

An Approach to Determine Exchange Information Requirements (EIR) for Metro Projects in Turkey

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Abstract

The paper represents a framework that can be followed while adopting Exchange Information Requirements for metro projects in Turkey. In contrast to the universal trend of implementing Building Information Model initially to superstructure projects, Turkey brought an obligation of BIM use for the first time in a metro project. Since 2014, metro projects tendered in Turkey, primarily in İstanbul, are BIM-mandated public projects. However, Employers have not yet developed organization-wide holistic standards to ensure delivered project will qualify their expectations. EIR define the requirements of the Employer regarding the content, delivery, and management of project related information including the roles and responsibilities of involved parties, applicable standards and milestones along the project lifecycle. It should clarify technical, commercial, and managerial aspects at different phases of a project. As each stakeholder is expected to be in full compliance with the document, EIR is fundamental for an Employer to ensure an efficient utilization of BIM methodology in accordance with a defined international BIM Standard, such as ISO19650. This paper aims to describe the aspects that should be included in EIR of metro projects in Turkey by analyzing similar EIR implementations around the world within the scope of international BIM Standard ISO 19650.

Keywords: Exchange Information Requirements, Building Information Modelling, metro projects, BIM, EIR.

Introduction

Exchange Information Requirements (EIR) is a document specially tailored for an Employer to clarify their requirements and expectations from projects with Building Information Modelling (BIM) use. The document aims to set out the information to be delivered and the standards and processes to be adopted by all project stakeholders along the project lifecycle. EIR should be included in tender documentation, enabling design contractors to respond with their pre-contract BIM Execution Plan (BEP) where their proposal to meet client requirements is explained in detail. Pre-contract BEP aims to define how the specified information in EIR will be provided by demonstrating the tenderer's proficiency in delivery and management of information. PAS 1192-2:2013 states it should include the Project Implementation Program

(PIP) setting out the capability, competence and experience of the tenderer, collaboration and information modelling objectives, project milestones, and the project delivery strategy. Comprehensive EIR is of vital importance for tenderers to develop appropriate and complete BEPs that include their clear plans for the whole construction process and also for the evaluation of tender responses, as it serves as a reference document to review tenderers' BEPs and award the contract (Wairi, 2018).

Clear definition of user's information needs prior to starting BIM processes explicitly enhances the outcomes of BIM implementation in any project. Furthermore, Ashworth et al. (2017) define a clear EIR as one of the fundamental principles of achieving BIM Level 2. The document covers technical, managerial, and commercial aspects of project delivery procedures. Technical aspects include software platforms, data exchange formats to be used, whereas managerial aspects refer to the standards, roles and responsibilities, coordination and collaboration processes. The latter, commercial aspects specify key issues such as BIM deliverables and competence assessment criteria.

In 2019, International Association of Public Transport (UITP) declared İstanbul as the lead city in the world that has the highest number of rail system construction projects at the same time by 17 ongoing projects (Alyanak, 2019). Although metro projects tendered in Turkey have been BIM-mandated public projects since 2014, Employers have not yet developed an EIR to standardize project delivery procedures. This paper aims to describe the aspects that should be included in EIR of metro projects in Turkey by analyzing similar EIR implementations around the world within the scope of international BIM Standard ISO 19650.

Research Motivation

The first metro project in Turkey that was designed using BIM technologies was initiated in 2015. The primary BIM-based metro project of İstanbul, which is being constructed in two parts by two different contractors, is expected to be in full service by 2021. As of June 2020, there are 16 metro projects with a total length of 71 kms being constructed in İstanbul, which are commissioned by 13 contractors and 8 design consultants. The goal is to build 49 km of additional metro lines by the end of 2023 (İstanbul Metropolitan Municipality, 2020).

Within the scope of the design studies of a metro project consisting of several stations, over 10.000 documents are produced and communicated between the project stakeholders. These documents are named according to diverse naming protocols, shared within different common data environment platforms in different data exchange formats.

In metro projects tendered in Turkey, different companies are usually in charge of design & construction of the project and operation & management of the built facilities. Consequently, the operating company often stays out of the initial procedures of the project such as planning and preliminary design resulting in incompatibility of project outcomes with their requirements. Their participation is essential for BIM Execution Plan to ensure the end product is compatible with their data requisition, internal procedures, and equipment and software preferences.

A major consequence of the absence of specified Employer requirements is to have projects with different modelling strategies. Each design consultant specifies the model structure and the level of detail that their models will have at different project phases in their BEP according to their internal standards. Models of uniform or at least comparable maturity level would be indispensable for future superposition of the city's metro lines into a federated master model.

In consideration of significant number of metro projects ongoing simultaneously in Turkey, the development of Exchange Information Requirements is of vital importance in maximizing the benefits of BIM implementation for all projects. Lack of EIR serving as a reference document disables design consultants from conceiving the appropriate BEP. There are many issues that could be standardized in accordance with Employer's requirements and implemented in each project's BEP such as document management procedures, model development strategies, data exchange formats, and software platforms in order to eliminate discrepancies between different projects.

Research Methodology

In order to determine the content of the Exchange Information Requirements for metro projects in Turkey, a literature review was conducted but a shortage of EIR-focused studies had been noticed. Most studies approach EIR from Facility Management (FM) point of view. Furthermore, specifications and guidelines mention the need for EIR but do not provide clear definitions of these requirements. ISO 19650, one of the most frequently used international standards for information management over the lifecycle of a built asset using BIM, describes a general framework for the content of the EIR. According to ISO 19650-1 (BS EN ISO 19650-1:2018, 2018), the managerial and commercial aspects should define the standards of information and how they should be produced while technical aspects should specify detailed information needed to respond to project information requirements. Although there might be several appointments made for a project, the combined EIR serves as a comprehensive set of information requirements addressing all project information requirements (BSI, 2014). Apart from identifying some aspects that must be described in the EIR, such as metrics determining levels of information need, ISO19650 does not provide a detailed EIR content as each project is unique as per its requirements. Therefore, the standard can be considered as a starting point while preparing the EIR and a final checklist while revising the document.

Three sample EIRs that were included in procurement documents of three different projects were examined in order to establish possible EIR content for metro projects in Turkey. The first EIR, will be referred as Case 1 hereafter, is from design & build project of a corridor of Regional Rapid Transit System (RRTS) network in India. It covers detailed civil, architectural, and electro-mechanical (E&M) design & construction works of 7 elevated stations and detailed planning of proposed 5 underground stations within the corridor of 106.5 km total length. Case 2 is the only project within the sample projects excluding design works which includes construction of 9 elevated metro stations, an associated viaduct, and all associated works within 26.1 km-long project scope, also located in India. The latter one, Case 3 differs from the others with its scope and location, as it is from a bridge & causeway project, which is a sub-project of a mega project of 28.000 square kilometers site area, located in Saudi Arabia. It covers detailed design, procurement of materials, fabrication, transportation, installation and commissioning of 3 bridges connecting mainland to an island and associated causeways. The project being a unit of a group of projects brings additional features to this EIR. All three cases and their characteristics are tabulated in Table 1.

Table 1. Sample EIR Cases.

Case	Case 1	Case 2	Case 3
Scope	Design & Build	Build	Design & Build
Details	Civil, Architectural, and E&M works of 7 elevated stations, detailed planning of proposed 5 underground stations of RRTS network	Construction of 9 elevated metro stations, associated viaduct and all associated works	Civil works of 3 bridges and causeways
Length	106.5 km length	26.1 km length	N/S
Location	India	India	Saudi Arabia

Table 2 outlines the contents of all sample EIR documents. Green color represents aspects that are common in all cases while blue color refers to the ones that are discussed in two EIRs, black color demonstrates the aspects that are included in a single EIR and red color highlights unique features corresponding to characteristics of the project. All cases have an introductory section explaining the purpose of the document itself, BIM goals of the projects and other case specific subjects. Since Case 3 is a part of a mega project, there are sections defining the mega project characteristics and requirements such as the overall goal of BIM adoption, main project breakdown, Employer’s BIM management organization to oversee information management of all projects. Although, each sub-project will have their own BIM Execution Plan (BEP), they will be in full compliance with the inclusive EIR.

All three cases have clear definitions of technical aspects such as BIM uses, LOD principles, coordinates, data exchange formats and software platforms. Case 3 have BIM uses that are specified as Employer mandated BIM uses which apply to all projects and also project specific BIM uses. LOD definitions and requirements are defined clearly for each project phase in all cases.

Applicable standards, roles and responsibilities, document naming convention, model structure, quality assurance processes, clash detection, and security & confidentiality are managerial aspects that are common in all cases. Case 1 and 3 have not specified model and coordination management issues such as model breakdown or clash detection rules explicitly, yet they have identified these issues to be defined in BEPs of the projects. As Case 2 refers to only the construction phase of the project unlike others, it has distinct definitions of development of construction, as-built, asset information models and clash detection procedures such as the content of the reports, sets to be used and clash classification system to be adopted. Case 1 specifies the details of Common Data Environment (CDE) to be detailed in BEP while Case 3 assigns the platform to be used and defines the review and coordination issue tracking procedures that will be followed.

Case 1 is the only EIR that discusses competence assessment and knowledge and skills requirements of design consultants and contractors while others only include BIM deliverables within commercial aspects.

Table 2. Contents of Sample EIR Cases.

	Case 1	Case 2	Case 3
Introduction	<ul style="list-style-type: none"> -Purpose of Document -BIM Goals / Objectives 	<ul style="list-style-type: none"> -Purpose of Document -BEP -BIM Objectives -Provisions of Modelling Services with Other Contractors -Coordinated Model Including Works of All Contractors 	<ul style="list-style-type: none"> -Purpose of Document -Main Project BIM Goals -Utilization of Project Information Model (PIM) -Main Project Breakdown -Employer's BIM management organization
Technical	<ul style="list-style-type: none"> -BIM Uses -LOD Principles & Requirements -Asset Information Requirements (AIR) -Data Exchange Protocols -Asset Information Model (AIM) -Coordinates -Model Production and Delivery Table (MPDT) -2D Graphical Output -Training -Software Platforms -System Performance 	<ul style="list-style-type: none"> -Potential BIM Uses -BIM Specification and LOD Definitions -File Formats for Exchange and Submittal -Asset Information Requirements (AIR) -Coordinates -Model Production and Delivery Table (MPDT) -Software Platforms -System Performance -Hardware 	<ul style="list-style-type: none"> -Employer Mandated BIM Uses -Project Specific BIM Uses Requirements -LOI Need-Standard and Approach -File Formats -Coordinates -Software Platforms -Survey Strategy
Managerial	<ul style="list-style-type: none"> -Applicable Standards -Roles and Responsibilities -Document Naming Protocol -Security -Process Mapping -Common Data Environment (CDE) -Design & Services Coordination -Geometric Quality Assurance & Quality Control -Data Segregation -BIM Validation Prior To Model Sharing -Exclusions in Model 	<ul style="list-style-type: none"> -Applicable Standards -Roles and responsibilities - File Naming and Folder Naming Convention -Limitation and constraints on Data Entries in Model -Integration with Maintenance Management System -Model Delivery -Ownership and Rights to BIM Deliverables (Construction Model/As-Built Model/Asset Information Model) -BIM Modelling Requirements -Modelling Guidelines for BIM Elements -Model Quality Assurance -Clash Detection Management -Clash Detection Reports 	<ul style="list-style-type: none"> -Applicable Standards -Roles & Responsibilities -Key Information Management Employer Contacts -Model Delivery -Model Breakdown -Model, File And Object Naming Convention -Model Ownership -Model Requirements -Common Data Environment -CDE Procedure Guideline -BIM360 Design Workflow Submissions -Employer CDE Procedure -Security & Confidentiality -Model Review Workshop -Coordination Issue Tracking -Clash Detection & Avoidance -Viewing And Navigating The Federated Model -Quality Assurance Processes
Commercial	<ul style="list-style-type: none"> -Competence -Knowledge and Skill Requirements 	<ul style="list-style-type: none"> -BIM Deliverables 	<ul style="list-style-type: none"> -BIM Deliverables

EIR Development for Metro Projects in Turkey

All three cases of EIR were included in the procurement documents of respective projects that were shared with the prospective design consultants or contractors. Considering the significant amount of ongoing metro projects in Turkey, it is quite possible that an Employer has several tenders progressing at the same time. In order to avoid any confusion, it would be beneficial for EIR to have an introduction section that includes the project information, associated projects, purpose of the document, BIM objectives and Employer's BIM management organization and contact list, if applicable.

As EIR serves as the reference document throughout the project lifecycle, the content, delivery, and management of project-related information should be clearly identified within technical, managerial and commercial requirements.

Technical, Managerial, and Commercial Requirements

In order to optimize BIM implementation in the project, EIR should clearly define Employer targeted BIM uses. Case 1 specifies BIM uses per preliminary design, definitive design, construction documentation, pre-construction, construction, and project handover phases with associated responsible party such as Design Consultant or Contractor and including file exchange formats while Case 2 briefly summarizes potential BIM uses. For a metro project Employer who deals with several projects, BIM uses definition of Case 3 which includes both mandated and project specific uses would be recommended, since mandatory BIM uses such as Design Authoring and 3D Coordination would be required in all projects, while project specific BIM uses such as Lightning Analysis or Disaster Planning would be required depending on the project characteristics.

Levels of detail expected from models at different project phases should be explained in detail to ensure that the prospective consultants/contractors fully comprehend the context of modelling studies involved in the project. Expressing clear and strict LOD definitions within EIR would enable Employer to have models from different projects that are comparable in terms of detail and could be combined in a federated master model.

Case 1 identifies software platforms that Employer uses and their input formats, emphasizing that the consultants/contractors need to ensure their respective software platforms can deliver output in the given format. Similarly, Case 2 specifies the requirements that software solutions should satisfy such as being IFC certified, while Case 3 directly recommends software applications and versions oriented for specific tasks such as 3D coordination or construction simulation. Recommendation of software solutions of Employer's preference would be beneficial for standardization of outputs from different projects. EIR should also specify submission file formats besides the native file such as .ifc, .3dpdf, and COBie asset data, if requested. Furthermore, in order to ensure all stakeholders could access and use information from models, system performance precautions such as maximum file size should be defined.

Another technical aspect that should be defined in EIR is related to the restrictions required to maintain accurate coordinates. In order to ensure models' integration with GIS based applications, International Terrestrial Reference System (ITRF) to be used and required modelling practices such as using "shared coordinates" system should be defined.

EIR must provide a list of applicable BIM standards and guidelines within managerial aspects that are required to be adopted by consultants/contractors in order to establish consistent collaboration and information delivery procedures. Roles and responsibilities which are discussed in all three cases, have critical role in ensuring consultant/contractor is aware of what is expected from their BIM team and enabling them to build the appropriate team. For instance, Case 3 requires BIM Staffing Plan that identifies responsible people per discipline, section or phase of the project together with their duration and extent of BIM experience, and description of prior BIM projects.

All phases of a metro project, including operation and maintenance, are important for the overall life cycle of the built assets. As mentioned earlier, Employer being in charge of design and

construction works but not being the operator of the facility is a common fact for metro projects in Turkey. Identifying Computer-Aided Facilities Management (CAFM) systems that will be used and their data requirements within EIR would be quite beneficial in enhancing end user integration to BIM processes of earlier phases of the project. Case 2 can be taken as an example as it specifies equipment data necessary for operation and maintenance (O&M) that must be defined for elements of Asset Information Model such as model number, installation date, item tracking number, references to O&M manuals, warranty data, etc.

To ensure the model information remains consistent and intact, EIR should define model division strategy, model and object naming procedures, and model quality assurance criteria. Data segregation refers to division of models by zones and disciplines to facilitate discipline specific deliverables, inter-disciplinary collaboration and operational efficiency in large scale projects. Although it depends on the scale of the project, Employer can set the general framework of model division strategy to be adopted in all projects. All projects having the same model and object naming convention would also be beneficial for document management standardization. Model coordination, quality control, and clash detection processes are remaining model – based managerial aspects that should be defined in EIR. Requirements such as maximum file size, clearing the file from unnecessary objects, views and schedules, regulating work sets can be specified to maintain file integrity and increase efficiency. Clash detection processes which will be described in detail in BEP should be discussed in EIR to give an insight to prospective consultant/contractor on expected coordination studies. As Case 2 is a project that only covers construction works, it provides detailed clash detection procedures to be followed in order to eliminate conflicts that might appear on site. It even provides lists of clashes to be reported, such as conduits and cable trays that clash through floor slabs.

Common Data Environment is a key aspect of any project that involves BIM use. Case 3 explains Employer's approach to information management through CDE in detail, involving a list of CDE platforms that Employer uses at different phases of the project. If the platform to be used has already been assigned, submission and review workflows, utilization of the features of the platform such as coordination issue tracking could be described for determination of information management procedures.

Being included in procurement documents, EIR serves as an informative document for tenderers that gives insight on the scope of BIM processes within the project. As in Case 2 and 3, EIR should provide a list of BIM deliverables within commercial requirements such as improved design review process using AR/VR technology, construction sequencing & simulation, integration with GIS platform, building systems analysis, energy analysis, lightning analysis, disaster planning or any other specific requirements. In order to ensure successful execution of BIM processes and procedures, BIM specific competence assessment could be defined in EIR as in Case 1.

Conclusion

EIR plays an essential role in a BIM based project as it provides clear definitions of Employer's needs, information delivery procedures, and BIM related processes at the very beginning of the project. Wairi (2018) states an effective EIR can improve productivity in terms of budget and duration, the quality of the built facility and enable effective management and operation of the built asset at lower cost through contribution to output information obtained by Employer at the end of the project.

Despite the significant number of ongoing metro projects in Turkey, which are all BIM-mandated projects, Employers have not yet developed an EIR to ensure end user's information requirements are clearly defined at procurement phase. This study aimed to determine what should be included in EIR for metro projects in Turkey. First, research motivation had been identified as the characteristics and differing outputs of metro projects in Turkey due to lack of standardization with the aim of establishing the necessities of EIR development. Then a literature review had been conducted and limited number of studies have been found focusing on creating EIR except some templates and a general framework provided by international standard ISO 19650. Therefore, EIR documents from three infrastructure projects from India and Saudi Arabia that have different scopes and contexts have been analyzed to determine possible contents of EIR for metro projects in Turkey. As ISO 19650 describes EIR contents within three main headings of technical, managerial, and commercial requirements, sample EIR cases were examined and compared based on these requirement categories. Common aspects that were included in all cases and case specific requirements were discussed to provide a framework for the aspects that should be included in EIR of metro projects in Turkey.

The differences between the scopes of sample EIRs verified that project characteristics define the content of the EIR. One EIR includes comprehensive discussions about an aspect, whereas the other contents with a brief description and refers to the topic as to be detailed in BEP such as CDE description in Case 1 and 3. While Case 1 briefly mentions CDE and directs to BEP for details, Case 3 specifies the platform to be used, review and coordination issue tracking procedures to be followed within the platform as they had already been determined within the organization. Another example is the explicit definition of clash detection procedures by Case 2, which is the only EIR that focuses only on the construction phase of the project, such as the clash classification system and report contents while others leave these issues to be defined in BEPs of their projects. Therefore, Employer should draw the boundaries of EIR and BEP by clear definitions of BEP content depending on project requirements.

Considering an Employer has several metro projects in İstanbul, for development of a comprehensive EIR that aims to standardize BIM related processes for all projects, Case 3 is the most suitable EIR to be taken as a reference as it includes both Employer mandated and project specific requirements. Upcoming studies for the corresponding EIR development should include customization of the needs specific to local conditions and interpretation of references within the context of local practices. Future works could also include interviews with Employers of metro projects and end users of built facilities to emphasize industry needs, problems encountered due to lack of EIR and further elaboration of EIR contents.

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