collaborative efforts between the influential industry stakeholders to promote BIM.

Problem statement

Akintola *et al* (2017) report that BIM has been present in the industry since 2010; however, its implementation in South Africa has not been effective nor widespread because there is no structured approach or strategy at a national level to promote and facilitate BIM implementation. Therefore, several studies have highlighted the need for more research on BIM implementation in South Africa (Chimhundu 2015; Froise 2014; Mtya 2019). Several more recent studies also found that BIM uptake in South Africa is low compared to other countries (Govender 2018; Meno 2020; Mtya & Windapo 2019). As a result, the competitiveness of the South African construction industry (SACI) is potentially under threat, and international companies are in an advantageous position to take work from local companies (Froise 2014).

Research design

This paper presents a proposal to facilitate BIM implementation across the local construction industry. First, existing research is explored with a specific focus on BIM implementation challenges and possible solutions to mitigate the challenges. Then, a qualitative methodology is followed which entails conducting semi-structured interviews with nine BIM experts. Finally, the interview findings are compared with the literature to provide a holistic, updated account of the status and prospects regarding BIM implementation in the SACI. The research contributes to BIM research and development and provides a proposal to guide the industry on the way forward.

LITERATURE REVIEW

Value of BIM

The benefit of BIM is experienced throughout an asset's life cycle, from initiation through to operation phases. Furthermore, BIM according to the ISO 19650 standard is a collaborative process that requires input from all project stakeholders in each phase. Therefore, project stakeholders might contribute to the BIM process differently. Figure 1 illustrates how project stakeholders contribute and benefit differently to and from the BIM process.

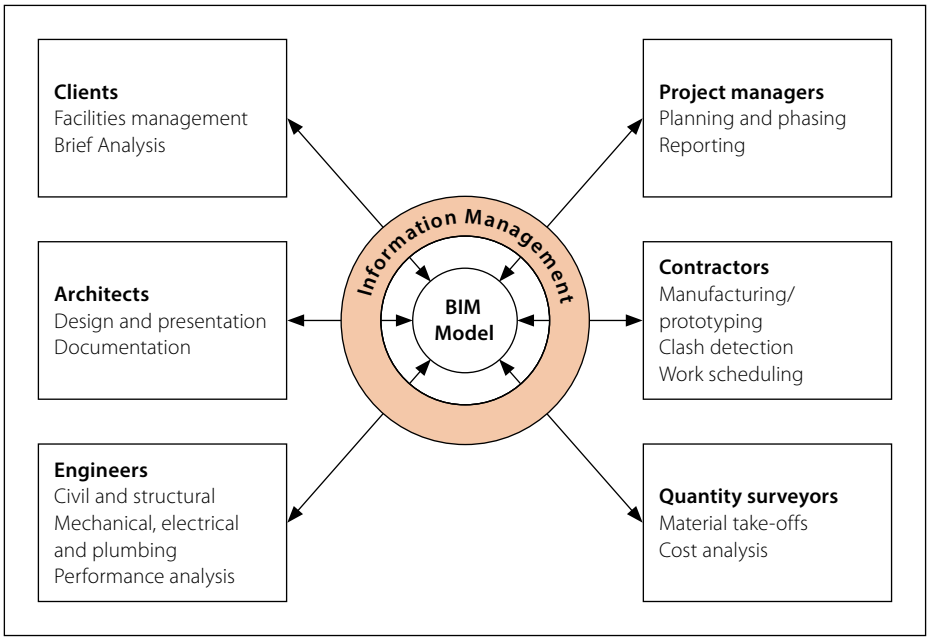

Figure 1 BIM application per project stakeholder (adapted from Ismail (2019))

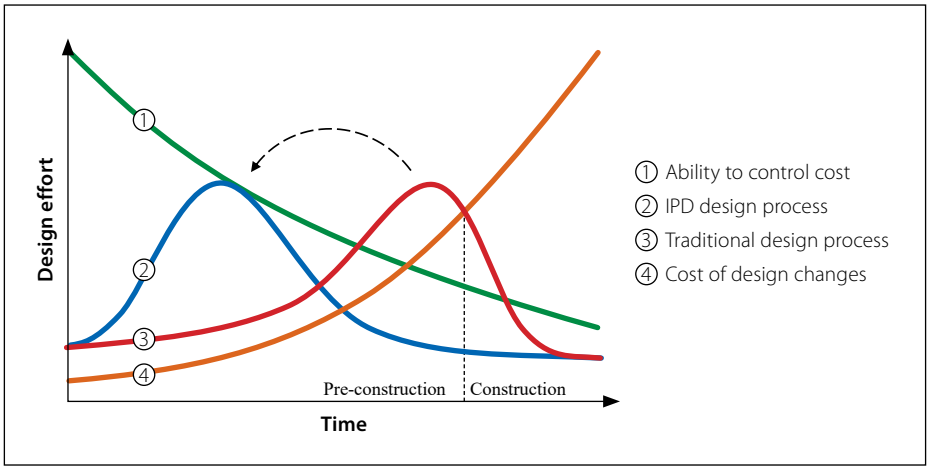

Figure 2 Traditional versus IPD design process (adapted from Smith & Tardif (2009))

Effective BIM implementation contributes to an integrated project delivery (IPD) approach (Froise 2014). The focus of an integrated project delivery approach is on project collaboration. Effective collaboration promotes quick and reliable exchange of project information, which leads to better project performance (Georgiadou 2019). Another significant advantage of BIM applied to a project is that a greater design effort is applied earlier on in the project through integrated project delivery than with traditional construction projects, as illustrated in Figure 2 (Smith & Tardif 2009).

In addition, BIM allows for the integration of multidisciplinary design fields early in the project, which reduces errors, design clashes and constructability constraints, which in turn reduces the amount of rework on a project (Ghaffarianhoseini *et al* 2017; Hwang *et al* 2019). Although the IPD process involves a similar design effort, this effort is shifted to an earlier stage (see the design effort shift in Figure 2). Putting in more effort at the start of the project enables important decisions to be made before construction commences and therefore reduces change orders later in the project, which will have a much more significant impact on the project cost (McGraw Hill Construction 2014b).

Past research on BIM implementation

BIM implementation should be considered according to the different levels or dimensions of analysis, namely organisation,

Table 1 Identified challenges to BIM implementation in the SACI

Challenges	Source from literature
Lack of BIM competency in industry and education	Chimhundu 2015; Kekana *et al* 2015; Tabesh 2015; Moodley *et al* 2016; Pillay *et al* 2018; Mtya 2019; Meno 2020
Lack of BIM research and awareness	Froise 2014; Kiprotich 2014; Chimhundu 2015; Kekana *et al* 2015; Govender 2018; Mtya 2019; Meno 2020
Lack of industry guidance and leadership for BIM implementation	Chimhundu 2015; Wortmann *et al* 2016; Akintola *et al* 2020
High implementation costs and uncertainty in returns	Kiprotich 2014; Chimhundu 2015; Akintola *et al* 2017; Meno 2020
Lack of a legal framework	Froise 2014; Chimhundu 2015; Akintola *et al* 2017; Meno 2020
Cultural and social barriers	Akintola *et al* 2017; Chimhundu 2015; Froise 2014; Meno 2020
Lack of government support	Kiprotich 2014; Chimhundu 2015; Akintola *et al* 2017; Meno 2020
Lack of support and drive from all project stakeholders and industry institutions	Akintola *et al* 2017; Chimhundu 2015; Froise 2014; Govender 2018; Kekana *et al* 2015
Ineffective traditional procurement system	Froise 2014; Chimhundu 2015; Akintola *et al* 2017; Ogwueleka & Ikediashi 2017; Govender 2018

Table 2 Identified solutions to implement BIM in the SACI

Solutions (initiatives)	Source from literature
Develop national standards and guidelines for local BIM implementation	Akintola *et al* 2017; Chimhundu 2015; Kiprotich 2014; Meno 2020; Mtya 2019; Wortmann *et al* 2016
Develop and promote education and training programmes	Chimhundu 2015; Kekana *et al* 2015; Froise 2014; Kiprotich 2014; Meno 2020; Pillay *et al* 2018; Tabesh 2015
Promote research and development in BIM	Chimhundu 2015; Froise 2014; Kiprotich 2014; Meno 2020; Mtya 2019
Increase government support	Akintola *et al* 2017; Chimhundu 2015; Froise 2014; Kiprotich 2014; Mtya 2019; Pillay *et al* 2018
Increased support from industry stakeholders	Chimhundu 2015; Froise 2014; Govender 2018; Kiprotich 2014; Meno 2020; Mtya 2019
Explore alternative procurement routes	Froise 2014; Chimhundu 2015; Akintola *et al* 2017; Meno 2020; Govender 2018; Ogwueleka & Ikediashi 2017

project, and industry (Brito *et al* 2021). While considering all levels of analysis, this study focused mainly on an industry perspective, specifically the SACI. Vidalakis *et al* (2020) proposed that BIM adoption should be facilitated in the industry through effective leadership, industry initiatives and peer education. However, Georgiadou (2019) noted that there is no single solution to implement BIM that works for everyone. Countries, projects and organisations all have different demographics and challenges that need to be overcome. Therefore, it is important to first gain a thorough understanding of BIM implementation challenges before the solutions are considered. Table 1 provides a summary of the main challenges to BIM implementation in the local industry, as identified by past research.

Although South African research on the solutions or initiatives to BIM implementation is limited, some studies have identified solutions for the limited implementation, as illustrated under various themes in Table 2.

International BIM implementation efforts

Since South Africa does not have a national BIM implementation plan or strategy, South Africa now has the advantage of developing a strategy based on experience from other countries. The BIM implementation strategies of three BIM-mature countries are roughly described in this section, namely Ireland, Singapore and the United Kingdom. Although many countries have similar strategies, these three were regarded as insightful and some aspects of these strategies could be applied to the SACI.

Ireland

The National BIM Council (NBC) of Ireland released a Digital Roadmap in 2017. The NBC consists of a committee of clients and representatives across the construction industry supply chain, and their key deliverable was to develop the National Roadmap to guide the digital transition in the built environment of Ireland (National BIM Council Ireland 2017).

The roadmap is divided into four categories: leadership, standards, education and training, and procurement. Each category contains several actions, events, or initiatives that will help improve digital uptake in the industry and improve the industry's performance. The Ireland roadmap also contains a second section where the key role-players in the industry responsible for events and activities are identified (National BIM Council Ireland 2017).

Singapore

Singapore's latest strategy involving BIM implementation is the Integrated Digital Delivery (IDD) implementation plan, which is led by the IDD steering committee (Building and Construction Authority 2018). Four million dollars were set aside as part of the IDD implementation plan to fund digital platforms that should assist construction firms to accelerate their digitalisation (Building and Construction Authority 2018). The IDD implementation plan consists of three main action plans, namely:

1. Promote and develop IDD by demonstrating it through actual projects.
2. Develop IDD platforms, solutions, and standards.
3. Increase IDD competency.

United Kingdom

The Digital Built Britain Level 3 BIM is the UK's latest strategic plan that builds on the BIS (Department of Business, Innovation and Strategy) BIM strategy and Construction 2025 (HM Government 2015). The Digital Built Britain vision does not only involve stakeholders in the construction sector, but it involves a national movement covering other sectors such as transport, education, health and finance, and includes smart cities and the digital economy (HM Government

2015). The Digital Built Britain strategy provides opportunities and innovations such as IoT, AI, smart cities and data analytics, to name a few (Royal Institution of Chartered Surveyors 2020). However, this strategy is perhaps somewhat too advanced to be adopted by South Africa, which is still at an infant BIM adoption stage.

Literature review conclusion

The literature review provided insight into the challenges and solutions of BIM implementation. In addition, the methods used by past authors were considered for the current study. Finally, the national BIM implementation efforts of Ireland, Singapore and the United Kingdom have lessons for the implementation of BIM in the South African context. The information from the literature was used as a basis to formulate a research methodology and to develop new findings in terms of BIM implementation challenges, solutions to the challenges, and national BIM implementation strategies.

METHODOLOGY

Research approach

From the past literature on BIM implementation, it is observed that quantitative studies used surveys as the main form of data collection, and qualitative studies used focus group interviews. For example, Mtya (2019) conducted a quantitative study by making use of surveys to assess South Africa's BIM maturity and capability. However, the aim of the current study is more complex, requiring an in-depth understanding. Therefore, a qualitative approach was adopted with the main form of data being semi-structured interviews with a focus group of BIM experts from the construction industry. This focus group could provide the authors with informed answers to complex questions that might have several answers or interpretations. This approach is similar to the approach taken by Sahil (2016) and Akintola *et al* (2017). Hence, these studies were used as guidance in developing the research methodology.

The chosen qualitative approach is phenomenological, similar to Sahil (2016), which is "*… a study that attempts to understand people's perceptions and perspectives relative to a particular situation*", according to Leedy and Ormrod (2016). Focus group interviews allowed the authors to study the perspectives and perceptions of BIM experts to gain insight into BIM implementation in South Africa. The study is also exploratory, similar to that of Chimhundu (2015).

Focus group demographics

The focus group participants were required to have a mature understanding of BIM and the SACI. Furthermore, the focus group needed to represent a diverse range of industry stakeholders, including architects, contractors, engineers, clients and academics, to prevent the results from being skewed towards a particular group's perspective. An adequate representation from the public and private sectors was maintained for a similar reason. Seven participants were from South Africa and two were from Ireland and New Zealand respectively but have lived in South Africa and could therefore provide meaningful insight to the discussions. The collective BIM experience of all participants adds up to a total of 68 years. Their collective experience in the construction industry adds up to 163 years. The participants' demographics, background and experience are shown in Table 3. The participants' names are not disclosed due to ethical considerations.

Data collection and analysis

Due to the rapid transformation of BIM in the construction industry, the literature alone did not contain the latest information about BIM. Therefore, there was a need to conduct interviews with BIM experts. The data collection process involved (1) the focus group selection process, (2) interview guide development, (3) conducting of the interviews, and (4) interpreting the interview results. Ethical approval for the study was obtained from Stellenbosch University under project number ING-2019-17095.

The data analysis process commenced during the interviews while the interviewer interpreted the participants' perceptions and made notes accordingly. The interview notes were sent to the participants for their review as a means of validation. Then the notes were analysed using the thematic analysis process as described by Braun and Clarke (2006). The interview responses were described using thick description, which describes the participants' perceptions in detail and captures the phenomenon's complexity to provide readers with an in-depth and complete picture of the phenomenon, allowing them to make informed interpretations (Leedy & Ormrod 2016). After describing the interview responses per question, the findings were obtained per research objective through a further step of thematic

Table 3 Participant background and expertise

Code	Background	Profession	Company type
P1	Civil engineering background from three continents. Working on government strategies to increase BIM implementation in local government.	civil engineer	client (public)
P2	Civil engineer. Experience on BIM projects internationally. Current business owner providing consulting for construction technology and digital transformation.	civil engineer	consulting (private)
P3	Owner of project management consultancy providing BIM services.	project manager	project management (private)
P4	Architectural background. BIM experience internationally. Current work involves digital twin cities, city development strategies and lean construction practices.	researcher and consultant	education (public) and consulting (private)
P5	Property developer working on an integrated BIM project in South Africa.	property developer	client (private)
P6	BIM software consultant and vendor.	software specialist	software supplier (private)
P7	Civil engineer and BIM champion, working on government projects.	civil engineer	client (public)
P8	Architectural background. Many years of BIM experience. Contributed to developing Ireland's digital roadmap. Providing BIM services and consulting.	architect, BIM specialist/ consultant	BIM consulting and support services (private)
P9	Digital engineer at a large consulting firm and running a BIM education business.	BIM manager, BIM specialist/ consultant	consulting (private)

analysis. Then the findings were compared to the literature. To conclude the process, the findings and discussion were used to develop the final proposal to facilitate BIM implementation across the SACI.

FINDINGS AND DISCUSSION

Challenges to BIM implementation

The challenges faced in South Africa were grouped according to five main themes, namely educational, cultural, legal, financial, and governmental. Although these challenges are grouped in specific themes, they should be viewed as part of an extensive system with interlinking relationships.

Educational

One of the primary barriers to BIM implementation was found to be the shortage of BIM skills in the industry. Moodley *et al* (2016), Pillay *et al* (2018) and Tabesh (2015) confirmed that the education and training curricula in South Africa did not produce graduates with the required BIM skills needed to deliver mature BIM projects. Furthermore, the participants emphasised the general lack of BIM awareness in the industry, especially among contractors and asset owners. P6 (from Table 3) claimed that industry professionals have a misinformed view of BIM, which prevents them from adopting it. Govender (2018) explained that this misinformed view is a result of the lack of efforts from industry institutions publishing information about BIM since they are responsible for informing and guiding the industry.

Cultural

Another common challenge was found to be the resistance to change. Industry professionals are used to a certain way of carrying out tasks and delivering projects, and are reluctant to explore modern processes. This was reflected in the literature by Akintola *et al* (2017), Chimhundu (2015) and Froise (2014). Another significant theme that was identified from the interview responses was the lack of collaboration between project stakeholders. Due to the competitive culture of the South African construction industry, project stakeholders are used to working in silos. However, working in silos is detrimental to the success of a BIM project, since a BIM project requires collaboration amongst stakeholders. Froise (2014) reinforces that the lack of collaboration in the industry creates a fragmented culture.

Legal

The two major themes regarding the legal challenges to BIM implementation were found to be the lack of formal guidance on projects regarding BIM processes and deliverables, as well as the outdated procurement system. Similarly, Akintola *et al* (2017) highlighted the lack of guidance in the form of BIM standards. Govender (2018) explained that, due to the traditional procurement system and the way contracts are setup, project stakeholders are hesitant to share information with one another, creating information silos. This lack of collaboration inhibits effective BIM implementation.

Financial

It was found that organisations in the SACI perceive BIM implementation as expensive and risky. Implementing BIM requires initial investments in upskilling, training, upgrading hardware and network infrastructure, and software licences. Although there is some debate about whether BIM is profitable or not, some participants strongly suggested that the expensive software licences do not meet the industry and market demands of South Africa. Furthermore, participants highlighted the risk of theft and vandalism, especially on rural and low-income sites in South Africa.

Governmental

The research found that there is a lack of government drive in promoting and facilitating BIM across the construction industry. Since 57% of construction projects in South Africa are publicly funded (CIDB 2021) and the industry is heavily regulated by public bodies (Anthony 2017), government leadership has a significant impact on BIM implementation. The importance of government policies and regulations was confirmed as a critical driver of uniform BIM implementation (Gu & London 2010; Porwal & Hewage 2013). The concern that evolved from the interview discussions was it would seem that the majority of industry experts are from the private sector and that the public sector may lack the expertise and competency to drive BIM. Furthermore, several participants mentioned that there is an industry perception that technology adoption contradicts government job creation initiatives.

Possible solutions to facilitate and promote BIM implementation

Raising awareness

From the interviews, it seemed that the first step towards increasing BIM uptake was to raise awareness across the industry. P1 (from Table 3) mentioned the need to initiate discussions between the private sector, the public sector, and educational institutions. Similarly, Froise (2014) recommended that contractors, as well as all organisations across the supply chain, should be made aware of BIM. P7 noted that BIM awareness could also be aimed at the public, which could promote public participation and excite the public about future projects.

Education and training

A major point of discussion was the need for a national upskilling programme aimed at developing the digital skills of existing employees and students. Similarly, Moodley *et al* (2016) also recommended the concept of a national education and training programme to upskill the industry. P6 and P8 mentioned that people need to learn how to produce, manage and exchange digital information. P1, P2 and P4 recommended allocating a percentage of a project's profit margin towards implementing BIM and upskilling the workforce's digital capabilities.

In addition to education and training, it was found that more research is needed on the impact of BIM in South Africa, which is supported by earlier studies by Chimhundu (2015) and Mtya (2019). Since BIM processes are rapidly evolving, it is essential to carry out continuous research to establish the current best standards for BIM implementation. This will change in time as the technology develops and the country's BIM maturity increases. Furthermore, there is a need to research the required skill sets in the industry to establish how university curricula need to be updated to produce competent graduates. It was found that built environment faculties should collaborate with the industry to develop a strategy to upskill the industry.

Promoting pilot projects

Promoting pilot projects and case studies was a commonly mentioned initiative to increase BIM uptake. Well documented case studies could provide proof of the concept to show organisations that BIM implementation is profitable in South Africa. Furthermore, case studies could be used to establish BIM guidelines and develop BIM standards and policies. The concept of pilot projects formed a key part of Singapore's integrated digital delivery strategy (Building and Construction Authority 2018), which motivates the need for such an initiative.

Developing standards

Similar to the concept of case studies, it was perceived that the development of a national BIM standard for South Africa could accelerate BIM uptake across South Africa, since standards dictate a best practice to implement BIM and guarantee success. Therefore, implementing BIM according to a BIM standard should be less risky, as explained by P4. Furthermore, a national BIM standard would eliminate confusion and fragmented BIM implementation (Akintola *et al* 2017; Chimhundu 2015; Mtya 2019). At the time of the interviews several participants suggested that the ISO 19650 standard be adapted to South Africa since it is regarded as the current international BIM standard (part of this standard has now been published in 2022 as SANS 19650-1). Akintola *et al* (2017) noted the importance of such a national standard being a jointly agreed upon document from a selected group of industry professionals and BIM experts representing the private and public sectors. The process of adopting the various parts of EN 19650 and development of related national annexes should therefore proceed.

Updating procurement systems

The participants commented that traditional procurement systems inhibit collaborative practices such as BIM and IPD. The need to update procurement systems in South Africa was confirmed by Windapo (2017). Participants suggested that contracts should accommodate the application of BIM systems and processes, addressing intellectual property and copyright concerns.

Developing software that meets South African needs

The study found that available software packages might not meet the SACI and market demand. P4 explained that the commonly used software packages are aimed at large AECO firms while the bulk of the industry consists of smaller firms. Similarly, Chimhundu (2015), Kiprotich (2014) and Mtya (2019) confirmed that smaller organisations struggle to implement BIM and that the available software does not meet their needs.

Government initiatives

Another solution identified was that the government should mandate BIM on public projects. P1 recommended the implementation of a framework with "hard" and "soft" mandates. "Soft" mandates mean that BIM is encouraged, promoted and preferred, and "hard" mandates mean BIM is formally enforced.

The participants reasoned that government organisations should realise the value of BIM and conform to the global trends of digital transformation to start developing digital and smart cities. The UK has been mandating BIM on public projects for several years, and it forms part of their Digital Built Britain agenda and development of smart cities. P5 recommended that the government could require building plan submissions in the form of electronic submissions rather than paper hard copies, which is what Singapore started to do many years ago (McGraw Hill Construction 2014a). Even though the digital competency might not yet lie within the governmental bodies to effectively construct and operate smart cities, the digital data could still be collected to be used in the future. Data is a valuable asset in today's digital era.

Key role-players responsible for facilitating BIM implementation

Many past studies have dealt with the challenges to BIM implementation in South Africa and identified some solutions to mitigate these challenges. However, limited research covers the important role-players needed to facilitate, accelerate and promote BIM implementation in South Africa. P8 emphasised the importance of leadership and accountability when it comes to BIM implementation. Therefore, this section covers the main role-players needed to increase BIM uptake in South Africa.

The SACI is a complex environment consisting of many different organisation types from the public and private sectors, each contributing to the delivery of construction projects. This complex environment makes it impossible to identify single organisations that could be responsible for facilitating BIM implementation across the industry. Therefore, this study considered the interview discussions and divided the industry up into four main functional groups that play a significant role in BIM implementation. The four groups are government, the education sector, private organisations, and software developers. It should be noted that some organisations may fall into multiple categories or functional groups and these main groups are developed purely for simplification reasons. The role and description of each of these groups are discussed below.

Government

To simplify, the government group consists of all government entities, municipalities, industry bodies, professional institutions, and voluntary associations (including the Engineering Council of South Africa (ECSA), the South African Institution of Civil Engineering (SAICE), Consulting Engineers South Africa (CESA), South African Institute of Architects (SAIA) …). The reasoning behind this grouping was that these organisations all play a role regarding governance, regulation, legislation and professionalism. Furthermore, government plays the role of being an initiator and driver, regulator, educator, funding agency, demonstrator and researcher (Ethiopian Construction Project Management Institute 2019).

Education sector

The education sector consists of organisations that provide training, education and research, such as universities, colleges, schools, training centres and research centres. These organisations are publicly or privately funded. The education sector plays an important role in research and development and in producing competent professionals. Furthermore, research is needed on the impact of BIM and the newly required skill sets and professions in the SACI. Furthermore, the education sector is responsible for teaching professionals the requisite technical BIM skills of how to produce, manage and exchange digital information.

Private organisations

Private organisations refer to all construction project organisations that are privately funded, such as architects, engineers and other consultants, contractors, clients, and all other organisations across the supply chain. Private organisations have the most difficult task among the four identified role-players, since BIM implementation within these firms requires private investment, which puts the business at risk. Furthermore, BIM adoption requires new skill sets and processes to be implemented in a firm. Therefore, effective change management is essential to increase a firm's digital or BIM competency. However, P8 explained that organisations such as those of architects, engineers and contractors, practise a professional service. Hence, it is their responsibility to remain updated on industry trends and to carry out their service using the best available tools and processes.

Software developers

Software developers play an important role regarding BIM implementation since they develop the platforms used to carry out BIM processes. According to Akintola *et al* (2017), software vendors were at the time the current drivers of BIM in South Africa due to the lack of government intervention. However, P4 mentioned that BIM software is aimed at the international market and does not suit the SACI and market needs. Therefore, software developers could find the opportunity in the market and produce software that meets the South African demographics. For example, they could produce simpler products with limited functions at a better price, aimed at smaller contractors who make up the bulk of the industry. Furthermore, software developers have the responsibility to train professionals on software use and provide technical support.

PROPOSAL

While some groups and organisations in South Africa are promoting the implementation of BIM in their sectors, the local industry lacks a coordinated effort to drive the process. From this investigation the authors were able to obtain a holistic perspective on the phenomenon, which allowed for the development of a proposal to facilitate BIM in the SACI. The proposal is based on the findings from the interviews and the literature. The discussion below presents the proposal under three headings, namely leadership, strategy, and roles and responsibilities.

Leadership

Throughout the literature and the interviews, it was found that leadership is vital for the success of BIM implementation in the industry. Other countries formed organisations to lead the industry. For example, Ireland established a National BIM Council, and the UK a BIM Task Group. It seemed that most of these committees, councils or boards consist of experts and professionals representing various fields of the industry. A similar approach is proposed for South Africa – such a local group could be called the South African National BIM Council (SANBC).

The SANBC could be separate from the existing industry bodies, professional institutions and voluntary associations such as the Construction Industry Development Board, the Council for the Built Environment, or SAICE. However, these industry bodies could have representatives in the SANBC, and the initiatives proposed by the SANBC could be reflected and executed by these industry organisations. Since the key role-players responsible for facilitating BIM across the construction industry were identified as the government, the education sector, private organisations and software developers, the representation of these groups in the SANBC is critical to the success of BIM leadership in the SACI.

Strategy

Once the SANBC is established, a clear BIM strategy or action plan with specific initiatives should be developed. For example, Ireland's NBC developed a "digital roadmap" to guide the industry. This strategy could include clear goals to develop the construction industry, such as those set by the UK in their Government 2025 strategy. However, the UK's latest goals in their Digital Built Britain agenda include goals reaching broader than just the construction industry and involve a digital agenda towards smart cities and IoT. South Africa could consider adopting some aspects of these global strategies towards a South African BIM strategy, while considering the nature and demographic makeup of the construction industry.

Pilot projects could form a central part of a national BIM strategy since it was a common theme in the interview discussions, and it was part of Singapore's IDD strategy. Well documented pilot projects could provide proof of concept while upskilling the industry. Pilot projects could be monitored through research. The research could update the BIM strategy, develop new guidelines and standards, and further guide the industry.

Roles and responsibilities

Leadership and strategy could give the industry direction. However, the strategy needs to be executed and monitored. Therefore, the main industry role-players could be assigned specific roles and responsibilities aligned with the strategy. The proposed initiatives falling under the main industry role-players are shown in Figure 3.

These initiatives are adopted from the findings of the interview discussions. The layout of Figure 3 suggests that the SANBC

South African National BIM Council (SANBC)

- Lead BIM implementation while guiding industry stakeholders in their role.
- Act as the sole source of information released about BIM in the South African construction industry.
- Develop a national BIM implementation strategy and action plan.
- Develop BIM standards.
- Raise awareness through discussions, seminars and workshops.
- Initiate and monitor BIM incentives.
- Initiate pilot projects and document them as case studies.

Government	Education sector	Private organisations	Software developers
■ Develop a BIM implementation framework with hard and soft mandates. ■ Update contracts and procurement systems. ■ Collect data to develop digital and smart cities. ■ Adapt regulations and policies. ■ Develop incentives towards BIM education such as subsidies and tax reliefs.	■ Develop a national upskilling and education programme. ■ Conduct research on BIM in South Africa, including the industry's skill demand. ■ Update university curricula to release BIM competent graduates. ■ Upskill the industry.	■ Determine the business value of BIM and develop an organisational strategy to implement BIM. ■ Implement BIM and upskill the organisation. ■ Partner with other organisations.	■ Provide software that matches the South African industry and market needs. ■ Provide technical BIM support.

Figure 3 Roles and responsibilities of main industry role-players

represents the leadership or drivers of the four main industry groups or role-players.

CONCLUSION

It was identified that there is not widespread and effective BIM implementation in the SACI, which threatens the industry's competitiveness. Therefore, the study aimed at developing a proposal to facilitate BIM implementation across the SACI.

The research provides an updated report on the challenges to BIM implementation faced by the construction industry and to the solutions, in terms of initiatives and strategies, to mitigate these challenges. The key role-players responsible for BIM implementation in the SACI were identified, namely, the government, education sector, private organisations and software developers.

Finally, a proposal is made to facilitate BIM implementation across the SACI, which entails three key concepts, namely leadership, strategy, and roles and responsibilities. This research could assist the industry to become aware of the challenges to BIM implementation and it could guide industry stakeholders on what can be done to increase BIM uptake in the industry.

Valuable findings

This section presents new and significant findings to BIM research in South Africa:

- BIM implementation is a significant challenge in the South African context, due to the costs associated with network infrastructure upgrades. Furthermore, the risk of theft and vandalism poses a specific challenge.
- A key finding is that the government should start collecting digital data to develop digital and smart cities, to benefit from the operational and maintenance benefits. Clients, public or private, could require building plan submittals in the form of BIM models.
- The available BIM software does not meet the specific demands of the SACI and market needs. The bulk of the industry consists of smaller organisations that do not find much benefit in complex, expensive software aimed at large international firms.
- There is a growing demand for digitally skilled professionals, especially regarding BIM modelling and software development.

Recommendations

The proposal to facilitate BIM implementation mentioned the need for investigating the impact of BIM, the skills demand and the software demand. In addition, the recommendations for future research include:

- The change in required digital skills to prepare for future changes and required skill sets.
- Determining the best way to measure and compare BIM maturity amongst organisations and countries.
- Measuring BIM maturity in South Africa and continuously assessing the maturity increase amongst different organisations and project types.
- Continuously researching whether the available software and technology in the market meet the needs of South African firms, especially smaller firms with limited budgets.
- Best practices in South Africa to implement BIM in an organisation, in a project and in the industry (case studies could form an essential part of this research).

REFERENCES

Akintola, A, Root, D & Senthilkumar, V 2017. Key constraints to optimal and widespread implementation of BIM in the South African construction industry. *Proceedings,* 33rd ARCOM Annual Conference, 4–6 September 2017, Cambridge, UK, 25–34.

Akintola, A, Venkatachalam, S & Root, D 2020. Understanding BIM's impact on professional work practices using activity theory. *Construction Management and Economics,* 38(5): 447–467.

Anthony, A 2017. Best practice in South African construction procurement law. Chapter 16. In Thai, K V (Ed), *Global Public Procurement Theories and Practices.* Cham, Switzerland: Springer, 291–310.

Braun, V & Clarke, V 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology,* 3(2): 77–101.

Brito, D M, Ferreira, E A M & Costa, D B 2021. Framework for Building Information Modelling adoption based on critical success factors from Brazilian public organizations. *Journal of Construction Engineering and Management,* 147(7).

Building and Construction Authority 2018. *Media release on IDD implementation plan.* Singapore: Building and Construction Authority.

Chimhundu, S 2015. *A study on the BIM adoption readiness and possible mandatory initiatives for successful implementation in South Africa.* MSc Dissertation. University of the Witwatersrand.

CIDB (Construction Industry Development Board) 2021. *Construction monitor – supply and demand.* Pretoria: CIDB.

Edirisinghe, R & London, K 2015. Comparative analysis of international and national level BIM standardization efforts and BIM adoption. *Proceedings,* 32nd CIB W78 Conference, (Applications of IT in the Architecture, Engineering and Construction Industry), 26–29 October 2015, Eindhoven, Netherlands, 149–158.

Ethiopian Construction Project Management Institute 2019. *Roadmap for adoption and implementation of BIM technology in the Ethiopian architectural, engineering and construction (AEC) industry.* Addis Ababa.

Froise, T 2014. *Building information modelling as a catalyst for an integrated construction project delivery culture in South Africa*. PhD Thesis. Port Elizabeth: Nelson Mandela Metropolitan University.

Georgiadou, M C 2019. An overview of benefits and challenges of building information modelling (BIM) adoption in UK residential projects. *Construction Innovation*, 19(3): 298–320.

Ghaffarianhoseini, A, Tookey, J, Ghaffarianhoseini, A, Naismith, N, Azhar, S, Efimova, O & Raahemifar, K 2017. Building Information Modelling (BIM) uptake: Clear benefits, understanding its implementation, risks and challenges. *Renewable and Sustainable Energy Reviews,* 75: 1046–1053.

Govender, K 2018. The awareness of integrated project delivery and building information modelling: Facilitating construction projects. *International Journal of Sustainable Development and Planning,* 13(1): 121–129.

Gu, N & London, K 2010. Understanding and facilitating BIM adoption in the AEC industry. *Automation in Construction*, 19(8): 988–999.

HM Government (UK) 2015. *Digital Built Britain level 3: Building Information Modelling – strategic plan*. London.

Hwang, B G, Zhao, X & Yang, K W 2019. Effect of BIM on rework in construction projects in Singapore: Status quo, magnitude, impact, and strategies. *Journal of Construction Engineering and Management*, 145(2): 1–16.

Ismail, M 2019. BIM implementation: Theory and practices. *BIM Talk.* BIM Africa.

Kekana, G, Aigbavboa, C & Thwala, W 2015. Understanding Building Information Modelling in the South African construction industry. *Proceedings,* Organization, Technology and Management in Construction (OTMC) Conference, Primošten, Croatia, 2–6.

Kiprotich, C 2014. *An investigation on Building Information Modelling in project management: Challenges, strategies and prospects in the Gauteng construction industry, South Africa.* MSc Dissertation. University of the Witwatersrand.

Leedy, P D & Ormrod, J E 2016. *Practical Research: Planning and Design,* 11th ed. Vol. 12. Harlow, UK: Pearson.

McGraw Hill Construction 2014a. *The business value of BIM for construction in major global markets*. SmartMarket Report.

McGraw Hill Construction 2014b. *The business value of BIM for owners*. SmartMarket Report.

Meno, T 2020. *An assessment of risk associated with digitalisation in the South African construction industry*. University of Johannesburg.

Moodley, V, Mathye, K & Radebe, S 2016. *Teaching BIM in schools of architecture of South African universities*. University of Witwatersrand.

Mtya, A 2019. *Evaluation of Building Information Modelling (BIM) adoption, capability and maturity within South African consulting and construction firms*. MPhil Thesis. University of Cape Town.

Mtya, A & Windapo, A 2019. Chapter 13: Drivers and barriers to the adoption of Building Information Modelling (BIM) by construction firms in South Africa. In Wu, P & Wang, X (Eds), *Innovative Production and Construction*. Singapore: World Scientific Publishers, 215–223.

National BIM Council Ireland 2017. *Roadmap to digital transition for Ireland's construction industry 2018–2021*. Dublin.

Natspec 2019. *Global 2019 update report*. Sydney, Australia: International Construction Information Society.

Ogwueleka, A C & Ikediashi, D I 2017. The future of BIM technologies in Africa: Prospects and challenges. In Wu, P & Wang, X & Li, H (Eds), *Integrated Building Information Modelling*. UAE: Bentham Science, 307–314.

Pillay, N, Musonda, I & Makabate, C 2018. *Use of BIM at higher learning institutions: Evaluating the level of implementation and development of BIM at built environment schools in South Africa*. University of Johannesburg.

Porwal, A & Hewage, K N 2013. Building Information Modelling (BIM) partnering framework for public construction projects. *Automation in Construction*, 31: 204–214.

Royal Institution of Chartered Surveyors (UK) 2017. *Building Information Modelling for project managers*. London.

Royal Institution of Chartered Surveyors (UK) 2020. *The future of BIM: Digital transformation in the UK construction and infrastructure sector*. London.

Sahil, A 2016. *Adoption of Building Information Modelling in developing countries: A phenomenological perspective*. Master's Dissertation. Colorado State University.

SANS 19650-1 2022. *Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling - Part 1: Concepts and principles*. Pretoria: South African Bureau of Standards (SABS).

Smith, D K & Tardif, M 2009. *Building Information Modelling: A strategic implementation guide for architects, engineers, constructors, and real estate asset managers*. New York: Wiley.

Tabesh, M 2015. *An investigation to introduce BIM in undergraduate civil engineering teaching to improve construction processes*. MEng Dissertation. Stellenbosch University.

BS (British Standard) 2019. *ISO 19650-1. Organization and digitization of information about buildings and civil engineering works, including building information modelling – Information management using building information modelling. Part 1: Concepts and principles*. London: British Standards Institution.

Vidalakis, C, Abanda, F H & Oti, A H 2020. BIM adoption and implementation: Focusing on SMEs. *Construction Innovation*, 20(1): 128–147.

Windapo, A 2017. *Determinants of the sustainability and growth of construction contractors*. University of Cape Town. DOI: 10.20944/preprints201707.0091.v1.

Wortmann, A E, Root, P D S & Venkatachalam, D S 2016. Building Information Modelling (BIM) standards and specifications around the world and its local applicability to the South African AEC sector: A critical review. *Proceedings*, 1st International BIM Academic Forum (BAF) Conference, 13–15 September, Glasgow, Scotland.