BIM Implementation in Mega Projects: Challenges and Enablers in the Istanbul Grand Airport (IGA) Project

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Abstract

The Architecture Engineering and Construction (AEC) sector has been facing considerable challenges recently due to the scale and complexity of the projects. Mega projects are more difficult to manage in terms of decreasing cost and increasing quality and productivity. Innovative approaches have been proposed to overcome the various challenges that the AEC sector tries to address. Achieving integration and thereby a more collaborative project environment is essential in this process. Today's key trend in successful business strategy is put as "combine and conquer" which includes innovating business models together with transforming the core engineering systems around digital. Accordingly, it has been observed that there is rapid increase in implementing Building Information Modeling (BIM) in mega projects. BIM provides significant increase in efficiency of project execution through optimizing project constraints of scope, time, cost, quality, and resources. Therefore, incentivizing all project parties to work in a collaborative fashion can be considered as an important key success factor. This study investigates the challenges and enablers of BIM implementation through a case study on Istanbul Grand Airport (IGA) Project in Turkey to provide a solid understanding of BIM applications in mega infrastructure projects

Keywords

Building information modeling (BIM) • Enablers • Challenges

106.1 Introduction

The construction industry is strongly externally influenced, project based, highly competitive and susceptible to high risk of failure. As Tatum [20] states, driving forces in the construction industry indicate that the ability to innovate is quickly becoming a competitive necessity. Accordingly, to rise to the top in efficiency, construction industry individuals should seek for innovative management solutions. This notion becomes subtler as the increase of complexity and scale of projects are in demand due to the rise in global competitiveness of construction market. As a result, building information modeling (BIM) technologies and concepts have been increasingly employed as one of the most promising tools in the architecture, engineering, and construction (AEC) industry worldwide [3, 10, 18]. However, adopted managerial and utilization strategies differentiate significantly when the infrastructure projects are of concern. Even though there are numerous case studies associated with BIM use in building projects, previous studies have failed to focus on BIM utilization in mega size infrastructure projects. In this respect, this study presents a case study on a mega size airport project—Istanbul Grand Airport

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(IGA) Project—to depict a clear picture of BIM applications via demonstrating the challenges and enablers that were encountered throughout the project management process.

106.2 Background

National Institute of Building Sciences buildingSMART alliance (2007) defines BIM as "a digital representation of physical and functional characteristics of a facility. As such, it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from inception onward." During the feasibility, planning, and development phase, BIM provides owners with information about the current state of the facility and generates information for analysis. During design and construction, BIM primarily supports information capture, communication, coordination, and construction. During the operations phase, BIM supports the performance monitoring of a facility and its systems [14]. BIM offers a holistic approach to construction management by creating and updating all necessary information in a digital environment and their reuse by responsible parties any time during a construction project's life cycle. Thus, it introduces a shared, interdisciplinary team experience and lifecycle evaluation concept to the highly fragmented AEC industry.

Smart Market Report on the trend of BIM use for infrastructure projects published by Dodge Data Analytics state that BIM users at a high level of implementation (on at least half of their projects) grew from 20% in 2015 to 52% in 2017 [11]. The forecasts show that between 2017 and 2019, there will be dramatic increase in BIM implementation among those deploying BIM on nearly all (75% or more) of their projects [11]. In the report, respondents determined the top benefits—that improve process and project outcomes—of BIM utilization for transportation infrastructure projects, as reduction in conflicts/field coordination problems, greater cost predictability, better understanding of project, improved schedule, and design optimization.

Ozorhon [15] proposed a framework to analyze project-based innovation in construction. The framework involves interacting components of innovation, where the rate of innovation is influenced by challenges and enablers that act as either negative or positive factors. In this research, these two components are investigated to better understand the BIM implementation as a digital innovation. Enablers can be described as major tools/strategies employed to realize innovation such as collaborative partnering, supportive work environment, leadership, commitment, knowledge management practices, reward schemes, innovation policy; whereas challenges are the primary factors that inhibit innovation such as unsupportive organizational culture, lack of financial resources, unwillingness to change, financial risks, temporary nature of projects, lack of collaboration among project partner [15].

Main enablers and challenges are identified specific to BIM implementation based on an extensive literature review. Enablers are collaborative working environment, advanced project monitoring and controlling system, BIM tools, and BIM Policy; whereas the challenges are lack of financial resources, lack of clear benefits, unsupportive organizational culture, lack of experienced BIM professionals, lack of awareness, lack of governmental support, and level of project complexity. Explanations and relevant sources for those factors can be found in Tables 106.1 and 106.2.

Similar to the enablers, main challenges of BIM implementation are also listed with their descriptions in Table 106.2.

Table 106.1 Enablers of BIM implementation

Enabler	Description	Source
Collaborative working environment	BIM integrates all stakeholders in a virtual environment to facilitate a collaborative working environment	[1, 3, 6, 14]
Advanced project monitoring and control system	BIM controls the subcontractors and eliminates any unforeseen cost over-runs while reducing waste on site as cost, time and quality	[8, 14]
BIM tools	Advanced digital tools provide rapid access to real-time project data	[1, 5, 8]
BIM policy	Companies' BIM strategies (e.g. BIM execution plans, workflows) and government mandates lead to increase in project individuals' awareness towards BIM use	[10]

Table 106.2 Challenges of BIM implementation

Challenge	Description	Source
Lack of financial resources	BIM utilization requires a significant initial investment due to high costs of sophisticated digital tools (e.g. BIM software, mobile tablets etc.), and education/training	[2, 5, 11]
Lack of clear benefits	It is hard to confirm that the realized benefits outweigh the costs of BIM implementation	[5, 13]
Unsupportive organizational culture	BIM implementation requires a change in technology and business process which may not easily aligned with organization's culture and capabilities based on the competencies of employees and technological assets	[5, 12]
Lack of experienced BIM professionals	Especially developing countries struggle with the socio-economic and technological environment that hinders the research and development so that the increase in qualified personnel	[9, 13]
Lack of awareness	Organizational awareness of the importance of BIM implementation is a critical factor for BIM maturity level which refers to the quality, repeatability and degree of excellence within BIM capability	[12, 19]
Lack of governmental support	There should be BIM policy dictating a systematic and standardized approach for BIM implementation together with incentives	[12, 13, 18]
Level of project complexity	BIM users having insufficient experience might have significant coordination problems while trying to implement BIM for highly complex projects	[17]

106.3 Methodology

This research adopts a qualitative methodology, in which a case-study approach is followed through semi-structured interviews for data collection. Case studies try to answer the how and why questions in research, allowing a more in-depth analysis [21]. There are four quality measures required to conduct case studies, as explained by Yin [21]: (1) construct validity, i.e., the quality of conceptualization or operationalization of the relevant concept; (2) internal validity, i.e., the causal relationships between variables and results; (3) external validity, i.e., the extent to which the findings can be generalized; and (4) reliability, i.e., repeatability with the same results.

In order to improve the validity of the case study, several strategies—such as focus groups, review of documents, and interviews—are employed as suggested by Yin [21]. Thus, this study adopts an exploratory case study in which the objective is to produce generalizations about BIM implementations in a mega-size infrastructure project through two components of construction innovation process framework. According to Scapens [16], main steps in a case study are as follows: preparation; collecting evidence; assessing evidence; identifying and explaining patterns; and report writing. In this study, similar approach is adopted. Accordingly, multiple key BIM users in the IGA project were interviewed to learn about the corporate policies and strategies regarding BIM implementation. The interviewees' roles and responsibilities are presented in Table 106.3 and the interview questions can be found in Table 106.4. Additionally, project documents related to the case study were compiled to be used in the analysis of enablers and challenges of BIM implementation. A case library has been created in order to allow repeatability of the study. Triangulation-which includes short descriptions of BIM journeys in Heathrow Airport and Denver International Airport (DIA) is also conducted to validate the claims made throughout the study. London Heathrow Airport has been using BIM since 2004 [14]. A case study was conducted on its BIM use during a 2008 airport terminal 5 project and it stated a high rate of direct savings related to its approach [14]. Also, DIA began to implement BIM in 2010 with its hotel and transit center project [4]. DIA's BIM model based approach leads to a faster construction pace with coordinated project timelines and effective collaboration around a central model [4].

Istanbul Grand Airport (IGA) is an international airport which has been under construction since 2015 in Arnavutkoy district on the European side of Istanbul, Turkey. IGA targets to be the largest airport in the world with 3 terminals, 6 runways, and an annual capacity of 200 million passengers. The project scope encompasses four phases. The first phase, that is planned to be completed in 2018, includes construction of 3 runways, a terminal with 5 piers with an area of 1.3 million m^2, and a carpark with an area of 700 m^2, and other site wide facilities. Based on the trend of rising passenger and air traffic

Table 106.3 Interviewees' roles and responsibilities

Interviewee	Role
BIM director	– Creation and execution of BIM strategy – Reviewing, monitoring and approving overall BIM process – Managing and providing necessary support for BIM implementation on the overall project – Reporting BIM delivery to the CEO and the board of the client
BIM manager	– Maintaining the BIM execution plan – Attending weekly BIM coordination meetings and BIM workshops – Performing regular QA/QC checks on discipline models to ensure compliance with project BIM standards – Ensuring the BIM project execution plan is followed through the project duration on a daily basis
BIM engineers	– Establishing communication between disciplines and BIM production team –Following RFI and clash procedures – Managing Vault and Buzzsaw environments – Ensuring up-to-date project information is transferred to BIM production

Table 106.4 Interview questions

Interview questions
Could you tell us about the airport project scope?
What are the key performance indicators?
Could you tell us about your role in BIM execution at the IGA project?
Could you tell us about the development of BIM plan from the conceptual stage?
Could you tell us about how BIM is applied at the IGA project?
How will BIM be used over the lifecycle of the airport?

movements to and through Istanbul (as current international airport—Ataturk Airport—is operating at or beyond its maximum capacity), IGA is considered as a potential world hub for international travel.

To actualize a fast track, mega scale project, like the IGA Project, in a time and cost efficient way; an innovative project delivery system—which could enable integration and control of all project individuals at all times—was required. Accordingly, it was decided to utilize BIM applications at its all dimensions (3D–7D) throughout design, engineering construction, and operation phases. Overall, BIM Plan of the IGA Project follows a fundamental strategy of providing digital transformation together with cultural change, which is basically bringing people, and technology together, in a single virtual platform.

106.3.1 Challenges

There are mainly two categories of problems that are encountered in the project, including engineering and managerial issues. These two categories associated with the challenges include lack of experienced BIM professionals, level of project complexity, and lack of awareness.

Regarding engineering problems, clash resolution process related to coordination between mechanical, electrical, plumbing (MEP) systems and special airport systems (SAS) has become one of the major issues both in design and construction phase concerning a wide variety of project individuals. Managing the flow of request for information (RFIs) and incorporating the solutions, which have been generated from different discipline perspectives, represent a major engineering management problem.

An airport project, due to its nature requires much different and complex type of mechanical systems that need large areas to be placed and to be activated altogether (Fig. 106.1). Figure 106.1 can indicate the challenge of project complexity, as there is a cluster of various types of pipe, duct and cable tray systems (e.g. HVAC ducting; plumbing pipes; fire sprinklers, electrical and IT cable trays, and heating and cooling pipes) at different levels of the terminal building which require to be coordinated accurately to aid in practicality on site.

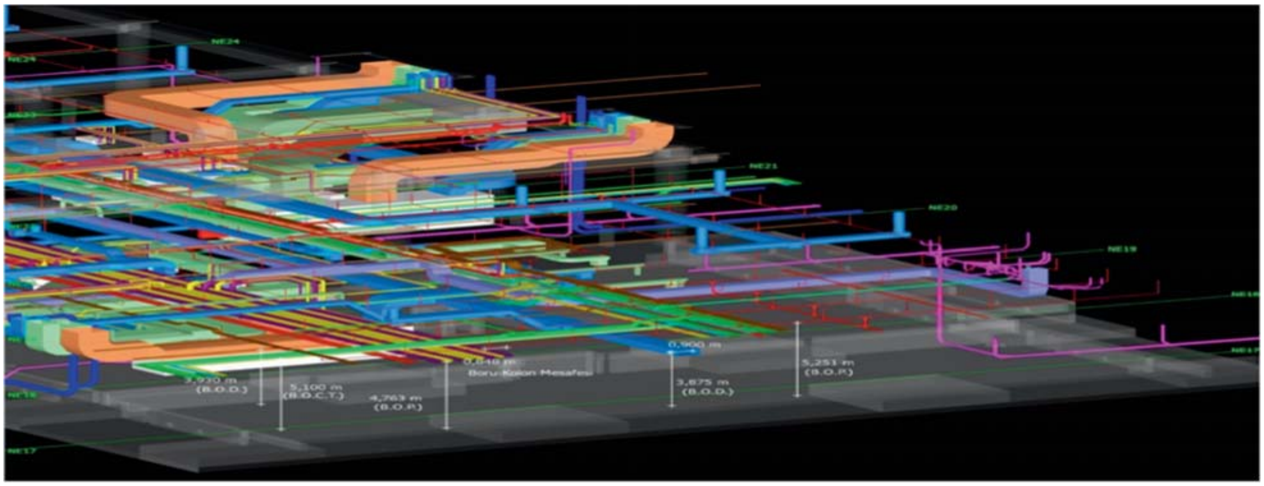

Fig. 106.1 Viewpoint of MEP systems

Moreover, baggage handling systems (BHS) placement has been a significant engineering challenge in IGA Project due to the requisite accuracy and the length (42 km) of the baggage routing. Initial engineering decisions are made upon for BHS systems' placement. Then, MEP systems including HVAC ducting, piping, electrical and IT cable trays are placed appropriately in architectural and structural envelope, and coordinated accordingly. However, because MEP subcontractors had limited experience in making interdependent disciplinary decisions in such a large-scale project, the coordination period included many conflicting iterative processes that needed to be defined and managed properly.

Regarding managerial issues, the major problem has been monitoring and controlling work on site. As far as the size and complexity of the project is concerned, managing all project individuals, mainly the subcontractors, becomes a very challenging issue that requires a substantial management plan. In the very beginning of the project, lack of awareness and experience of subcontractors and so that their resilient attitudes against engaging BIM process in their daily site and office work leaded to a necessity of training all subcontractors through facilitated workshops.

Not only the IGA Project case, but also the other aforementioned mega airport project case studies—Heathrow T5 and DIA expansion—bear similarities in managerial issues. Heathrow was firstly challenged by different project managers bringing different management styles and approaches to the project in the space of four years [7]. Secondly, it had space constraints which prevented co-location and full integration at the beginning of the project [7]. On the other hand, DIA mostly tackled the problem of reaching a consensus on collaboration in BIM environment [4].

All in all, achieving cultural change in complex projects is a struggling process. Incompatibility of site work with BIM model is one of the most crucial problems, because it has been known that the issues detected regarding discrepancies between coordinated BIM model and already manufactured zones on sites have potential to cause future coordination problems, waste and cost over-runs.

106.3.2 Enablers

To overcome the challenges faced throughout the implementation of BIM in this mega airport project, there are strategic control mechanisms including periodic BIM workshops for educational purposes.

It is essential to demonstrate how BIM is taken over to the subcontractor on site and how BIM leads to the installation work of subcontractor on site. There are control mechanisms provided by the pre-set BIM execution plan and strategy, and also BIM Workflow (Fig. 106.2) at the very beginning of the project; and via these mechanisms subcontractors are fully integrated into BIM environment. The BIM Department—that is represented as BIM Management Team in Fig. 106.2—is responsible of managing, integrating, and monitoring and controlling of the BIM model data input from project subcontractors of various airport design disciplines. BIM models are generated at different level of details and the concurrent engineering and design proceeds. Clash reports; 4D scheduling; reporting quality assurance and quality control (QA/QC) on site are provided BIM Department to have effective control mechanism on subcontractor's work. Weekly BIM workshops, and BIM coordination meetings are used as communication tools to oblige subcontractors to use BIM tools. Also, these BIM

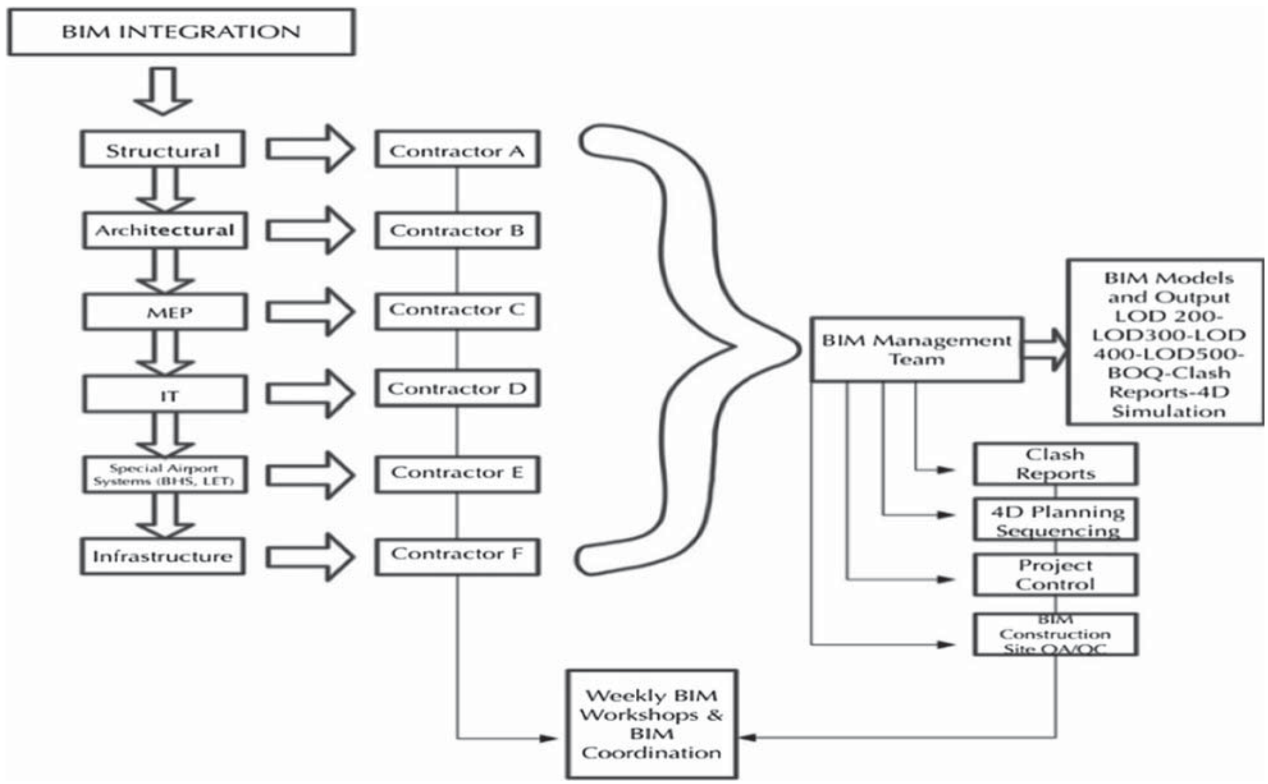

Fig. 106.2 IGA project BIM workflow

tools used to provide a cloud-based virtual platform for BIM integration are presented in Fig. 106.3. The use of these BIM softwares enables the IGA Project individuals to have controlled work—sharing, BIM coordination, design review, change visualization, quality management, and issue management, access to RFIs and submittals, and notification of inspection documents.

BIM policy of the company declares strict contractual obligations for all subcontractors to make them follow and utilize BIM process into their work processes such as using mobile tablets on site for filling out Notification for Inspection (NFI) Documents to get their progress payment. All coordination issues are detected on site by the client's BIM site engineers for each manufactured zone. The issues are reflected on Autodesk BIM 360 Field system periodically to track each subcontractor's performance on site. These reports are internally shared weekly so that BIM processes enhance the control mechanism. Accordingly, project parties who consist of the designers and subcontractors are led to get familiarized with

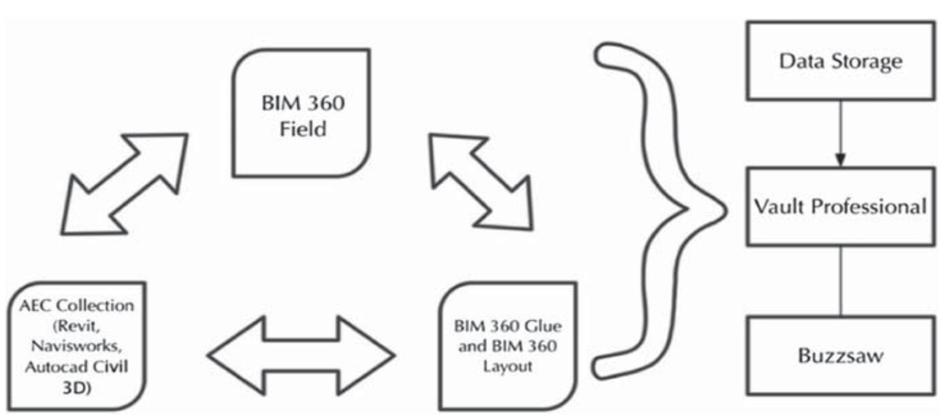

Fig. 106.3 IGA project BIM tools for virtual platform

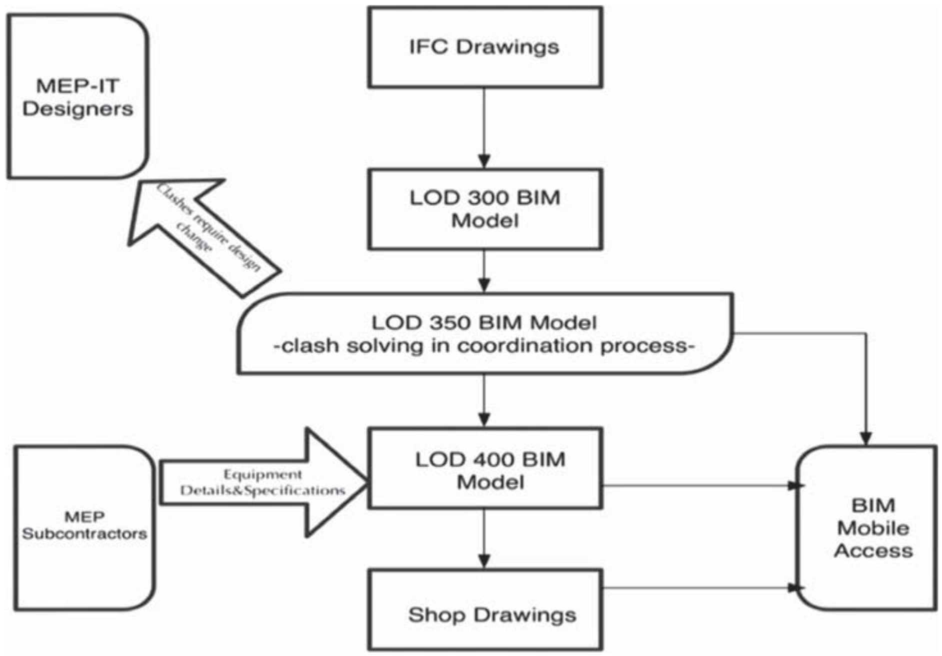

Fig. 106.4 MEP-IT coordination workflow

using the products of BIM in a harmonized fashion. For instance, on the site, there are 150 mobile tablets that provide all coordinated BIM models to the site engineers to assist them in carrying out zone wise production. Apart from 3D models, approved 2D shop drawings are also provided for the field via mobile tablets.

Along with the production on site, QA/QC is conducted with the help of digital documentation which supports cloud-based access for all related site engineers. All of these applications take place on Autodesk 360 Field platform. Additionally, a 4D model including 30,000 activities has been generated to track the progress on a daily and monthly basis to have dynamic control over the progress of the project.

Disciplined and zone-wise clash detection is utilized throughout design and construction phases. The frequency of clash detection and resolutions depend upon the frequency of design revisions. The airport systems integration is dynamically controlled via periodic clash detection. The periodicity is determined by the submission schedule of subcontractors. However, the BIM department determines and controls the coordination process of mechanical, electrical, plumbing and information technologies (MEP-IT) systems with a separate coordination workflow due to their highly complex nature in such a mega scale airport project (Fig. 106.4). The workflow depicts concurrent engineering and design in a fast track fashion and the responsible parties in this process. The main objective is to resolve the clashes in LOD 350 BIM level with MEP designers and proceed to the extraction of shop drawings out of the clash-free BIM model to push the work on site. The BIM model are continuously fed by various details such as equipment details and specifications throughout the workflow. Every update on BIM models and shop-drawings are shared in cloud system and made accessible via mobile tablets on site.

Heathrow and DIA also followed similar approaches to overcome the major challenges they faced to in the BIM implementation process. “Central to the delivery of T5 has been the concept of integrated teams” [7] indicates the enabler of collaborative working environment. On the other hand, BIM policy can be seen as the major enabler for DIA to be proactive in their BIM process as the project team stated “We tried to predict the obvious issues and create a number of workflows to help solve those problems before they arose” [4].

106.4 Conclusion

Implementation of BIM in the airport projects significantly differentiates from the typical applications of BIM to new building construction in which the focus is on design and construction of a lone building. BIM use for airport construction requires more complex BIM implementations compared to buildings, because the airport design and construction incorporate a varying mix of infrastructures including terminals, runways, passengers' gates, car parks and transportation systems including railways and roads so that an airport construction project comprehensively covers the aspects of those different construction types. In the case study, BIM is being used from the early briefing and concept design through detailed design and construction phases. Since the project stakeholders have recognized the crucial benefits and advantages of using BIM that make concurrent design and construction possible, it has been also decided to use BIM in the facility management phase after the completion of the construction. Essentially, it is realized that BIM has a significant impact on the following matters: power of having authority on subcontractors while managing the work and delivering on site; improving quality of design and construction stage; reducing waste both on site and office; fast resolution of issues on site; enhancing collaborative work.

Holistically, the research proposes a systematic way of assessing the BIM applications via two components of innovation framework that are enablers and challenges. Even though the success of the BIM implementations can not be quantified at this stage since the IGA Project is still ongoing, via referring to previous studies in the literature and similar real life case studies on completed projects, one can conclude that BIM—as construction innovation—brings benefits at all levels. The interviews, observations, analysis of documentations show that even though introducing cultural change is difficult to achieve, the willingness of the project team members to integrate their work on BIM platform overcomes the barriers.

For further studies, to deepen the discussion of BIM implementation measures, a comparative analysis of two case studies from different geographies encompassing similar type and scale of infrastructure projects may be conducted; and same framework for analyzing innovation in construction may be used.

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