Cite this article
Tekin H and Atabay Ş
Building information modelling roadmap strategy for Turkish construction sector.
Proceedings of the Institution of Civil Engineers – Municipal Engineer,
https://doi.org/10.1680/jmuen.17.00001

Research Article
Paper 1700001
Received 30/12/2016;
Accepted 25/01/2018

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Keywords: building information modelling (BIM)/management/project management

Municipal Engineer

ice publishing

Building information modelling roadmap strategy for Turkish construction sector

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Building information modelling (BIM) has shown itself as a leading factor in increasing the production and efficiency in the construction sector in many countries. The construction sector in Turkey has made considerable progress in recent years, but the sector lacks effective construction management and information technologies. In order to make further progress and to achieve global goals, the use of BIM is of utmost importance for the construction sector in Turkey. With this perspective, the present study aims to propose a strategic roadmap for BIM adoption to the Turkish construction sector. For this purpose, individual interviews were carried out to reveal the current state of BIM use in Turkey, a strengths, weaknesses, opportunities and threats (SWOT) analysis was conducted and the best practices in BIM adoption worldwide were investigated. The study intends to contribute to the relevant literature by suggesting a roadmap for the preparation of BIM standards as well as underline the importance of education, technological adaptation, public incentives and sanctions.

1. Introduction

The construction industry has begun to gain a new identity with the building information modelling (BIM). The associated general contractors of America have the following definition of BIM (AGCA, 2005: p. 3): '*Building Information Modeling is the development and use of a computer software model to simulate the construction and operation of a facility. The resulting model, a Building Information Model, is a data-rich, object-oriented, intelligent and parametric digital representation of the facility, from which views and data appropriate to various users' needs can be extracted and analysed to generate information that can be used to make decisions and improve the process of delivering the facility.*' In the UK Government's report Industrial strategy: government and industry in partnership, BIM is perceived as follows (HM Government, 2012: p. 3): '*Building Information Modelling (BIM) is a collaborative way of working, underpinned by the digital technologies which unlock more efficient methods of designing, delivering and maintaining physical built assets. BIM embeds key product and asset data and a 3 dimensional computer model that can be used for effective management of information throughout a project lifecycle – from earliest concept through to operation.*' Unlike the traditional methods, BIM gathers not only the elements of design but also the elements of time, cost and all other elements of the project life cycle. In the BIM system, the information model contains geometric elements as well as non-geometric elements, which greatly impedes the inefficiencies of the classical building process (Gu and London, 2010; Yan and Damian, 2008). BIM maximises productivity, information sharing and coordination among different disciplines.

Leading countries in the construction sector have built their strategic plans based mainly on BIM and accelerated their efforts to adopt this system. Many discussions and studies are conducted for the application of BIM tools as the significance of BIM is noticed (Dispenza, 2010). In this sense, countries need to analyse their structures well and determine the most suitable roadmaps.

The construction sector that employs a wide number of people in Turkey has grown rapidly in recent years as a result of increasing public investments, population and changing socio-cultural structure. Turkish construction companies have successfully completed more than 7000 projects in more than 100 different countries and the total volume of these projects is approximately US$ 30 billion (TMB, 2015). As announced by the Minister of Economy, the goal of the Government is to increase the volume to US$ 150 billion by 2023 (DHA, 2013). According to records acquired from the last six years of Engineering News Record (ENR) magazine's Top Global Contractors' List, which ranks the 250 largest world construction contractors, based on total construction contracting revenue, Turkey regularly ranked second with around 30–50 companies (ENR, 2017). Although Turkish contractors have recently gained important achievements worldwide, Turkey is quite unsuccessful in the field of engineering consulting. According to the Construction and Environment Report of the Turkish Association of Independent Industrialists and Businessmen, although Turkey competes with almost every country in the field of contracting, and is also actively involved in the field of international consultancy, Turkey is not on the

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world order list (MUSIAD, 2014). Turkey's economy does not really get the share it deserves from the acquisitions in the projects that Turkish contractors undertake because the projects are carried out by foreign consulting firms and building materials apart from certain material classes are imported from different countries (MUSIAD, 2014). The main reasons can be summarised as: (1) lack of adequate technologies in the field of construction and (2) disorganised project management structure. In order to eliminate these problems and further develop, the Turkish construction sector needs BIM, which is an updated system enabling a high level of information sharing.

2. Methodology

In this study, a strategic BIM roadmap is proposed by using a qualitative research method, strengths, weaknesses, opportunities and threats (SWOT) analysis and comprehensive overview of best practices. The flowchart of the study is shown in Figure 1.

Individual interviews were carried out both in Turkey and in other countries. A qualitative approach was preferred to get richer and more reliable data. After gathering information from the interviews, a SWOT analysis was conducted to clearly see the strengths and weaknesses, opportunities and threats. In addition, an overview of best practices is given by combining the interview data and literature review. After the data analysis, a strategic BIM roadmap was proposed for the Turkish construction sector.

3. Individual interviews – a qualitative approach

Interviews were held with sector professionals and academics both in Turkey and abroad to establish a sound BIM roadmap for Turkey. The interviews in Turkey were aimed to reveal the perspective of the adoption of BIM applications in the country, to identify the sources of distress, and to gather information required for the roadmap to be made. The purpose of the interviews abroad was to determine the implementation strategies of the countries that have adopted or are in the implementation process of the BIM system. All information obtained from the interviews was used to develop a convenient roadmap for the Turkish construction sector. A total of 36 interviews were carried out, 21 of which were conducted in Turkey. The profile of the interviewed practitioners who were selected from a variety of fields is shown in Table 1. The duration of each interview was between 60 and 90 min.

The data obtained from the interviews were analysed in accordance with the following headings

(*a*) Reasons for the companies to adopt BIM into their systems
(*b*) Benefits of BIM applications
(*c*) Problems in the implementation of BIM
(*d*) Requirements for the implementation of BIM throughout the country
(*e*) Common problems and strategies of different countries

3.1 Reasons for the companies to adopt BIM into their systems

The majority of the companies using BIM in Turkey have started the process of implementation in order to undertake major projects abroad. Even though BIM is accepted as a revolution in the construction sector by many companies, the adoption progress in Turkey is very slow. The use of BIM is not systematic or based on individual efforts. While three-dimensional (3D) visualisation in BIM at level 1 is particularly common in architectural designs, its use at levels 2 and 3 is rather low. An ideal use of BIM covers the period from the design phase to the demolition phase which can be possible with levels 2 and 3 BIM use.

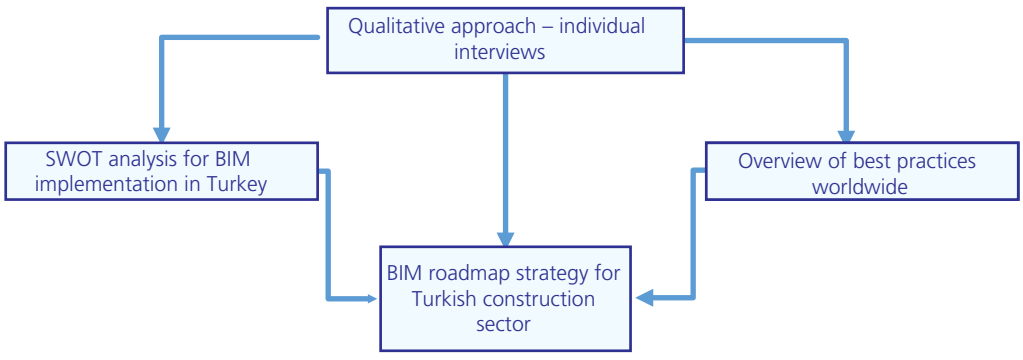


Figure 1. Overview of the study

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Table 1. Profile of the interviewed practitioners

Turkish construction sector			Other countries			
	Type of Organisation	Description		Type of Organisation	Country	Description
1	International contractor	Large scaled, mostly aviation projects	1	Public works institution	Singapore	Supports BIM adoption throughout the country
2	International contractor	Large scaled, mostly railway projects	2	International consultant	Singapore	Large scaled, project management
3	International contractor	Large scaled, mostly the energy sector and transportation	3	International contractor	Qatar	Large scaled, mostly tunneling projects
4	International contractor	Large scaled, mostly the energy sector	4	University	UK	Academician with appreciable BIM experience
5	International contractor	Large scaled, mostly the energy sector and heavy industries	5	Research institution	Germany	Researcher with IT technologies experience
6	Local contractor	Large scaled, mostly housing	6	University	USA	Professor with appreciable BIM experience
7	Local contractor	Large scaled, one of the biggest housing contractors	7	University	Spain	Structural BIM researcher
8	Local contractor	Large scaled, one of the biggest housing contractors	8	University	Spain	Researcher in BIM adoption to education system
9	Architectural designer	Medium scaled, mostly prestigious projects	9	University	Spain	Researcher with BIM experience
10	Architectural designer	Medium scaled, mostly skyscrapers	10	Architectural designer	Spain	Medium scaled, mostly housing
11	Architectural designer	Medium scaled, mostly environmental projects	11	Consultant	Spain	Medium scaled, mostly BIM adoption
12	Designer and consultant	Medium scaled, all kinds of construction	12	Consultant	Spain	Medium scaled, mostly BIM adoption
13	Software supplier	BIM software supplier	13	Local contractor	Thailand	Medium scaled, mostly housing
14	Architectural designer	Small scaled, mostly housing	14	Architectural designer	Thailand	Medium scaled, mostly prestigious projects
15	Architectural designer	Small scaled, mostly housing	15	University	Thailand	Professor with appreciable BIM experience
16	Local contractor	Small scaled, mostly housing				
17	Local contractor	Small scaled, mostly housing				
18	Local contractor	Small scaled, mostly housing				
19	University	A well-known professor with appreciable BIM experience				
20	Municipality	BIM executive in a public project				
21	Municipality	An experienced directorate in urban renewal projects				

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The efforts and contractual obligations of firms play important roles in the development of BIM in Turkey. Its perception as a fashion and trend is another driving factor for many companies. Some companies try to adopt BIM without conscious research just because it is a trend. This clearly reflects the effect of socio-cultural influences. Hundreds of subcontractors are included in large-scale projects. Decisions taken by large construction firms and investors can also lead directly to the market. BIM obligations in projects force all stakeholders to use BIM. One reason behind this obligation is to benefit from the advantages of BIM. Some firms that are aware of BIM's advantages have tried to adopt BIM regardless of any obligation.

3.2 Benefits of BIM applications

In terms of visualisation, it is found that the majority of companies are interested in BIM use. Most of the companies that were interviewed emphasised that BIM provides much more effective and clear project presentations. BIM offers a better quality and more realistic design than classical ways. Some companies have been observed to be using BIM effectively in their planning steps. It is possible to combine a model produced in any BIM software with a work schedule prepared in the planning programme with the help of an interface programme, which makes it easy to control both the reporting and the progress of the work in terms of time and cost. Clash detection is another important property Turkish firms benefit from. BIM offers a much more useful way than classical superposition. Constantly revised projects in Turkey particularly cause designers to lose time. BIM also strengthens the marketing and presentation capabilities of the companies in the housing sector which is crucial in the Turkish construction industry. Most apartment sales are made through model presentations. In addition, BIM provides important contributions to occupational safety. In high-rise projects that include voltage lines, the work of cranes can be pre-modelled and the possible occupational troubles can be avoided. Experts argue that BIM decreases the duration of quantity surveys drastically and gives much more accurate results compared with the classical methods. BIM also makes it possible to simplify the work by collecting the functions of the programmes used for different aspects of a project under a single programme.

3.3 Problems in the implementation of BIM

BIM is a new technology for companies and employers. Therefore, most of them know very little about its use. It has been thought that BIM is only applied to the important parts of the projects considering that the total design would take a long time and BIM does not necessarily have to be used for all parts. It is envisaged that different disciplines work on the same BIM model. However, in practice, mostly two-dimensional (2D) drawings are converted into 3D models and each discipline works separately.

One of the most difficult barriers in BIM adoption is the resistance to new technologies. The lack of open-minded culture, the fear of the unknown and being attached to old habits are the main causes of this barrier. Another issue is the fact that the number of experts in the field of BIM is very limited in Turkey. The use of BIM tools is not enough for the successful implementation of BIM since it requires good construction and design knowledge. Another difficulty in BIM implementation is high initial investment cost. The high software license fees, strong hardware requirements and necessity to hire BIM experts are the main factors increasing this cost. Most of the subcontractors in Turkey seem to be interested in BIM, but prefer to carry on with the classical methods due to the challenges encountered and the costs of investment.

Most of the architectural design firms experience difficulties due to the different procedures of each municipality and the non-standard processes during the approval phase of the drawings. Since BIM is a structure that standardises the processes, it seems difficult to adopt BIM to the existing system. Several decisions need to be made during the approval phase of the drawings and it is also necessary to evaluate how the following phases will be affected. Therefore, the design phase is a stage that requires more effort compared with the classical method. Due to the shortcomings of Turkish architectural companies, many contractors prefer foreign firms as the designers. One of the main reasons for this is the absence of BIM standards as well as CAD and layer standards. A non-standard design mechanism remains weak in the global competitive environment. Design standards and guidelines are extremely important in terms of development.

3.4 Requirements for the implementation of BIM throughout the country

According to the experts, the use of BIM in public projects is crucial for Turkey to adapt this system throughout the country. In addition, the Government should encourage companies to implement BIM. Tax reductions and bonuses can be offered to stimulate the use of BIM. Moreover, experts underline the significance of BIM education. In this regard, academicians follow the developments in the field of BIM very closely. The relevant programmes at universities should offer both theoretical and practical courses, thus providing the sector with graduates who are capable and experienced in using BIM. The Turkish construction sector has suffered from the lack of CAD standards, which resulted in many complicated problems in all kinds of projects. All the practitioners highlighted the importance of the preparation of BIM standards. Investor demand is also vital for the development of BIM across the country.

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Increasing the investor awareness of BIM may result in increasing quality, ease of project management and more effective facility management. BIM costs tend to decrease in line with the rising demand and widespread adoption. Software suppliers offer package programmes and various discounts for BIM tools. In the current competitive environment, companies do not find it economical to choose BIM due to its extra initial costs.

Many industry executives point out that the attitude towards BIM is becoming more positive compared to the past. In recent years, project management was not a popular area, but today the level it has reached in Turkey is very promising. The potential for the widespread implementation of BIM makes software suppliers put in more effort to create new markets and increase the number of users. The number of BIM programmes is currently very limited. It would be a good idea to cooperate with BIM software suppliers for inexpensive licensing and training activities on win-win principles.

3.5 Common problems and strategies of different countries

Interviews with foreign professionals from a variety of countries were conducted in addition to the Turkish professionals. The main goals of this variation were to analyse all kinds of problems confronted during BIM implementation and to understand the best practices all over the world.

Based on the results of the interviews, it can easily be claimed that there are serious breakthroughs in BIM. It is also obvious that most of the problems the Turkish construction sector has encountered have also been seen in the applications worldwide. Some of the problems can be summarised as follows: (1) both employers and contractors are inadequate in the usage of BIM, (2) there are standard deficiencies in the adoption of BIM, (3) people resist to change and (4) Governments do not take an active role in BIM adoption.

In the countries where BIM implementation is mandatory, it has been seen that research and development activities progress rapidly; BIM and construction information technologies have made considerable progress.

4. SWOT analysis for BIM implementation in Turkey

To build a sound BIM roadmap, a SWOT analysis was developed primarily based on the information received from the interviews and the literature review. Thanks to SWOT analysis that focuses on the four elements, the users can determine the factors influencing a strategy, action or initiative and recognise the parts more effectively needed for a plan (Taylor, 2016). Figure 2 shows the SWOT analysis for BIM implementation in Turkey.

While the current problems of the construction sector in Turkey continue, the interest and necessity of BIM increase in both public institutions and the private sector. BIM has been used in one of the most important public railway projects in Turkey, namely the İstanbul Kabatas–Mecidiyekoy–Mahmutbey (KMM) Metro Line. Most of the critical parts of the project from the preparation of the project documentation to the acoustic and vibration design service were carried out with the help of BIM technology, which gave the users very positive results (PE, 2017). As a result of the success of BIM technology in such big projects, the Istanbul Metropolitan Municipality wishes to conduct many other important projects with BIM and to compose a global BIM database. Another important project in which BIM is effectively used is Istanbul's 3rd Airport Project, which is currently still under construction. By using BIM applications in special projects such as airports, an average of 15% on savings in construction costs and 15–20% in facility management can be achieved besides reaching an environmentally friendly and economic structure in accordance with the modern era (Infotron, 2017). The use of BIM in such prestigious and large-scale projects is also very important for promoting BIM. As far as the private sector is concerned, many international Turkish contractors have established BIM centres both at home and abroad, and have employed a significant number of engineers and technical staff in these centres. In addition, many construction companies working locally and internationally have been trying to adapt their existing teams to BIM by the help of workshops and training programmes. Companies have begun to use this new technology on their projects, and enforce their subcontractors to use BIM. In recent years, Turkish construction companies have preserved their status in the list of 250 largest world construction contractors (ENR, 2017). This also shows these companies' achievements in BIM, as nowadays most international projects require an advanced level of BIM knowledge. Although the Turkish construction sector lacks a project management system and standards, BIM seems to be a very strong solution to overcome such problems. Both the public and the private sector have started to benefit from BIM and have got positive results.

Furthermore, the fact that global software suppliers see Turkey as a crucial market contributes to the required infrastructure for BIM implementation. The rapidly growing construction sector in Turkey is an important market for BIM software suppliers. Therefore, they organise a lot of BIM training programmes and workshops in Turkey and make considerable investments to promote and spread BIM throughout Turkey. Software vendors have significantly reduced the licensing prices of BIM software tools by offering package programme options. Companies and public institutions can now acquire these licenses much easier compared to the past. This eases the rapid development of BIM in Turkey.

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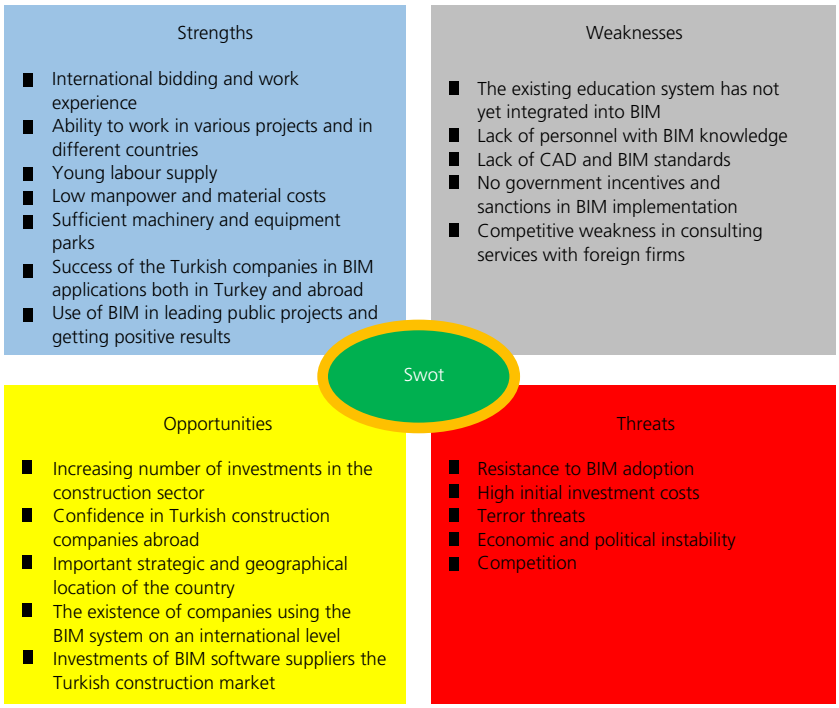


Figure 2. SWOT analysis for BIM implementation in Turkey

5. Overview of the best practices worldwide

This section provides an overview of the best practices worldwide by analysing the data collected from the interviews and the literature review. The roadmaps of the United States, Singapore, Finland and the United Kingdom were selected due to their leading roles in the implementation of BIM.

5.1 The United States

According to a study conducted by the National Institute of Science and Technology in the United States, a loss of US$ 15·8 billion was determined due to inefficient work in the construction sector in 2002 (Gallaher *et al.*, 2004; GSA, 2007; Yee *et al.*, 2010). Another study showed that, while the productivity in non-agricultural industry had increased drastically, the productivity in construction sector had decreased between 1964 and 2003 (Teicholz, 2004). The main problems to be eliminated were the lack of coordination, incomplete or incorrect as-built projects, mistakes in quantity surveying and high-energy consumption of buildings (GSA, 2007; Yee *et al.*, 2010).

BIM technology and its real benefits to the General Services Administration (GSA) were originally developed at Stanford University (Yee *et al.*, 2010). In particular, 3D and four-dimensional (4D) BIM applications were carried out in various public projects in New York, Houston and Los Angeles, providing great benefits both in shortening the project duration and reducing the cost (Yee *et al.*, 2010). In 2003, the GSA Public Building Service (PBS-OCA) published the 3D–4D BIM programme that aims to ensure that the GSA works more efficiently and the design quality and construction requirements are met at the highest level (GSA, 2007; Yee *et al.*, 2010)

From 2003 to 2007, 35 pilot projects were executed by BIM, ten of which were completed by 2007 (Zeiss, 2013). When the GSA was as successful as desired in the pilot projects, BIM became an obligation for all projects submitted to the Public Service Commission, which has been utilising the design fund from the 2007 financial year with a decision taken in 2006 (Zeiss, 2013). In addition, the GSA encouraged the use of BIM not only in its own projects but also in other private sector investments. With the imperatives of these obligations and incentives, many projects in the United States have begun to implement BIM. Figure 3 shows the timeline of BIM adoption in the United States. Between 2007 and 2016, many guides were published and the role of BIM was evaluated in many areas such as spatial programme validation, 4D phasing, 3D imaging, energy performance and operations, circulation and security validation (GSA, 2007).

5.2 Singapore

Starting in 2003, the construction industry in Singapore has been transformed based on two purposes, to establish the

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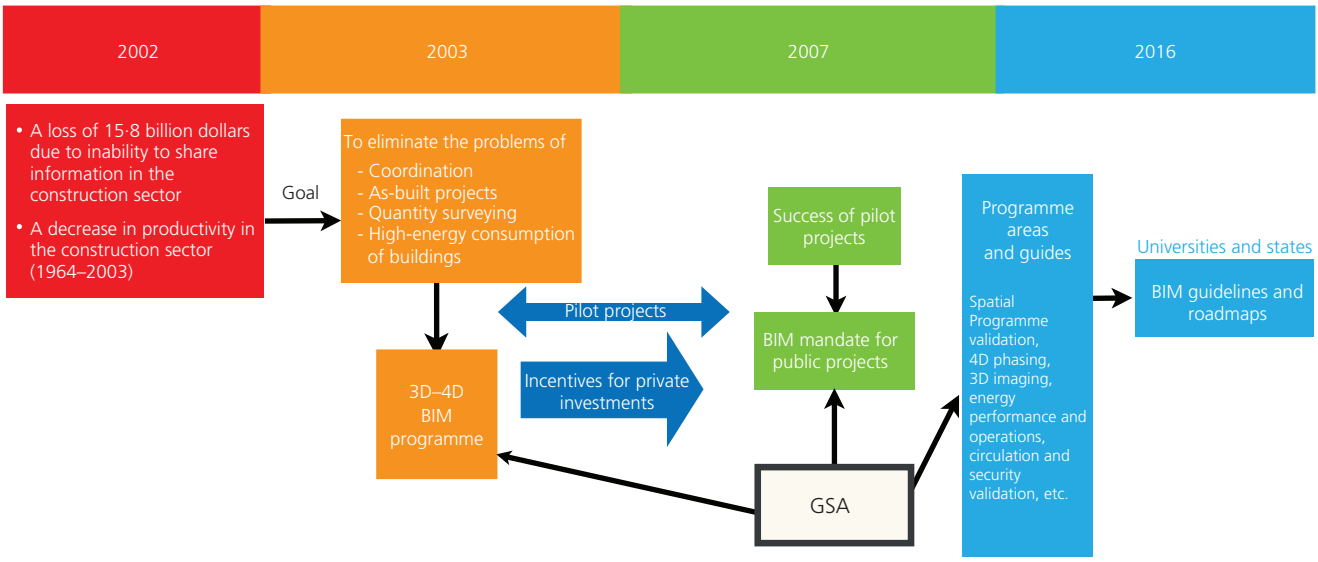


Figure 3. BIM implementation in the United States

fastest building permission system and to improve construction productivity (Zeiss, 2014a)). In 2010 and 2011, architectural, mechanical, electrical, plumbing and structural BIM models were accepted through an e-submission system by various agencies, followed by a public mandate for architectural BIM e-submissions for building projects greater than 20 000 square meters in 2013 and 5000 square meters in 2015 (BCA, 2011; Zeiss, 2014a). In addition, the Building Construction Authority (BCA) published a BIM Roadmap in 2010 (BCA, 2011), in order to orient all stakeholders towards BIM use in the construction sector.

The BCA Academy cooperated with many higher education institutions and organised trainings for a variety of audiences, from senior executives to students in order to increase the implementation of BIM (BCA, 2011; Zeiss, 2014a). In addition, the BCA has cooperated with many higher education institutions to ensure that BIM education is included in related course contents in higher education. The Government established the BIM Funding Institution (CPCF) to minimise the financial difficulties during BIM adoption experienced by the members of the Singapore Association of Contractors (Fatt, 2013).

5.3 Finland

Starting in 2001, Senate Properties that manages a major part of the real estate assets owned by the Government has implemented a series of pilot projects to analyse and improve the use of product models that originated from 1960s and 1970s in Finland (SP, 2009; Wong *et al.*, 2009; Zeiss, 2014b). Based on the feedback received, it was decided that sufficient infrastructure was provided at the end of the 6th year and the Senate Properties BIM Requirements was published in 2007 for mandating the use of BIM models meeting the IFC (Industry Foundation Classes) standards in public projects (SP, 2009; Wong *et al.*, 2009). The timeline of BIM adoption in Finland is shown in Figure 4. Many government agencies and companies are involved in R&D work on BIM and work to promote BIM throughout the country. According to a research conducted in 2007, the BIM usage and BIM applications in compliance with IFC was estimated to be 33% (Kiviniemi, 2007; Wong *et al.*, 2009). One hundred and eight BIM projects were completed within the technology programme, namely Sara – Value Networks in Construction (2003–2007), launched by TEKES, the Finnish Funding Agency for Technology and Innovation (Arayici and Aouad, 2010; TEKES, 2008).

In 2012, Senate Properties published the Common BIM Requirements (COBIM, 2012), which gives new construction and renovation techniques as well as the use of buildings and facility management. In addition to Senate Properties, BuildingSMART and the private sector, real estate holders and various other groups contributed financially to the preparation of Common BIM Requirements (COBIM, 2012). According to the Finnish BIM survey conducted in 2013, it was estimated that the BIM awareness was to be 87% and COBIM awareness was to be 52% (Finne *et al.*, 2013). This shows us Finland's success in BIM adoption.

5.4 The United Kingdom

The UK Government had planned to make a profit of 2 billion GBP corresponding to 15–20% of the total budget in

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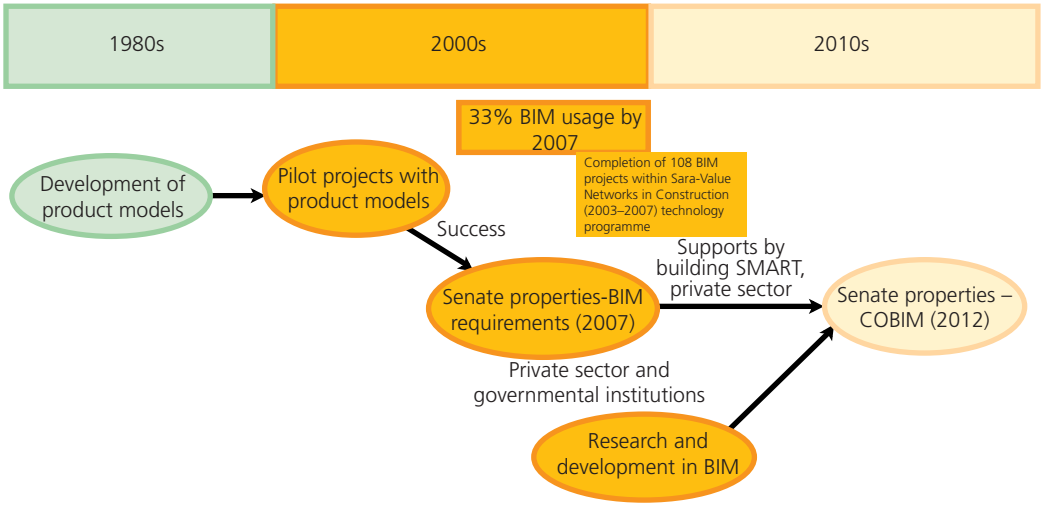


Figure 4. BIM implementation in Finland

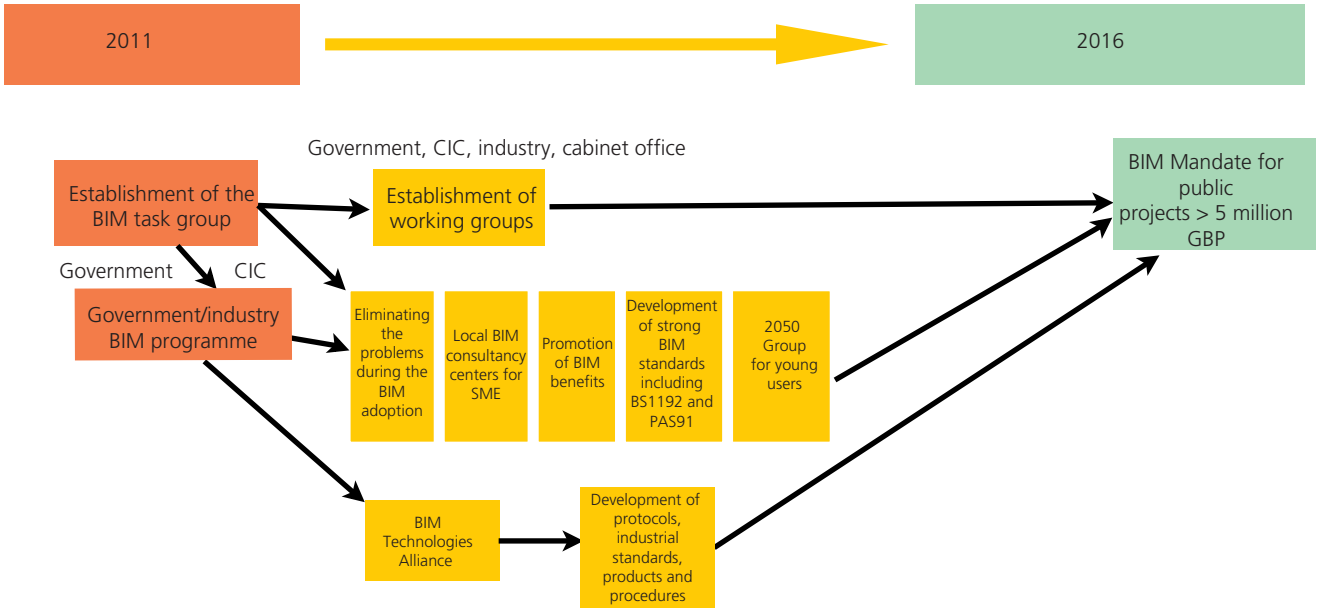


Figure 5. BIM implementation in the United Kingdom

2012–2015 by adapting BIM to government agencies (HM Government, 2012). In order to achieve this goal, a BIM Task Group was established in 2011 and this was followed by the announcement of the Government/Industry BIM programme which requires construction firms to be fully 3D BIM collaborative in order to win a contract over £5 million by 2016 (HM Government, 2012; Zeiss, 2016). Figure 5 shows the BIM implementation in the United Kingdom.

Under this programme, Government, the Construction Industry Council (CIC) and industry have (HM Government, 2012):

- Established many groups, teams and bodies to eliminate the problems during the BIM adoption and enable all parties included in the construction sector to adopt BIM more easily.

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- Established 'Regional BIM Hubs' to give consultancy to small- and medium-sized enterprises (SME) and smaller clients.
- Worked with private sector clients and cooperated with many government institutions to enable widespread use of BIM and promotion of BIM benefits.
- Worked with British Standards Institution (BSI) and other organisations to contribute to the development of new standards including British Standard (BS) 1192-2 (BIS, 2015a) and PAS 91 (BIS, 2015b).
- Worked for the first steps of the production of a 'digital plan of works' to assist to inform an industry aligned process.
- Established a '2050 Group' to attract the technical expertise of the young users and developed a core set of skills and training requirements.

In addition, the BIM Technologies Alliance with the objective of working with Government and industry to develop BIM products, data content and industry standards, protocols and procedures.

6. BIM roadmap strategy for the Turkish construction sector

Combining the data received from the qualitative approach, SWOT analysis and overview of the best practices, a BIM Roadmap strategy is proposed as shown in Figure 6. As the first step, a BIM Group in the leadership of the Government with the co-operation BuildingSMART, the private sector and chambers, unions and foundations should be established in order to follow every aspect of BIM adaption and make the roadmap dynamic with every feedback received from each step.

Since BIM is a system that improves the coordination of all stakeholders, the first and foremost priority should be the preparation of BIM standards which should be again the task of the said BIM Group. It will be of great benefit to receive help from BuildingSMART, which opens chapters around the world supporting BIM adoption. The BIM Group should first prepare a draft standard through the analysis of the existing structure, then implement the standard into pilot projects and finally develop a final standard by obtaining feedback from pilot projects and present it in order for it to be used in BIM implementation. The standard should also include prospective BIM plans and include the responsibilities of all stakeholders in the construction industry. It is also necessary to establish an infrastructure that will ensure the widespread of BIM throughout Turkey. The infrastructure requires government incentives and sanctions, the establishment of an educational system based on BIM and technological adaption. The BIM mandate is a very effective driving factor for the industry. After establishing the required infrastructure, BIM should be compulsory for public projects. This mandate should be implemented gradually from large-scaled projects to small-scaled public projects. Support should be provided to all stakeholders of the sector and students by establishing funds for training activities and giving scholarships for BIM researchers. Before the BIM mandate, the Government should provide incentives for BIM using firms by making tax reductions and various other amendments.

Education is one of the most important parts of building a BIM infrastructure. Universities should ensure that all academicians in the relevant programmes have BIM knowledge by organising regular trainings and the researchers to make maximum contribution to BIM adoption. In addition, it is necessary to update a BIM-focused curriculum in the relevant departments. Since BIM is a system that requires great experience, it is important for students to do compulsory BIM internships during their studies. In order to gain knowledge about practical BIM applications, seminars, conferences, competitions and workshops should be frequently held at universities. In order to present the sector with qualified BIM experts, more BIM-specific post-graduate programmes are required. In order to encourage young people in the field of BIM, it is necessary to offer scholarship programmes for domestic and international studies. The number of partnerships between the Government, universities and the private sector is very limited. Increasing this number is a must for BIM adoption, research and development studies.

Another important task is the technological adaptation. The growing market of BIM increases the competition among BIM software suppliers. A win-win co-operation with these companies will help to reduce both license fees and initial investment costs for companies and public institutions. The housing sector in Turkey is the most important part of the construction sector. The submissions for building permits are carried out through classical methods. Most contractors suffer from the loss of time and non-standard applications. Since the design period is extended with BIM implementation, establishing automation and e-submission systems will reduce the initial slowdown of BIM, thus firms in the housing sector will accelerate to adopt BIM.

7. Conclusion

This study points out the necessity of BIM to increase the efficiency of the Turkish construction sector, which has been developing rapidly in recent years. In order to build a true BIM roadmap for Turkey, individual interviews were held with professionals both in Turkey and abroad. A SWOT analysis was conducted, followed by the analysis of the best practices and finally a BIM roadmap was proposed. It was emphasised that a BIM Group should be established to lead the roadmap

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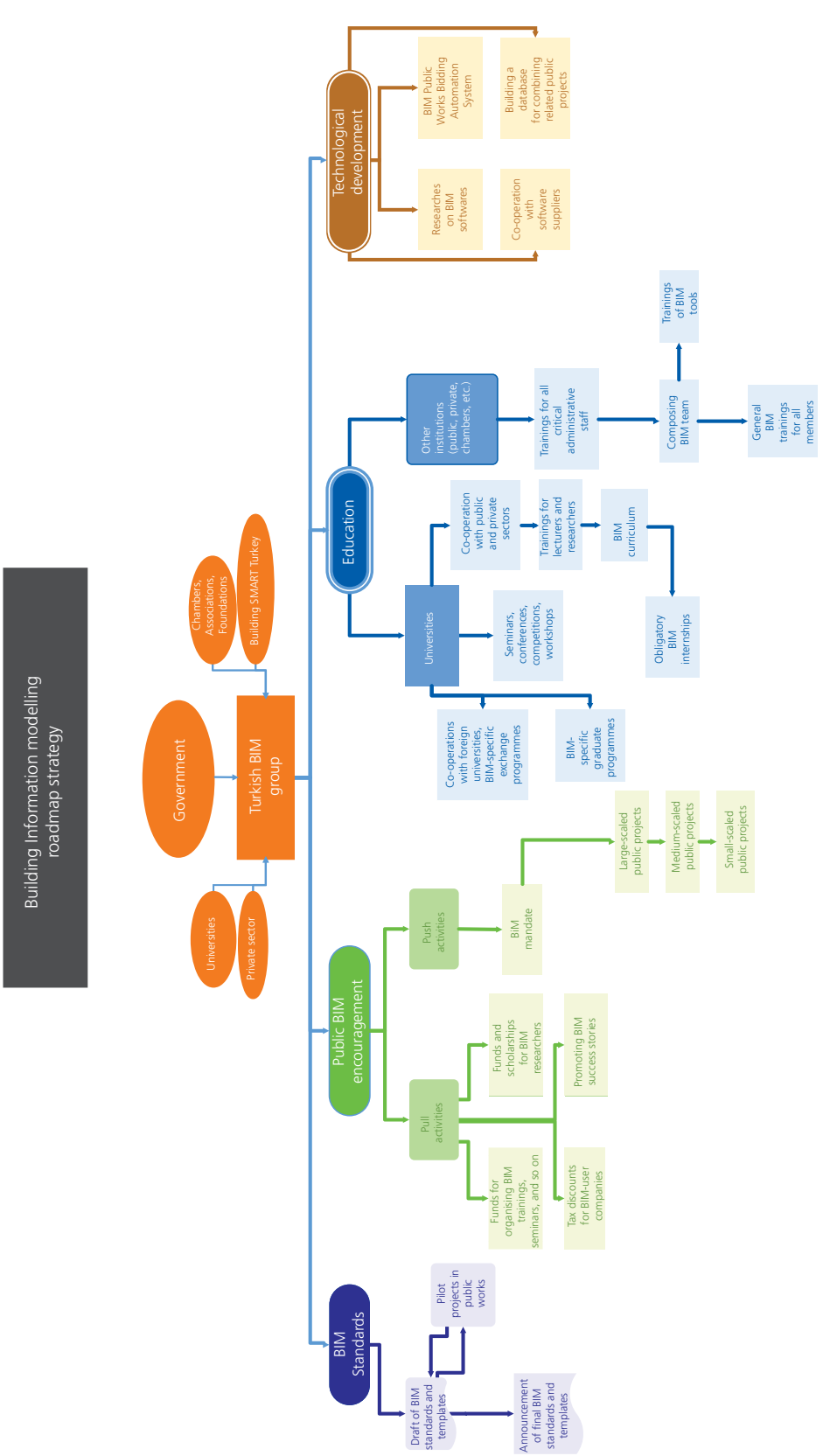


Figure 6. BIM roadmap strategy for the Turkish construction sector

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and that this group should work on four important topics, which include the preparation of BIM standards, public sanction and incentives, education and technological adaptation. In Turkey, there is no national CAD standard available, which results in negative consequences for the sector. BIM aims to maximise the coordination of all stakeholders. Therefore, the preparation of BIM standards is of top priority in order to take the first step in the implementation of BIM. Public encouragement is another crucial point to enable the sector to adopt BIM. The number of BIM experts is very limited in Turkey. For this reason, establishing BIM-based education and training programmes should be accelerated. Since BIM is a technological element, parallel to education, studies on the technological adoption of BIM should be conducted in order to support its implementation. A combination of all these elements will provide the necessary conditions for BIM adoption in Turkey.

Acknowledgements

This research is part of the PhD research project 'Creation of the Building Information Modelling (BIM) Roadmap for the Turkish Construction Sector' (Project ID: 2016-05-01-DOP01), supported by Yıldız Technical University Coordinatorship of Scientific Research Projects.

REFERENCES

AGCA (Associated General Contractors of America) (2005) *The Contractor's Guide to BIM*, 2nd edn. AGC Research Foundation, Las Vegas, NV, USA. See https://www.engr.psu.edu/ae/thesis/portfolios/2008/tjs288/Research/AGC_GuideToBIM.pdf (accessed 10/12/2017).

Arayici Y and Aouad G (2010) Building information modelling (BIM) for construction lifecycle management. *Construction and Building: Design, Materials, and Techniques* (Doyle SG (ed.)). Nova Science Publishers, Hauppauge, NY, USA, pp. 99–118.

BCA (Building Construction Authority) (2011) All set for 2015: the BIM roadmap. *Build Smart: A Construction Productivity Magazine*, December: pp. 2–14. See http://www.bca.gov.sg/publications/BuildSmart/others/buildsmart_11issue9.pdf (accessed 20/08/2016).

BSI (2015a) BS 1192:2007+A2:2016: Collaborative production of architectural, engineering and construction information. Code of practice. BSI, London, UK.

BSI (2015b) PAS 91:2013: Construction prequalification questionnaires. BSI, London, UK.

COBIM (Common BIM Requirements) (2012) http://files.kotisivukone.com/en.buildingsmart.kotisivukone.com/COBIM2012/cobim_1_general_requirements_v1.pdf (accessed 16/06/2015).

DHA (Dogan News Agency) (2013) *11 Ayda 23.7 Milyar Dolarlık İnşaat İşi*. Doğan Haber Ajansı, Ankara, Turkey (in Turkish). See http://www.dha.com.tr/11-ayda-237-milyar-dolarlik-insaat-isi_562138.html (accessed 05/12/2016).

Dispenza K (2010) The daily life of building information modeling (BIM). *Design News*, 29th June. See http://buildipedia.com/aec-pros/design-news/the-daily-life-of-building-information-modeling-bim (accessed 15/05/2015).

ENR (Engineering New Records) (2017) *Top 250 International Contractors*. ENR, Troy, MI, USA. See https://www.enr.com/toplists/2017-Top-250-International-Contractors-1 (accessed 10/12/2017).

Fatt CT (2013) *Singapore BIM Roadmap, Presentation in Building Construction Authority*. Building & Construction Authority, Singapore. See https://www.cic.hk/cic_data/pdf/about_cic/news_and_update/past_event/chi/2013_11_29%20%20Mr%20CHENG%20Tai-fatt.pdf (accessed 10/12/2017).

Finne C, Hakkarainen M and Malleson A (2013) *Finnish BIM Survey*. See https://www.rakennustieto.fi/material/attachments/tutkimus-_ja_kehittamistoimita/6JKcTDSMO/BIM_Survey_Finland_findings.pdf (accessed 16/03/2016).

Gallaher M, O'Connor A, Dettbarn J and Gilday L (2004) *Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry, NIST GCR 04-867*. National Institute of Standards and Technology, Gaithersburg, MD, USA. See http://nvlpubs.nist.gov/nistpubs/gcr/2004/NIST.GCR.04-867.pdf (accessed 18/11/2017).

GSA (U.S. General Services Administration), PBS-OCA (Public Buildings Service Office of the Chief Architect) (2007) *GSA BIM Guide Series 01*. GSA, Washington, DC, USA.

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

HM Government (2012) *Industrial Strategy: Government and Industry in Partnership-Building Information Modelling*. HM Government, London, UK.

Infotron (2017) *3rd Airport Project and Construction Technologies*. Infotron, Istanbul, Turkey. See http://www.infotron.com.tr/index.php/plm-catia/18-urun-gelistirme/haberler-ug/439-bim-3-havalimani-projesi-ve-insaat-teknolojileri (accessed 07/06/2017).

Kiviniemi A (2007) *Finnish ICT Barometer 2007*. Tekes, Helsinki, Finland. See http://cic.vtt.fi/buildingsmart/index.Php (accessed 25/05/2015).

MUSIAD (Turkish Association of Independent Industrialists and Businessmen) (2014) *Construction and Environment Sector Report*. MUSIAD. Ankara, Turkey.

PE (Prota Engineering) (2017) http://www.protamuhendislik.com.tr/EN/Project/kabatas-mecidiyekoy-mahmutbey-metro-line (accessed 15/06/2017).

SP (Senate Properties) (2009) *BIM Guidelines*. SP, Helsinki, Finland.

Taylor NF (2016) SWOT analysis: what it is and when to use it. *Business News Daily*, 28th March. See http://www.businessnewsdaily.com/4245-swot-analysis.html (accessed 29/06/2017).

Teicholz P (2004) Discussion on U.S. construction labor productivity trends, 1970–1998. *Journal of Construction Engineering and Management* **127(5)**: 427–429.

TEKES (2008) *Sara – Value Networks in Construction 2003–2007*. Tekes – the Finnish Funding Agency for Technology and Innovation, Helsinki, Finland, Technology Programme Report No. 2/2008.

TMB (Turkish Contractors Association) (2015) *Turkish Contracting in the International Market*. TMB, Ankara, Turkey. See http://www.tmb.org.tr/doc/file/YDMH-2015-03-Tr.pdf (accessed 20/05/2015).

Wong AKD, Wong FK and Nadeem A (2009) Comparative roles of major stakeholders for the implementation of BIM in various countries. In *Proceedings of the International Conference on Changing Roles: New Roles, New Challenges, Noordwijk Aan Zee, The Netherlands*, pp. 5–9.

Yan H and Demian P (2008) Benefits and barriers of building information modelling. In *Proceedings of the 12th International*

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Conference on Computing in Civil and Building Engineering. Tingshua University Press, Beijing, China, vol. 161.

Yee P, Matta C, Kam C, Hagan S and Valdimarsson O (2010) The GSA BIM story. *Journal of Building Information Modeling* 20–21.

Zeiss G (2013) *Widespread Adoption of BIM by National Governments, Between the Poles*. See http://geospatial.blogs.com/geospatial/2013/07/widespread-adoption-of-bim-by-national-governments.html (accessed 20/10/2016).

Zeiss G (2014a) *Singapore Mandates BIM e-Submissions for Building Projects Greater Than 5000 Square Meter, Between the Poles*. See http://geospatial.blogs.com/geospatial/2014/12/singapore-mandates-bim-e-submissions-for-projects-greater-than-5000-square-meters.html (accessed 11/03/2016).

Zeiss G (2014b) *BIM Market in Tornado of Demand in Finland, Between the Poles*. See http://geospatial.blogs.com/geospatial/2014/11/status-of-bim-in-finland-a-bimearly-adopter.html (accessed 20/06/2015).

Zeiss G (2016) *BIM Adoption in the UK Surpasses 50%, Between the Poles*. See http://geospatial.blogs.com/geospatial/2016/08/bim-adoption-in-the-uk-rises-to-over-50.html (accessed 11/09/2016).

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