Existing Practices of Building Information Modeling (BIM) Implementation in the Public Sector

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***Abstract*— The Government of Malaysia has taken a proactive action by implementing the strategic ICT-driven or ICT-enabled transformation programmes and ICT plays a critical role in ensuring their efficient and effective implementation. However regardless the efforts, the implementation of BIM in Malaysia mostly on the private sector driven and it is still between BIM level 0 and BIM level 1. As many of countries across the globe have shown great interest and their public sector plays an important role in leading the market towards BIM adoption, the Government of Malaysia and its agencies by capitalising the existing hard and soft-infrastructures in Malaysia should play significant roles to help in stimulate BIM technology in Malaysia to be comparable with other developed countries. This paper through literature review aims to establish a clear understanding about the global BIM implementation in the public sector, to determine the public sector readiness to adopt BIM in Malaysia and to investigate the potential of BIM implementation within the public sector. In addition, suggestions on the focus of the other research papers on BIM implementation within the public sector will be included.**

***Keywords*—** *Building Information Modelling, Public Sector, Electronic Submission, Malaysia Public Sector*

1. Introduction

Globally, the public sector plays an important role in leading the market towards BIM adoption. In the USA, General Services Administration (GSA) is the major public client that has implementing BIM in the public sector [1]. Along with the USA, the public sector of other countries such as the UK, Finland, Norway, Denmark, Hong Kong, Australia and Singapore have also started on BIM adoption [1-4].

Most importantly, several countries across the globe have shown great interest in the direction of BIM implementation within the construction industry. However every country features its own planning and has evolved in a different way. A study conducted by McGraw Hill Construction has shown that the overall construction sector across the world is gaining great value from BIM, with 75 per cent of contractors utilising BIM globally showing positive returns on BIM investments [5]. The report shows that contractors in the UK, US, Canada, France and Germany are utilising BIM progressively. Meanwhile, contractors in Australia, New Zealand, Japan, South Korea and Brazil are still in the early phases of the use of BIM [5].

As the rest of the world moves towards adoption of BIM technology, Singapore is the first country that has proved successful BIM can be used in the public sector through electronic submission. Singapore would not want to be left behind, causing the public sector to take the lead in driving wider BIM adoption despite the fact that there is a lack of demand for BIM during BIM adoption [4]. Therefore, it suggests that the public sector plays a

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significant role in expediting BIM adoption throughout the industry.

However, the situation is contrary to Malaysia, the neighbouring country of Singapore. In Malaysia, regardless the efforts in transforming the nation to become a high-income and developed nation by the year 2020 through the ICT-driven or ICT-enabled strategic programmes, adoption of BIM in Malaysia is mostly driven by property developers and contractors, while the government mainly supports the training for BIM adoption [5].

Therefore, the main objective of this study is to review the implementation of the Building Information Modeling (BIM) in the public sectors of few countries including Malaysia. At the end of this study, the reader will understand the BIM, adoption of BIM and the room for implementation of BIM in Malaysia.

2. Literature review

2.1 Building Information Modeling (BIM)

Currently, there are many different definitions of BIM. A couple of definition from the idea of Building Information Modeling focuses on the model and information attached to that model. According to Kiviniemi, Tarandi et al. [6], Building Information Model is an object-oriented, architecture engineering construction (AEC) specific model and a digital representation of a building to facilitate exchange and interoperability. Then, it moves to the idea of Building Information Management which is about creating, using and maintaining digital information for the integrated design, construction and operations of a building by Kiviniemi [7]. Whereas, Building Information Model (BIM) is defined by international standards as "shared digital representation of physical and functional characteristics of any built object […] which forms a reliable basis for decisions" [8].

For the purpose of this research, the BIM definition refers a set of interacting policies, processes and technologies (as illustrated in Figure 1) that generate a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle [9].

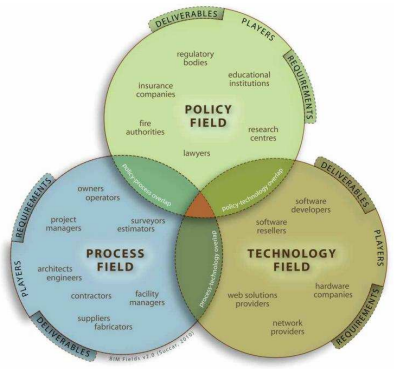

Figure 1 - The interlocking fields of BIM implementation [9]

It is also important to highlight that, from a technical aspect, BIM adoption has improved the collaboration among project stakeholder, minimising errors and field changes and producing a more efficient and reliable delivery method that reduces cost and time in the whole life cycle of a building project [10]. This is of course support the public sector initiative to enhance their delivery services via adoption of the latest knowledge and technologies.

2.2 BIM adoption

According to Rogers [11], adoption is a decision to make full use of innovation as the best course of action available. At the same time, Rogers [11] defined technology adoption as the process through which organisations or individuals decide to make full use of an innovation in their daily businesses. Meanwhile, Khasawneh [12] claims that technology adoption is the first use or acceptance of a new technology or new product. Therefore, in this case BIM adoption would be the process where organisation or individuals decide to accepting and utilising BIM technology.

The obvious impacts of new technology adoption are the benefits gained by the user and the costs of adoption [13]. Due to the fact that the adoption of BIM results in additional cost such as training staff on new process and workflow, training staff on new software and technology, purchasing software and technology, and change in work process [14].

Meanwhile, the adoption of BIM is divided into three groups of activities covering various scopes and it indicates that BIM is able to integrate

technologies and processes through attributed 3D models [15-16]. These groups are:

- Within an office involving software determination, dealing with IT issues and training.
- Across the design team involving software determination, dealing with IT issues, as well as contractual and legal issues.
- Across the project delivery team involving procedural scope such as design, estimating, coordination, scheduling, submittal review, fabrication, review agency and facility management as well as contractual and legal issues.

Apart from that, the level of BIM adoption can be defined by using the Bew-Richards Diagram. In 2008, Mervyn Richards and Mark Bew developed the BIM Maturity Diagram which indicates the BIM maturity development process from Level-0 to Level-3 BIM, as shown in Figure 2 [17].

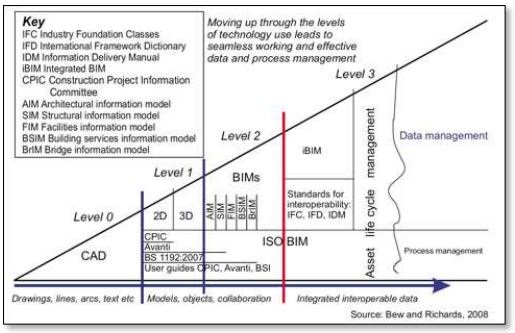

Figure 2 - BIM Maturity Diagram [17].

The diagram illustrates in what way the implications of data and process management have on BIM and a brief outline of every level is listed below [18].

Level 0 - Use 2D CAD files to produce data and exchange information.

Level 1 - There is a collaboration tool with a common data environment to manage 2D or 3D formats with some standard data structures and formats.

Level 2 - The production of 3D models with attached information in separate BIM tools and the integration based on proprietary interfaces. 4D and 5D cost elements can be included in this approach.

Level 3 - This is fully implemented BIM managed by a collaborative model server which supports fully open process, web based data integration, using IFC standards [18].

3. Methodology

This paper is part of an on-going research on the potential use of the BIM-based electronic submission in Malaysia. In order to ensure that the data is gathered comprehensively and accurately, multiple approaches including literature and semi-structured interviews have been employed.

Literature review is a fundamental step to narrow the scope and define the aim of the study. Wisconsin [19] believed that an in depth literature review is a "critical analysis of a segment of a published body of knowledge through summary, classification, and comparison of prior research studies, reviews of literature, and theoretical articles." It undoubtedly is important in establishing familiarity with a body of knowledge and ascertains credibility through incorporating and summarising what is known in an area. Hence its will provide a direction of research beforehand as it provides a chance to gain knowledge from others and show how an existing project is linked to it, and stimulate new ideas before formulating hypotheses to be tested. This is precisely what this paper intends to present.

Through the literature review, the definition, concept, application, and related issues of BIM implementation in the public sector is examined and highlighted. All the data and information are compiled directly from journals, proceeding and bulletin, reports, books, articles and other printed materials internationally and nationally. As being discussed as above, this is very important and helpful in the process of developing the theoretical sections of the actual research.

In addition, a multiple case study approach has been chosen and semi structured interview was conducted for the purpose of a better understanding of the current status of adoption of BIM in the Malaysian public sector, as well as to identify the

its potential to facilitate electronic submission concerning building approval. Fifteen semi-structured interviews were conducted with participants on different hierarchical levels within public sector bodies. The main goal of the interview is to gain knowledge of adoption of BIM, their view, barriers for use and to assess the potential of BIM for building plan approval. Since BIM technology is still new in Malaysia, no public sector has implemented BIM in their organisation. Therefore, the interviews were conducted with selected local authority officers, public sector body officers and researchers. The participants were chosen for their relevance to the conceptual questions and they have experience in processing building plans, planning permission, project development and electronic submission.

4. Global BIM implementation in the public sector

The following section reviews the current status of BIM implementation in the public sector around the world including Singapore, Hong Kong, USA, UK, Finland, Denmark, Norway and Australia. There are some countries where BIM is not promoted, whereas others mandate the use of BIM with BIM guidelines.

4.1 Singapore

In August 1991, the government of Singapore introduced an information technology master plan (IT200) with a vision to transform Singapore into a global centre for science and technology. One of the major economic sectors that had been recognised that could exploit information technology (IT) was construction and real estate. Therefore, in September 1995 the Construction and Real Estate NETwork (CORENET) was launched during the BauCON Asia ’95 Conference in order to reengineer and streamline the fragmented work processes in the construction industry [20]. Since then, CORENET has undergone several stages of development and enhancement. In 1997, CORONET e-PlanCheck was introduced and has utilised BIM in order to automatically check electronic building plans for compliance to regulatory requirements [21].

The Building and Construction Authority (BCA) is continually encouraging CORENET in collaboration with other regulatory authorities and several industry associations, for instance the Urban Redevelopment Authority, the Land Transport Authority, the Public Utility Board, Singapore Power, the Housing & Development Board, the Singapore Institute of Architects, the Institution of Engineers, the Association of Consulting Engineers, the Real Estate Developer's Association, and the Singapore Contractor Association [21].

In 2008, Singapore launched the Construction Real Estate NETwork (CORENET), the world’s first Building Information Modelling (BIM) electronic submission [4]. CORENET streamlines the procedure for regulatory submission which enables the project team to submit only one building model that contains all the required information. Influenced by this accomplishment, Norway, Australia and Japan have utilised CORENET as a basic principle for their pilot projects [21]. On the other hand, in the USA all General Services Administration (GSA) construction projects are required to submit BIM data via the Spatial Program Validation and Automated Design Guide Checking [22].

In 2010, BCA implemented the BIM Roadmap with a few strategies that had been identified, to mandate the use of BIM, and the public sector organisations initiated the promotion by leading the way in introducing BIM requirements for all new public sector building projects started in 2012 [4]. Apart from that in 2011, the BIM Roadmap has been revised to steer the industry towards wide adoption of BIM by 2015 [23].

In addition, in May 2012 the Singapore BIM Guide version 1.0 was published with the aim of giving clarity on the requirements of BIM usage at different stages of a project [24]. In year 2013, the Singapore BIM Guide version 2 was released to encourage BIM adoption [25]. While the BIM Essential Guide Series was also released in order to provide references on good BIM practices and are targeted at new BIM users in Singapore [26].

4.2 Hong Kong

Since year 2006, Hong Kong’s Housing Authority (HA) has initiated BIM on a trial in a few of their developments of public rental housing projects and the HA has set a target for full implementation of BIM in year 2014 and 2015 [27]. In year 2009, the HA decided to utilise BIM in selected projects as well as the development of standard modular flats

and libraries design [3]. In addition, the HA has set up a BIM Centre and published a BIM Standards Manual, BIM User Guide and BIM Library Components Design Guide with the purpose of facilitating the process for successful implementation of BIM [28].

At the same time, Hong Kong Institute of Building Information Modelling (HKIBIM) was established and it was the first professional institute in the world for promoting and facilitating BIM applications [3]. HKIBIM plays a role by creating a medium for communications among several stakeholders which includes the government departments and the construction-related professional institutions [3].

4.3 USA

In the USA, the General Services Administration (GSA) announced a National 3D-4D-BIM program through the Office of the Chief Architect of its Public Buildings Service (PBS) in 2003 [29]. The PBS is the main administrator of the commercial area as well as administering workspaces for the federal government in the US [22]. At the same time, the GSA utilises BIM technology such as simulation, visualisation, coordination, and optimisation from 3D and 4D to develop quality and efficiency throughout the lifecycles of its projects. In 2007, the GSA enforced the utilisation of BIM for spatial program validation to be delivered in advance of final concept delivery on all its projects [30]. Therefore for that purpose, GSA has released a series of guides to facilitate the spatial program validation, and especially for several areas of its 3D-4D-BIM program including energy performance, 3D laser scanning, 4D phasing, circulation, building elements and facility management [29].

In addition to that, there are several other governments who have taken steps to implement BIM in the USA. U.S. Army Corps of Engineers (USACE) in year 2008 for instance, required BIM to be utilised as a standard for their new design-build projects in an effort to produce best practice design models for the different facility types [31]. Apart from that, a few other US federal agencies which are successfully employing BIM are the U.S. Coast Guard, NASA, and the Smithsonian Institute [32].

4.4 UK

In May 2011, the government of the UK announced the Government Construction Strategy (GCS) with the purpose of minimising the cost of government construction projects by 15% to 20% in year 2015 [33]. The GCS requires fully collaborative 3D BIM as a minimum by year 2016 and all documentation, data project and asset information must be delivered electronically [33]. Consequently, a number of strategies have been developed to ensure that all public sector projects will be adopting at least Level 2 BIM by 2016 [18]. At the same time, the BIM Industry Working Group has also recommended several important strategies to support the government's plan of action as below [18]:

- Leave complexity and competition in the supply chain.
- Be very specific with the supply chain provider about what is asked for.
- Measure and make active use of outputs.
- Provide appropriate support infrastructure.
- Take progressive steps.
- Have a clear target for the “Trailing Edge” of the industry.

In addition, the AEC (UK) Standards Committee released a series of BIM standard documents to facilitate the Architectural, Engineering and Construction industry in the UK to migrate from CAD to BIM [34].

4.5 Finland

Since year 2001, Senate Properties, a government-owned enterprise has implemented a few pilot projects to establish and explore the use of BIM [35] and according to Kiviniemi [36], the HUT-600 project by Senate Properties was the first IFC-based integrated BIM project in the world. The successful experiences from these projects have made a significant impact and subsequently Senate Properties has decided to start to use BIM technology in its projects from October 2007. At the same time, Senate Properties published BIM Requirements which is the first global effort to use IFC-based BIM to cover all design domains [36].

In addition, Senate Properties and BuildingSMART Finland developed a series of guides called the 'Common BIM Requirement 2007' in year 2012 [37]. The guide consists of 13 series and has taken into account various aspects such as architectural design, structural design, MEP design, visualisation, quality assurance, energy analysis, quantity take-off, facility management and construction [37].

4.6 Denmark

In year 2007, Denmark mandated the use of BIM technology on all government funded projects and the requirements also known as Byggherrekravene [2]. Therefore since that, all players participating in public sector construction projects have had to adopt a range of new methods, digital routines and tools [38]. Apart from that, the Danish Enterprise and Construction Authority introduced a series of guidelines associated with 3D through its Digital Construction Program in order to meet the specifications in file and database based CAD/BIM applications such as 3D Working Methods and Layer, 3D CAD Manual 2006, Object Structures 2006 and 3D Working Method [2].

Meanwhile, there are other Denmark federal organisations that are effectively implementing BIM include The Palaces and Properties Agency, The Danish University, the Property Agency and Defence Construction Service, Gentofte Municipality and KLP Ejendommehave [38].

From then on, the Danish Parliament made a decision to widen the use of BIM as mandatory for all local and regional projects valued over DKr20 million (€2.7 million) in June 2011, which is expected to create a major impact across the whole nation [39].

4.7 Norway

In Norway, the Norwegian Agency of Public Construction and Property (also known as Statsbygg) is the major AEC/FM sector client. Statsbygg has been given a task to improve efficiency in the AEC/FM sector, by formulating and engaging in R&D projects heading to process simplifications and a more efficient utilisation of ICT tools in the AEC/FM sector from the Norwegian Parliament [40]. Therefore, Statsbygg initiated utilisation of BIM and implemented a BIM pilot project in northern Norway in 2003 [41].

From that point, in May 2007 Statsbygg announced the use of digital BIM for all Statsbygg's buildings, throughout their entire lifespan [42]. Therefore in 2008, Statsbygg produced BIM Manual ver 1 in order to deal with the BIM and IFC format adoption, followed by BIM Manual 1.1 in 2009 and BIM Manual 1.2 in 2011 [43].

Apart from that, in year 2003 the collaboration of three government organisations; in particular the National Office of Building Technology and Administration (BE); Statsbygg; and the Norwegian Defence Estates Agency launched Byggsøk as an effort to implement BIM based systems in the field of zoning, building and construction [44,45]. Byggsøk is a public system for preparing, submitting and handling electronic planning proposals and planning applications [46].

4.8 Australia

Within the last few years, numerous Australian industry reports and studies have highlighted the opportunity for BIM to generate economic value and improve the approach construction projects deliver [47]. Following that, buildingSMART Australasia has prepared a National Building Information Modelling Initiative report for the Department of Industry, Innovation, Science, Research and Tertiary Education with a plan for the targeted adoption of BIM and relevant processes and digital technologies for the construction industry [48].

The report suggested that the Australian Government will mandate the requirement for full collaborative BIM based on open standards for information exchange (generally known as Open BIM) for all its projects by 1 July 2016 [48]. Subsequently, there are several of proposed project work programs, comprised of Procurement, Education, BIM Guidelines, Project Data and BIM Libraries, Regulatory Framework, Process and Data Exchange, and Pilot Projects that are required to be carried out as part of the National BIM Initiative Implementation Plan in acceptance of the growing nature of BIM application and its utilisations [47].

5. BIM implementation within the Malaysia public sector

5.1 Malaysian public sector readiness

Public sector readiness assessment is essential to understand the degree to which governments are equipped to produce certain governmental services online and utilise ICT for internal operating of the government [49]. There are many institutional, organisational and technical elements to be considered and many researchers suggest people, process and technology as the main underpinning elements of ICT readiness [50-52,79]. In addition, it is important to assess the organisational readiness with measurable terms, specifically people, process and IT infrastructure, prior to any BIM investment [17].

Significantly, governments around the world are utilising ICT to perform their activities and operations. Furthermore, the ICT adoption in governments shifts the techniques to deliver services and organise public offices [53]. The utilisation of technology to improve the delivery and access to government services to benefit corporate partners, citizens and personnel, is usually referred to as electronic government (e-government) [54].

However, according to Asgarkhani [55], developing efficient e-government techniques both in local or federal governments relies upon the status of the ICT sector and electronic readiness that relates to countries, organisations and cultures. This is due to the outcome of e-government reforms and depends on its aims and objectives, the technological capabilities and the organisational practices [56].

Malaysia is striving to become a high-income and developed nation by the year 2020 [57]. Most all of the strategic transformation programmes are very much ICT-driven or ICT-enabled and ICT plays a critical role in ensuring their efficient and effective implementation. Starting with the preparation of ICT infrastructures, human-capital development and 'e-Government' under the Multimedia Super Corridor initiative (MSC Malaysia) in 1996, the effort continues under the current Prime Minister Mohammad Najib bin Tun Haji Abdul Razak, one outcome being the government introduction of the National Transformation Policy (NTP) in the 2012 budget.

This continuous effort has resulted in Malaysia having an ICT Development Index (IDI) of 5.04 in 2012 [58]. This makes Malaysia on a par with Brunei and the Maldives as the only group of developing countries in the Asia and Pacific region that have IDI values above the global average. Additionally, a study carried out by the World Economic Forum (WEF) and INSEAD has found that Malaysia can be benchmarked by other ASEAN countries in terms of leveraging ICT to enhance the impacts of ICT in their social and economic environment. In 2012, with an index score of 4.8 out of a maximum score of 7.0, Malaysia is ranked at 29th out of 142 economies; 8th out of 22 Asia Pacific economies and 2nd in ASEAN [59].

Malaysia recognises that ICT plays a critical role in ensuring the efficient and effective implementation of strategic transformation programmes in achieving the vision of the future. The Digital Transformation Programme (DTP), an initiative under the NTP for example, incorporates pure ICT-based projects aimed at providing transformational changes in five broadly categorised dimensions - technological, economic, social, governance and environmental [60].

This demonstrates that Malaysia is always trying to provide a conducive environment for ICT and the country's key stakeholders (individuals, businesses and governments) are ready to accept and use ICT in their activities. Even in 10 years ago, managers of Malaysian construction firms, for example, have been described as being familiar with the use of computers and the internet, are very much exposed to technology/new technology and are interested in adopting new technology [61]. Thus, this creates a great opportunity for developing ICT innovations especially BIM to be applied generally to all Malaysia's economic sectors and to the public sector in particular.

5.2 Current status of implementation

The Malaysian government stated the benefits of having an integrated software application and standardisation for achieving effective workflow for development and implementation of a project. In a local context, the Malaysian Government announced the Electronic Government (e-government) initiative to improve the quality of public service delivery, to make it more efficient and productive, as well as allowing enhancement of the relationship between the government, its residents and businesses [62]. One of the projects of the e-government flagship road map is E-plan and one of the application systems in it is

Electronic Planning Submission and Approval Systems [63]. Subsequently, a number of non-BIM based electronic submissions have been developed, for instance the Selangor Electronic Planning Approval System (SEPAS) for the Selangor State Town and Country Planning Department [64], the Intelligent CAD Checker System for building plan approval [65], the development of a computerised development control and approval system for the Planning and Development Control Department, City Hall of Kuala Lumpur [66] and Sumber-Putra for planning and building control submissions in Putrajaya [63].

At the same time, the government also encouraged construction players to adopt ICT during the Infrastructure & Construction Asia's Building Information Modelling & Sustainable Architecture 2009 conference which is the first BIM conference in Malaysia [67]. This announcement indicated an early commitment from the government to implement BIM [68]. Therefore, in 2010, the Public Works Department of Malaysia (PWD) initiated a BIM pilot project for the National Cancer Institute (NCI) in Putrajaya [69]. PWD is the largest technical department under the Ministry of Works Malaysia (MOW). PWD is responsible for all design, planning, construction, development and maintenance of public infrastructure and government buildings in Malaysia [70].

The RM639 million NCI project was completed two weeks ahead of schedule and was handed over to the Health Ministry in 2013 [71]. PWD also plan to utilise BIM to perform analyses for instance site analysis, spatial program validation, design review, clash analysis and 4D construction schedule simulation in several pioneer projects such as the Health Clinic Project in Maran, Pahang, the MACC Administration Complex Project in Shah Alam, Selangor and two school projects in Perak and Melaka [72,73].

Other than that, the PR1MA Corporation Malaysia (also known as PR1MA) has initiated BIM in their development of affordable housing which is 1Malaysia People's Housing in order to deliver with both good quality and increased work efficiency [74].

Apart from that, the Construction Industry Development Board Malaysia (CIDB Malaysia) has taken a proactive stance by promoting workshops and awareness programs with the industry player. CIDB Malaysia is a statutory body under MOW and was established in 1994 to develop the capability of the construction industry by putting great focus on professionalism, innovation and knowledge through the improvement of quality and productivity [75]. In July 2013, CIDB Malaysia established the National Steering Committee of Building Information Modelling (BIM) representing related government departments, professional bodies, private sectors and academia to determine the way forward for a larger implementation of BIM [76].

Meanwhile, the implementation of BIM in the Malaysian construction industry is still low and there are only a few that companies have utilised BIM in their projects [77]. This is due to a lack of BIM knowledge and there are still no guidelines for BIM implementation. However, all the companies that have implemented BIM in their construction projects acknowledge the advantages that they have achieved by adopting BIM, while at the same time ensuring the success of BIM implementation [77].

A study conducted by the Construction Research Institute of Malaysia (CREAM) found that the barriers in implementing BIM in construction are cost, system requirements, lack of knowledge and readiness to change [78]. According to Haron [68], the Malaysian construction industry is still in the initial phase of BIM implementation. Hence, the adoption of BIM by Malaysian construction players is between BIM level 0 and BIM level 1 [77].

In general, Zahrizan, Ali et al [77] stated that top management and technology have an essential role to ensure the successful implementation of BIM. On the other hand, the construction players believed that the government should perform the major role by initiating pilot projects with the intention to provide a clear understanding of BIM implementation as well as raise their confidence, and after that mandate the utilisation of BIM in construction projects [77].

6. Conclusions

This paper has given an overview of the BIM implementation in the public sector around the world as well as the current status of its implementation in Malaysia. The review shows the several countries across the globe have shown great interest in the direction of BIM implementation and their public sector plays an important role in

leading the market towards BIM adoption. Even though the implementation of BIM in those countries has evolved in many different pathways, the fundamental issues is that the government has given a full support and most of the BIM projects were started through government entities having a mandates to impose the use of BIM for their initiatives.

Therefore similarly in Malaysia, it is believe by given that the existence of the hard and soft-infrastructures in Malaysia, the government and its agencies need to play significant roles to help in stimulate BIM technology in Malaysia to be comparable with other developed countries. Furthermore, with the availability of the application systems under E-plan flagship projects such as the Sumber-Putra [63], Selangor Electronic Planning Approval System (SEPAS) [64] and others would facilitate and expedite the adoption of BIM in the Malaysian public sector. The potential use of the BIM-based electronic submission will be the focus of the other research papers.

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