Implementation of Building Information Modelling (BIM) on Public Infrastructure and Building Projects in Qatar

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Abstract

Building Information Modelling (BIM) is a term that has been referenced around the world by many practitioners and researchers. This modern methodology for project delivery improves the quality, time, and cost of any type of asset. BIM is not just applicable for buildings, it is equally applicable to utilities, infrastructure, and civil engineering projects. The Public Works Authority of Qatar recognizes the importance and the imperative of collaborative BIM to enhance design, construction, operation and maintenance of its building and infrastructure assets. The authority commits to the implementation of BIM and mandates its use on all public infrastructure and building projects over the complete lifecycle. This paper illustrates the implementation roadmap and strategy, in accordance with the Corporate Strategy and Qatar National Vision 2030, to adopt modern methodologies for design and construction delivery across the country. Anticipated benefits in each project stage will be highlighted, as well as the selection of standardized BIM uses within the authority and its supply chain. The authority has developed and published the *Ashghal BIM Standards* (ABIMS), which comprise of various specifications, templates, and guides. Those standards build on the existing code of practice for the collaborative production of architectural, engineering and construction information (ISO-19650: 2018). Finally, the historic establishment of a corporate BIM policy is fundamental for an enterprise and industry-wide adoption, building the governance on a unique concept – the four components of BIM Implementation – namely foundation, organisation, operation, and technology.

Keywords: Digital Transformation; BIM; Building Information Modelling; Information Technology; BIM Implementation

1 Introduction

More than USD $200bn was budgeted for the investment in the massive development of new roads, stadiums, facilities, and other major projects in the State of Qatar in the period between 2011- 2022. Most of this budget is dedicated to the transport sector that is required to support FIFA World Cup Qatar 2022 and Qatar National Vision (QNV) 2030 to meet the rapid infrastructure and economic growth (Ministry of Municipality, 2016). The QNV 2030 aims at transforming Qatar into an advanced country, capable of sustaining its own development and providing for a high standard of living for all its people for generations to come (General Secretariat For Development Planning, 2008). Qatar's National Vision defines the long-term goals for the country and provides a framework in which national strategies and implementation plans can be developed, such as the Corporate Strategy 2018-2022 of the Public Works Authority 'Ashghal'. This strategy aimed at "continuously enhancing customer satisfaction through leading project and asset management services and solutions" (Public Works Authority, 2018) and has set the foundation for the implementation of Building Information Modelling (BIM) within Ashghal for public infrastructure and building projects in the State of Qatar.

Before initiation of the 'Implementation of BIM programme' the subject has not been entirely new to Ashghal, since several design and construction projects have been tendered and delivered with 'some' BIM requirements. In 2017, the Public Works Authority piloted the implementation of lean construction principles within a few projects in Qatar to improve project performance and predictability of delivery. Following realization of tangible benefits through the pilot application, Ashghal made it contractual to implement Lean in future projects (Al-Buenain et al., 2020).

One of the major challenges can be observed in the way projects are managed by different departments within Ashghal, where each is responsible to tender, deliver or even maintain specific assets, like roads, drainage networks, or buildings. This occasionally has led to variations in project BIM requirements and non-uniform contractual scope within projects in different departments. The implementation of BIM in project contracts was not mandatory, since no new or existing company policy has demanded it. In addition, the lack of relevant standards within the authority and local industry has led to misinterpretations and different understanding of delivery requirements. It has been a logical consequence that a unified and company-wide digital transformation initiative, including revision of policies and processes, development of standards and templates, shall be the only way forward.

The purpose of this paper is to highlight and summarize key efforts in the BIM implementation journey of Ashghal. It shall elaborate how to structure the implementation of BIM within an authority with a variety of infrastructure and buildings projects. Further it illustrates a realistic timeline for an implementation considering existing inhouse staff and supply chain capabilities. The paper starts with a review on literature and methodology, before results of the Ashghal BIM implementation programme will be discussed. Finally, the paper will give a conclusion and recommendations.

2 Methods

Benefits of BIM as a methodology for project delivery to improve efficiency and quality of work were proven by numerous case studies and implementations on company and national level. The complex-scale project "Lusail Plaza" in Qatar has demonstrated how BIM integration in the coordination process can decrease clashes and improve progress of work during the construction phase (Abotaleb et al., 2020). Benefits can be expected in each project stage for a variety of stakeholders, including the owner, the designer, contractor and facility manager. Especially, benefits for the authority as the owner and operator have been aimed at, such as design benefits, increased building quality, improved collaboration, improved commissioning and handover of facility information, and integration with asset operation and maintenance systems (Eastman et al., 2011).

A majority of construction companies report a positive return on invest (ROI) on their BIM programs and that contractors in all markets are planning to expand their BIM programs over the next years (McGraw Hill Construction, 2014). A report on the business value of BIM for infrastructure revealed 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. Between 2017 and 2019, the growth in BIM implementation is most dramatic among those deploying BIM on nearly all (75% or more) of their projects, with the percentage almost doubling from 17% to 32% (Dodge Data & Analytics, 2017).

The higher management in Ashghal has not questioned if BIM can generate benefits for future design and construction projects, but has proclaimed a top-down implementation of BIM programme and tasked the project team to develop a respective scope and roadmap, tailored to the nature of Ashghal's business. The team investigated the "state of the art" and maturity of BIM adoption internationally,

where reports display the significant adoption of BIM by Governments throughout the world (McAuley, 2017). A focus has been set on Hongkong and Singapore as a case study, which are not only comparable to the size of Qatar but also have taken a pragmatic approach in mandating BIM, including adequate technical specifications and education programmes.

The *Roadmap for Digital Design and Construction* from the Federal Ministry of Transport and Digital Infrastructure in Germany aims on a gradual introduction of BIM, in which the first phase constitutes the preparatory phase and a second phase which starts with systematic scaling up the application of BIM in a larger number of pilot projects, before the broad implementation will begin in a third phase (Federal Ministry of Transport and Digital Infrastructure, 2015). This has ultimately inspired the Ashghal BIM implementation roadmap, which will be elaborated in the next chapter.

3 Results

3.1 Objectives

At the programme kick-off, the team has defined main corporative objectives for the BIM implementation to highlight areas for improvement and emphasize on a project lifecycle approach:

- Deliver intelligent 3D models for building and infrastructure projects to be used throughout the lifecycle of the programme.
- Facilitate collaboration, design proofing, and constructability reviews.
- Ensure a coordinated design by clash avoidance to reduce errors in the field.
- Streamline planning, progress reporting, and cost control.
- Improve commercial and contract management.
- Enhance visualization for communication and decision making.
- Support operation & maintenance with handover of reliable and accurate asset data.
- Take leadership in national BIM implementation.

3.2 Implementation Roadmap

Taking leadership in the national BIM implementation has been imperative to the senior management, since the Public Works Authority of Qatar is in a prominent position to lead innovation initiatives and drive a country-wide adoption of construction technologies, especially when it comes to improvements of industry standards and policies. The *Ashghal BIM Implementation Roadmap* (**Fig. 1**) illustrates a staged implementation strategy, consisting of three stages from the year 2018 to 2022.

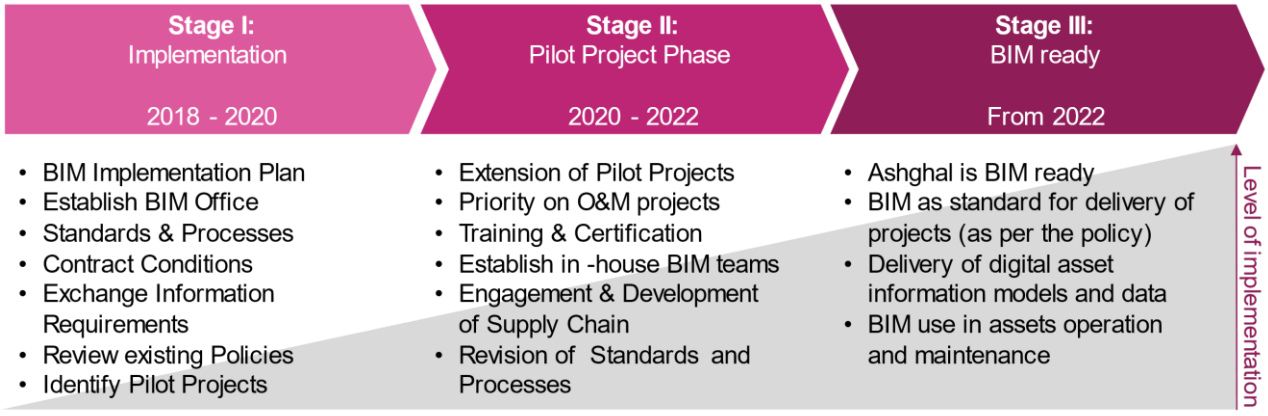

Fig. 1: Ashghal BIM Implementation Roadmap

The first stage ‘Implementation’ describes the foundational development of documents, from the overall implementation plan to other paperwork like policies, standards, and templates. It also included the organisational setup and implementation of one core team to lead and govern the subject within the company and coordinate between departments and other internal or external stakeholders. The second 2-year stage ‘Pilot Project Phase’ allowed the practical use of documentation on pilot projects, where the focus was set on the asset handover and technical procedures to integrate data from As-Built information models into operation & maintenance, in particular geospatial information system (GIS) and enterprise asset management system (EAMS).

The application of new standards on pilot projects also allowed to engage with the supply chain to gather valuable feedback for a revision of standards and processes. A training and certification programme has been rolled out to develop existing staff capabilities and establish in-house teams in concerned departments. The third stage from 2022 onwards marks the readiness of the authority, where BIM is mandatory for the delivery of design and construction projects as per company policy with the ultimate objective to use asset information models and data for the operation & maintenance.

BIM is not just about publishing a mandate or procuring software licenses, hence the definition of the implementation scope required an analysis of all relevant aspects including the inclusion of new roles like the *Information (or BIM) Manager* where challenges have to be identified along the project lifecycle and categorized (Grys & Westhorpe, 2011). The Ashghal implementation team has applied this unique concept to structure the implementation and governance into the *Four Components of BIM* (**Fig. 2**), namely *Foundation*, *Organisation*, *Operation*, and *Technology*.

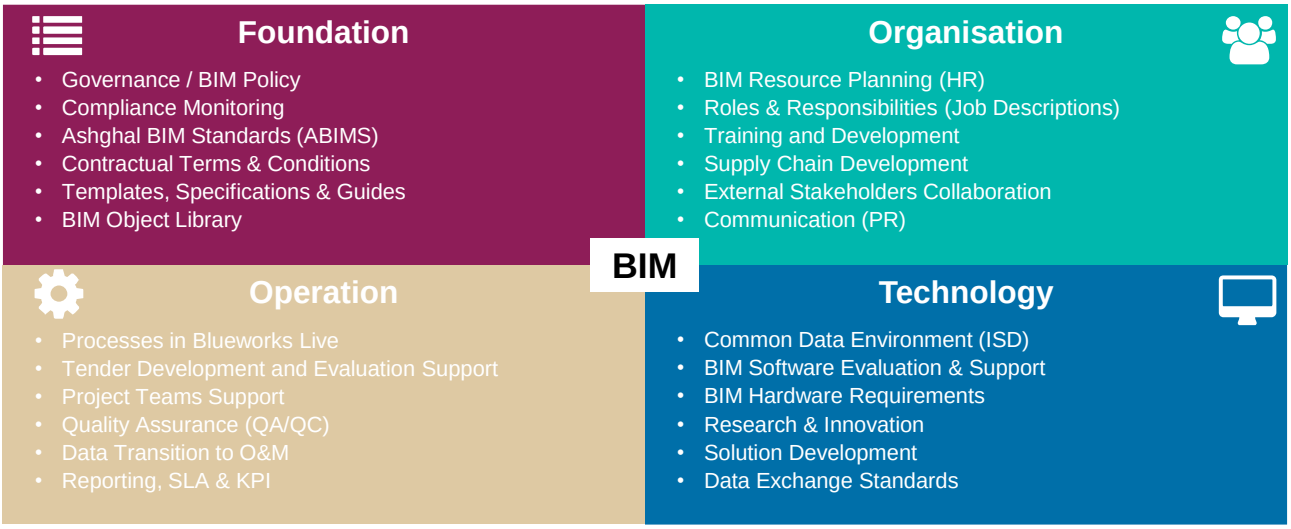

Fig. 2: Four Components of BIM

3.3 Foundation

The core of the *‘Foundation’* component is the corporate BIM policy, in which Ashghal commits to implement key aspects like to ensure delivery of *Asset Information Models* (AIM), produce in-house design works using model-based workflows and processes, implement a *Common Data Environment* (CDE), and train employees to achieve necessary BIM software capabilities. The Policy is applicable to all roads, highways, drainage, and buildings tenders and projects across the design, construction, and operation & maintenance phases, unless they are specifically exempted by Ashghal (Public Works Authority, 2022). The policy also defines guidelines, roles, and responsibilities of concerned departments, structured into the four components of BIM.

The team has developed and published the *Ashghal BIM Standards* (ABIMS), which comprise of various specifications, templates and guides. Those standards build on the existing code of practice for the organization and digitization of information about buildings and civil engineering works, including Building Information Modelling, namely *Part 1: Concepts and principles* (ISO, 2018a), *Part 2: Delivery phase of the assets* (ISO, 2018b), *Part 3: Operational phase of the assets* (ISO, 2020a), *Part 4: Information exchange* (ISO, 2022), *Part 5: Security-minded approach to information management* (ISO, 2020b).

Qatar Railways Company has cooperated with Ashghal before initiation of the programme and provided support including the full documentation of *Qatar Rail BIM Guidelines* (QRBG) as input for Ashghal standards development. The goal of the QRBG implementation is to secure consistent information delivery of the projects contracted under the Qatar Rail BIM programme. This is achieved by providing contractors with clear guidance and delivery requirements in the form of BIM guidelines (Qatar Railways Company, 2017). Another supporting documentation has been provided by the *Qatar-BIM Project* (Dawood, 2014) directed by Prof. Nashwan Dawood (School of Science and Engineering, Teesside University) and funded by the *Qatar National Research Fund* (QNRF). The publications and objective reports of this project have given recommendations for the development of standards and requirements in Qatar. Hafeez et al. (2016) aimed to develop a set of principles and recommendations for the employers information requirements (EIR), which are applicable to Qatar's construction sector.

Finally, to support in-house design, a library with an initial amount of 250 BIM objects has been developed in coordination with the Designs Department. The objects have been modelled to an agreed level of development for drainage (93 objects), roads (57), and buildings (100).

3.4 Organisation

The '*Organisation'* component is focusing on the people, internal staff as well as external supply chain. The implementation programme has been executed by a core team of specialists, managed by a corporate BIM Lead, and supported by an external consultant. The assignment of focal points and BIM champions in each department ensured the internal support and coordination within the organisation. A crucial factor for success has been the setup of a decentralized BIM organisation with one governance team on top and a Lead in each department, which is responsible to grow the internal team as per department needs based on project workload and requirements. This structure allows an allocation of expertise and knowledge at the place where BIM is happening, instead of centralising all staff in one place and risk that BIM is executed in a silo.

For the standardisation of internal BIM positions, the team has developed job descriptions with required competencies, key responsibilities, and qualification criteria. The *BIM Specialist* is in a senior role and is managing and overlooking BIM delivery for Ashghal projects within the department. The *BIM Coordinator* assists the *BIM Specialist* in coordination and execution of BIM projects, while the *BIM Technician* has the primary function to support in the production and management of information models and creation of accurate design drawings or other model derivatives, as well as quality assurance.

To ensure internal knowledge transfer, a comprehensive learning and development programme has been rolled out. A total of 17 training modules have been developed (refer to Fig. **3**), which were divided into seven (7) management and ten (10) software trainings.

BIM Management Training

Code	Module Name
M1	BIM Implementation and Fundamentals
M2	BIM Strategy, Procurement, and Governance
M3	BIM QA & QC
M4	BIM for Management
B1	BIM for Design
B2	BIM for Construction
B3	BIM for Operation and Maintenance

BIM Software Training

Code	Module Name
S1	Software Training: Design Authoring (Architecture)
S2	Software Training: Design Authoring (Structure)
S3	Software Training: Design Authoring (MEP)
S4	Software Training: Design Authoring (Infrastructure)
S5	Software Training: Construction Scheduling 4D
S6	Software Training: Measurement & Cost Management 5D
S7	Software Training: Design Review
S8	Software Training: Design Coordination
S9	Software Training: Model Viewing
S10	Software Training: Rendering & Visualisation

Fig. 3: Ashghal BIM Learning & Development Modules

The management modules cover topics like BIM fundamentals, procurement, quality assurance and include sessions for practical application during design, construction, and operation & maintenance. The software modules cover hands-on trainings in selected software applications, including design authoring and review, design coordination, construction scheduling and measurement. Due to the global pandemic in the years 2021-2022 the training programme has been rolled out in a mix of classroom and online training sessions.

3.5 Operation

The *'Operation'* component refers to the operational setup of the authority to perform BIM, specifically the integration into internal business processes and establishment of communication procedures and reporting methods. The majority of practical BIM execution on projects is being delivered by Ashghal's supply chain, such as design consultants, supervision consultants, and contractors. However, a significant amount of activities is assigned internally, such as design authoring, design review and approvals, model compliance checks, clash detection, quantity surveying, document & data management, etc.

The BIM governance function within Ashghal is assigned to the Engineering Information Systems Section within the Engineering Services Department, the 'home' of BIM, CAD & GIS. This core team has established a number of internal services to support BIM activities, including digital request forms, procedures and a service level agreement. In addition, the team has identified around 35 touch points in the existing business processes across departments and made required amendments to enable BIM-based project delivery, such as 'Develop Tender Documents,' 'Develop in-house Design & Design Development,' 'Manage Projects Handover, and 'Manage Design Review.'

A concept and procedure for project monitoring and reporting has been established, which includes project dashboards for status tracking during tender and delivery stages. An essential element is the continuous coordination with focal points and specialists of internal departments, supported by a communication website for any BIM matters, such as access to standards, templates, contacts, dashboards, and training documentation.

The practical application of information models for specific purposes is often referred by the industry as 'Model Uses' (Succar, 2019) or 'BIM Uses' (Pennsylvania State University, 2019). BIM Uses are intended or expected project deliverables and can be defined as a method of applying Building Information Modelling during an asset lifecycle to achieve one or more specific objectives.

Pennsylvania State University (2019) initially lists 25 BIM Uses, and Succar (2019) expands a Model Uses Table to 52 general uses with hundreds of potential synonyms. The Ashghal team decided to initially focus on ten (10) main BIM Uses (refer to Fig. **4**), to standardise general requirements on projects and encourage the concept of practicality and simplicity.

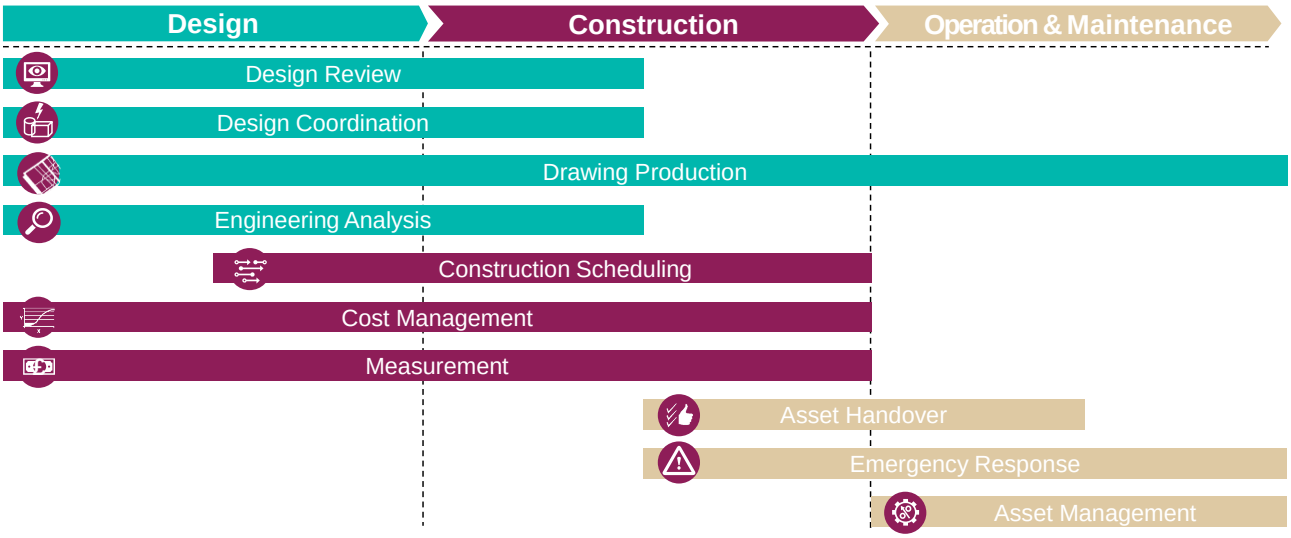

Fig. 4: Main Ashghal BIM Uses

According to the corporate BIM policy, all projects shall employ those selected BIM Uses, as applicable for the project stage and detailed in the project requirements and BIM standards, but not limited to (1) Design Review, (2) Design Coordination, (3) Drawing Production, (4) Measurement, (5) Construction Scheduling, (6) Cost Management, (7) Engineering Analysis, (8) Asset Handover, (9) Emergency Response, (10) Asset Management.

3.6 Technology

The *'Technology'* component involves all required IT-related topics to enable a smooth transition to BIM-based project delivery, such as computer hardware, software applications, data exchange, and cloud collaboration technologies. Personal computers for approximately 2000 Ashghal employees have to be regulary maintained, upgraded and exchanged. The team has identified required hardware specifications for desktop and laptop computers. A 'Standard' and 'Performance' configuration has been defined for each, which resulted in four different specifications. The 'Standard' has been assigned to users mainly working in regular office applications, having low interaction with 3D models (e.g. viewing only) and drafting in CAD applications. Power users primarily authoring 3D models and running clash detection or other engineering analysis applications have been assigned for the 'Performance' configuration.

The selection and procurement of software licenses followed an analysis of market leading solutions for certain BIM activities and consideration of existing internal staff skills and capabilities. The intention was to define a corporate software standard for main activities, such as buildings design authoring, roads and drainage design authoring, clash detection, design review, structural analysis, planning & scheduling, quantification, cost management, and visualisation. To enable smooth collaboration with the supply chain and enable compatibility of data submissions, selected software applications and file formats have been incorporated in the *Ashghal BIM Standards*.

Another strategic decision has been made with the introduction of cloud-based BIM technologies, which allows architects and engineers to easily access 3D information models and coordinate from

virtually anywhere. Storing information models in the cloud means project members can upload and access the latest version of their models, and work from one single source of truth. Design issues and clashes on a construction project can be detected quicker since actual data is used by the entire team. Further, cloud technology has been implemented for project visualisations and reviews of data submission by Ashghal's supply chain, which required an integration with existing project management systems.

4 Conclusion & Recommendation

This paper highlighted key elements of Ashghal's BIM implementation programme to emphasize that BIM impacts various business areas and is not just about technology alone. The focus has not been set on the question if BIM should be implemented for public projects in Qatar, but rather how the implementation scope shall be structured and what roadmap is suitable considering staff and supply chain capabilities. A staged implementation roadmap with an embedded phase for pilot projects can be recommended to any organisation where internal capabilities are middle to low.

Essential for a successful implementation and commitment from all staff is the foundation component with a corporate policy and standards. The methodology of using the four components of BIM can be transferred to any organisation in the construction sector. A top-down approach with a committed support by the higher management is fundamental for a structured and sustainable implementation programme.

Finally, it can be expected that the Public Works Authority will continue to improve BIM project delivery on public projects and take leadership in the national BIM implementation to contribute towards a country-wide adoption and development of national BIM standards for the entire Qatar construction sector.

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